Mobile Information Systems

Federated Learning, Internet of Things, and Edge Computing for Smart Services

Lead Guest Editor: Muhammad Zakarya
Guest Editors: Atta ur Rehman Khan and Santosh Tirunagari

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Retraction

Retracted: Research on the College Students' Venture Risk Assessment Model Based on the LightGBM Algorithm

Mobile Information Systems

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In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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Retraction

Retracted: Realization Path of College Students' Network Ideological and Political Teaching System in the New Media Environment

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Mobile Information Systems
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Retraction

Retracted: A Diversified Integration Method of IPE Teaching Resources Based on Ant Colony Algorithm

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Mobile Information Systems
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Retraction

Retracted: Physical Exercise Improves Academic Performance: Based on CNKI Meta-Analysis Evidence

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Retraction

Retracted: Application Analysis of Artificial Intelligence Algorithm in Accounting Field under the Background of Innovation Economy

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Retraction

Retracted: The English Teaching Mode under the Environment of Computer Technology

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[1] W. Liu and W. Shi, "The English Teaching Mode under the Environment of Computer Technology," *Mobile Information Systems*, vol. 2022, Article ID 1510057, 8 pages, 2022.

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Retraction

Retracted: A BP Neural Network Model for Evaluating the Literature and Art Career of College Students' Political and Ideological Education

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[1] Y. Jing, "A BP Neural Network Model for Evaluating the Literature and Art Career of College Students' Political and Ideological Education," *Mobile Information Systems*, vol. 2022, Article ID 3020040, 9 pages, 2022.

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Retraction

Retracted: A Classification Technique for English Teaching Resources and Merging Using Swarm Intelligence Algorithm

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Retraction

Retracted: Evaluation of the Modern Value of Imperial Examination Culture in the Context of Cultural Confidence Based on Deep Learning Models

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[1] X. Zhao, "Evaluation of the Modern Value of Imperial Examination Culture in the Context of Cultural Confidence Based on Deep Learning Models," *Mobile Information Systems*, vol. 2022, Article ID 9748146, 11 pages, 2022.

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Retraction

Retracted: Design of Experiential Teaching System for Solfeggio in Normal Universities Based on Machine Learning Algorithm

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[1] K. Liu and J. Awang bin Othman, "Design of Experiential Teaching System for Solfeggio in Normal Universities Based on Machine Learning Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 3622567, 14 pages, 2022.

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Retraction

Retracted: A Self-Adaptive Recommendation Method for Online Ideological and Political Teaching Resources Based on Deep Reinforcement Learning

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Retraction

Retracted: Influencing Factors of Students' Ideological and Political Education, Identity, and Practice Concept Based on Double-Hurdle Model

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Retraction

Retracted: Importance of Integrating Traditional Physical Education into Physical Education Teaching Using Big Data

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Research Article

Perspectives of Collaborative Governance: Integration of Social and Cognitive Computing with Complex Networks

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In the current era, big data play a very important role in various government organizations. Therefore, it is necessary to connect government big data with the national modern governance system since it is a crucial resource, asset, technology, and service support facility for government departments. The government information system requires complex system engineering. The collaborative governance of government data by integrating cognitive computing and complex networks is conducive to eliminating the contradiction and tension between policies and policy subjects. It can reduce the cross and overlap of functions between different departments and form a collaborative mechanism of other governance subjects. The suggested mechanism enhanced the government governance content integrity and system synergy. The modernization of the system is also boosted by governance capacity.

1. Introduction

Government information construction has developed rapidly. Big data have become an important national development strategy, an important asset, an infrastructure, and a service mode [1]. Many scholars and experts call for adjusting government's organizational structure in academic research and practice. To progressively create a big data-driven governance paradigm, social governance should prioritize maximizing collaboration and sharing. With the participation and integration of various social subjects, the intelligent government develops continuously [2–4]. However, the breadth and depth of government big data applications are insufficient in the specific application process. There are still problems in data opening, data sharing, big data centers, and big data service platform construction. Lack of big data application mechanism and legal protection, the government is facing the problem of big data talent shortage, managers backward ideas, and so on [5, 6]. Government big data as a service has been put out in the big data environment, therefore its features and value are covered by those of big data as well. Government big data application services are experiencing challenging service issues and inadequate service quality. Government big data network security and privacy protection are also encountering obstacles. The next generation social network system for smart cities is examined by [7] using a model for software reconfiguration and cognitive computing. In order to provide effective representation and increase robustness, the software reconstruction model is combined with improved versions of traditional social networks in the design of the model. In addition, it is also faced with the imbalance of the government's big data ecosystem. The government big data application system increasingly involves many people, machines, and things, showing the characteristics of complexity, relevance, dynamics, openness, diversity, and hierarchy.

IoT is becoming more sophisticated, interactive, and intelligent than cognitive computing, which is emerging as the third computer era. As time passes, cognitive computing

has the capacity to continuously learn through its interactions with data, people, and circumstances. Through self-improvement and learning, it grows better over time. In order to explore prospects for coinnovation, Chen et al. [8] manipulated customer data and the application of cognitive computing technologies to dynamic capability theory. They also looked at how this improvement enabled complexity theory approaches. The situations in which data mining can be used to address significant issues in complex network theory applications are illustrated [9]. These situations show how the proper integration of complex network metrics can lead to improved classification rates when compared to conventional data mining algorithms. AI is necessary for the Internet of Things. Cognitive IoT (CIoT) is the name given to intelligent IoT. The cognitive IoT employs cognitive computer, a novel computing paradigm that is frequently referred to as the third computing era. IoT will become more sophisticated, intelligent, and engaging thanks to cognitive computing [10].

2. Government Big Data Classification Organization from the Perspective of Super Network

In this section, we discuss government big data classification organization and government open data resources in detail.

2.1. Government Big Data Classification Organization. The external big data generated within the government and collected by the government for work development and management service needs are important to the government's decision. This definition mainly defines government big data from the attribute of big data resources and the dimension of resources [11]. Therefore, it can also be called government big data resources. Accordingly, industry departments pay more attention to data disaster recovery. Still, due to the lack of top-level design and overall planning, there are some phenomena, such as follow-up construction and repeated construction in some local data disaster recovery centers. In addition, the structure of data disaster recovery requires high capital and technology, and the one-time investment is huge. Therefore, the classification of government data should be based on the natural attributes of data, such as scientificity, stability, practicability, and scalability.

Government big data classification has diversity according to different methods. This is because government big data classification must meet the needs of users. Still, in fact, the needs of users are diverse, so a single classification method is bound to be difficult to meet the personalized needs of users. In addition, the classification of government big data is uncertain. For example, if divided by subject, these data may not have a suitable subject, or they belong to one subject and conform to another; if it is divided according to institutions, these data sources may not be just a single department. If the division is unreasonable, it will affect the sharing and utilization of data. In addition, some data resources can be distinguished only from the perspective of the level and degree, so we should pay attention to the flexibility of classification.

The flow of data flow in the process of government big data classification and organization roughly presents three structures. The first is the central radiation type, where the data collection, processing, retrieval, and transmission are concentrated in the organization's data center. The data center provides and publishes data according to the data request required by each department. The second is horizontal, where there is spontaneous regular or irregular organizational data exchange within the organization. The third type is crisscross. Each department manages part of its data independently and establishes interdepartmental links. Finally, the data will be concentrated in the data center. The flow structures of these three data streams are realized under organizational power. The differences in the organizational power of these three structures are analyzed from the perspective of a super network.

2.2. Classification and Organization System of Government Open Data Resources from the Perspective of Hypernetwork. From the users' perspective, the problems existing in the data resource classification of China's government open data websites can be summarized as the following two points: first, the depth and accuracy of open data resource classification are not enough; second, the classification method is single. First, the depth is not enough. According to the observation results of the data disclosure directory of domestic government data open websites, the categories are only level 1 and level 2 in-depth. Furthermore, some have only level 1 directory without level 2 and level 3 directories. Therefore, in terms of resource coverage, the resources currently provided are difficult to meet the main needs of the public. Secondly, the accuracy is not enough. For example, the first-level category covers major fields such as politics, economy, culture, science and technology, and ecological environment. However, the content resources listed under the second-level category are not complete. The first-level directory and content do not have a strong division or matching degree. Furthermore, there is a problem with the lower-level category being next to the upper-level category, which causes issues with data retrieval and low precision. In addition, the metadata description is not detailed enough, and most of them only contain some simple data attributes. These attributes seriously restrict the open serviceability of government big data resources and cannot effectively meet the public's demand for value-added development and reuse of data resources.

Government managers coordinate the classification of government open data resources, catalog classification experts, and data open resource users. Big data resources are transformed from chaos to order through the process of categorizing resources using various categorization dimensions, examining the relationships between data, filtering, sorting, and adding labels to data. Its goal is to create a sensitive, organized, natural, understandable, concise, lively, harmonic, and unified classification system structure.

With such a system, consumers may easily find, browse, and use government open data resources.

3. Government Big Data Management from the Perspective of Super Network

3.1. Key Issues of Traditional Government Big Data Management. This paper roughly divides government information sharing into three stages and summarizes its characteristics. In the first stage, the focus of China's government information resource sharing is vertical information sharing, which is characterized by information sharing among fields, levels, and specialties. Its application is mainly to facilitate government management. In the second stage, China's government information resource sharing began to emphasize horizontal information sharing, but it has an obvious trend of data center, which is characterized by centralized cross-domain, cross-department, and cross-platform information sharing. Its application is to better help government decision-making, which is decision-making sharing. In the third stage, the focus of sharing is still horizontal sharing, but more attention is paid to distributed sharing. Its feature is centralized distributed, that is, to ensure the depth and breadth of sharing, its application is to better help government decision-making and public services, the need of building an intelligent government, and service decision-making sharing.

In specific practice, the government information resource sharing mode can be generally divided into the following two types: one is the point-to-point (P2P) information sharing mode; the other is the information sharing and exchange mode of the information resource management center, as shown in Table 1. These two modes have different characteristics, advantages, and disadvantages and also have their own applicable scenarios.

The data disaster recovery center aims at "soft" disasters such as network hacker attacks, computer viruses, illegal intrusion, human operation errors, or malicious destruction, as well as "hard" disasters such as natural disasters such as fire and flood or hardware failures. It is an emergency remedy for data recovery and business continuity caused by network paralysis, data loss, and business interruption. It is an important infrastructure and service application center in the national information security system. The value of data is higher and higher. The loss of data will bring great harm to social and economic development and public life. Therefore, various industry departments pay more and more attention to data disaster recovery, but due to the lack of top-level design and overall planning, there are some phenomena such as follow-up construction and repeated construction in some local data disaster recovery centers. The construction of data disaster recovery requires high capital and technology, and the one-time investment is huge. The self-built model will consume a lot of energy for the organization, and the outsourcing model also has the risks of the system being out of control, key data loss, and so on. Local disaster recovery cannot cope with regional disaster risks. Remote disaster recovery can deal with a wide range of disaster risks, but the investment cost is high.

3.2. Government Big Data Super Network Management Based on Blockchain. Blockchain is a public ledger based on computer programs. It is a widely participated distributed accounting method. Its essence is to jointly maintain the reliability of the database through decentralization and distrust. It is a tool to help people cooperate in complex and multifields that are not familiar with each other. The main logical entities involved in the blockchain system can be abstracted into department business centers, alliance nodes, other nodes, department data centers, and information databases. Among them, the alliance node is mainly composed of the data centers of civil affairs, health, education, public security, finance, and other government administrative departments or service institutions. Each data center is the information generated and managed by each business field. Alliance nodes include two functions: information transmission and information processing. Each alliance node can provide point-to-point and point-to-multipoint information routing, information transmission, and other functions to store and share data through the consensus mechanism and smart contract function automatically operated by the blockchain system. The imported information is encrypted by the cryptographic algorithm and cannot be tampered with. All alliance nodes jointly maintain and supervise the information. Only when the information of this node is consistent with that of other nodes, that is, to ensure that the information is reliable and nonrepetitive, it can be imported into the blockchain storage system and stored and backed up in the information database. Other nodes are mainly ordinary users such as the public, enterprises, institutions, and nonprofit organizations. After being authorized by the government administrative department, they can search the basic information of individuals in the database and cooperate with the entry of node information.

The method of government information collaborative sharing and data disaster recovery based on blockchain draws on the advantages of traditional data sharing and disaster recovery methods. It can not only realize point-to-point information sharing and exchange among multiple departments but also realize decentralization and distrust. At the same time, it can be backed up, shared, and used many times, and information traceability management, which greatly increases the scope and efficiency of information sharing. Generally speaking, it has the core characteristics and advantages of good credibility, high security, strong transparency, expandability, economy, real-time, and so on.

4. Government Big Data Service from the Perspective of Super Network

4.1. Government Big Data as a Service Approach from the Perspective of Hypernetwork. The definition given in this paper is that government big data as a service are a process of providing services on demand based on the data as a service model and supported by modern information and communication technology, using the perspective of government big data super network and taking users as the center, including data discovery, data fusion, and data interaction. Government big data as a service are an infrastructure and

Table 1: Characteristics, advantages, and disadvantages of two traditional information resource sharing modes.

Pattern	Features	Advantage	Shortcoming
Point-to point (P2P) information sharing mode	Each department needs to establish a connection independently to share the corresponding data information	Decentralized, independent of a third party, two points can be shared and exchanged, with simple structure and convenient implementation	Do not use many to many sharing, poor scalability; poor manageability
Information-sharing mode of information resource management center	A unified information resource management center needs to be established. The data of all departments are centralized in the information resource management center, which is responsible for storing, configuring and exchanging data	Network utilization is relatively high; the information resource management center can backup and notarize the shared content and conduct centralized supervision; high manageability	High requirements for capacity and performance of information resource management center; poor safety

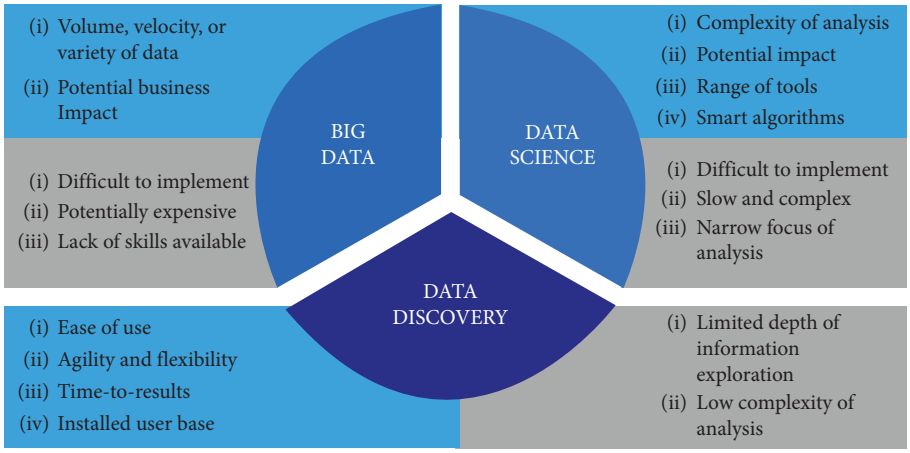

Figure 1: Government big data as a service conceptual model.

a necessary condition for the intelligent construction of the government, with obvious hierarchy. The conceptual model of government big data as a service is shown in Figure 1, which is mainly composed of resources, technology, services, and environment.

Government big data as a service are proposed in the big data environment, so the characteristics of government big data as a service also cover the characteristics and value of big data. Its main characteristics are integration, rapidity of resource allocation, and interaction of public participation:

(i) *Fusion*. Integration is the guarantee of good and quality data as a service, which is first reflected in integration, including cross-platform, cross-department, cross-level, and cross-field data integration, system integration, and equipment integration, which is conducive to solving the information gap and information island, promoting data integration and sharing, and realizing interconnection and interoperability. Secondly, it is multidimensional. Services are diverse in form and content, service channels, and data visualization analysis.

(ii) *The Rapidity of Resource Allocation*. Big data is large in scale and quantity. How to obtain the data required by users from massive data and provide it to users accurately and timely is one of the difficulties faced by big data application services. Data is a service. Through cloud computing, it can realize rapid configuration and rapid calculation in time and space through the accumulation and flow of data resources to ensure on-demand services.

(iii) *Public Participation and Interaction*. The data as a service model change the passive state of receiving government data services in the past by building a public demand expression mechanism and change the passive state into action through the active application. The form, state, and quantity of data can be controlled according to their own needs. In the service process, it can also communicate and interact with government service personnel, clarify or change their own requests, and obtain personalized services through participation and interaction.

4.2. Government Big Data for Public Service Is the Service Guarantee System. The government's big data capability evolved from the big data capability, emerged from the application of big data technology to government work, and the government's ability to obtain, process, and apply data to ensure scientific decision-making and efficient operation. Specifically, the connotation of government big data capability includes three aspects: data acquisition capability, data processing capability, and data application capability. The development of a data resource catalog classification system and the capacity of the government's big data centers for collaborative sharing and data disaster recovery should both benefit from the expansion of big data services. Strengthening the supervision and guarantee capacity of data security, data privacy, and data fraud, improve the development and reuse capacity of data and convert more dormant data into available data.

The value of data is mainly reflected in the matching degree between data association, sharing, and demand. The operation of data association and sharing can be understood as the process of the data resource configuration. Therefore, according to the degree of resource development and actual demand, the utilization of data value can be divided into four types: inefficient, deficient, wasteful, and efficient. In the era of big data, data are widely dispersed in different carriers. Therefore, it is necessary to change the data from disorder to order to form a complex but rule-based data cyberspace. The whole network organization is to connect each node on the network, realize the self-flow of data on the whole network, effectively schedule each node on the network, coordinate the connection between nodes, and completely solve the problem of data island.

The government's public service must thoroughly implement the purpose of serving the people wholeheartedly, and change the negative impression that it was difficult for the public to enter, do things, and look ugly in the past. The

implementation of government policies and the promotion of services need the cooperation of the general public. Therefore, government services must also establish a good reputation, form network communication, and unite the hearts of the people. The capability and manner of public service of a local government department in particular frequently influence the regional economy and social growth. It can effectively entice investment, talent, and other things. As a result, the management division of the public sector of government needs to learn from the practice of keeping up relationships between businesses and other organizations as well as users. Organizations and users place a high value on sustaining users, providing excellent user service, encouraging strong user commitment, and maintaining active user communication.

5. Conclusions

Government informatization construction is a complex system of engineering. As an important resource, asset, technology, and service support facility of government departments, how to deeply integrate government big data with the national modern governance system is a hot issue widely concerned by academia and practice. The government big data application system is a complex system of engineering. Through the research from the perspective of a super network, we have a further understanding of the characteristics of government big data. We suggested solutions to the problems in government big data classification organization and government big data management. We also provided countermeasures for integrating government big data and government service modes. The suggested mechanism enhanced the government governance content integrity and system synergy. The modernization of the system is also boosted by governance capacity.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

IPoE Enhanced Reliability Model Based on SDH Optical Transmission for Intelligent Power Dispatching

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Internet of Things (IoT) technology is one of the more advanced network communication technologies at present, and the IoT-based power dispatching system can improve the operation efficiency of power system. As the number of power users increases dramatically, higher requirements are put forward for the communication and management of IoT-based devices. The authentication method of traditional network structure can no longer adapt to the huge number of clients. For the problem of insufficient reliability of IPoE authentication method at the present stage, this paper proposes a model to enhance the reliability of IPoE authentication method. First, an intelligent scheduling optimization method based on SDH optical transmission technology is designed to complete the optimization of the scheduling network. The time delay of the communication network is reduced, and the reliability of the network is increased. Second, a data online collection module is established to complete the first optimization of the communication network. Finally, SDH optical transmission technology and design communication network terminal are integrated. The second optimization of the communication network is completed. After experimental testing, the proposed model can intelligently optimize the IoT-based power dispatching network. A standardized, manageable, and secure large-scale remote dispatching solution is realized.

1. Introduction

Power dispatching is an effective management method used to ensure the safe and stable operation of the power grid, reliable external power supply, and orderly production of various types of power [1–3]. As the most direct means of power dispatching command and ordering, dispatching telephones require high reliability. Not only under normal circumstances but also in severe weather conditions, and when power system accidents occur, it is also necessary to ensure that the telephone is unblocked. The dispatching trumpet is a dispatching telephone, an important deployment method. The functional framework of IoT-based power dispatch automation system is mainly divided into support platform, real-time monitoring and analysis application layer, dispatch planning application layer, and dispatch management application layer. The application of IOT-based power dispatching automation system is conducive to improving the accuracy and automation efficiency of power dispatching. At present, it is mainly used to extend the PCM to the direct adjustment factory station [4]. But the technology also faces some problems. PCM only carries dispatch calls and faces the problems of outdated equipment, lack of spare parts, and insufficient technical support from manufacturers, which affects the safe operation of the power grid to a certain extent. NGN technology such as softswitch is a new technology for dispatching calls [5, 6], which must be carried based on IP network. The current technical system of the power dispatching and switching network is mainly circuit switching. Although the switching technology has developed into IP switching technologies such as softswitch and IMS, due to the high reliability requirements of power dispatching telephones, the dispatching and switching network based on circuit switching will still be used in power dispatching and switching networks. The industry has played a major role for a long time. The natural dependence of softswitch technology on IP bearer network has led to the unavoidable hidden danger of network security since its

inception. The power integrated data network does not cover power plants and remote power stations, and the network security of the data network to carry dispatching telephones needs to be tested, and the use of IP transmission dedicated line to carry a large number of MSTP ports, and it is difficult for MSTP equipment among different manufacturers to communicate with each other [7]. This places higher requirements on IP bearer networks. The traditional PPPoE (Point-to-Point Protocol over Ethernet) access control method can no longer meet the needs of full-service operations. The introduction of the IPoE (IP over Ethernet) [8–10] access control method can make up for the shortcomings of the PPPoE method and has a good development prospect. However, there are still some problems in the reliability of IPoE [11], such as the response to some abnormal situations. This paper analyzes and discusses the reliability of the IPoE system in the network routing equipment, proposes corresponding solutions for the problems raised, and verifies the feasibility of the solution. The emergence of communication networks satisfies people's receiving and viewing of information such as images, audio, and video, but network delay has become a difficult problem in current communication. SDH optical transmission technology is the abbreviation of Synchronous Digital Hierarchy, which has the ability to reconnect, cross, and transmit lines. It is a relatively reliable and advanced communication technology and has been widely used by people. Today's communication network gaps are large, the real-time performance of the network is poor, and the stability is also a difficult problem to solve. Therefore, applying SDH optical transmission technology to communication networks [12–15] is an optimization method for today's communication networks..

In response to the above problems, we propose corresponding solutions. (1) This article uses IPoE authentication method based on SDH technology. Compared with the PPPoE authentication method, the complicated PPP session establishment process is removed. The authentication process uses Sec-Initiator to initiate authentication, so that DHCP Request packets and IP packets can create a new session when the original session is deleted, and when the session is not deleted, the normal IPoE process can solve the problem that the user cannot go online problem. (2) Based on the communication network optimized by SDH optical transmission technology, establish a data online collection module, and collect the communication data online through the network to improve the collection efficiency. (3) Integrate SDH optical transmission technology to design a communication network terminal. This terminal needs to achieve fast download speed, few network delay times, or low delay speed.

2. Related Work

2.1. IPoE Authentication Technology. IPoE is the abbreviation of IP over Ethernet. IPoE refers specifically to the technology of transmitting IP packets on the E1 link. Currently, there are two mainstream methods: dedicated chip implementation and logic FPGA chip implementation. Dedicated chips are generally used in pairs at both ends of the E1 link and use proprietary protocols to encapsulate IP packets. In this way, the product port specifications and function indexes are greatly constrained, and the cost is high, so it is not an optimal solution. The logic FPGA chip is used to implement, and the dedicated protocol is also used. On the one hand, the transmission security is guaranteed. At the same time, the subsequent protocol adjustment is relatively flexible, which can realize the expansion of the business in the future. This method can also achieve a better balance between deployment capacity and port cost and is more suitable for practical scale applications. The encapsulation definition of IPoE is given in TR101 (DSL access standard based on Ethernet), and the user interface encapsulation can be called IPoE. It omits the encapsulation of PPP in PPPoE. IPoE technology is an access authentication method introduced by the DSL Forum WT-146. It is based on the conversion of the DHCP protocol into a RADIUS authentication message to realize the user access authentication method and control. In order to obtain information such as the user's MAC address and access device port, the DHCP Option82 option is inserted into the access device, replacing the PPPoE dial-up software embedded in the user terminal, and the mechanism for obtaining the required access information is moved to the network device so that the user terminal continues to maintain its original versatility and flexibility. Therefore, compared with PPPoE, IPoE has obvious advantages in carrying services such as video and long-term online services, which provides necessary guarantees for the evolution of IP networks to multiservice bearing.

Compared with the PPPoE authentication mode, the IPoE authentication mode removes the complicated PPP session establishment process, and the rest is basically the same as the existing PPPoE authentication process, as shown in Figure 1.

First, the user's service terminal sends a DHCP Discover message carrying the corresponding Option 60 information; the message is relayed to the BRAS through the Layer 2 access device, and the Layer 2 access device can insert Option 82 into the DHCP Discover as required to provide the user line information. The BRAS receives the DHCP Discover message and extracts the relevant information and caches it. Use the RADIUS protocol to initiate authentication to the Radius Server to obtain the user's business control and QoS policy. After the authentication process is completed, the BRAS forwards the cached DHCP Discover message to the DHCP Server. After that, the DHCP server interacts with the user terminal to complete the dynamic IP address allocation process, the user terminal obtains an IP address, and the BRAS binds the user's service control and QoS policy to the IP address. When the user can start to surf the Internet, the BRAS detects that the user traffic sends a charging request to the RadiusServer. After the user goes offline, the Host sends a DHCP release message. After the BRAS receives it, it sends a stop accounting request to the Radius Server and forwards the DHCP release message to the DHCP Server.

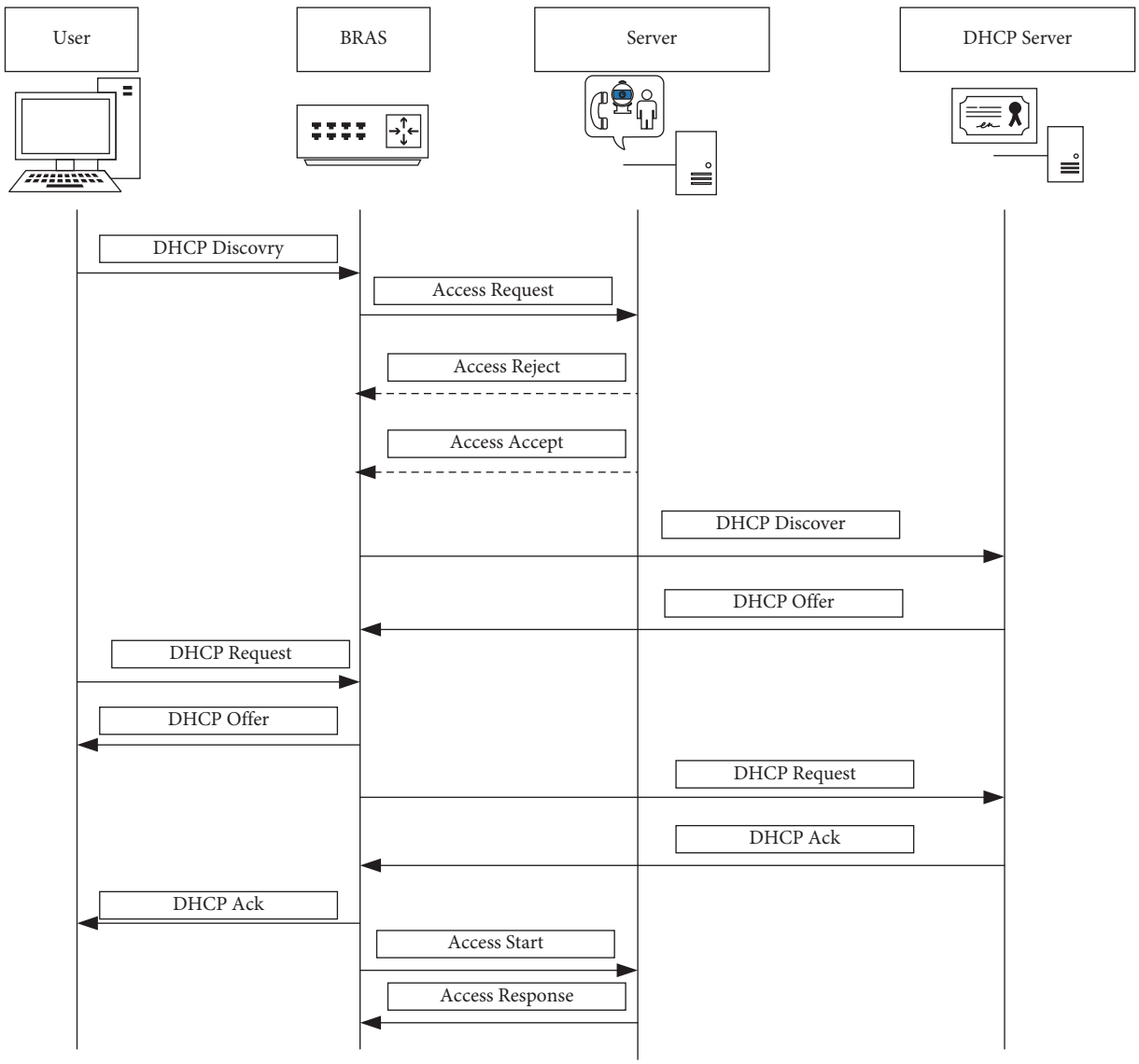

Figure 1: IPoE certification process.

In this process, the corresponding security detection and protection basically meet the needs of refined operations. However, IPoE is still insufficient in reliability, and there will be client exceptions, IPoE service exceptions, and so on. There is still a need to strengthen the handling of exceptions on the client and server sides.

2.2. Optical Transmission Technology Based on SDH in Power Grid Dispatching. SDH optical transmission technology is the abbreviation of Synchronous Digital Hierarchy. It has the ability to reconnect, cross, and transmit lines. It is a relatively reliable and advanced communication technology [16, 17]. SDH technology has many advantages: (1) unified bit rate and unified interface standard; (2) using byte multiplexing technology, the upstream and downstream signals in the network become very simple; (3) SDH equipment can accept various new; (4) rich overhead ratios are arranged in the SDH frame structure, which greatly strengthens the operation, maintenance, and management functions of the network and facilitates centralized management. Figure 2 shows how SDH works.

SDH protection methods are divided into two categories: channel protection and multiplex section protection. In channel protection, service information is protected on a per-channel basis. In normal times, service signals are also transmitted in the protection section, that is, dual transmission and selective reception. In industrial production applications, the common channel protection mechanisms mainly include two-fiber single-phase channel protection and two-fiber bi-directional channel protection. In another method, the inverted ring is based on the signal quality of the multiplex section between nodes. When a fault occurs in the protection ring, the service information of the multiplex section between the entire nodes is turned to the protection ring. Doing so saves the bandwidth occupied by the service transmission.

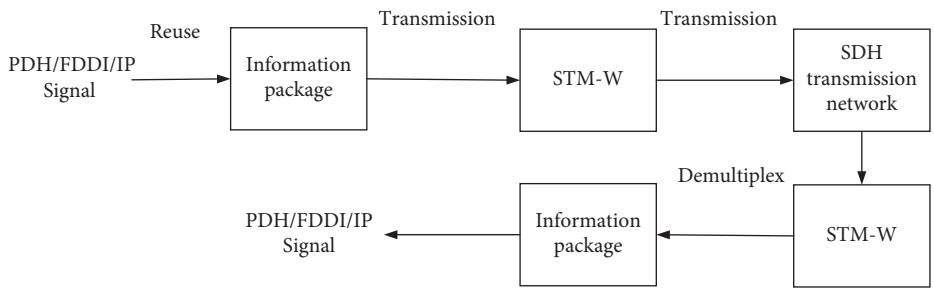

Figure 2: Schematic diagram of how the SDH system works.

3. Method of This Article

This chapter mainly introduces the IPoE enhancement method proposed in this paper and the grid trumpet scheduling method based on SDH technology.

3.1. IPoE Authentication Method Applied in Power Grid Dispatching. In the daily dispatching process of the power grid, there is a problem that the client cannot go online due to the abnormality of the client. Mainly because the server deletes the session, the message sent by the client cannot create a new session. For the two cases of abnormal client, there will be two kinds of packets, namely DHCP Request packet and IP packet. It is only necessary to allow these two packets to create a new session when the original session is deleted and to follow the normal IPoE process when the session is not deleted to solve the problem that users cannot go online. The DHCP Request message and IP message that create the Session at this time are collectively referred to as Sec-Initiator.

3.1.1. DHCP Request Trigger. There are two ways to trigger the creation of a Session by a DHCP Request message. First, you can use the Mac address as a keyword to search for a list of existing sessions and create a new session if not found. However, when the number of user sessions is large, it will take a certain amount of time to search once. Second, by summarizing the scenarios in which Request packets are generated, it can be found that there are three situations in which DHCP Request packets are generated: (1) Request packets in the normal process; (2) Request packets in the renewal process; (3) Sec-Initiator in the Request message. For the first and second cases, the Session is generated by the Discover message, and the Request here does not need to generate the Session again. When the first situation occurs, the user has not applied for a legal IP and has not specified the applied IP; that is, the Request IP field and SrcIP in the DHCP Request message are both 0.0.0.0. The second case is when the contract is renewed, the user already has a legal IP; that is, the SrcIP field is not 0.0.0.0. When the Request message in the third case is generated, because the user knows that he is disconnected, he is still in the state of no IP, but if he wants to continue to use the IP used before, he must fill in the disconnection in the Request IP field. The IP is used before the line, and the SrcIP field is still 0.0.0.0. After analysis, it can be seen that whether a new session needs to be created can be determined through the comprehensive judgment of the Request IP field and the SrcIP field in the DHCP Request message, thus saving the trouble of finding the entire Session list. The process is shown in Figure 3.

3.1.2. IP Triggering Method. Consistent with the idea of creating a Session with a Request message, if you directly use IP as a keyword to find a Session, the efficiency will be low. According to the analysis, in the normal IPoE process, in addition to the user's voluntary offline, the DHCP lease expires, and AAA forces the user to log off, which will delete the session. The text cannot pass normally. You can make a cached record every time you delete a session, and only record basic information such as IP and Mac for the session with IP, and then delete it completely after a period of time. In this way, when searching by IP, only the IP on the cache needs to be searched, and the efficiency can be greatly improved. Obviously, the abnormal disconnection of the user does not follow the normal offline process, so it is only necessary to delete the lease expiration and AAA forcibly offline and record the cached session of the IP. When the IP packet received by IPoE is found in the cache deletion record, a new session will be created with IP as the keyword and then entered the process of authentication to the AAA Server, but the application for IP is less than that triggered by the DHCP packet. The process is shown in Figure 4.

3.2. IPoE Authentication Method Reliability Scheme Design. According to the design of the above-mentioned enhanced reliability scheme, some adjustments need to be made to the original IPoE system. First, in the process of message processing, add the processing of messages in the Sec-Initiator phase according to the above scheme. When processing the IP in the Sec-Initiator phase, the cache list of the deleted session needs to be used. This list needs to be generated when the original IPoE system deletes the session, and the steps of adding and deleting the cache list are added to the process of deleting the session except the user's active application to go offline.

Second, it is necessary to store the original Session structure into two parts: user-mode Session and kernel-mode Session. The main storage contents of Session include SessionKey, AuthInfo, State, ProfileId, and OptionInfo. SessionKey, as the name suggests, is a key feature that can uniquely identify a Session information, which can be

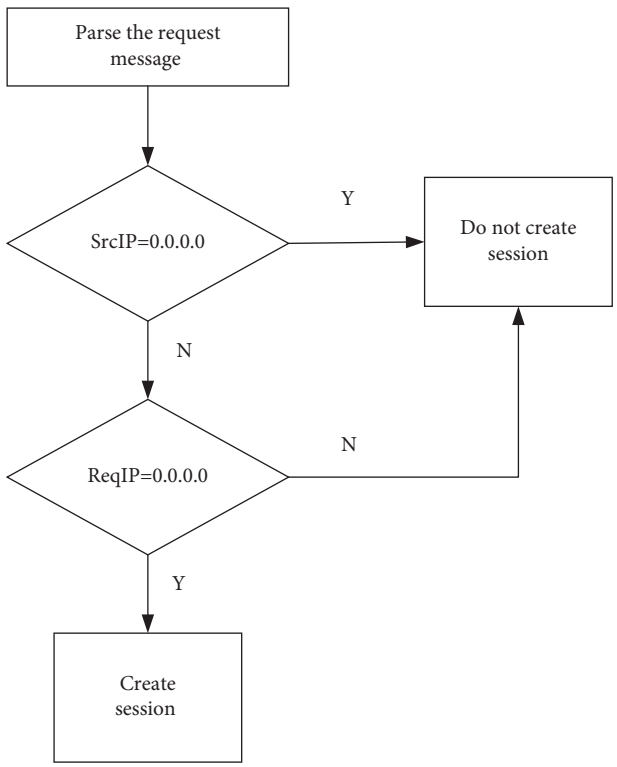

Figure 3: The Request message triggers the creation process.

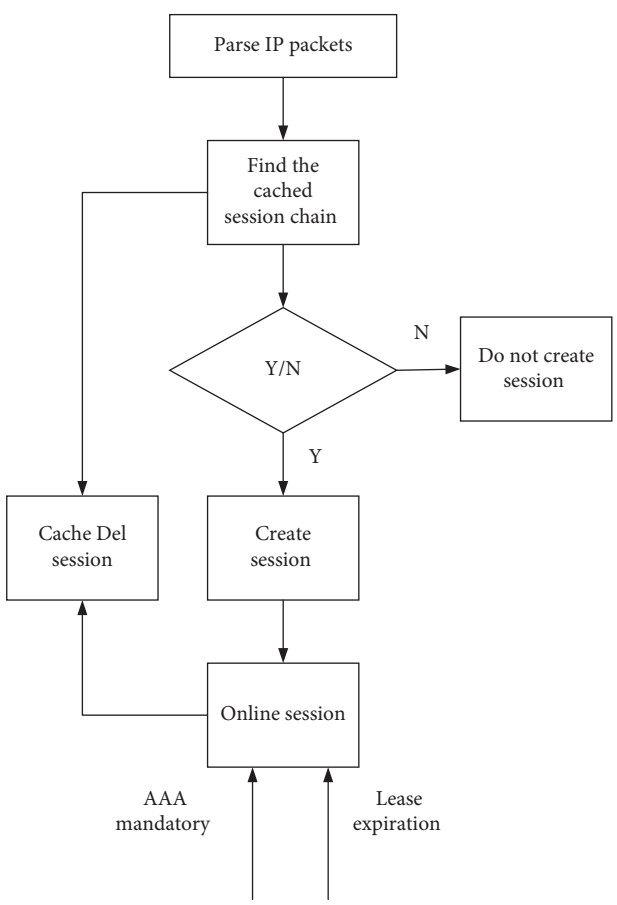

Figure 4: IP packet creation flowchart.

composed of one or several features. In the IPoE system, the SessionKey undoubtedly needs to be stored in both the kernel and user mode. It is defined as EDHC-P_SESSION_KEY_S, including interface index, client IP, client Mac, and client VlanID. AuthInfo is the username and password that records the user's authentication to AAA. State identifies the authentication state a user is currently in. ProfileId records the user policy ID issued by the session after successful authentication. OptionInfo records Option82 or Option60 information in DHCP packets.

3.3. Power Grid Dispatching Network Terminal Based on SDH Optical Transmission Technology. The function of establishing an information online collection module is to improve the communication speed of the communication network. Therefore, it is necessary to break through the traditional way of collecting information, not limited to independent collection and solidified collection, and combine the advantages of both. To establish a parallel or series collection line, keep the collected information in a state of mutual connection, and ensure that the communication network avoids lines that may cause network congestion in the process of collecting information, and the network flow control function can be realized from the entire communication network. The online acquisition module also needs to have the ability to optimize the communication efficiency. When receiving information, according to the collected information, it will mark out the communication congestion section, avoid or transfer the communication section, and connect to the other side of the communication at the fastest speed. The establishment of the information online collection module is to combine the communication services of the communication network to divide different network traffic. The network layer module, the middle layer module, and the sink layer module are connected to the 30 kV network layer receiver under different operating traffic, and it is connected with the 100 kV middle-layer receiver through the F interface, and the middle-layer receiver is merged into the 220 kV sink-layer receiver through the G interface. According to different communication forms, different collection flows are designed. Increase the flow voltage, and reduce the network delay.

Based on the information acquisition module established above, it can be analyzed that the current communication network terminal functions are relatively simple, and the SDH optical transmission technology stands out in the transmission technology due to its unique advantages of reconnecting lines. Therefore, when optimizing the communication network, it is necessary to integrate SDH optical transmission technology. Transmission technology, a new type of power grid dispatching communication network terminal, is designed.

First, using SDH optical transmission technology, the communication network terminal is designed to add the function of a small processor in addition to the functions of making calls, watching videos, and downloading audio, which can communicate without interrupting the purchase of goods. SDH optical transmission technology can break

through the influence of the CPU, and the phenomenon of communication interruption due to network delay or network instability will no longer occur. Second, it is necessary to have the function of distinguishing information and multimedia processing, and application software is connected through the network to make the communication network more diversified, and the network speed and communication environment are improved for different communication conditions. With the popularization of intelligence, communication network terminals need to be further optimized. On the basis of independent operation, the communication platform should be improved to make the communication process private. Finally, based on SDH optical transmission technology, by changing the network line, the communication network terminal can be effectively connected with external equipment, realizing the exchange of component functions, improving the singleness of the previous communication network terminal, and developing in a more intelligent direction.

In the optimization design of network core performance, the optimization of destructive resistance and delay is very important. In terms of optimizing the core performance of the communication network, the communication delay is one of the key factors for the poor core performance of the communication network. Considering the requirements of network invulnerability and delay, the communication network speed should be balanced as much as possible. If there are too many communication devices between points, the communication speed will be relatively reduced. Especially when the information passes through a relatively congested network path, the communication time increases, and the communication quality deteriorates. The delay in the communication network is eliminated, which not only improves the delay performance of the communication network but also the core performance of the communication network. In order to ensure the optimization of the core performance, it is necessary to control the communication network resources, and at the same time, the sender and the receiver at both ends of the communication need to cooperate with each other to predict the hidden dangers of the communication network path and ensure the smooth application of the core performance.

4. Simulation Results and Analysis

4.1. IPoE Enhanced Method Reliability Verification. In order to verify the validity of the two reliability schemes, the Sec-Initiator packet triggers the user to go online, and the session recovery when the IPoE service is abnormal, the verification is carried out in the networking model. The networking model is shown in Figure 5.

4.1.1. Functional Test. First, verify the DHCP Request message. Through Sec-DHCP, enter 10 Request IP fields to carry valid IP and the SrcIP field is 0.0.0.0 DHCP Request message. Check the Session information of the IPoE Device, you can see that these 10 packets are all online, and the IP address is the IP address carried in the Request IP. Then, enter 10 RequestIP and SrcIP fields through Sec-DHCP,

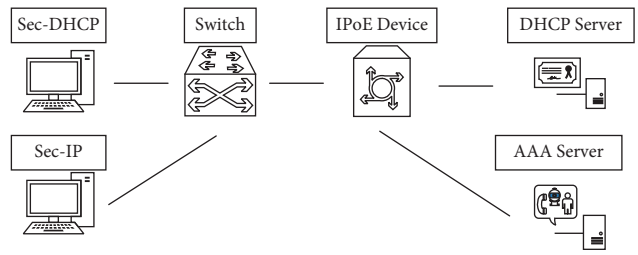

Figure 5: Schematic diagram of the networking model for verifying the IPoE enhanced reliability solution.

both of which are 0.0.0.0, and the RequestIP field is 0.0.0.0. The SrcIP field is a DHCPRequest message with a valid IP. Checking the IPoE Device does not generate relevant Session information. Then, verify the IP packets. Enter 10 valid IP packets through Sec-IP, check the session information of the IPoE Device, and show that 10 sessions are generated, and all are online. Finally, verify the session recovery scheme during IPoE soft restart. In order to verify the recovery of the session after the IPoE soft restart, it is necessary to input 10 packets through Sec-DHCP first, and check that the packets are all online at the IPoE Device. Then, kill the IPoE process on the IPoE Device, and check that the Session information does not exist. Restart the IPoE process, and check the session information after 30 seconds. All 10 sessions have been restored and are online.

4.1.2. Stress Test. In order to verify the reliability of the scheme, a stress test was carried out on the above scheme. Through the tester, the IPoE Device has been injected with the full specification of 32 k traffic for a long time. The result shows that only a few sessions fail to go online, and the rest of the sessions can go online normally, and the online rate can reach 98.6%. The reason why a few sessions fail to go online may be due to router packet loss and other reasons.

4.1.3. Performance Test. In addition to functional test and stress test, the performance of the IPoE system in this solution was also tested. The results show that on the IPoE Device, there can be an average of 450 sessions going online per second, which is acceptable.

Through the verification of the above two reliability schemes, it is confirmed that the scheme in this paper is feasible, and it can be seen from the verification that the effect of this scheme is relatively ideal, which can effectively enhance the reliability of the IPoE system.

4.2. Power Grid Scheduling Simulation Based on SDH Optical Transmission Technology. Establish a communication network model based on SDH optical transmission technology, connect 3 devices on the network cable, fold the network cable into 3 segments, and design the traffic of 5 Mb/s and 15 Mb/s for the network cable through OPEN software. The same design of the network is made, and simulation experiments are carried out to verify whether the optimization method designed in this paper is feasible.

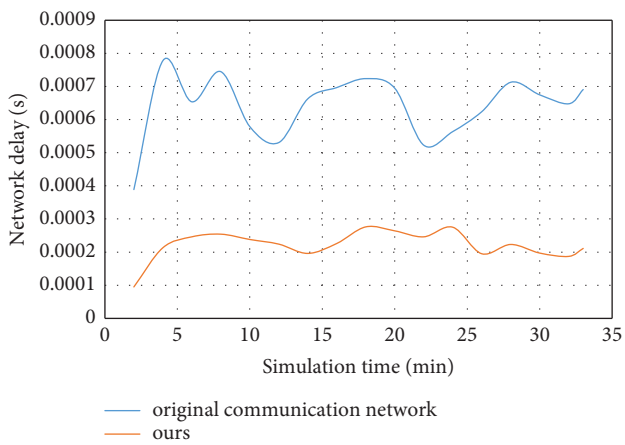

Figure 6: Simulation effect of grid dispatching network delay based on SDH technology.

After the simulation experiment, the simulation results obtained are shown in Figure 6. The simulation results are the network delay comparison diagram, the abscissa is the simulation time, and the ordinate is the network delay at different simulation times. It can be seen from Figure 6 that the original communication network is within half an hour, the network delay at different simulation times is more than 0.00040 s, and the fluctuation range is relatively large, which is basically maintained at about 0.0070 s. The communication network designed in this paper is under the same conditions. The delay is about 0.0020 s, and the fluctuation range is small. In the scenario of power grid dispatch simulation, the overall delay of the method in this paper is low, and the fluctuation is small. Therefore, the communication network designed in this paper is more real time.

To sum up the simulation results, the model proposed in this paper achieves smaller network delay, smaller network fluctuation, and more real-time performance in power grid dispatching.

5. Conclusion

Internet of Things (IoT) technology is a professional network technology with strong advancement at this stage, and its joint application with power system can improve the operation efficiency of power network and provide better guarantee for operation quality. In this paper, an enhanced model of IPoE authentication method based on SDH optical transmission technology is proposed for the application of IoT in power network. First of all, based on the authentication method for the IPoE system, improve the reliability of the network. On this basis, the SDH data acquisition module is designed to optimize the network. Finally, the SDH technology is integrated to complete the optimization of the system to achieve the purpose of reducing delay. In this paper, a simulation experiment is carried out on the above method. Experiments show that the model proposed in this paper can effectively solve the above problems and enhance the reliability and low delay of the power dispatching network. It can intelligently optimize the energy consumption of the power industry and achieve standardized, manageable, and secure scale remote dispatch. The model proposed in this paper is currently used in the power grid dispatching scheme, and the method of this model is similar to the dispatching system in the railway network. In the future, based on this model, further research can be carried out in the railway scheduling problem, so that the model has a wider range of applications.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Cognitive Neural Computation Modeling of Human Brain Information Storage and Extraction Based on Intelligent Computing

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With the development of neurological and brain science, human beings have more understanding of the memory mechanism of the brain. Therefore, using the memory mechanism of the brain to store and retrieve images is one of the most popular research fields in the world. Memory is an important part of the human cognitive system, and it is the basis for the realization of higher-level cognitive activities. Human perception and memory are closely related. If people lose the ability to perceive, then people's memory function will not be able to display. The current storage and extraction of brain information are mostly based on mathematical principles, without considering the memory mechanism in the brain, so the correctness and effectiveness of these methods are not high. Therefore, this study adopts an intelligent algorithm based on PCNN to denoise, segment, identify, and retrieve images. On this basis, a new learning method is adopted. This method can realize online incremental learning and can realize the storage of brain image data without predetermining the size and structure of the network. And when necessary, the information is extracted or not based on the distance between the detected versus the stored data. The test shows that when the number of images is 25, the present technique has an accuracy of 100% and the time required is 2345 s. Compared with the median filtering method, the efficiency of the present technique is greater.

1. Introduction

With the continuous development of cognitive neuroscience, human beings have more understanding of the memory mechanism of the brain. Therefore, using the memory mechanism of the brain to store and retrieve information is one of the most popular topics in the world. A large number of experiments have shown that it is a very effective method to use the memory mechanism of the brain to store and extract image information. According to the current research results, the memory of the human brain is a process of repeated evolution in the human brain through the process of memory, retention, and reproduction. Therefore, it is of great theoretical and practical significance to study the mechanism of human memory and apply it to computer vision, especially how to express, store, and retrieve when necessary in the brain.

Scientists have done the following research on cognitive neurocomputational modeling. Coccoli et al. believe that, in innovation, cognitive computing systems and big data are the key points [1]. How to use big data to improve human cognition is an important topic in the current field of intelligent computing. Chen et al. made a comparison and analysis from the aspects of deep learning data representation, cognitive model, parallel computing, and its application in big data environment. Several issues and development directions based on deep learning in big data are discussed, which provides a reference for future research [2]. The main problem of these studies is the low efficiency and accuracy of the model, for which this study introduces intelligent computing.

For intelligent computing, the main research results are as follows. Zhang et al. introduced various applications and technologies of integrated intelligent systems, as well as the

advantages and disadvantages related to learning theory and expert systems [3]. With the rapid development of human society, the process of urbanization of the world population is also advancing rapidly. Urbanization brings many challenges and problems to urban development. Today, many countries are actively responding to the call for smart cities. Tong et al. discussed the current status of smart city development, provided the context of smart city development, and briefly defined the concept of smart city. Based on these definitions, a framework for the smart city is described. Various types of intelligent computing to make cities smarter are discussed and analyzed, along with specific examples [4]. Khan et al. proposed an intelligent computational method to study the resonance behavior of the Dauphin formula. The proposed method is a combination of artificial neural network and Firefly algorithm. A novel feature of ANN activation is the use of cosine functions and some error measurements are given in tables and graphs to discuss the convergence and accuracy of the scheme. The trajectories of the dynamical systems are also complemented with geometrical descriptions of the amplitude and angular frequency for different values of the phase level [5]. Saleem Durai and Sundaresan proposed a new intelligent computing framework that uses fuzzy machine clustering with extreme learning and formulates adaptive and cognitive energy and power allocation rules based on kernels [6]. Sabir et al. proposed a new standard for computational neural networks, using statistical operators to test the performance of GNN-PSO-SQPS to ensure the accuracy of research data [7]. In this study, intelligent data processing is introduced to improve the performance and accuracy of the model.

In the recall test trial, what the model does is extract semantic information about the test stimulus image. When the number of learning image samples is 5, the accuracy of the algorithm in this study is 63.2%, and the required time is 457 s; the accuracy of the median filtering algorithm is 42.1%, and the required time is 2192 s; when the number of learning image samples is 10, the accuracy of the algorithm in this paper is 65.6%, and the required time is 1076 s; the accuracy of the median filtering algorithm is 46.8%, and the required time is 4197 s.

2. Cognitive Neural Computational Modeling Methods

Generally, computational models based on cognitive psychology are only applicable to descriptive memory, that is, episodic memory and semantic memory. Contextual memory experiments generally include two stages: the learning stage and the testing stage [8]. A series of stimuli, such as a list of words, was presented to the subject to memorize. In the test, subjects reconfirmed (distinguishes what has been learned and what was not learned) or memory (from which detailed information learned is extracted), and recall is divided into cued recall, free recall, and associative recall [9].

Abstract models of episodic memory attempt to describe mental operations that enable reaffirmation and recall, but they do not specify how they are performed in the brain. Although there are huge differences between different scene memory retrieval modes, most of the current abstract modes share the same property: individual memory, which is the so-called "memory imprint" [10]. Storage is an individual's storage of transformed information in the brain for later retrieval when needed. Extraction refers to taking the information stored in the brain out and making use of it when the individual needs it. During learning, imprints are placed separately in long-term memory due to this independent assumption that new imprints will not have an impact on the integrity of previously stored imprints. The words in the study list will be saved as a scene image, where the scene vector is an incomplete and error-prone copy. Every time a word is learned, a new piece of information is stored into each feature. During the test phase, the model will be compared against all entries stored in memory based on the test hints. Adding this information all together, one can calculate an overall matching familiar signal [11]. Most hypothesized recognition memory is related to the overall degree of matching of the signal. Semantic memory is our ability to construct internal representations that allow us to predict what people cannot see [12].

The CLS model incorporated some widely accepted views on the division of labor between the hippocampus and the medial temporal cortex, explaining why the brain requires two distinct specialized learning and memory systems [2]. The CLS model is a biologically based model. The medial temporal cortex forms the bottom layer of the model's structure and is a distributed, overlapping system capable of incrementally integrating context to extract underlying semantic structures; the hippocampus is a sparse, pattern-separating system responsible for the rapid learning of episodic memory. Therefore, the medial temporal cortex is mainly responsible for semantic memory and the hippocampus is mainly responsible for episodic memory [13].

Memory elements in hippocampal and medial cortical networks are represented by excitatory activation patterns distributed across different network units. Excitatory activation propagates through positive synaptic weights, the overall level of which is controlled by other factors [14]. In the CLS model, learning takes place in the hippocampus and in subregions of the medial temporal cortex using simple learning rules. When the connection between transmitter and receptor neurons is strengthened, the connection between the two also weakens [15].

This model suggests that incremental learning occurs in the medial cortex, with each training resulting in relatively small adaptive changes in synaptic weights [16]. The model hypothesizes that this property enables the hippocampus to rapidly recall any event-related activity pattern, regardless of whether they are similar [17].

The hippocampal model applies the generally accepted ideas about how the hippocampus works [18]. In the brain, the entorhinal cortex forms a bridge between the hippocampus and the cerebral cortex. The superficial layers of the entorhinal cortex receive input from the hippocampus and the deeper layers of the entorhinal cortex receive output from the hippocampus [19]. In the test phase, when the hippocampal model received the preconditioned input model from the

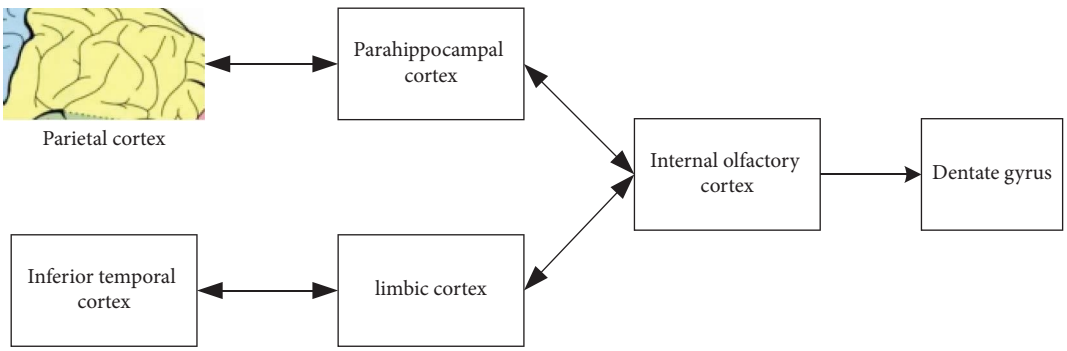

Figure 1: Information storage and extraction process of the hippocampal model.

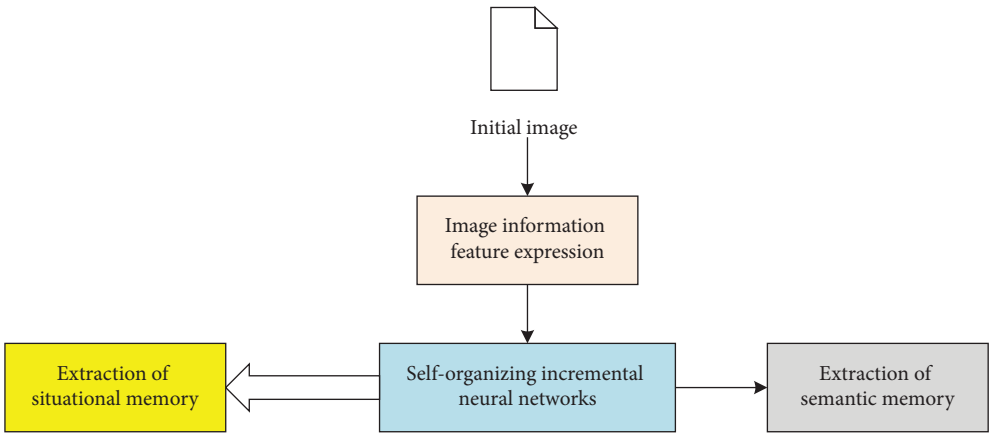

Figure 2: A cognitive neural computing framework for image information storage and extraction.

entorhinal cortex, the model was able to reactivate the CA3 model corresponding to this whole element, which strengthened the weights of the entorhinal cortex circuitry and strengthened the CA3 loop. As the weights became stronger, reactivation extended from the representation of the CA3 element to the representation of the CA1 element and from the representation of the CA1 element to the representation of the output element of the entorhinal cortex. Thus, the hippocampus is able to retrieve the full version of learned patterns from the entorhinal cortex in response to partial cues. Figure 1 shows the information storage and extraction process of the hippocampal model.

In the framework of the CLS model, two models are included: the hippocampus and the medial temporal cortex. The two models have their own division of labor. The hippocampal model is responsible for quickly remembering specific events, and the medial temporal cortex model is responsible for slowly learning semantic information in the environment. This framework model is used to interpret large amounts of human and animal data and is considered one of the most sophisticated models in the field of neural networks. Combined with the CLS model framework, a cognitive neural computing framework for image information storage and extraction is designed, as shown in Figure 2.

The self-organizing incremental neural network can perform online incremental learning, and each learning and training will update the weights of the nodes in the network, and the result of the update is to make the network structure more in line with the distribution of data. These properties are fully consistent with the assumptions of the CLS model for the function of the medial temporal cortex. Therefore, a neural network was used to simulate the online incremental learning ability of the medial temporal cortex. Since the various structures and functions of the hippocampal model in the CLS model conform to the physiological structure, they were not changed. In this framework, the neural network models the medial temporal cortex for storing and retrieving semantic memories, and the hippocampus model for storing and retrieving episodic memories. The hippocampus has two functional modes, encoding mode and retrieval mode, corresponding to the learning phase and the testing phase, respectively. In encoding mode, CA1 activation was driven primarily by neural networks; in retrieval mode, CA1 activation was primarily driven by memory traces stored in CA3.

The feature extraction stage of image processing is the basic link of image retrieval. Only correct description and extraction of features can ensure the accuracy of recognition. When storing and extracting image information, the establishment of the image information feature expression model is the key factor that determines the quality of image information storage and extraction results. The establishment

of the image information feature expression model is to complete the storage and extraction of image information by extracting the characteristics of the image itself and expressing it in a certain way. When establishing the image information feature representation model, it is necessary to consider which features to represent the image, and good features can not only reduce the complexity of the operation but also improve the accuracy of extraction; the second is to determine the features of the image. Then, how to accurately extract these features, a good feature extraction method can play a multiplier effect with half the effort. Due to the complexity of image information, there is no unified feature selection method so far. Generally speaking, for different applications, different feature extraction and selection methods are used. However, qualified image features should have the following characteristics: (1) distinction: features should have a large amount of identifying information, unique to the target image, and have good distinguishability; (2) reliability: refers to the stability within the class, the same type of images must have similar or the same eigenvalue; (3) autonomy: refers to the autonomy between types, the characteristics of each type should be different, and the difference between the types is greater than the difference within; (4) low-dimensional number: with the increase of the feature dimension, the amount of operation also increases, and it should be converted into a low-dimensional feature space as much as possible.

For an image, there are usually three methods to extract local features in the image. (1) Dense sampling: the most commonly used dense sampling method is the uniform segmentation method. This method divides the image sample into several small blocks uniformly according to a certain scale and then uses a large set of small image blocks obtained as the features of the image, and these features are also the basis for the generation of the dictionary. There is also a commonly used dense sampling method: the sliding window method. This method takes the small image block contained in the window as a local area by sliding the window, and the size and content of the local area change with the window size and the pixel interval of window sliding. In the obtained set of small image patches, this method may result in partial overlap between the small image patches. (2) Machine sampling: the random sampling technique is to randomly sample an image and describe it as a feature. The disadvantage of this algorithm is that random sampling will cause local areas in the image to be in the background, thereby affecting the expression of objects in the image. (3) Detection and sampling of points of interest: the development history of local features was looked at. The invariance of local features is a hot research topic and the key to its development. The invariant feature of an image is the invariant representation or description of the image, that is, the essence of an image different from another image, including rotation invariance, scale invariance, affine invariance, and illumination invariance. In real life, humans only focus on the target of interest, and the same is true for local features. The coordinate position of the point of interest in the image is also what people care about, and the size and shape of its neighborhood are also taken into account.

There are two types of image feature extraction methods: global and local feature extraction. The former is generally used to describe the content of the entire image, such as color, texture, and shape, and is obtained by counting all points in the image. Since it contains the entirety of the image, it is somewhat robust to random noise. However, due to the changes of illumination, scale, rotation, and other changes in the image, the global features will also change, which cannot be accurately described. For this reason, the neural network algorithm in intelligent computing is introduced in this study. The so-called intelligent computing is to use the laws of nature, especially the laws of the biological world, to solve problems through simulation. It has the characteristics of self-learning, self-organization, and self-adaptation and has been widely used in various fields.

Artificial neural network has the ability of self-organization and self-learning. It can receive training samples and discover the rules and inherent characteristics of the data in the training samples during the learning process. With these rules, the neural network can quickly classify and identify when the subsequent test samples are input. The feedback characteristics of the neural network, that is, the inappropriate characteristics of the data characteristics are obtained from the training samples and fed back to its characteristic group, and the reasonable correction makes its intelligence perform better; the neural network has parallel processing capability, which makes it possible to process its data quickly and make real-time processing possible. Because the number of nodes in the neural network is limited, there is too much information to learn and memorize in real life. This means that the neural network may need to use limited weights to store unlimited input information, that is, use the competitive learning theory to store information. The artificial neural network can well approximate any complex nonlinear relationship so that its performance is improved, thereby improving the fault tolerance and storage capacity of the system.

The basic unit of the PCNN neural network model is the pulse-coupled neuron. These basic units are connected to each other to form a single-layer two-dimensional locally connected feedback network. Each neuron consists of three parts: the receptive field, the modulation field, and the pulse generating part. The PCNN model does not need to be trained and has self-organization ability, and the threshold changes dynamically according to the time and the results of surrounding neurons. Spike-coupled neurons are the basic components of spike-coupled neural networks. Numerous parameters of pulse-coupled neurons have nonlinear relationships that restrict each other. The relationship between the parameters of the PCNN model determines its different characteristics from general neural networks: variable threshold characteristics, synchronous pulse firing phenomenon, capture characteristics, dynamic pulse firing phenomenon, automatic wave characteristics, and comprehensive spatiotemporal characteristics. PCNN has the characteristics of synchronous pulse release, and PCNN has good rotation invariance, scale invariance, and

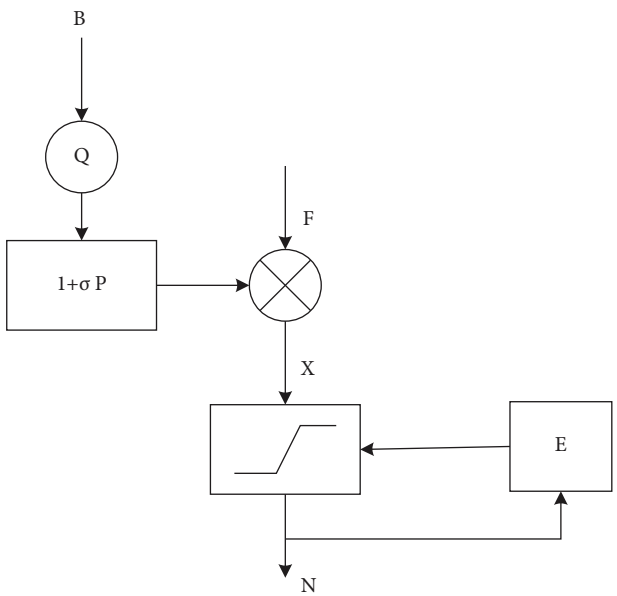

Figure 3: Basic structure of a single pulse-coupled neuron.

signal intensity invariance in image processing. The basic structure of a single pulse-coupled neuron is shown in Figure 3.

The neurons of PCNN have the characteristic of variable threshold decay, which decays exponentially with the passage of time, and the internal activity term of the neuron is greater than the current dynamic threshold and emits pulses. The firing cycle of each neuron is different. In a certain period, the dynamic threshold of each neuron will decay with a certain period and release pulses at various moments, showing a dynamic pulse distribution. When the neuron is in motion, the visible wave propagates in a similar way to a wave, and its propagation direction is similar to that of the wavefront neuron. This is the dynamic pulse distribution and waveform characteristics of PCNN. The distribution and capture characteristics of synchronous pulses are exactly in line with the distribution of dynamic pulses and the characteristics of automatic waves. The former has static characteristics and the latter has dynamic characteristics. The pulse signal in the static state is the spatial characteristic of the input signal, while the output of the dynamic signal is the time-domain characteristic of the signal. At the same time, the number of pulses' output reflects the spatial nature of the system. At different moments, the number and sequence of output pulses reflect the temporal characteristics of the input signal, which is the comprehensive spatiotemporal characteristics of PCNN. The synchronous pulse firing phenomenon and the capture feature in the PCNN features constitute the static properties of the PCNN model. The dynamic pulse firing phenomenon and the autowave characteristics constitute the dynamic characteristics of the PCNN model.

During image processing, the details and edges of the original image are preserved as much as possible. In image noise, impulse noise occupies a large proportion. In this study, PCNN and edge preservation algorithm are combined to eliminate noise and extract edges. Figure 4 shows the basic steps of the algorithm.

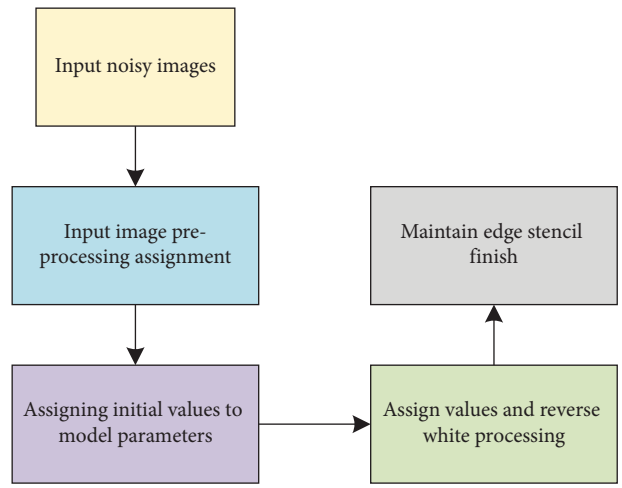

Figure 4: Basic steps of the algorithm.

The following is the relevant formula of the algorithm of PCNN combined with the algorithm of preserving the edge:

$$\begin{aligned} F_{uv}[b] &= U_{uv}, \\ P_{uv}[b] &= \sum_{kp} Q_{uvkp} N[b-1], \\ X_{uv}[b] &= F_{uv}[b](1+\varepsilon P_{uv}[b]), \\ B_{uv}[b] &= \begin{Bmatrix} 1, X_{uv}[b] > E[b-1], \\ 0, X_{uv}[b] \le E[b-1], \end{Bmatrix}, \\ E_{uv}[b] &= e^{-\delta} E_{uv}[b-1] + Y_E B_{uv}[b], \end{aligned} \tag{1}$$

where U_{uv} is the gray value of the corresponding pixel point, F_{uv} is the input to the neuron, P_{uv} is the connection input of the neuron, X_{uv} is internal activity items, and E_{uv} is dynamic threshold,

$$\mathrm{ME} = \frac{1}{A \times B} \sum_{m=0}^{A-1} \sum_{n=0}^{B-1} [\mathrm{f}(m,n) - \overline{f}(m,n)]^2, \tag{2}$$

where $f(m,n)$ is the original image,

$$\begin{aligned} \sigma_0 &= \sum_{a=0}^{t} \frac{aL_a}{q_0}, \\ \sigma_1 &= \sum_{a=t+1}^{A-1} \frac{aL_a}{q_1}, \end{aligned} \tag{3}$$

where σ is the average gray value,

$$\begin{aligned} \sigma &= \sum_{a=0}^{A-1} aL_a, \\ h &= q_0(\sigma_0 - \sigma)^2 + q_1(\sigma_1 - \sigma)^2, \end{aligned} \tag{4}$$

where h is between-class variance and σ is the overall average gray level of the image,

$$h(t^*) = \arg\left\{\operatorname*{Max}_{0 \le t \le A-1} [h(t)]\right\}, \tag{5}$$

where $h(t^*)$ is segmentation threshold,

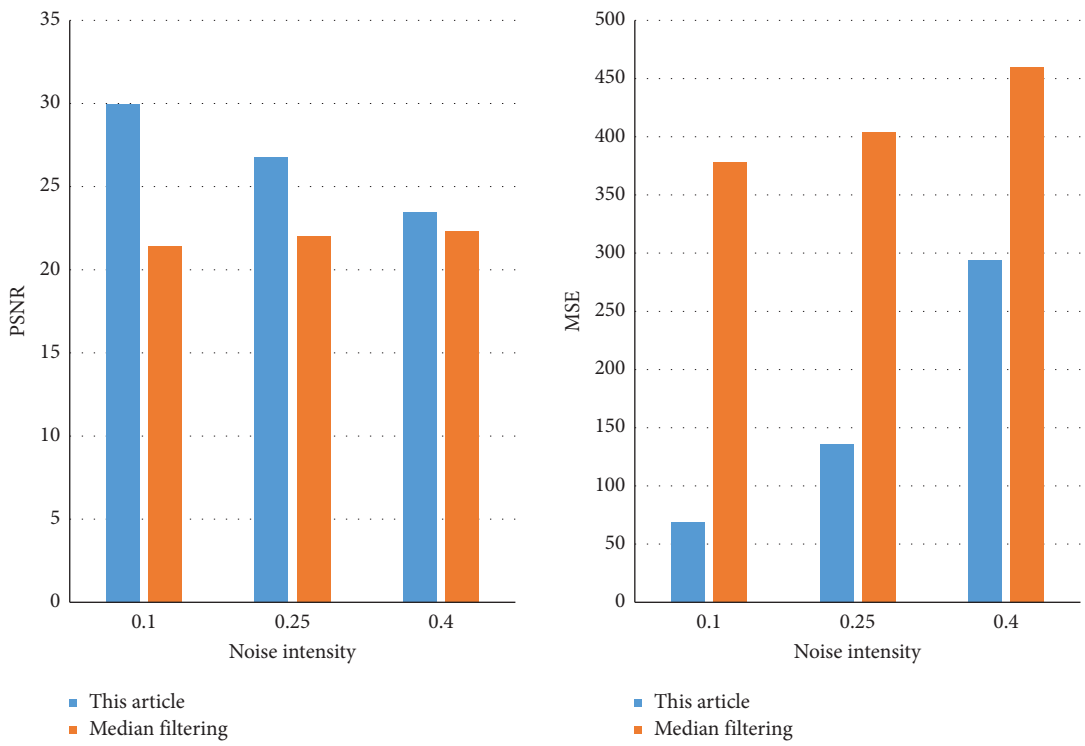

Figure 5: Comparative results of indicators.

$$t^* = \mathrm{Arg}(\mathrm{Max}(\varphi(t))), \tag{6}$$

where t^* is optimal threshold,

$$L = -L_0 \log_2 L_0 - L_1 \log_2 L_1, \tag{7}$$

where L is the entropy value after segmentation,

$$e = \frac{1}{2} \sum_{o=1}^{w} \left(s_0(k) - no_0(k)\right)^2, \tag{8}$$

where e is the error function.

$$\begin{aligned} X_l &= \sum_{v=1}^{l} Q_{lv} m_v, \\ Y_l &= X_l - \theta_l, \\ N_l &= \tau(Y_l), \end{aligned} \tag{9}$$

where $X_l$is the result of a linear combination, θ_l is bias threshold for neuron units, and τ is the activation function

3. Cognitive Neural Computational Modeling Experiments

As a comparison, the image denoising method in this study is processed by median filtering. Compared to the algorithm used in this work, both methods perform postprocessing on the processed image to remove the edges to verify the effect of the simulation experiments. To better describe the effect of noise removal, besides the subjective evaluation, the objective evaluation, root mean square, and signal-to-noise ratio are also used to describe the two parameters. Figures 5 and 6 show the index comparison results.

As the figures show, in both experiments, the signal-to-noise performance of the algorithm in this study is larger than that of the median filtering method. The mean square mistake of the proposed algorithm is less than that of the median filtering method, and the experimental data reflect the superiority of the algorithm. From the simulation outcomes, it is clear that the algorithm in this study retains more details than the median filtering method in terms of the visual effect of the subjective evaluation criteria.

In order to verify the effectiveness of the cognitive neural computing model for image information storage and extraction based on intelligent computing, in all experiments, the selected images are processed in grayscale. After the image information is learned, the recognition test experiment is carried out first, and a test stimulus image is given to determine whether it has been learned. As shown in Figures 7 and 8 and Table 1, the accuracy of the database recognition test is shown.

From the above data, it can be seen that the recognition ability of the model in this study is very strong. When the learned sample images are relatively small, the model will still make mistakes in judgment. However, when the learned sample images reach a certain number, the model can basically judge all the learned images. When the number of samples of learning images is 5, the time required by the method in this study is 236 s, the time required by the median filtering method is 475 s, and the time required without the algorithm is 2212 s. The method in this study greatly improves the use efficiency.

In a recall test trial, what the model does is to extract the semantic information of the test stimulus image, that is, the name of the test stimulus image itself. Similar to the recognition

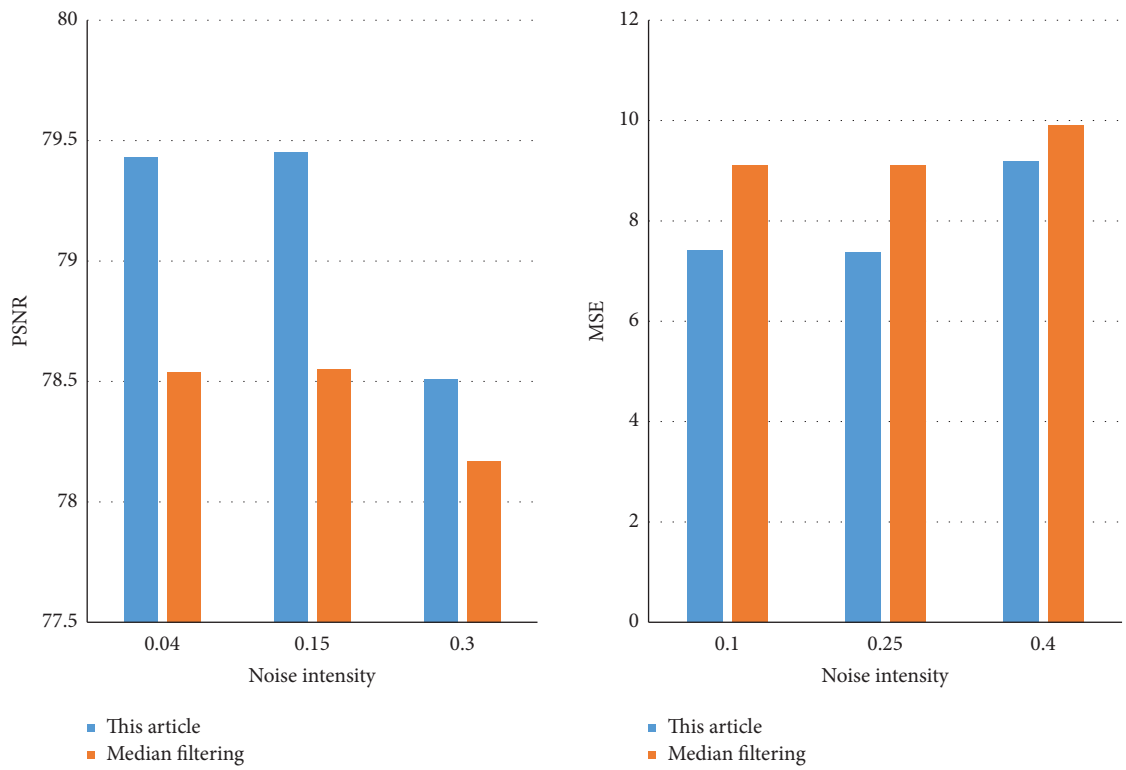

Figure 6: Comparative results of indicators.

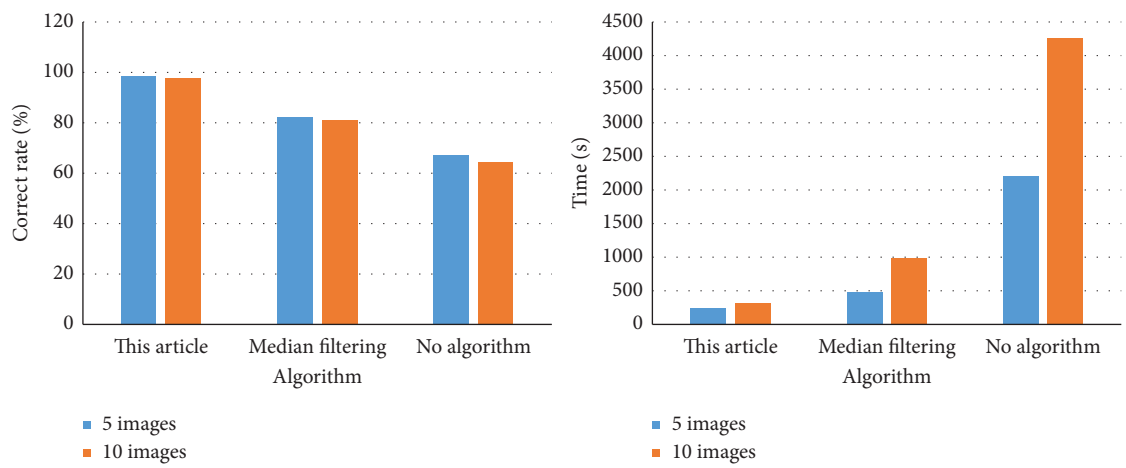

Figure 7: Correctness of database recertification test.

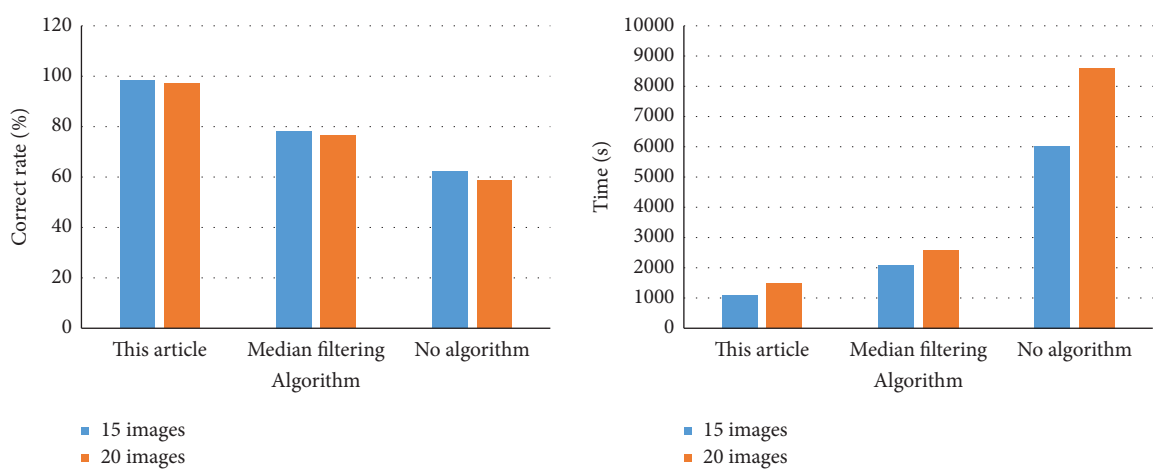

Figure 8: Correctness of database re-identification test for 15 and 20 images.

Table 1: Correctness of database re-identification test for 25 and 35 images.

Number of learning image samples	This article		Median filtering		No algorithm	
	Correct rate (%)	Time (s)	Correct rate (%)	Time (s)	Correct rate (%)	Time (s)
25	100	2345	72.4	3192	61.3	9772
30	100	2689	71.8	3810	62.7	9964
35	100	2927	70.6	4537	60.9	10124

Table 2: Correctness of recall tests.

Number of learning image samples	This article		Median filtering	
	Correct rate (%)	Time (s)	Correct rate (%)	Time (s)
5	63.2	457	42.1	2192
10	65.6	1076	46.8	4197
15	68.5	2049	49.2	6152

Table 3: Correctness of recall tests.

Number of learning image samples	This article		Median filtering	
	Correct rate (%)	Time (s)	Correct rate (%)	Time (s)
20	72.8	2568	43.2	8574
25	74.2	3214	45.2	9762
30	83.2	3894	43.1	9987

test, the recall test results may also be misjudged; that is, the name of the test stimulus image may be incorrectly recalled, or the learned image may be judged as unlearned. As shown in Tables 2 and 3, the accuracy of recall test is shown.

From the data in the table, it can be seen that the recall results of the method using the algorithm of this study to select features are higher than the median filter recall results, but the learning time is much lower than the median filter method. This shows that the method of selecting some features in the algorithm in this study can effectively represent the features and improve the operation speed.

4. Conclusion

The purpose of learning and memory is to understand how people store and retrieve information based on past experience. The development of cognitive psychology, cognitive neuroscience, physiological anatomy, and other disciplines has further developed some information processing mechanisms in the human brain. Based on a review of the physiological basis of brain memory mechanism, this study introduced some representative memory models based on cognitive psychology and combined them to simulate the memory function of the medial temporal lobe and hippocampus of the brain. This study made preliminary predictions in this regard. Due to the limitation of the source of information and academic standard, omissions are inevitable in this paper's research. At the stage of analysis of the current situation, the analysis is not comprehensive, reflecting only the changes of the relevant indicators, lacking judgment, and analysis of the internal enterprise; in theory, it has not been understood in depth. When the number of images increases and the size of the dictionary increases, the computational overhead required for its learning and encoding becomes larger and larger, far from being comparable to that of humans. Therefore, improving and proposing new sparse coding algorithms is also one of the focuses of our future research. This study summarized the study in his section and pointed out the shortcomings of this study. It is necessary to consider improving the hippocampal model, simulate various structural functions of the hippocampal model, and complete the rapid retrieval of episodic memory.

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Disclosure

The authors confirm that the content of the manuscript has not been published or submitted for publication elsewhere.

Conflicts of Interest

The author declares that there are no potential conflicts of interest in our paper.

Authors' Contributions

The author has seen the manuscript and approved to submit to the journal for publication.

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Research Article

A Real-Time Tourism Route Recommendation System Based on Multitime Scale Constraints

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In order to increase the capability of real-time intelligent recommendation of tourists' information on cross-regional city-level tourist routes with epidemic normalization, a real-time intelligent recommendation algorithm for cross-regional city-level tourist routes with epidemic normalization based on multi-time scale constraints is proposed. Under the training of limited samples, the tourist correlation model of the epidemic normalization of cross-regional city-level tourist routes is created. In addition, two kernel functions i.e. the mixed and the global are assembled to excerpt the correspondence features of the epidemic normalization cross-regional city-level tourist route recommendation information. As a result, the well-known particle swarm optimization (PSO) procedure and algorithm with multitime scale constraints are adopted to carry out the adaptive learning of the epidemic normalization cross-regional city-level tourist route recommendation, and the convergence control of the recommended method is comprehended through mining the geographic information data sets of cities. This paper analyzes the universality and ergodicity of tourists' personal interest preferences and social characteristics in urban tourism and combines a gradient algorithm to carry out particle swarm evolution and self-adaptive optimization for the recommendation of cross-regional city-level tourist routes with a normalized epidemic situation, so as to realize the group real-time intelligent recommendation of tourists' information on cross-regional city-level tourist routes with the normalized epidemic situation. The model outcomes indicate that the exactitude and precision of cross-regional city-level tourism route information recommendation with this algorithm are decent, and the convergence of the swarm intelligence optimization (SIO) problem is robust, which can circumvent dipping into the local optimal solution in the process of real-time intelligent recommendation of tourism routes and improve the intelligence and global stability of cross-regional city-level tourism route recommendation with epidemic normalization.

1. Introduction

With the speedy improvement of the economy, the public's corporeal standard has enriched obviously, and to a greater extent, people begin to pay attention to rich spiritual life, which promotes the development of tourism. However, under the background of epidemic normalization prevention and control, it brings great challenges to the tourism industry. At present, people mainly search for travel information on the Internet to customize their travel plans, but the information overload problem on the Internet is becoming more and more serious, so it is necessary to establish a model for recommending cross-regional city-level travel routes with epidemic normalization. Combining the distribution characteristics of cross-regional city-level travel routes with epidemic normalization, the reliability of recommending cross-regional city-level travel routes with network modeling big data cost analysis can be improved [1]. Therefore, to a greater extent, academics begin to recompense consideration to the exploration of travel route planning. Most tourists will be restricted by many factors such as traffic, expenses, time, scenic spots, and hotels. When

making travel plans. However, the existing research does not fully consider tourists' preferences and constraints, and it is difficult to really meet the individual needs of tourists [2].

The normalized cross-regional city-level tourist routes are realized by a personalized network of independent education and statistics facilities rendering to tourists' personal predilections. Tourists' statistics and knowledge resource information on the normalized cross-regional city-level tourist routes want to be boosted, categorized, and kept adaptively rendering to the tourists' predilections [3]. The resource scheduling and personalized recommendation of the normalized cross-regional city-level tourist routes are combined with the multisource distributed design method to improve the resource scheduling ability of the normalized cross-regional city-level tourist routes and the ability to extract tourists' urban tourism interests and preferences [1]. In the cross-regional city-level tourist routes with complex epidemic normalization, personalized recommendation and resource optimization scheduling are carried out for complex and diverse online learning resources rendering to the tourists' past visit archives and predilections, so as to encourage the information practice and progress the energetic communication aptitude of the cross-regional city-level tourist routes with epidemic normalization [4]. It is of countless implications to revise the personalized real-time intellectual recommendation procedure of cross-regional city-level tourist routes with epidemic normalization in the optimization design of cross-regional city-level tourist routes with epidemic normalization. In the traditional methods, the personalized endorsement and communal detection approach for cross-regional city-level tourist routes with normalized epidemic situations mainly comprise intelligent PSO procedure, data clustering recommendation system, association rule-based mining process, and fuzzy PID recommendation procedure, etc., and the topological structure of cross-regional city-level tourist routes is optimized according to multilevel epidemic situation normalization [5].

Combining the appropriate features of the recommendation tasks and information sharing, a data clustering center for a personalized recommendation of epidemic normalization cross-regional city-level tourist routes is established, and an algorithm for a recommendation of epidemic normalization cross-regional city-level tourist routes is designed by using association rule mining method, so as to develop and progress the personalized appearance aptitude of epidemic normalization cross-regional city-level tourist routes. Related literature has designed the recommendation algorithm for epidemic normalization cross-regional city-level tourist routes, and achieved certain research results. Among them, in [6] it is proposed based on a community discovery algorithm of epidemic normalization cross-regional city-level tourist routes based on parallel recommendation, compelling the tourist manners value, tourist ingesting value, and faithfulness of the epidemic normalization cross-regional city-level tourist routes as independent variables. The fuzzy decision-making model for public detection of the epidemic normalization cross-regional city-level tourist routes is established, and the optimization design of the epidemic normalization cross-regional city-level tourist route recommendation model is carried out by combining the association mining method. Nevertheless, the calculation cost of this technique is enormous, and the real-time performance of the epidemic normalization cross-regional city-level tourist route recommendation is not good.

In [7], a community discovery and recommendation algorithm of epidemic normalization cross-regional city-level tourist routes founded on the transformation factor assessment and intellectual and adaptive PSO is proposed. The synchronization tag of epidemic normalization cross-regional city-level tourist routes communities is established, the community association attribute features of epidemic normalization cross-regional city-level tourist routes are extracted, and the association amongst the interaction degree within groups and recommendation consequence is investigated. To realize personalized recommendations of cross-regional city-level tourist routes for epidemic normalization, this method has poor intelligence in the process of recommending cross-regional city-level tourist routes for epidemic normalization, and its global optimization ability is not strong [8].

To elucidate the aforementioned difficulties, in this paper we suggest a real-time intelligent recommendation algorithm for cross-regional city-level tourist routes based on multitime scale constraints. Firstly, under the training of limited samples, the tourist correlation model of the epidemic normalization cross-regional city-level tourist routes is created, and the two kernel functions, i.e., the mixed and the global are assembled to excerpt the association features of the epidemic normalization cross-regional city-level tourist route recommendation information, and the well-known PSO procedure with multitime scale constraints is adopted to carry out the adaptive learning of the epidemic normalization cross-regional city-level tourist route recommendation. At that moment, the convergence control of the recommended procedure is comprehended through mining the geographic information data sets of cities, and the universality and ergodicity of individual tourists' urban tourism interest preferences and social characteristics are analyzed. Combined with the gradient algorithm, the particle swarm evolution and self-adaptive optimization of the epidemic normalization cross-regional city-level tourist route recommendation are carried out, and the real-time intelligent recommendation of the epidemic normalization cross-regional city-level tourist route information is recognized. As a final point, the simulation exploration illustrates the loftier performance of the anticipated technique in enlightening the personalized real-time intelligent recommendation ability of cross-regional city-level tourist routes with the normalized epidemic situation. The following are some of the fundamental contributions of our work:

(1) We propose a real-time intelligent recommendation algorithm for cross-regional city-level tourist routes based on multitime scale constraints
(2) The tourist correlation model of the epidemic normalization cross-regional city-level tourist routes is assembled, and two kernel functions, i.e., the mixed and the global are created
(3) The particle swarm optimization algorithm with multitime scale constraints is adopted to carry out the adaptive learning of the epidemic normalization cross-regional city-level tourist route recommendation

The remaining manuscript is systemized in the subsequent fashion. In section 2, we discuss the tourism recommendation information model and correlation feature extraction. The recommended algorithm optimization process is deliberated in section 3. The simulation experiment and result analysis are validated in section 4. As a final point, section 5 recaps the manuscript and talks about promising future research.

2. Model for Tourism Recommendation and Extraction of Correlation Features

2.1. Recommended Information Transfer Model of Urban Tourist Routes. In order to comprehend the personalized recommendation and characteristics identification of epidemic normalization cross-regional city-level tourist routes, the parallel recommendation procedure is practiced to excerpt the tourists' interest preferences and mine statistics, and a hybrid system of the mixed and global kernel functions is assembled to excerpt related structures of epidemic normalization cross-regional city-level tourist route recommendation information. The fuzzy decision function of epidemic normalization cross-regional city-level tourist route recommendation evidence is acquired through the restricted sample training. This should be noted that the self-organizing nonlinear mapping, which is denoted by Φ: $x \in R^n \longrightarrow F$, is created to characterize the information transmission space of epidemic normalization cross-regional city-level tourist routes, and the recommended information of epidemic normalization cross-regional city-level tourist routes is mapped to high-dimensional feature space by combining fuzzy decision-making and intelligent swarm optimization [9–11]. In fact, this is expected that the recommended sample set for training of cross-regional city-level tourist routes with the normalized epidemic situation is $x_i \in R^n$, in which the personalized characteristic quantity $\{(x_1, y_1), (x_2, y_2), \cdots, (x_n, y_n)\}$ of cross-regional city-level tourist routes exemplifies the input vector of the anticipated recommendation system, $y_i \in R^n$ is the target quantity worth for the personalized recommendation of cross-regional city-level tourist routes, and $x_i \in R^n$ is the sample number of cross-regional city-level tourist routes. Collective with the association rule mining procedure, the objective function of the anticipated real-time intelligent and adaptive recommendation system of cross-regional city-level tourist routes with the normalized epidemic situation is as follows:

$$\begin{aligned} &\text{minimize}\frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n}(\xi_i + \xi_i^*), \\ &\text{subject to } y_i - (w'\Phi(x_i) + b) \le \varepsilon - \xi_i, \\ &(w'\Phi(x_i) + b) - y_i \le \varepsilon - \xi_i^*, \\ &\xi_i, \xi_i^* \ge 0, i = 1, 2, \cdots, n; C > 0. \end{aligned} \tag{1}$$

Wherein ξ_i and ξ_i^* exemplify the semantic ontology attributes, characteristics, and features and the corresponding association rule variables of cross-regional city-level tourist routes distribution. The generalized learning procedure is implemented to carry out and perform adaptive learning in the development of cross-regional city-level tourist routes recommendation, which is the cost factor recommended for cross-regional city-level tourist routes, and is implemented to understand the punishment control of wrong and incorrect samples. Note that, by adopting the PSO control, the dissimilarity function of the personalized recommendation of cross-regional city-level tourist routes is as follows:

$$f(x) = \sum_{i=1}^{n}(\alpha_i - \alpha_i^*)K(x_i, x_j) + b. \tag{2}$$

Wherein α_i and α_i^* are the recommended attribute values and template category numbers of cross-regional city-level tourist routes, respectively. In addition, the variable $K(x_i, x_j)$ is a symmetric kernel function, in fact, sustaining the Mercer circumstance, and b represents the recommended threshold of cross-regional city-level tourist routes.

This should be noted that each data tuple's feature vector set is built, and a hybrid kernel function is created by using the local kernel function (RBF kernel function) and the global kernel function (polynomial kernel function) as control decision functions for the recommendation of cross-regional city-level tourist routes with a normalized epidemic situation, and its expression is as follows:

$$K_{\min} = \beta K_{poly} + (1 - \beta)K_{rbf}, \beta \in (0, 1). \tag{3}$$

Wherein $K_{poly} = [(x \cdot x_i) + 1]^2$ represents the fuzzy personalized feature distribution kernel function recommended by cross-regional city-level tourist routes, and $K_{RBF} = \exp(-\gamma\|x - x_i\|^2)$ represents the RBF kernel function of confidence trustworthiness of cross-regional city-level tourist routes with the normalized epidemic situation. In fact, its purpose is to adjust the impact of both kernel functions over the whole mixed kernel function, which is also known as, the weight coefficient. Therefore, an information transmission model for the recommendation of cross-regional city-level tourist routes with a normalized epidemic situation is constructed, and the tourist characteristics of cross-regional city-level tourist routes with a normalized epidemic situation are extracted and personalized recommendation design is carried out by combining the hybrid optimization method of particle swarm optimization [12].

2.2. Extraction of Correlation Features of Recommended Information of Tourist Routes. Over the foundation of assembling both the hybrid and the universal kernel functions, this paper extracts the correlation features of the recommended information of cross-regional city-level tourist routes with a normalized epidemic situation and adopts the data set mining of urban geographic information to realize the convergence control of the recommendation process, so as to obtain the potential tourist variables of cross-regional city-level tourist routes with a normalized complex epidemic situation, which are expressed as: $\{S_1, S_2, \cdots, S_L\}$ by four tuples. Taking the tourism interest preference and the distribution of urban geographic and cultural information resources as control constraints, the characteristic abstraction conveyance regulator prototype of the personalized recommendation system for the cross-regional city-level tourist routes is as follows:

$$\alpha_{\text{desira}}^{i} = \alpha_1 \cdot \frac{\text{Density}_i}{\sum_{\text{i}} \text{Density}_i} + \alpha_2 \frac{AP_i}{AP_{\text{init}}}, \tag{4}$$

where in

$$\begin{cases} \alpha_1 + \alpha_2 = 1, \alpha_1, \alpha_2 \in [0, 1], \\ \alpha_2 = \dfrac{\max_{\text{i}}(AP_i) - \min_{\text{i}}(AP_i)}{AP_{\text{init}}}. \end{cases} \tag{5}$$

The aforementioned two formulas, in fact, symbolize the sparse coefficient from relay node U to the monitoring node of cross-regional city-level tourist routes with a normalized epidemic situation, where $M_i[t_l > M_m \vee M_n$, $M_m[t_m > M_j$, $M_n[t_n > M_j$, represents the scoring explanatory variable of recommended information of cross-regional city-level tourist routes, and $N_2(u) = \{v | d_G(u, v) = 2\}$ exemplifies the average mutual information of tourist characteristics U of cross-regional city-level tourist routes with a normalized epidemic situation, where $(i \neq m \neq n \neq j, a \neq b \neq c)$. Under the constriction controller of connotation instructions, the prospective association features of cross-regional city-level tourist routes with a normalized complex epidemic situation are obtained using the following equation:

$$\varepsilon_t(i, j) = \frac{\alpha_t(i) a_{ij} b_j(o_{t+1}) \beta_{t+1}(j)}{\sum_{i=1}^{N} \sum_{j=1}^{N}} \alpha_t(i) a_{ij} b_j(o_{t+1}) \beta_{t+1}(j), \tag{6}$$

wherein $|\text{Re}v(u)|$ represents the characteristic distribution point set of cross-regional city-level tourist routes, $\text{Re}v(u)$ represents the number of tourist nodes, a_{ij} represents the tourist scoring measurement information of cross-regional city-level tourist routes with a normalized epidemic situation, b_j represents the joint mutual information recommended by cross-regional city-level tourist routes, and $Or\,de\,r(\text{Re}v(u))$ represents the matching degree of nodes in the distribution space of cross-regional city-level tourist routes according to their personalized behavior characteristics. Uniting the connotation rule constraints and the chaotic mapping, the self-adaptive clustering of cluster intelligence information of cross-regional city-level tourist routes is carried out, and the recommended cluster output of cross-regional city-level tourist routes is gotten as mathematically illustrated in the following equation:

$$\begin{aligned} f_{\text{lg}-M}(z) &= \left(f_{\text{lg}}(z), f_{\text{lg}-x}(z), f_{\text{lg}-y}(z)\right) \\ &= \left(f_{\text{lg}}(z), h_x * f_{\text{lg}}(z), h_y * f_{\text{lg}}(z)\right). \end{aligned} \tag{7}$$

Note that in the above equation, the notation $f_{\text{lg}}(z)$ exemplifies the score value of tourist items recommended by cross-regional city-level tourist routes with a normalized epidemic situation, thus obtaining the quadruple expression of correlation feature extraction of cross-regional city-level tourist routes with the normalized epidemic situation as follows:

$$\begin{aligned} \max \{ &\left|Ch(u) - Ch(u) \cap Ch(u_2)\right| + \left|Ch(u) \cap Ch(u_2)\right| \\ &\left|Ch(u_2) - Ch(u) \cap Ch(u_2)\right| + \left|Ch(u) \cap Ch(u_2)\right| \} \\ &= \max \left\{ |Ch(u)|, \left|Ch(u_2)\right| \right\} \leq \Delta. \end{aligned} \tag{8}$$

In the above formula, $Ch(u)$ represents the association rule coefficient of cross-regional city-level tourism route recommendation, and node v is added to $R2(u)$ in order to comprehend and understand the dynamic characteristic abstraction of personalized tourist features and characteristics [13].

3. Optimization of the Recommendation Algorithm

3.1. The Gradient PSO Procedure. Over the foundation of assembling a hybrid system which is in fact from the mixed and the global kernel function to excerpt the correlation features of the recommendation statistics of epidemic normalization cross-regional city-level tourist routes, an improved design of the real-time intelligent recommendation algorithm for epidemic normalization cross-regional city-level tourist routes is proposed in this paper. For the multiconstraint multiobjective tourist route planning problem, if only the objective function is weighted, the global optimal solution may not be obtained, so this paper practices the enhanced greedy set of rules to elucidate the optimal tourist routes. In the actual tourism scene, tourists are more thinking about which scenic spot is suitable to go next when the current scenic spot is finished. The greed algorithm is one of the most commonly used algorithms to solve the problem of route planning. However, in this paper, aiming at practical problems, an improved greedy algorithm is used to recommend the top M routes with the highest scores for tourists to choose [14].

The improved greedy algorithm is described as follows: tourists start from the recommended hotel, only consider the top N scenic spots with the highest constraint score based on their current location, and only consider the scenic spots they have never visited. Because tourists have to return to the hotel, when tourists visit all the scenic spots and finally return to the hotel, the hotel constraint score of 10I is no longer considered. So we can get M routes, calculate the total

score of each route, and finally only keep the top M routes with the highest total score for tourists to choose from. Set the objective function to maximize the total score of the route and the number of types of scenic spots under the condition of satisfying the user constraints. Taking advantage of the initial value sensitivity, regularity, universality, ergodicity, and other advantages of a chaotic map, the universal optimization regulator of the recommended procedure is performed, and as an outcome, the Logistic map is assembled, whose manifestation is mathematically given in the following equation:

$$y_i = \mu y_i (1 - y_i), \tag{9}$$

wherein $y_i \in [0, 1]$ is the random number, μ is the group real-time intelligent recommendation control parameter of cross-regional city-level tourist routes with the normalized epidemic situation. Generally, it takes a value of 4, and a gradient particle swarm algorithm is constructed. d is assumed that in a dimensional gradient particle swarm search space, m represents the population composed of particles and $S = \{P_1, P_2, \cdots, P_m\}$ represents the clustering center of tourists' urban tourism interest preference intelligent search particles in the current dimensional solution space [16]. It represents the current optimization speed of the traversing particle $P_i^d(t)(i = 1, 2, \cdots, m)$ of the cross-regional city-level tourism route with the normalized epidemic situation, and $P_{best}^d(t)$ characterizes the paramount position which is practiced by the particle $V_i^d(t)(i = 1, 2, \cdots, S)$ itself. The personalized recommendation gradient particle swarm optimization expression of the cross-regional city-level tourism route with the normalized epidemic situation is obtained as follows:

$$\begin{cases} V_i^d(t+1) = W \cdot V_i^d(t) + C_1 \cdot R_1 \cdot \left(P_{\text{best}}^d(t) - P_i^d(t)\right) \\ +C_2 \cdot R_2 \cdot \left(G_{\text{best}}^d(t) - P_i^d(t)\right), \\ P_i^d(t+1) = P_i^d(t) + V_i^d(t+1), \end{cases} \tag{10}$$

wherein $V_i^d(t)$, $V_i^d(t+1)$, $P_i^d(t)$, $P_i^d(t+1)$ is the transmission coefficient and correlation dimension feature quantity of tourists' urban tourism interest preference mining on the cross-regional urban level tourism routes at the current moment and the next moment of the particle, respectively. In addition, the route with the highest total score is a learning factor for tourists, and W is generally between 25 and 25. Similarly, the variables C_1 and C_2 represent the search radius and global search threshold of gradient particle swarm optimization, respectively, when assuming taking random numbers between [0, 1]. It is the inertia weight of the route with the highest total score for tourists' preference. Combined with gradient PSO, the step length of the optimization modification, which is iterative, of the recommended procedure of epidemic normalization cross-regional city-level tourist routes is performed [17]. This should be noted that for each interval the modification formula of the real-time intellectual recommendation system for the epidemic normalization of cross-regional city-level tourist routes is obtained as follows:

$$W(t+1) = 4.0W(t)(1 - W(t)), \tag{11}$$

$$W(t) = W_{\min} + (W_{\max} - W_{\min})W(t), \tag{12}$$

wherein the notation $[W_{\min}, W_{\max}]$ is the range values for the inertia weight factor recommended for cross-regional city-level tourist routes indicating the normalization of the epidemic situation, generally taking (0.5, 0.6).

3.2. Implementation of Real-Time Intelligent Recommendation Algorithm for Tourism Route. The particle swarm optimization algorithm with multitime scale constraints is used to carry out adaptive learning of cross-regional city-level tourism route recommendations for epidemic normalization [14]. The convergence regulator of the recommendation development is comprehended by mining the geographic information data set of cities, and chaos is familiarized within the process of the optimization in terms of the inertia factor W. In the gradient PSO learning process of cross-regional city-level tourism route recommendation for epidemic normalization, search radius R_1 and R_2 are introduced, and the updated formula is as follows:

$$R_i(t+1) = 4.0R_i(t)\left(1 - R_i(t)\right), \tag{13}$$

wherein $R_i(t) \in (0, 1), i = 1, 2$, rendering to the gathering of the tourists, the fuzzy feature measure of epidemic normalization cross-regional city-level tourism route distribution is pulled out, the chaos is familiarized into the two learning factors, as denoted by C_1 and C_2, and the learning formula for recommending epidemic normalization cross-regional city-level tourism route is updated as follows:

$$C_i(t+1) = 4.0C_i(t)\left(1 - C_i(t)\right), \tag{14}$$

$$C_i(t) = C_{\min} + (C_{\max} - C_{\min})C_i(t), \tag{15}$$

wherein $i = 1, 2$, $[C_{\min}, C_{\max}]$ is the preliminary population prototype for the gradient PSO. After a scenic spot is played, the top N scenic spots with higher scores are searched as the next scenic spots to be played according to the current scenic spots, and whether joining the scenic spot meets the time constraint and cost constraint of tourists is calculated. If not, the scenic spot is abandoned [18]. If all scenic spots no longer meet the time or cost constraint of tourists, the convergence control coefficient obtained after the tourists' play is defined as illustrated mathematically in the following equation:

$$\delta^2 = \sum_{i=1}^{m} \frac{F_i - F_{\text{avg}}}{F}. \tag{16}$$

Wherein m is the number of particles in the recommended particle swarm of the cross-regional city-level tourism route with a normalized epidemic situation, F_i is the adaptability of particle i to tourists' learning of urban tourism interest preference on the cross-regional city-level

tourism route with a normalized epidemic situation, F_{avg} is the average adaptability of the particle swarm, and F is the recommended control objective function, which is used to limit the size of δ^2, and is expressed as follows:

$$F = \begin{cases} \max\limits_{1\le i\le m}\left|F_i - F_{avg}\right|, \max\limits_{1\le i\le m}\left|F_i - F_{avg}\right| > 1 \\ 1, \qquad\qquad \text{其他} \end{cases}. \tag{17}$$

If $\delta^2 < \mathrm{H}$, H is a given constant, the precocious judgment and adaptive processing of tourists' characteristics mining on the cross-regional city-level tourist routes with a normalized epidemic situation are carried out. For the particles falling into a precocious state, the gradient reduction method is adopted to make them jump out of the local optimum, and the realization of this algorithm is described as follows:

$$V_i^d(t+1) = 4.0V_i^d(t)\left(1 - V_i^d(t)\right), \tag{18}$$

$$V_i^d(t) = V_{\min} + \left(V_{\max} - V_{\min}\right)V_i^d(t), \tag{19}$$

wherein $[V_{\min}, V_{\max}]$ is the range of particle velocity of self-adaptive recommendation for cross-regional city-level tourist routes with epidemic normalization [18]. By using the connotation regulation taking out and the local optimization controller methods, the updated formula of recommendation for cross-regional city-level tourist routes with epidemic normalization is obtained as follows:

$$\begin{cases} V_i^d(t+1) = W(t)\cdot V_i^d(t) + C_1(t)\cdot R_1(t)\cdot\left(P_{best}^d(t) - P_i^d(t)\right) \\ + C_2(t)\cdot R_2(t)\cdot\left(G_{best}^d(t) - P_i^d(t)\right), \\ P_i^d(t+1) = P_i^d(t) + V_i^d(t+1). \end{cases} \tag{20}$$

In the above formulas, $t = 1, 2, \cdots, T$ and T represent the maximum iteration times of the population. The convergence regulator of the recommended method is comprehended by mining the geographic information data set of the city. In order to show the system better, it is supposed that the tourist chooses the hotel scenic spot as shown in Figure 1, and the tourist stays in Hotel H, and the tourist expects to get the maximum tourism income. According to the above scenic spots A, B, C, and D, which route should he choose to play, he can get the maximum income while meeting the time constraint of tourists for 8 hours, and the cost constraint is 300 yuan. Assume that $n = 2$, that is, when the greedy algorithm is used, each scenic spot expands downwards into two scenic spots, and the number of routes with the highest revenue output, at last, does not exceed three. According to the threshold judgment result, whether the convergence criterion is satisfied or not is judged and appropriate decisions are made.

The particle swarm optimization and self-adaptive optimization are carried out for the recommendation of epidemic normalization cross-regional city-level tourist routes combined with a gradient algorithm [19]. The convergence regulator of the recommended procedure is comprehended by mining the city's geographic information data set, and the

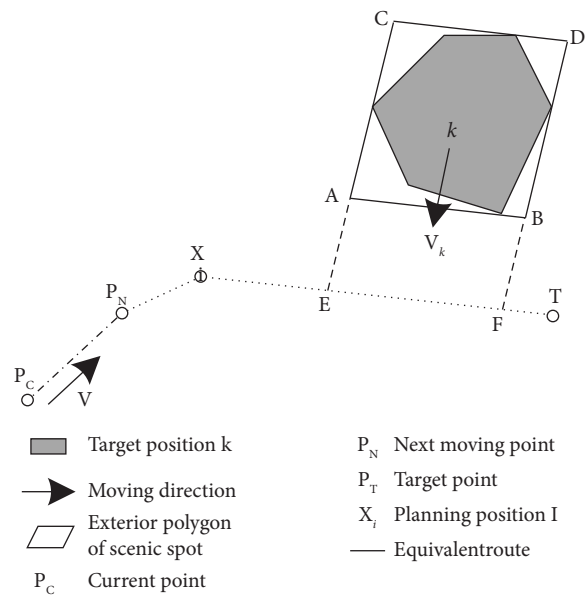

Figure 1: Schematic diagram of recommendation model of hotels and scenic spots selected by tourists.

universality and ergodicity of individual tourists' urban tourism interests and social characteristics are investigated. In fact, the PSO and the process of self-adaptive optimization are carried out for epidemic normalization cross-regional city-level tourist routes combined with gradient algorithm, so as to comprehend the real-time intelligent recommendation of tourists' information on epidemic normalization cross-regional city-level tourist routes [20].

4. Simulation Experiment, Results, and Discussion

In order to validate the accuracy and convergence of the anticipated technique in the real-time intelligent recommendation of cross-regional city-level tourist routes for the normalization of the epidemic situation, a simulation experiment was conducted. The system includes eight functional modules, including login and registration, the introduction of hotel attractions, preference constraint selection, tourist route planning, hotel information management, route, itinerary management, user information management, and scenic spot information management. Users who want to use the intelligent planning system for tourist routes must register first, and then they can log in after successful registration. After entering the system, users can first choose the information of the scenic spots they are interested in to browse [21]. Secondly, users can come to the preference constraint selection module, enter their own personalized constraints, including travel time, travel expense budget, and the conditions of favorite hotels and scenic spots, and submit them to the background server.

The server in the background will obtain the personalized constraints of users, recommend the hotels and scenic spots with the highest scores for users according to the model established above, and then plan a number of tourist routes for users to show to them with the maximum profit.

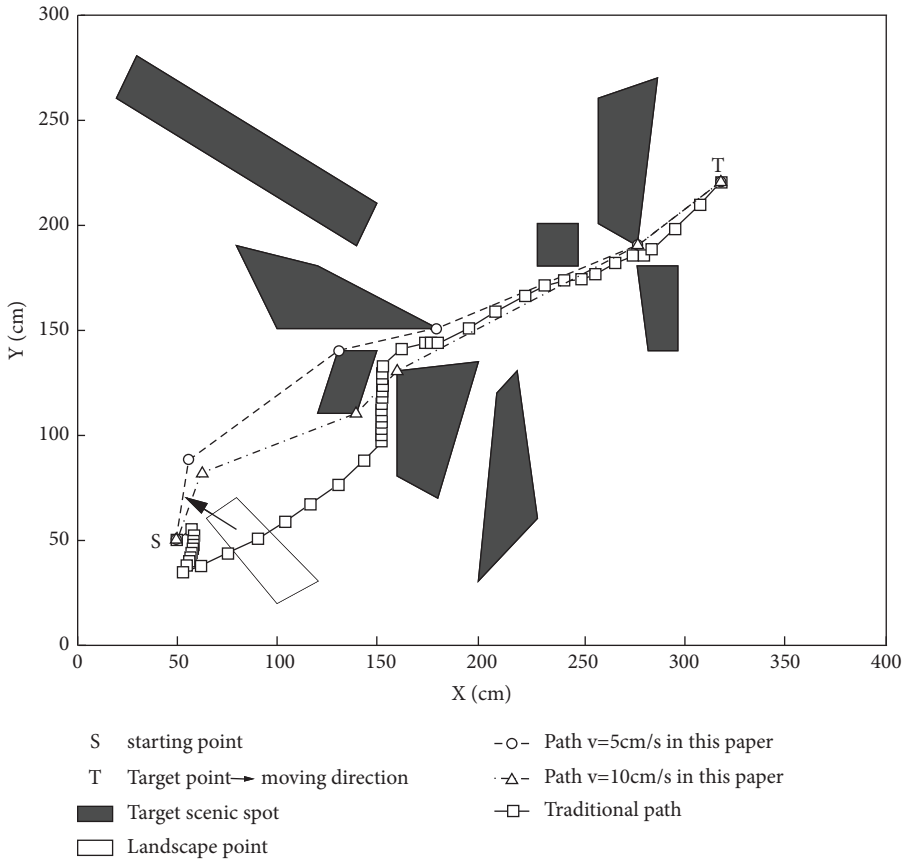

Figure 2: Normalization of epidemic situation. Cross-regional city-level tourist routes.

Users can also manage their past itineraries anytime and anywhere. Administrators have the authority to add, delete and check the information of hotel and scenic spot users, the quantity of tourists that were verified is 2,000, the trial function of the PSO is assumed as type and combination of the ZDT series test functions, the amount of all particles in a particular particle group in D-dimensional universe is 20, the recommended simulation time is 1.3 s, and the iteration is carried out for 6,000 times. The mining results and findings of tourists' urban tourism interest preferences on the cross-regional city-level tourist routes with a normalized epidemic situation are shown in Figure 2.

With the method of this paper, the real-time recommendation method of tourist routes based on multitime scale constraints is adopted, and the result of route optimization recommendation is shown in Figure 3.

Taking the results of route optimization and recommendation in Figure 3 as the input test sample set for tourists' urban travel interest preference for the epidemic-normalized cross-regional city-level tourism route, the adaptive learning of the epidemic-normalized cross-regional city-level tourism route recommendation was performed, and the curve of the convergence was acquired as made known in Figure 4.

According to the analysis of Figure 4, the self-adaptive learning ability of real-time intelligent recommendation of epidemic normalization cross-regional city-level tourist routes by this method is strong, and the universality and ergodicity of urban tourism interest preference and feature mining of epidemic normalization cross-regional city-level tourist routes are good. Additional test the errors of dissimilar approaches in recommending cross-regional city-level tourist routes for epidemic normalization, and get the comparison results as given away in Figure 5. The examination of the results in Figure 5 displays that the accuracy of this method in recommending the information of cross-regional city-level tourist routes with epidemic normalization is decent, and the nondivergence of the swarm aptitude optimization is significantly robust so that the real-time intelligent recommendation process of cross-regional city-level tourist routes with epidemic normalization can be avoided from falling into a local optimal solution.

On this basis, the formulation of tourists' travel plans first needs to determine the tourist attractions they want to visit and the hotels they stay in. Based on this, this paper sets up a hotel attraction scoring model, sets tourists' preference design for hotels and attractions, integrates the information of related hotel attractions, and according to the preference information input by tourists, puts a good hotel and attractions for tourists to choose. In this way, there is no need for tourists' past travel data, so there is a problem of "moving after a cold." This paper also establishes a multi-constraint and multi-objective tourism route planning model. After tourists have determined their tourist attractions and hotels,

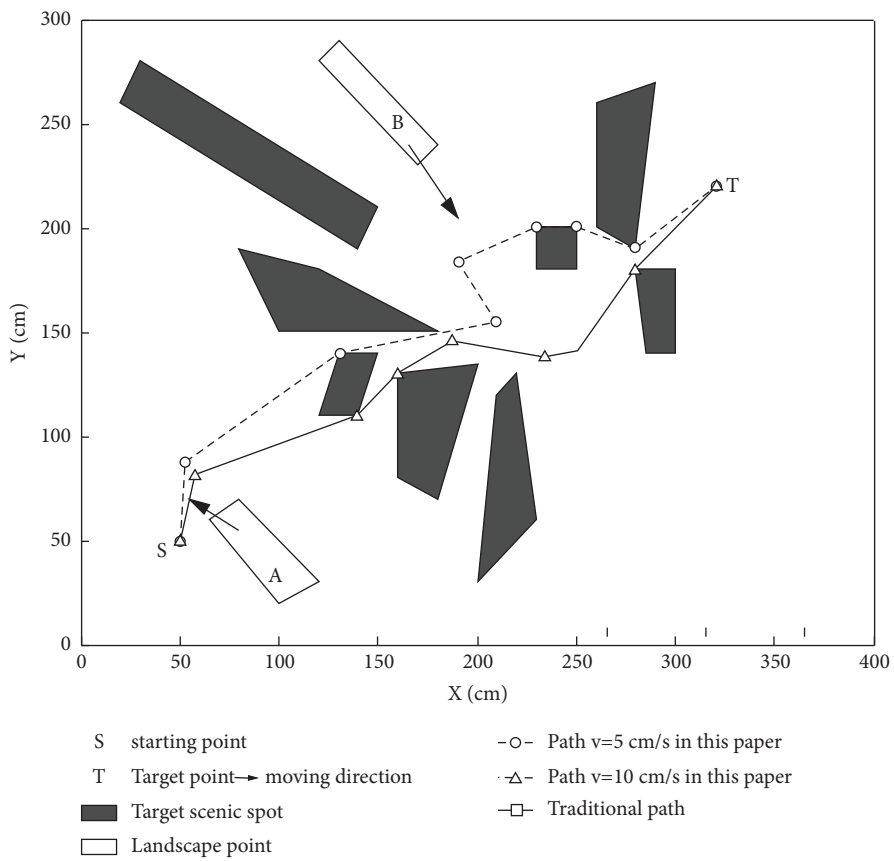

Figure 3: Route optimization recommendation results.

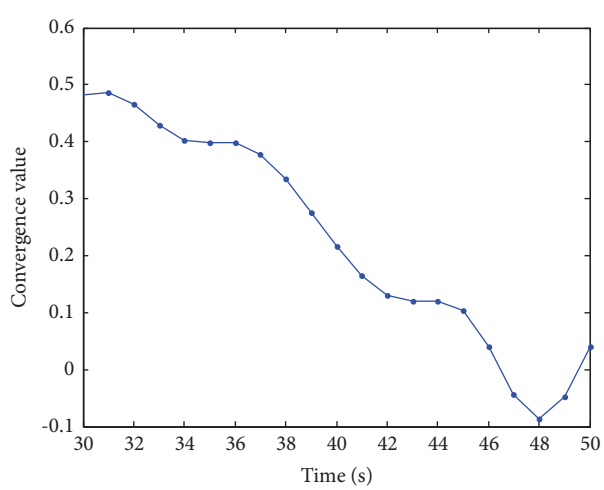

Figure 4: The learning curve of real-time intelligent recommendation of cross-regional city-level tourist routes after epidemic normalization.

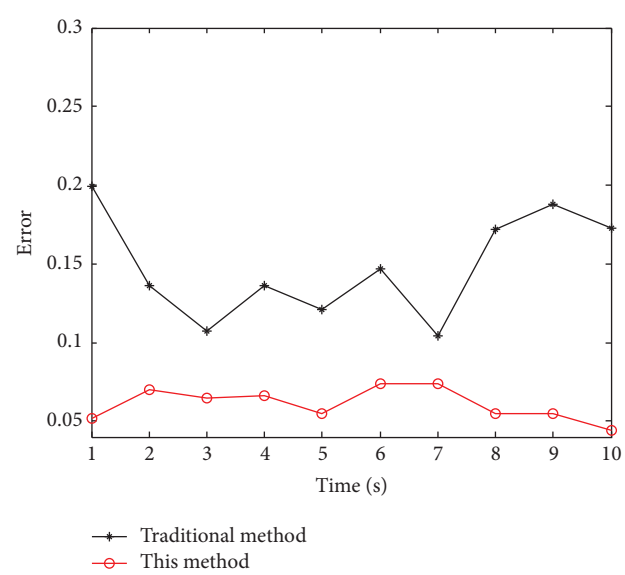

Figure 5: Error comparison of recommendation of cross-regional city-level tourist routes in normalization of the epidemic situation.

the next problem they face is how to determine their tour order [22]. According to the actual needs of tourists, this paper puts forward a tourism route planning model, which sets the starting point and ending point of tourism to be hotels, practices the enhanced greedy procedure and set of rules to solve the model, and finally, obtains the most profitable tourism routes. The model fully considers the realistic factors and has certain rationality and usability.

5. Conclusions and Future Work

According to tourists' historical visit records and preferences, personalized recommendations and resource optimization scheduling can be carried out to promote the information use of cross-regional city-level tourist routes

with the normalized epidemic situation. This paper proposes a real-time intelligent recommendation algorithm for cross-regional city-level tourist routes with the normalized epidemic situation based on multitime scale constraints. Under the training of limited samples, the tourist correlation model of epidemic normalization cross-regional city-level tourist routes is constructed, and the correlation features of epidemic normalization cross-regional city-level tourist routes recommendation information are extracted. In addition, subsequently, the convergence governor of the recommended procedure is comprehended by mining the city's geographic information data set, and the universality and ergodicity of tourists' individual urban tourism interest preferences and social characteristics are examined. In fact, the particle swarm evolution and dynamic optimization of epidemic normalization cross-regional city-level tourist routes recommendation are performed by combining the gradient process, so as to comprehend the real-time intelligent endorsement of epidemic normalization cross-regional city-level tourist routes. The research shows that the accuracy of information recommendation of epidemic normalization cross-regional city-level tourist routes by the anticipated process is decent, and the antidivergence of the swarm intelligence optimization is significantly robust so that the real-time intelligent recommendation process of epidemic normalization cross-regional city-level tourist routes can be avoided from dwindling into local optimal solution, and the intelligence and global stability of epidemic normalization cross-regional city-level tourist routes recommendation are enhanced. In fact, this has virtuous application significance in a real-time intellectual recommendation, as well as, in the personalized learning of epidemic normalization cross-regional city-level tourist routes [15].

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Evaluation of Music Art Teaching Quality Based on Grey Neural Network

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The study and implementation of music art teaching quality monitoring systems as a major teaching management project in Chinese colleges and universities has been in continuation for a decade. An essential challenge in the management of colleges and universities is that how to assess the teaching abilities of music and art professors fairly and objectively. The system is designed and implemented by separating the front end and back end of browser + server to provide examination services in the way of cloud computing. This system primarily gathers the students' multidimensional data including sound intensity, pitch, and beat. Then a grey neural network is used to analyze the students' sound intensity, pitch, and beat. After evaluation process, the scores of the final examination in colleges and universities are uploaded to the backstage server in real-time.

1. Introduction

In the recent decade, the research and practice of music art teaching quality monitoring systems has been studied and implemented as a key teaching management project in colleges and universities in China. In quality monitoring management, the test and evaluation of music art teaching effect and teaching state are important links. The process of gathering a large amount of sample data, processing, summarizing, and assessing it is known as the quality evaluation of music and art training. This work has mainly gone through three stages [1].

(i) The manual operation takes place, in which most teachers and students fill out the evaluation form and the management staff manually compiles statistics and performs calculations.

(ii) The introduction of computer processing and data collection in the form of computer card reading is used. Realizing paperless evaluation using a computer network is the third step.

(iii) The approach will displace the first two and gain popularity.

The evaluation of the teaching quality of music and art course is a routine teaching assessment where every college needs to carry out every academic year. To evaluate the teaching quality of music and art teachers and timely understand the real situation of teaching is an important issue in the management of colleges and universities [2, 3]. It is difficult to manually operate the evaluation questionnaire with the expansion of the school and college. The manual evaluation can no longer meet the requirements of the new teaching situation. It contains several drawbacks including excessive recurring capital expenditure, heavy organizational workload, problematic data statistics, low efficiency, ease of error, lack of intuitiveness in statistical analysis, querying, and browsing. Therefore, from the technical level of evaluation, there is an urgent need to establish a convenient, efficient, reasonable, and scientific evaluation system for the teaching quality of music and art courses. This will play a great role in promoting the teaching quality of music and art and evaluating the teaching quality [4].

At present, the music art teaching quality evaluation system used in colleges and universities still has some limitations and problems that needs to be solved:

(i) The system function is not targeted. Each system is independent;

(ii) The evaluation software only has basic statistical functions. It does not make full use of a large amount of basic data accumulated in the past to carry out comprehensive evaluation of teaching quality;

(iii) Most evaluation systems are relatively closed, with one-way flow of information and lack of information interaction;

(iv) Evaluation systems generally carry out static evaluation, which is difficult to reflect dynamic evaluation information;

(v) Network security and confidentiality are not enough, and the evaluation data are easy to be changed, affecting the authenticity of the evaluation.

The design objectives of the music art evaluation system include the following aspects:

(i) It has a good and clear user interface and is easy for users to use. It can better attract evaluators to participate actively;

(ii) There should be user permission confirmation. Different users should be given different permissions and perform different operations;

(iii) Be able to maintain the database and count the data on the network;

(iv) Provide good help to make users familiar with system operation as soon as possible;

(v) The system design is close to the needs of daily office operation, and the system maintains good compatibility with the educational administration system;

(vi) It has good data portability.

The music art quality evaluation system designed in this paper adopts two modes: c/s and b/s. The users are students, teachers, supervisors, and educational administrators. After logging in, students can see all the course information learned in the current semester and can evaluate the teaching of the courses according to the set evaluation index information. After the evaluation is completed, evaluation information is saved or submitted. The submitted evaluation information cannot be modified. Teachers can conduct self-evaluation and peer evaluation after logging in. After the evaluation results, the students comments can be queried and can be evaluated by evaluation indicators. The administrators of departments can query the evaluation of their teachers. The printout of the evaluation statistical table and evaluation statistical analysis report of all teachers can be taken for archiving and reference. The quality evaluation administrator of the academic affairs office can query the evaluation scores, rankings, and comments of teachers in the college. The administrator can print the evaluation statistics and evaluation analysis tables of teachers in the college.

With the development of computer network [5], it is possible to use web-based technology and new mathematical models to evaluate music and art teaching quality evaluation in colleges and universities. First, B/S mode is used to replace C/S mode making full use of the advantages of the network to meet the needs of students and teachers' geographical dispersion. The web server is used as the B/S application portal. The evaluation system adopts Java, XML, and component encapsulation technology. It adopts a three-tier architecture which makes the developed system more inclusive and extensible. It puts data security in a very important position and interacts with the database server with the web server to ensure data security. At the same time, the system should have an efficient security mechanism, including identity authentication, authority inspection, data confirmation, and other security measures [6–8].

According to the requirements of the ministry of education, we will further deepen the reform of the educational supervision and management system. It includes to strengthen the supervision of schools, guide schools to develop their own characteristics, promote the all-round development of students' morality, intelligence, physique, art, and labor. To carry out supervision, evaluation, and monitoring full use of the Internet, big data, cloud computing is made. However, music evaluation is different from the traditional language, number, and English test as singing is a highly subjective activity. How to achieve subjective activity evaluation through objective quantitative evaluation method is the focus and difficulty of current research. With the vigorous development of mobile digital technology and the improvement of domestic copyright protection awareness, the music streaming media industry has made great progress. A series of music streaming media giants such as Tencent music and NetEase music, and foreign giants such as Spotify and Apple music, have been born at home and abroad. According to the data released by the world record industry association in 2020, the global music-related business revenue increased by 9.7% year-on-year basis. Out of this, the streaming music revenue exceeded US $8.9 billion accounting for 47%. The massive music track library makes users to face great challenges in music information retrieval. Music can be regarded as a kind of voice signal, but it is more diverse and complex. It is composed of different beats, harmonies, and melodies according to certain rules. With the emergence of deep learning, music classification technology has entered a new stage of development. The success of deep learning in speech recognition and image processing makes it a future development goal in the field of music evaluation. At present, the subresearch directions in this field include music genre recognition, music emotion recognition, and music work recommendation. Among them, streaming media (music) recommendation has become an indispensable and important part of the current e-commerce system. The success of Tiktok, Douban, and NetEase cloud music is inseparable from the optimization and application of streaming media recommendation algorithm.

2. Related Work

The improvement of classroom teaching effect is the starting point of classroom teaching evaluation. The research on effective teaching has gone through behavior observation,

psychology research, and comprehensive method research. It mainly focuses on the evaluation criteria of classroom teaching [9]. Foreign researchers first pay attention to the research on whether the teaching process is effective. It includes observing teachers' teaching behaviors under effective teaching situations, summarizing the characteristics of these behaviors, promoting them, improving teaching effectiveness, and further studying effective teaching to evaluate teachers' classroom teaching, so as to change the inefficient situation of classroom teaching. The view of effective teaching holds that the key to teaching is what teachers should do in the classroom, how to make correct decisions, and how to realize these decisions [9].

At the beginning of the last century, western countries evaluated teachers' classroom teaching according to the evaluation grade scale. The evaluation grade scale, which emerged during the European and American educational measurement movement, was the main basis for evaluation at that time which was originated from the decades of prevalence in the early twentieth century. However, the validity of this scale is almost equal to zero because the content of the scale itself is unscientific and lacks systematic development and research, so the results are not reliable and effective [10].

In the 1950s, educational evaluation began to enter the field of classroom teaching which indicates that with the development of modern educational evaluation research, systematic classroom observation methods providing more information have replaced the original teachers' teaching evaluation rating scale that was simply formulated in pursuit of quantification. The influence of observation method in classroom teaching evaluation has gradually increased, and it has been used in classroom teaching evaluation but there are some disadvantages. For example, classroom evaluation is mechanical and rigid, which has become a common trend of classroom teaching evaluation in this period. It overemphasizes objective and verifiable results and requires the objectification and standardization of evaluation results.

Exploring relatively scientific and rational theory and the practice teaching mode, can better [11] discuss the strategy of combining violin theory teaching with practice teaching. The Purpose of Constructing Piano Teaching Innovation Model is that any kind of the education has a certain goal. The success of education must rely on a variety of ways to achieve the established goals [12] and pay attention to playing technique. In our country's piano teaching, teachers often start from the two essences of piano, one of which is to learn the technique [13]. As per reference [14], analyze several problems in current situation, including the lack of information infrastructure construction of music professional production and education integration in colleges and universities under the background of Internet, low modern information literacy of professional teachers in colleges and universities, and low efficiency of cooperation between colleges and enterprises. According to [15], it improves the quality and level of vocal music teaching by reconstructing the teaching model. In [16], the main focus was on the in-depth discussion on the cultivation strategy of music quality for students majoring in preschool education. The work in [17] demonstrates the help of MOOC teaching mode on college vocal teaching and explains the application strategy of MOOC college vocal teaching mode of college vocal teachers. We should constantly strengthen the innovative concept of vocal music education in combination with the actual situation of colleges and universities [18]. It has no bearing on evaluation, feedback, or advancement. Therefore, the superior performance of neural network is used [19] to solve nonlinear problems and construct a music art TQE method based on convolutional neural network (CNN) while other influential works are discussed in [20].

3. Design of Music Art Quality Monitoring System

3.1. Overall System Process. The situation of the grass-roots examination room is complex, and there are insufficient IT technicians with rich practical experience, therefore, there are many risks in the examination organization. The Software as a Service (SaaS) model is quickly becoming a more affordable solution for all businesses, especially small ones to supply business applications. By using SaaS services, we can greatly reduce the risk pressure of customers' IT infrastructure construction and operation costs. The university music and art quality monitoring system adopts b/s architecture. It is deployed in the cloud to provide services to customers (examination organizers) in the way of SaaS. The main development languages used include Java and python. Using relevant technologies and frameworks, candidates sing songs according to the track requirements through the designated examination machine in the examination room (the sound is read in by the sound card). After the data is encrypted, it is transmitted to the university music art quality monitoring system server through the Internet. The algorithm evaluation of the target audio file (student score) is carried out in the background, and the quantitative score is given. The examination room is complex and there are not enough technicians with rich practical experience, so there are many risks in the examination organization. By using SaaS services, we can greatly reduce the risk pressure of customers' IT infrastructure construction and operation costs. The successful online operation of the system has great enlightening significance and broad market development space for the landing practice of artificial intelligence technology, the combination of production and learning, the application of e-commerce music streaming media technology, and the quantitative evaluation and research of other university disciplines(such as art and sports).

Figure 1 is the overall flow chart of the music art quality monitoring system. Teachers/administrators can log in to the teacher system management terminal, upload examination tracks (original sound, score, and accompaniment band), set scoring weights (different requirements for students of different levels), maintain school and student information (taking the school as the unit for examination). Thus, teachers/administrators create examinations and other functions. Under the guidance of the examination room teachers, students can log in to the examination machine and perform vocal music singing according to the requirements of

the examination questions. The system will automatically retrieve the test paper (audio file) and submit the test content, which will be sent back to the server remotely through the Internet. The music art quality monitoring system server will quantitatively score the test content. Teachers can derive test scores and conduct teaching reflection research.

3.2. Application of Grey Neural Network in Music Art Evaluation. The two models require different amounts of data which is the main discrepancy between the grey prediction model and the neural network prediction model. The contradiction between the two can be reduced if the right sample size is chosen, and the benefits of the two can be combined to create a combination model that is more accurate. Therefore, the first problem to be solved is to determine the amount of data when building the composite model. Generally, the fitting accuracy is used to describe whether the model is suitable for this prediction. However, for the neural network prediction model, the fitting accuracy is often very high, even reaching the fitting accuracy of 1, and its prediction accuracy is not necessarily still very high. Therefore, this study considers both fitting accuracy and prediction accuracy when evaluating the model, defines the comprehensive prediction accuracy, and measures the excellence of the model with the comprehensive prediction accuracy. Thus, the optimal data volume of the model is obtained by the grey neural network combination model.

In order to make full use of the historical information and give full play to the advantages of the combined model of grey neural network, this paper first sets the sample number as a dynamic variable value, takes the maximization of the comprehensive prediction accuracy of the model as the goal, and selects the best sample number of modeling data as the sample size of the prediction model. Suppose a total of N statistical values are obtained. The first $n-2$ sample data are used to build the model, and the last two samples are selected to test the prediction accuracy of the model.

Step 1. Level ratio test: for a given original sequence $X^{(0)}$, if you want to establish a GM (1, 1) model with high accuracy, the battery limit coverage of level ratio $\sigma^{(0)}(k)$ of $X^{(0)}$ needs to meet the following conditions.

Suppose $X^{(0)} = (x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n))$, if the level ratio meets

$$\sigma^{(0)}(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)} \in \left(\bar{\frac{2}{e^{n+1}}}, \frac{2}{e^{n+1}}\right), k = 2, 3, \cdots, n. \tag{1}$$

Then GM (1, 1) model can be established for the sequence $X^{(0)}$.

Step 2. Suppose $\{\alpha(1), \cdots, \alpha(t), \cdots, \alpha(N-2)\}$ is the sample data sequence, let $t_o = 1, \cdots, N-6$, and let $\{\alpha(t_o), \cdots, \alpha(t), \cdots, \alpha(N-2)\} = \{x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n_1)\}^T$ successively.

Step 3. Take different values of t_o, build GM (1, 1) respectively for time series prediction, then take the predicted values under different GM (1, 1) models as inputs and the actual values as expected outputs, build BP neural network for training, and get the final predicted values.

Step 4. Determine the optimal sample number n: set the fitting value of the original data as a $\widehat{X}^{(0)}(k) = (\widehat{x}^{(0)}(1), \widehat{x}^{(0)}(2), \cdots, \widehat{x}^{(0)}(n))$,

Then the residual sequence of the original data sample is $Q^{(0)} = (\widehat{q}^{(0)}(1), \widehat{q}^{(0)}(2), \cdots, \widehat{q}^{(0)}(n))$, where

$$q(k) = x^{(0)}(k) - \widehat{x}^{(0)}(k), k = 1, 2, \cdots, n. \tag{2}$$

Absolute, average absolute percentage error, and precision are defined as follows:

$$\begin{aligned} \mathrm{APE}(k) &= \left|\frac{q(k)}{x^{(0)}(k)}\right| \times 100\% = \left|\frac{x^{(0)}(k) - \widehat{x}^{(0)}(k)}{x^{(0)}(k)}\right| \times 100\%, \\ \mathrm{APE} &= \frac{1}{n-1}\sum_{k=2}^{n}\left|\frac{x^{(0)}(k) - \widehat{x}^{(0)}(k)}{x^{(0)}(k)}\right| \times 100\%, \\ \mathrm{Accuracy} &= (1 - MAPE) \times 100\%. \end{aligned} \tag{3}$$

Assume that the fitting accuracy is prediction accuracy. Therefore, the comprehensive prediction accuracy is defined as follows:

$$P = \alpha \times N\,\mathrm{Accuracy} + \beta \times P\,\mathrm{Accuracy}, \alpha + \beta = 1. \tag{4}$$

The objective is to minimize the comprehensive prediction error, that is, the corresponding sample size under the objective of maximizing the comprehensive prediction accuracy is the number of preferred sample sizes n, so $\{\alpha(N-n), \cdots, \alpha(t), \cdots, \alpha(N)\} = \{x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n_1)\}^T$ is selected as the sample data, and Steps 2 and 3 are repeated to establish SGMBP (1, 1) for prediction.

In the past, traditional machine learning often used manual extraction of target features for model training [16, 20]. In the field of music, it mainly used basic data such as loudness, frequency, and beat. However, the music of different genres often differs greatly, and it is difficult to design and extract acoustic abstract features such as musical

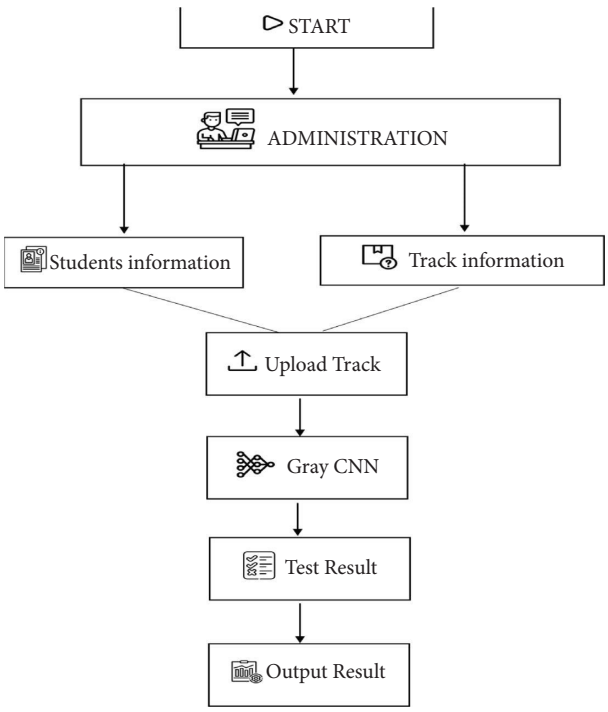

Figure 1: System flow chart.

instruments, rhythm, and harmony by hand. The explosive growth of commercial music streaming media makes it impossible to recommend music through manual annotation in terms of commercial cost. Deep learning can automatically capture the high-level abstract features of the target through the nonlinear relationship generated by the connection of multiple hidden layers. With the great increase in CPU and GPU computing resources, the theory becomes practical and feasible. The grey convolution neural network model group can greatly improve the accuracy of image classification by improving the depth of the convolution neural network. This paper attempts to train a convolution neural network to read the Mel spectrum and judge music style. Figure 2 is the structure diagram of the grey convolutional neural network. The input layer, convolution layer, pooling layer, and complete connection layer make up the network's basic architecture. The input layer is responsible for receiving data, especially high-dimensional data. The convolution layer extracts features through convolution kernels of different sizes to achieve a local weight-sharing effect. Facing the huge amount of computation caused by parameter explosion, the pooling layer is responsible for reducing the dimension of the convolution layer operation results and preventing overfitting operations. The main methods include meaningful pooling and maximum pooling. The full connection layer, also known as the Densen layer, is responsible for mapping high-dimensional data to one-dimensional data. The output layer is responsible for the final result judgment. This paper is a multi-classification design.

In the final examination of a music major in a university in 2021, according to the opinions of the music examination organizers, students of different grades should be differentiated in terms of test difficulty. We have made threshold adjustment intervals for the singing sound speed, sound intensity, and tone of students of different grades. In specific applications, we can provide different criteria according to the nature of different levels of examination.

(i) Sonic control

The rhythm speed of students' singing songs is slightly accelerated or slowed down to the original a times. The value of a is selected within (0.7, 1.3), and the extra or shortened singing time is cut or filled. The motivation for this method is that students' singing speed is often inconsistent, and the standard can be relaxed for students in lower grades.

(ii) Intensity adjustment control

Intensity adjustment refers to a slight change in the loudness of the recorded music which can increase or decrease the loudness of the original music.

(iii) Tone adjustment control

Considering that the vocal cord structure of male and female students is different, the tone of music can be changed because even a small shift would not significantly alter the music's original style. The technique used in this research is to alter the audio by adding or removing C semitones.

4. System Training and Test

The public database is used in this study to train on music classification. This database consist of 10,000 audio clips, which is categorized by musical genres.

The 10 music styles mainly include reggae, metal music, hip-hop, disco, pop music, blues, classical music, rock, country music, and jazz. Each style consists of 1000 segments usually of 30 seconds with a sampling frequency of 22050 Hz and a single channel. The image resolution is $240 * 320$, the activation function is RELU, and the output layer function is softmax for the final classification of music styles. The training cycle epochs are set to 160, the batch size is set to 64, and Adam is used as the gradient optimization descent method in the convergence process of convolutional neural network training. A total of 10000 Mel spectrum diagrams are obtained by using the grey neural network. Each diagram is cut into 30 subgraphs according to the time of 100 seconds, a total of 30000 Mel spectrum subgraphs. Then it is divided into a training set and a verification set by $17:6$. As a small-scale data training, the convolution layer of the grey neural network is appropriately cut, and the first 5 of 130 are selected. The accuracy changes of the training set and verification set are shown in Figure 3. The basic convergence is achieved at about 40 rounds, and the accuracy of the verification set is close to 95%. The error training is shown in Figure 4.

We can see from Figure 4 that our systematic error is getting smaller and smaller with the increase in the number of iterations. It shows that the effect of our music art evaluation system is very good. After 400 iterations, the system error is stable at 0.15.

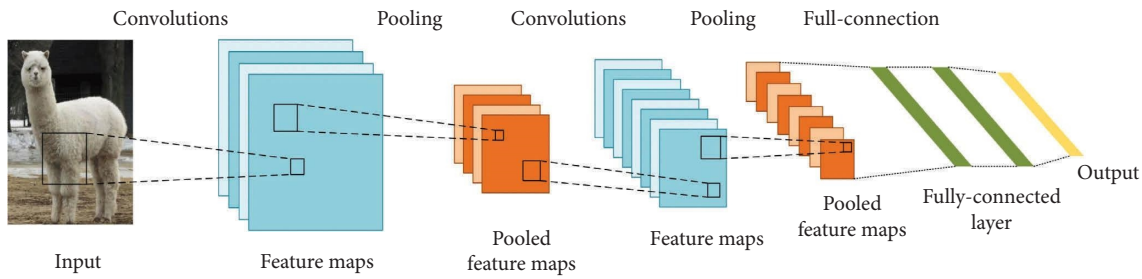

Figure 2: The structure diagram of grey convolutional neural network.

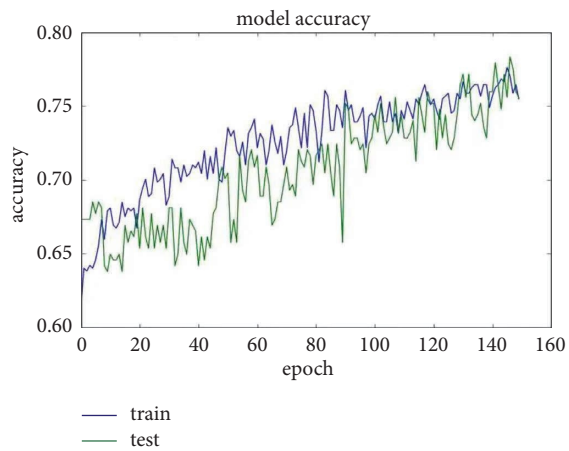

Figure 3: Accuracy variation of training set and verification set.

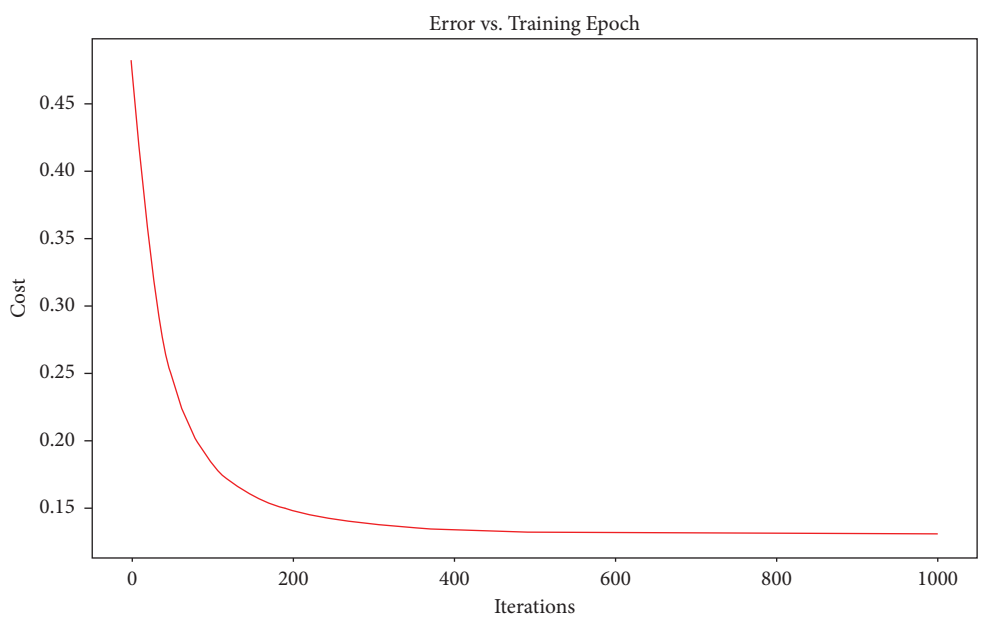

Figure 4: Error training cure.

5. Conclusions

In Chinese colleges and universities, a significant teaching management project has been used over a decade to study and implement quality monitoring systems for music and art instruction. To properly and honestly evaluate the teaching abilities of music and art professors is considered as a crucial task in college and university administration. According to the national guidance on music graduates, this paper requires each university to provide guidance on the quantitative evaluation mechanism of music education art for music graduates. This research develops a cloud-based system for monitoring the quality of university music instruction art based on the national guidance. The main

development languages used are Java and python, as well as *C*. The system reads basic music signal characteristics such as sound intensity, pitch, and beat. The grey neural network is used to assess the music map and conduct a preliminary study of artistic sense. The results of the final test in colleges and universities are uploaded to the backstage server real-time following the review procedure. The successful online operation of the system has reference significance for landing practice of artificial intelligence technology, combination of industry and learning, e-commerce, and music streaming media recommendation. In future, further exploration such as the emotional analysis of vocal singing and automatic music composition, will be made in the analysis of music artistic sense.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Financial Big Data Intelligent Service System Based on Cloud Computing of Internet of Things

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The financial big data intelligent service system belongs to the technical field of financial data management. It is an innovation of the client and server of the financial service system, which promotes the electronic office of the financial system. This paper aimed to analyze the cloud computing means of the Internet of things (IoT), select a more suitable specific algorithm, and conduct an in-depth study of the financial big data intelligent service system so that it can better serve the current financial situation. This paper gave a general introduction to the cloud computing of the Internet of things, researched and analyzed the financial big data intelligent service system machine, and applied the cloud computing of the Internet of things to the research of the financial big data intelligent service system. Based on the experiments in this paper, it can be seen that among the students in the three colleges and universities in place A, 567 people thought that they can adapt to the intelligent financial system better than the already employed salesmen, and 245 people held a negative attitude. It showed that the intelligent development of financial systems is a trend, but at the same time, it is also a development trend to strengthen the business training capabilities of professionals. The experimental results of this paper showed that the process of studying the financial big data intelligent service system based on the cloud computing of the IoT is more scientific and effective than using other means to analyze the experimental data, and it has greater reference significance for the intelligent development of the financial system.

1. Introduction

The Internet of things can connect various information-sharing channels and networks, and realize the intercommunication between humans and machines in time and space. Its basic features include the overall perception of object information, the realization of information sharing through the network, and the intelligent processing of the acquired information. Cloud computing has powerful computing capabilities and can reduce the processing burden of user terminals.

The research on the financial big data intelligent service system is a direction of development in the data age. There were many scholars who analyzed services related to financial systems, and there were scholars who studied intelligent service systems, but few scholars analyzed it from the perspective of cloud computing of the IoT. Based on the cloud computing technology of the IoT, this paper analyzed the financial big data intelligent service system, discussed the development of the financial service system in the field of intelligence, and effectively improved the service system. This paper used the cloud computing technology of the IoT to study the financial big data intelligent service system, and expanded the research methods in this direction, which had certain practical significance.

The innovation of this paper is that this paper analyzed the financial big data intelligent service system based on the cloud computing of the IoT.

2. Related Work

The financial system is an operating system that is necessary for an operating organization to supervise and control the internal economic activities of the organization. At present,

the demand for big data intelligence research on it is very extensive. Therefore, there are many scholars who have studied the financial big data intelligent service system. Li used the proportional analysis method to analyze and predict the operating performance of Acoustech Bhd, and put forward some suggestions for the adjustment of the company's asset structure [1]. Emmanuel and Ekpenyong made research on Nigeria's economic development through relevant financial analysis methods. Particularly after the discovery of crude oil in the local area, too much emphasis has been placed on oil resources, and economic development has been relatively simple [2]. Peng et al. believed that when pricing derivatives, it was necessary to use numerical methods to deal with high-dimensional problems. Therefore, based on the Lévy process, two sensitivity estimation methods were proposed and applied to the parameter estimation of Lévy-driven stochastic volatility models [3]. Haan and Sturm's research showed that financial variables can exacerbate income inequality [4]. Higham et al. proposed a double-implicit Milstein scheme that can be used in a family of financial models and has no strict time limit [5]. The analysis of financial status by these scholars focused on the analysis of financial models or the financial status and influencing factors of a certain region. The research on the financial intelligent service system was less involved, and it was rarely combined with big data, such as cloud computing of the IoT.

The Internet of things can connect smart devices to the network, and cloud computing can provide a perfect solution for the expansion of IT facilities. Therefore, scholars are very keen to explore the application of cloud computing for the Internet of things. Perera et al. believed that the IoT was a dynamic global information network, and aimed to stimulate the further development of the IoT by investigating the intelligent solutions of the IoT to determine the technologies, functions, etc. [6]. Stojkoska and Trivodaliev's research mainly discussed the relationship between a smart home and the Internet of things, and proposed some improvement schemes for the future challenges of the Internet of things [7]. Kshetri's research was to discuss the relationship between blockchain and IoT security performance. It was proposed that when using blockchain, in order to avoid security incidents, it was necessary to contain the vulnerabilities of IoT security in a targeted manner [8]. Xia et al. believed that the image encryption technology will make the CBIR technology in the plaintext field unusable, so they proposed a scheme that can use the CBIR technology on the basis of image encryption without revealing privacy [9]. Wei et al. believed that the existing static grid resource scheduling algorithms cannot meet the needs of cloud computing, so he proposed a cloud resource allocation model based on the hidden Markov model (HMM) to establish the incomplete information Stackelberg game (IISG) [10]. These researchers' research on the IoT and cloud computing generally focused on promoting network development or reducing network vulnerabilities.

3. Method of the Financial Big Data Intelligent Service System Based on Cloud Computing of the Internet of Things

3.1. Financial Big Data Intelligent Service System. The financial system is an organization or positions and personnel established around financial goals, which generally supervise and control the financial operations within the organization [11]. The financial big data intelligent service system is a system that provides intelligent services to an organization and its business activities based on the information sources obtained from big data, and belongs to the technical field of financial data management [12, 13]. Figure 1 shows the traditional accounting manual account display.

The financial big data intelligent service system is a new type of intelligent service system based on traditional financial services, using big data intelligent means to carry out technological innovation. Therefore, its basic financial system means have also been innovated accordingly [14]. Figure 2 is an intelligent financial service system.

The financial big data intelligent service system includes the financial intelligent management system [15]. Its basic functions are shown in Figure 3.

3.2. Cloud Computing for the IoT. The cloud computing of the Internet of things is a new computing model, which has high commercial value because it is generated on the basis of parallel, distributed, and grid operations [16, 17]. Cloud computing can remotely obtain the information resources of the data center through the Internet for computing, storage, and other services. Therefore, users can adjust the amount of information resources they want to obtain according to their own needs. For users, it has better adaptability [18, 19]. Cloud computing enhances its computing services in a low-cost and low-overhead way, gaining a large number of loyal users. Figure 4 is a simple demonstration of cloud computing for the Internet of things.

The cloud computing processing of the IoT includes the field of image processing. Therefore, the method of cluster analysis is more effective for data processing in this area [18]. The premise of cluster analysis is computation, which contains two types, data matrix and dissimilarity matrix [19].

Data Matrix. The q-dimensional data with r samples form an observation matrix M, that is,

$$M = \begin{pmatrix} m_{11} & m_{12} & \cdots & m_{1q} \\ m_{21} & m_{22} & \cdots & m_{2q} \\ \vdots & \vdots & \ddots & \vdots \\ m_{r1} & m_{r2} & \cdots & m_{rq} \end{pmatrix}. \quad (1)$$

Any row in this formula represents a sample, any column represents an indicator variable, and each object corresponds to a q-dimensional vector.

Figure 1: Traditional accounting manual.

Figure 2: Smart service financial system.

Dissimilarity Matrix:

$$\begin{pmatrix} 0 & \cdots & \cdots & \cdots & 0 \\ e(2,1) & 0 & \cdots & \cdots & \vdots \\ e(3,1) & e(3,2) & 0 & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ e(r,1) & e(r,2) & \cdots & \cdots & 0 \end{pmatrix}. \tag{2}$$

$e(a,b)$ represents the quantification of the dissimilarity between the two samples a and b, and is a non-negative number. The dissimilarity matrix has two properties. One is $e(a,b) = e(b,a)$, and the other is $e(a,a) = 0$.

The problem that the clustering criterion needs to solve is to determine the degree of similarity between two different pattern vectors and the type of attribution [20]. When a function criterion is used to define the similarities and differences between patterns, this function is usually called a clustering criterion function, and the clustering criterion is obtained by finding the extreme value.

The clustering criterion function is usually defined as follows:

$$B = \sum_{b=1}^{t} \sum_{m \in S_b} M - P_b^2. \tag{3}$$

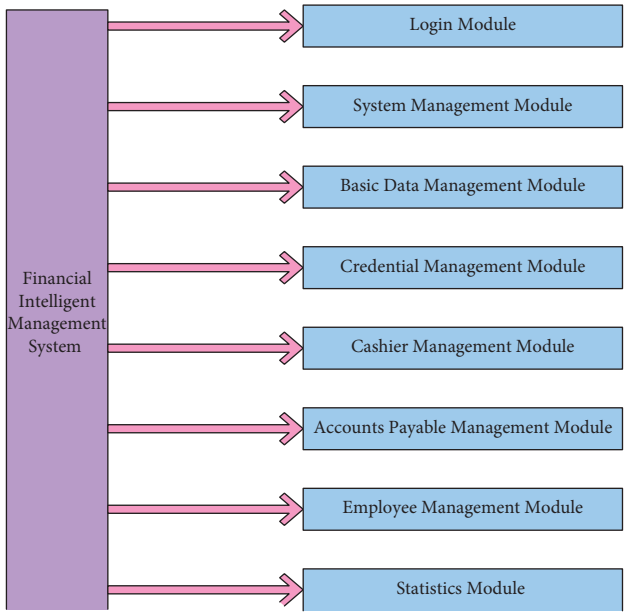

Figure 3: Display of the basic functions of the financial function management system.

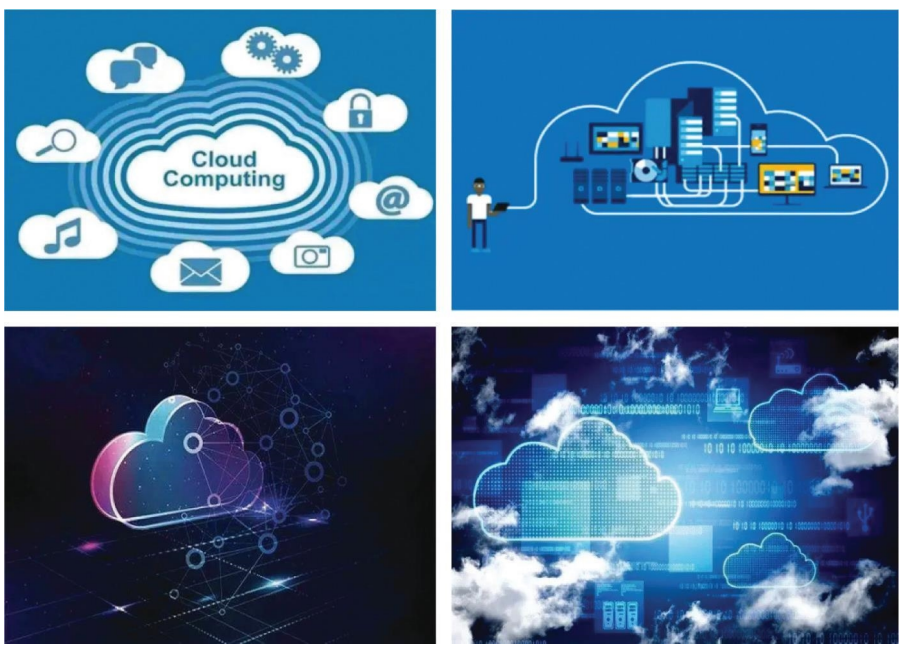

Figure 4: Simple demonstration of cloud computing for the IoT.

Among them, t indicates that there are t patterns. $P_b = 1/R_b \sum_{X \in S_b} M$ is the mean vector of pattern samples in S_b, R_b is the number of pattern samples in S_b, and B represents all samples belonging to t cluster categories and their corresponding error sums of squares.

Because the clustering algorithm includes a variety of specific algorithms, and this paper mainly combines the K-means clustering method, the following will focus on the algorithm. The K-means clustering algorithm randomly selects K objects as the initial value of the cluster center, and assigns it to the closest cluster center by calculating the distance between each independent object and each seed cluster center. These objects are assigned to the cluster centers that are closest to them. When all objects are assigned, each cluster center is recalculated based on the existing objects until a certain termination condition is met.

If the r individuals are divided into k categories, then the two individuals m_1, m_2 with the farthest distance among all individuals are selected as the aggregation points, that is,

$$e(m_1, m_2) = e_{a_1 a_2} = \max\{e_{ab}\}. \tag{4}$$

By determining m_{a_3}, the minimum value of the example with the first two aggregation points is equal to the maximum value of the smaller examples with m_{a_1} and m_{a_2}, that is,

$$\begin{aligned}&\min\left\{e\left(m_{a_3}, m_{a_n}\right), n = 1, 2\right\}\\&\quad = \max\left\{\min\left\{e\left(m_b, m_{a_n}\right), n = 1, 2\right\} b \neq a_1, a_2\right\}.\end{aligned} \tag{5}$$

The steps are repeated until k cluster points are determined.

The steps are as follows:

If the set of the k initial cluster is

$$G^{(0)} = \left\{m_1^{(0)}, m_2^{(0)}, \ldots, m_k^{(0)}\right\}. \tag{6}$$

That is,

$$\begin{aligned}L_a^{(0)} &= \left\{m\colon e\left(m, m_a^{(0)}\right) \leq e\left(m, m_b^{(0)}\right) b = 1, 2, \ldots, k, b \neq a\right\}\\&\quad (a = 1, 2, \ldots, k).\end{aligned} \tag{7}$$

Thus, an initial classification $L_a^{(0)} = \left\{L_1^{(0)}, L_2^{(0)}, \ldots, L_k^{(0)}\right\}$ is obtained.

From the initial class $L_a^{(0)}$, a new cluster $G_a^{(0)}$ is computed, that is,

$$m_a^{(1)} = \frac{1}{r_a} \sum_{m_g \in L_a^{(0)}} m_g \, (a = 1, 2, \ldots, k). \tag{8}$$

Among them, r_a is the number of samples in the initial class $L_a^{(0)}$, resulting in a new set $G^{(1)} = \left\{m_1^{(1)}, m_2^{(1)}, \ldots, m_k^{(1)}\right\}$. From $G^{(0)}$, the reclassification is performed, that is,

$$\begin{aligned}\% \quad L_a^{(1)} &= \left\{m\colon e\left(m, m_a^{(1)}\right) \leq e\left(m, m_b^{(1)}\right) b = 1, 2 \ldots k, b \neq a\right\}\\&\quad (a = 1, 2, \ldots, k).\end{aligned} \tag{9}$$

The steps are repeated z times to get the following:

$$L_a^{(z)} = \left\{L_1^{(z)}, L_2^{(z)}, \ldots, L_k^{(z)}\right\}. \tag{10}$$

Among them, $m_a^{(z)}$ is the center of gravity of $L_a^{(z-1)}$, $m_a^{(z)}$ is not necessarily the sample, and the classification tends to stabilize as z increases gradually. During the calculation, if a certain z, $L_a^{(z+1)} = \left\{L_1^{(z+1)}, L_2^{(z+1)}, \ldots, L_k^{(z+1)}\right\}$, and $L_a^{(z)} = \left\{L_1^{(z)}, L_2^{(z)}, \ldots, L_k^{(z)}\right\}$ are the same, the calculation is terminated.

Similarly, clustering patterns need to be tested for dissimilarity, that is, to measure the similarity between the same patterns and the dissimilarity between different classes of patterns [21]. The q-dimensional data with r samples are given by

$$m_a = \left(m_{a1}, m_{a2}, \ldots, m_{aq}\right)^T (a = 1, 2, \ldots, r). \tag{11}$$

m_a is the a row of the matrix M. At this time, each sample can be regarded as a point in the q-dimensional space, that is, a q-dimensional vector. The distance between any two vectors is marked as $e(m_a, m_b)$.

The distance between any two vectors is not negative, that is, $e(m_a, m_b) \geq 0$, and when $m_a = m_b$,

$$e\left(m_a, m_b\right) = 0. \tag{12}$$

When the distance between vectors is symmetric,

$$e\left(m_a, m_b\right) = e\left(m_b, m_a\right). \tag{13}$$

When it is a triangle inequality,

$$e\left(m_a, m_b\right) = e\left(m_a, m_k\right) + e\left(m_k, m_b\right). \tag{14}$$

Since in general, the distance used is generally Euclidean distance. Assuming that M_a, M_b is two r-dimensional modes, $M_a = (m_{a1}, m_{a2}, \ldots, m_{ar})^T$, and $M_b = (m_{b1}, m_{b2}, \ldots, m_{br})^T$, the Euclidean distance is defined as follows:

$$\begin{aligned}E\left(M_a, M_b\right) &= M_a - M_b = \left(M_a - M_b\right)^T \left(M_a - M_b\right)\\&= \left(m_{a1} - m_{b2}\right)^2 + \ldots + \left(m_{ar} - m_{br}\right)^2.\end{aligned} \tag{15}$$

Figure 5 is a simple diagram of the Euclidean distance.

In addition to the Euclidean distance, there is also Ming's distance:

Assuming that M_a, M_b is an r-dimensional pattern vector, the distance between M_a and $M_b$is given by

$$E_p = \left[\sum_{k=1}^{r} m_{ak} - m_{bk}^p\right]^{1_p}. \tag{16}$$

Assuming that M_{ak}, M_{bk} represents the k component of M_a and M_b, respectively. Among them, when $p = 2$, Ming's distance is equal to the Euclidean distance, and when $p = 1$, it becomes the "neighborhood" distance, which is expressed as follows:

$$E_1\left(M_a, M_b\right) \sum_{k=1}^{r} m_{ak} - m_{bk}. \tag{17}$$

If all the values of the pattern vector take ± 1, it is a binary pattern, and the Hamming distance can be used to measure the dissimilarity between patterns. Assuming that M_a, M_b is an r-dimensional pattern vector, the Hamming distance between M_a and M_b is given by

$$E_h\left(M_a, M_b\right) = \frac{1}{2}\left(r - \sum_{k=1}^{r} m_{ak} \cdot m_{bk}\right). \tag{18}$$

Among them, when the values of each component of the two mode components are different, the Hamming component is r, and when they are the same, the Hamming component is 0.

The angular similarity function is expressed as follows:

$$S\left(M_a, M_b\right) = \frac{M^{Ta} M_b}{M_a \cdot M_b}. \tag{19}$$

Formula (19) refers to the cosine of the angle between the mode vectors M_a, M_b, which can reflect the feature of geometric similarity. When the value of the feature is 0, 1, $M_a^T M_b$ is the number of features shared between the two vectors.

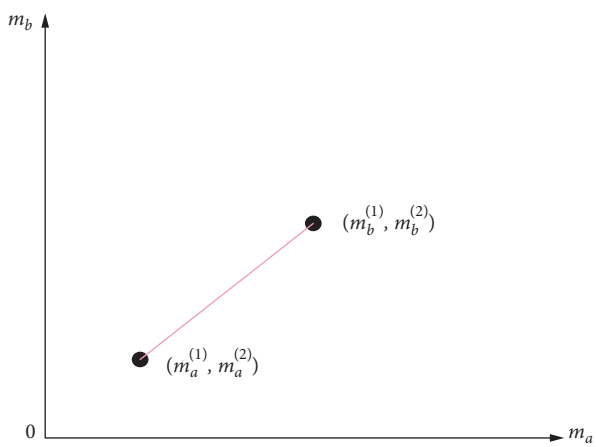

Figure 5: Schematic diagram of the Euclidean distance.

$$M_a \cdot M_b = \left(M_a^T M_a\right)\left(M_b^T M_b\right). \tag{20}$$

4. Experiment of the Financial Big Data Intelligent Service System

4.1. Scheme Design of the Financial Intelligent Service System. The financial service system is generally a system for supervising and coordinating the business activities of an organization or group. The intelligent financial service system based on big data involves many modules of Internet information, including expanded user access, login information identification, employee salary distribution, financial inquiry, online billing, online banking charges, central processing system, and database and execution operation modules. It involves all aspects of users' financial use.

In order to better understand the relevant achievement data of the financial big data intelligent service system, and to further reveal the practical development significance of the intelligent financial service system to enterprises and the public, this paper distributed questionnaires to students majoring in financial management in three universities in place A. Among them, the students in University X were the research objects of the experiment, and the students majoring in University Y and University Z were the experimental control group. A questionnaire survey was conducted. A total of 900 copies of the "Financial Big Data Intelligent Service System Questionnaire" were distributed, 300 copies were distributed to each college, and a total of 812 copies were recovered, of which 275 copies were collected by X college, 264 copies were collected by Y college, and 273 copies were collected by Z college. The effective recovery rate was about 90.2%.

The setting and analysis process of this questionnaire fully combine the Internet of things and computing methods for cluster analysis. In this questionnaire, 7 questions are set, and the sample data are analyzed in detail.

4.2. Discussion Results of the Financial Big Data Intelligent Service System. This questionnaire survey on the financial big data intelligent service system has set a total of 7 questions, including the respondents' own professional-level grasp, whether the financial service system needs to be intelligent, the practicability of the financial service system after big data intelligence evaluation, what is the prospect of the financial big data intelligent service system, whether the students can accept the intelligent financial service system, whether the students can adapt to the intelligent financial system better than the already employed salesmen, and whether the intelligent financial system can be better for customer maintenance.

4.2.1. Respondent's Mastery of Relevant Professional Level. According to the analysis process of the experiment, it can be seen that the respondents' own level of mastery of financial management-related majors is closely related to whether they can better understand the intelligence of the financial service system. Table 1 shows the professional level of the respondents.

It can be seen from Table 1 that among the students majoring in financial management in the three colleges and universities, most of the students' appraisal of their professional level is in the general or better range. There are 701 students, accounting for 86.3% of the valid questionnaires. Only some students think their professional level is poor. There are 111 students, accounting for 13.7% of the valid questionnaires. According to the data in the table, the professional level of the students in the *X* college is the best among the three colleges, and there are 252 students at the average and better level, accounting for 31% of the valid questionnaires. The professional level of students in University Z is in the middle of the three universities. There are 234 students at the average and better level, accounting for 28.8% of the valid questionnaires. The overall level of students in University Y is also good, but the students with poorer level are the most among the three universities, with 49 students, accounting for 0.06% of the valid questionnaires.

4.2.2. Whether the Financial Service System Needs to Be Intelligent. Students majoring in financial management's views on the intelligentization of financial service systems can illustrate the development trend of intelligentization of financial service systems. Figure 6 is a reference to the demand for the intelligent financial service system.

From Figure 6, it can be seen that students majoring in financial management generally believe that the financial service system needs to be developed intelligently. Particularly, the students from University Z, 223 people, agree with the intelligent development of the financial service system, accounting for 27.4% of the valid questionnaires. Of course, there are 212 people from *X* university in the experimental group who agree with the intelligent development of the financial service system, accounting for 26.1% of the valid questionnaires. Among them, there are also many students with negative attitudes, 188 people, accounting for 23.2% of the valid questionnaires. Analysis of the reasons shows that these students generally believe that the

Table 1: Respondents' professional level.

	Poor	Normal	Better
X	23	156	96
Y	49	173	42
Z	39	132	102

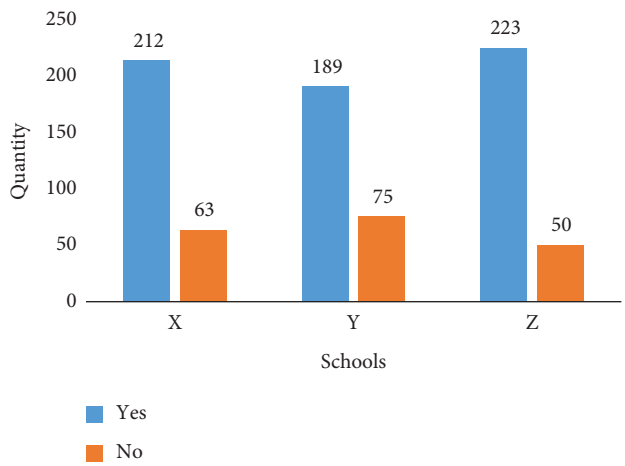

Figure 6: Financial service system intelligent demand reference table.

traditional financial service system has a clearer division of labor and a higher employment rate than the intelligent system.

4.2.3. Practicality Evaluation of the Financial Service System after Intelligentization. The most important evaluation factor for the intelligent development of the financial service system is its practical evaluation. Table 2 is the statistics of the evaluation data of the financial big data intelligent service system by the students.

It can be seen from Table 2 that most of the students have a neutral or good attitude towards the financial intelligent service system. There are 675 people, accounting for 83.1% of the valid questionnaires, and 137 people hold a disapproval attitude, accounting for 16.9% of the valid questionnaires. Analysis of the reasons shows that students who agree with the intelligent financial system have learned a lot about intelligent financial systems in the classroom. It is generally believed that intelligent service can bring a good service environment to customers, and can provide customers with more detailed personalized services. Most of the students who do not agree with it have had a short internship experience. They do not deny the intelligent development of the financial service system, but believe that the intelligent development is not perfect, and the development of the too intelligent system is difficult for customers who do not know much about the system. Therefore, it believes that the convenience of the intelligent financial service system needs to be further improved.

Table 2: Evaluation reference of the current students on the financial big data intelligent service system.

	Poor	Neutral	Better
X	42	125	108
Y	61	151	52
Z	34	116	123

Table 3: College students' views on the prospect of the financial big data intelligent service system.

	Decline	Neutral	Bright Prospects
X	36	125	114
Y	42	133	89
Z	25	97	151

4.2.4. Prospect of the Financial Big Data Intelligent Service System. Students majoring in financial management should have a keen attitude towards the development status and prospects of the financial system. Table 3 is the outlook of the students on the financial big data intelligent service system.

It can be seen from Table 3 that most of the students have a neutral or bright outlook on the development of the financial big data intelligent service system. There are 709 students, accounting for 87.3 of the valid questionnaires. There are 103 students who think that the development of system intelligence has no prospects, accounting for 12.7% of the valid questionnaires. An in-depth study of the reason is related to the intelligent evaluation of the financial service system. Most students believe that the intelligent system is convenient for life, so they are optimistic and supportive of its development prospects. A small number of students believe that the development of intelligence may only facilitate the efficiency of staff. For customers without relevant professional knowledge, it will undoubtedly increase the difficulty of understanding, which will easily cause the service system to struggle.

4.2.5. Whether the Students Can Accept the Intelligent Financial Service System. Students are likely to work in related industries after graduation, so they will become the main force in the financial system industry. Whether students accept the intelligent financial service system has a profound impact on the intelligent development of the system. Figure 7 shows the statistics of whether students can accept the intelligent financial service system.

It can be seen from Figure 7 that the students majoring in financial management in the three colleges and universities think that they can better adapt to the intelligent financial service system, and only a small number of students think that they cannot adapt. Analysis of the reasons shows that, on the one hand, it is related to the textbooks and lesson plans that colleges and universities are in touch with when teaching students of this major, and on the other hand, it is related to the students' own learning ability. The development of intelligent systems affects not only the objects, customers, and practitioners, but also students who are preparing to enter the industry. When the level of students

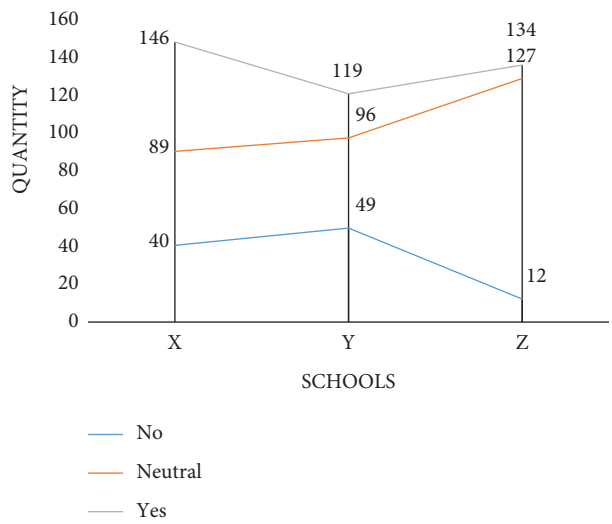

Figure 7: Statistics on whether students can accept the intelligent financial service system.

cannot keep up with the development of intelligent technology, it will greatly affect the further development of the financial system. Therefore, it is very important to provide students with professional knowledge training and professional skills training.

4.2.6. Whether the Current Students Can Better Adapt to the Intelligent Financial System than the Already Employed Salesmen. The knowledge learned by the students in school will be more intelligent than the knowledge and technology learned by the practitioners during the school, but the students in the school lack practical operation experience than the practitioners. Therefore, it is necessary to count whether the students in the school can better adapt to the situation of the intelligent financial system than the practitioners, as shown in Figure 8.

As can be seen from Figure 8, the overall situation shows that 567 students of financial management majors in the three colleges and universities think that they can adapt to the intelligent financial system better than those who have already practiced, accounting for 69.8% of the valid questionnaires. There are 245 people who hold a negative attitude, accounting for 30.2% of the valid questionnaires. Analysis of the reasons shows that students who think that they can better adapt to the intelligent development of the financial system are because the professional knowledge and skills training they have received in schools have been combined with the current social development status and because they think they can better adapt to the information age. Students who think that they cannot better adapt to the intelligent development of the financial system mainly think that their professional knowledge is not solid enough, and they have less practical training experience and are not clear about their future development goals.

4.2.7. Whether the Intelligent Financial System Is Better for Customer Maintenance. The main point of the financial

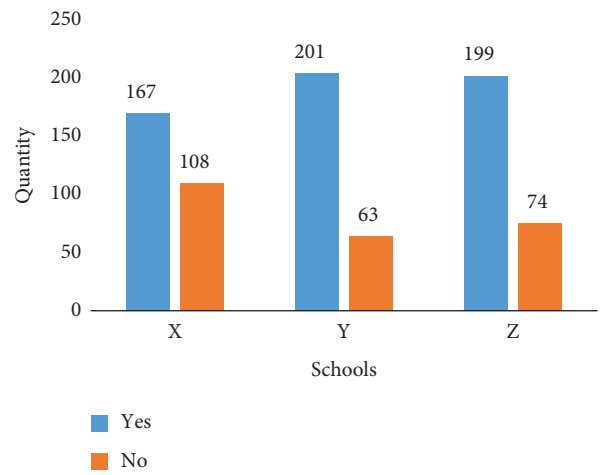

Figure 8: Whether the current students can better adapt to the intelligent financial system than the already employed salesmen.

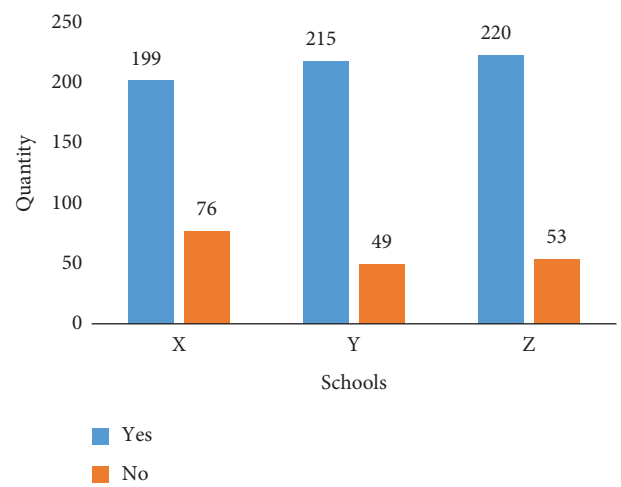

Figure 9: Students' evaluation of whether the intelligent financial system can better maintain customers.

system is to provide customers with convenient financial assistance functions, and whether the intelligent financial system can better maintain customers is one of the values of its intelligent development. Figure 9 is the evaluation of the students on whether the intelligent financial system can better maintain customers.

According to Figure 9, students generally believe that only the financial service system can better maintain customers. Of course, there are also a small number of students who are against it. Students who think that the intelligent financial service system can better maintain customers think that the intelligent financial service system is more refined than manpower, and can better provide personalized services. Students with dissenting opinions believe that the systematic implementation of intelligent financial services must be carried out under the guidance of professionals with rich experience or the clients themselves have relevant financial knowledge. Otherwise, customers cannot adapt to the use of the intelligent financial service system.

4.3. Application of Cloud Computing of the Internet of Things to the Financial Big Data Intelligent Service System. Based on the analysis, it can be seen that the cloud computing for the IoT can be well combined with the financial big data intelligent service system. Development in the age of intelligence has enabled the financial big data intelligent service system to be analyzed from multiple perspectives, which can show the good development prospects of the financial big data intelligent service system in many aspects. However, due to the lack of in-depth learning of IoT cloud computing, this experiment only conducted questionnaire analysis on a total of 900 students majoring in financial management from three colleges and universities in place A, and did not analyze the specific groups of a school and the financial intelligence service system.

5. Discussion

This paper is devoted to the research of cloud computing-related algorithms of the IoT, and applied to the research of the financial big data intelligent service system. This is not only the expansion of the cloud computing of the IoT in the research field of the financial big data intelligent service system, but also the further exploration of the research on the financial big data intelligent service system, and a new attempt for the intelligent development of the financial service system. By conducting a questionnaire survey on 900 students majoring in financial management in place A, on the basis of the existing IoT cloud computing, the algorithm is improved and combined with the intelligent financial service system, and practical conclusions are obtained.

Through the exploration of this case, it can be seen that the method of analyzing the financial big data intelligent service system based on the cloud computing of the IoT is more scientific than the traditional method. The measurer further discussed the development of the financial big data intelligent service system by means of the IoT cloud computing, optimized the algorithm in the process of specific experimental exploration, and finally obtained the best solution for this experiment.

6. Conclusion

Through the analysis of the questionnaire survey, the following conclusions are drawn. The development of the IoT can promote the diversification of intelligent analysis methods. The related algorithms of the IoT cloud computing can be better combined with the research on the financial big data intelligent service system, and play a great role in the further detailed intelligent development of the financial service system. Through the questionnaire analysis of the students majoring in financial management, this paper drew the conclusion that the intelligent development of the financial system was an inevitable trend in the current society. However, how the financial service system can be developed more humanely and how can it better meet the needs of customers are a question worthy of constant exploration. Therefore, the innovation of the financial service system must improve the service concept, enhance the user satisfaction, and proceed from the actual needs of users.

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declare that they have no conflicts of interest with any financial organizations regarding the material reported in this manuscript.

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Research Article

Innovative Economic Development Path Using Double-Cycle New Pattern Data Discovery for Industrial Internet of Things

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The use of smart sensors and actuators to improve industrial and manufacturing processes is known as the industrial internet of things (IIoT). Innovative economic growth is one of the key elements required for the success of IIoT in contemporary industry. Innovation in IIoT is essential for fostering high-quality economic growth and achieving a competitive edge. This study aims to conduct in-depth research on the development path of an innovative economy based on data mining under the new pattern of double circulation in order to enhance industrial innovation capability, realize the modernization of the industrial chain, and accelerate the development of industrial innovation in IIoT. The first step is to use the five urban agglomerations for path analysis of innovative economic development. The five metropolitan agglomerations' pertinent facts are provided, and their industrial structure's composition and proportion as well as the input and output of innovation are all examined. We then constructed a model for analyzing the link between technological innovation and economic growth. The investigation of the innovative economic development path based on data mining is achieved using the Microsoft time series technique and the expectation-maximization algorithm to examine the data of innovative economic development. The experiment demonstrates that the method proposed in this study has strong data mining stability and ideal data clustering advantages. In IIoT, it can be used to effectively increase data mining's efficiency and innovation capacity for the growth of a knowledge-based economy and creating a new pattern in which innovation and market growth are mutually reinforcing.

1. Introduction

In IIoT, instead of relying on a tangible connection to a particular object, the innovation economy relies on individuals' inventiveness to develop and execute new concepts, goods, and services. A company's ability to adapt and face the difficulties of change frequently depends on innovation [1]. It encourages growth because stagnation can be harmful to any company. In today's extremely competitive environment, it is essential to achieve organizational and economic success through innovation. Innovation helps to boost economic growth, which is one of its key advantages. In other words, innovation can increase productivity, which is the ability to produce more with the same amount of input [2]. The economy expands as productivity increases and more products and services are produced.

With the development of the industrial internet of things, the new double circulation pattern aims to improve the stability of China's economic development by taking the demand for China's economic development as its primary priority. We employed the domestic circular economy's smoothness to create a new, large circular economy system, which grows gradually and improves the industrial chain and supply chain, as well as reduces the country's reliance on external and international markets [3]. The full use of China's advantages in super-large-scale economic markets develops China's advantages in participating in international competition and cooperation under the new circumstances, thereby strengthening the initiative of China's economic opening up and thus creating a new pattern of double circular economic development. All of them are dependent on increased industrial innovation capacity, and it follows

that increasing the growth of the industrial innovative economy is essential for implementing the new model of double circulation development [4].

In the field of IIoT, some developed nations have made their objective to slow down China's transformation and upgrading, especially with developments in the global competition of science and technology between China and other developed countries. China's core technology has not been effectively developed in recent years using IIoT, and its development has been seriously hampered, reflecting the poor quality of innovation in China [5]. This has slowed down the industrial chain, supply chain, and innovation of China's important strategic industries in the development process. The majority of the fundamental technologies for industrial development are ineffectively developed [6]. Therefore, strengthening industrial innovation capacity is essential for achieving industrial upgrading and modernizing the industrial chain. It has a special role in the formation of the new double-cycle pattern. Therefore, by using the industrial internet of things, the direction of industrial innovation and economic development is studied in this article.

The innovations of this study are as follows:

(1) Using the five urban agglomerations, we perform a path analysis of innovative economic development, present the pertinent data of the five urban agglomerations, and analyze the composition and proportion of the industrial structure of the five urban agglomerations, as well as analyze the innovation input and output and construct an analysis model of innovative technology and economic development. Then, the data of innovative economic development are explored using the Microsoft time series technique and the expectation-maximization algorithm, and the data mining study of the innovative economic development path is carried out.

(2) The approach outlined in this research study offers optimum data clustering benefits and excellent data mining stability when compared with previous creative economic growth route analyses. It can significantly increase the effectiveness and capacity for the invention of data mining for creative economic growth and create a new pattern where innovation and market are mutually reinforcing.

The remaining parts of the study are structured as follows: Section 2 is the related work. Section 3 is the research on the development path of the innovative economy using data mining for IIoT. Section 4 is the analysis of the IIoT's multiagent innovation economy's development path. Section 5 is the experimental result, and section 6 is the conclusion of the study.

2. Related Work

In the field of IIoT, enhancing industrial innovation capabilities can successfully implement the modernization of the industrial chain against the new double circulation pattern. Therefore, the innovative economy's growth trajectory is carefully examined. Bai et al. [7] conducted the Yangtze River Economic Belt panel data analysis from 2008 to 2018, to estimate the degree of provincial digital economy growth and examined the effects of regional innovation capability on digital economy development using the spatial Dobbin model. The study's findings indicate that the degree to which the digital economy is developing significantly affects the industry's capacity for innovation and contributes to the advancement of both product and technological innovation. The development of the innovative economy is negatively impacted by the research matrix. The level of economic development, the input of financial resources for scientific research, and the input of human resources influence the growth of the innovative economy. Therefore, it enhances the industrial technology connections and resource sharing, removes obstacles to innovation and growth of the digital economy, allocates innovation resources effectively, enables precise resource input for innovation, and raises the application level of the digital economy. However, this approach does not enhance industrial innovation capacity. Yi [8] proposed a method for completing the transition from the conventional economic mode to the intelligent mode and the quantitative growth mode, with the goal of extending the development space of the digital economy to the real economy. The development level of the digital economy and the innovation efficiency of high-tech panel data from 30 Chinese provinces are used to assess and analyze the businesses between 2014 and 2020, and the impact of the digital economy on the innovation efficiency of high-tech industries is empirically tested. The findings of the investigation indicate that the growth of the digital economy can significantly increase the effectiveness of industrial innovation. However, the efficacy of technical industrial innovation is influenced by economic progress although the impact has continuously diminished due to regional and industrial heterogeneity. The innovative efficiency of the industry that develops the innovative economy can be significantly increased by the growth of the innovative economy in China. The growth of the digital economy has a significant impact on the communication equipment manufacturing and electronic sectors. As a result, various recommendations for development are made, including the effective growth of the digital economy and an increase in research and development (R&D) spending, although the implementation of these ideas is difficult. Zhang et al. [9] used nonphysician practitioner (NPP)/VIIRS day/night band (DNB) data as well as pertinent information permitted by provincial patents and developed a geographically weighted regression model to analyze the spatial clustering of the number of patents granted in 31 provinces from 2013 to 2018, except for Hong Kong, Macao, and Taiwan. This model examines technological innovation's effects on economic development. It is based on the results of Moran's I measurement and Lisa's clustering. The results of the experimental study demonstrate that there is a substantial polarization in the geographical distribution of technical innovation in China, with low levels of creativity in the central and western regions and a concentration of

invention in the eastern coastal districts. Governments have created strategic policies that are appropriate for the growth of innovation in the local area and those which enhance the quality and transformational path of patents, increase investment in innovative research and development, enhance the intensity of economic opening, strengthen the mechanism of innovation cooperation among provinces, and create an ideal innovation system. However, this method does not improve the efficiency of innovative economic development. Litvinenko [10] increased the degree of opening up the western area and supported the high-level growth of the open economy in light of the new pattern created by the large-scale development of the western region in the new age. The characteristics of Western open economy is relatively small development scale and low competitiveness. China's western economy can avoid several drawbacks, such as weak competitiveness and poor internal and external connection, because of the new design, which places China's massive cycle at its center and supports the expansion of both domestic and worldwide double cycles. We thereby create an innovative pilot zone that combines the import absorption and transformation accumulation zone with the innovation technology system in response to new growth points and development prospects. The western area can use multilevel development channels to promote both external growth and regional development. However, it has the ability to coordinate and optimize the construction and market issues as well as the opening management mechanism. It can utilize open innovation as a platform to support the coupling of linkage and economic marketization. Due to the realization of the elements affecting the flow of commodities, creative economic development can progressively transit into high-quality development. However, this article does not propose specific measures.

3. Research on the Development Path of Innovative Economy Using Data Mining for IIoT

The IIoT is a subcategory of the Internet of Things (IoT) that focuses on its applications and uses cases in contemporary industries and manufacturing and is well suited to the architecture of intelligent manufacturing industries. An innovative economy in the IIoT aims to realize new ideas, originate them, and propose policies that will promote the growth of new approaches [11]. The economics of innovation is becoming increasingly important as countries are shifting from industrial production models to a knowledge-based economy. Instead of the physical attribution to a specific product, the creative potential of citizens to develop and execute new ideas, products, and services is used to study increasingly massive datasets and to enhance market segmentation using IIoT [12]. This section of research on the development path of the innovative economy using data mining for IIoT is further divided into the following subsections.

3.1. Data Description

3.1.1. Overview of Urban Agglomeration. The five largest urban agglomerations in China are used in this article to analyze the data. The Yangtze River Delta, Beijing Tianjin Hebei, the Pearl River Delta, the middle sections of the Yangtze River, and Chengdu Chongqing are considered China's five urban agglomerations. The five metropolitan agglomerations collectively cover 993200 square kilometers. In Figure 1 [13], the specifics of the five metropolitan agglomerations are displayed. China's five largest urban agglomerations' population densities and per capita gross domestic product (GDP) are displayed in Table 1 for the year 2019.

According to the statistics in Table 1, there are certain discrepancies between different urban agglomerations' levels of innovation, scientific research, international exchange, and collaboration. Population density and per capita GDP are used for measuring an urban agglomeration's present degree of innovation and economic growth. The urban agglomeration's population density and the regional yearly GDP are positively correlated. Among the five urban agglomerations, the Pearl River Delta urban agglomeration has the greatest per capita GDP and the largest population density. Compared with the other four urban agglomerations, there has been a greater overall degree of innovation and economic development. In addition, the Yangtze River Delta urban agglomeration has the lowest population density among the five urban agglomerations, but it has a higher per capita GDP because it has institutions for scientific research and foreign exchange, as well as the growth of innovation fields speeding up the increase in per capita GDP [14].

3.1.2. Composition and Proportion of Industrial Structure. The industrial structure is shown in Figure 2. The tertiary industry in China is larger than the secondary industry, and the secondary industry cares about the primary industry, according to its five major industrial structures. The proportion of industrial structure in the five urban agglomerations varies significantly, nonetheless, and some industrial elements, including the Beijing Tianjin Hebei Urban Agglomeration Research Institute and high-tech, are quite advanced. Beijing Tianjin Hebei urban agglomeration, one of the five main urban agglomerations, has the highest percentage of tertiary industry. In addition to Shanghai, which is regarded as the financial hub, the Yangtze River Delta urban agglomeration benefits from improved topographical circumstances and two provinces (Zhejiang Province and Jiangsu Province) where the Internet of Things is relatively advanced. In the urban agglomeration of the Yangtze River Delta, the tertiary and secondary industries are comparatively balanced, producing an economy of coordinated cooperation and scientific labor division [15]. The Chengdu Chongqing urban agglomeration, which has been controlled by Chengdu for the past two years, has a strong

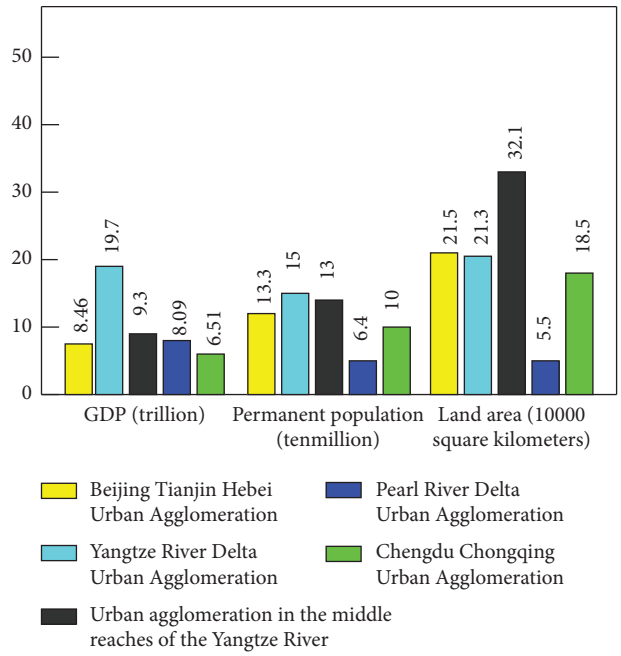

Figure 1: Basic data about China's five largest metropolitan agglomerations.

Table 1: Statistics of population density and per capita GDP of the five largest urban areas in China in 2019.

Urban agglomeration	Population density (person/km^2)	Per capita GDP (10000 yuan)
Beijing Tianjin Hebei urban agglomeration	525.7	7.48
Yangtze River Delta urban agglomeration	707.4	13.12
Middle Yangtze River urbanization	398.6	7.22
The urban agglomeration of the Pearl River Delta	1163.5	13.57
Chengdu Chongqing urban agglomeration	540.4	6.50

historical backdrop, beautiful natural surroundings, and a rapidly expanding high-tech zone that fuels the growth of the urban innovative economy. The neighborhood is developing extremely quickly.

3.1.3. Input and Output of Innovation. The R&D industry specifically refers to research and development industries. The development of the R&D industry represents the innovation level largely, as shown in Figure 3. The number of employees for the R&D institutions in Beijing Tianjin Hebei Urban Agglomeration ranks first among the five urban agglomerations. This is primarily related to the top universities and scientific research facilities in the nation being located in the Beijing Tianjin Hebei Urban agglomeration, which has a greater capacity for knowledge production that supports the growth of regional innovation. The Yangtze River Delta urban agglomeration is among the five urban agglomerations in terms of investments in research and development projects. A cultural province with numerous top-notch universities includes the Jiangsu Province. In comparison to the other five major urban agglomerations, the urban agglomeration has the best capacity for knowledge generation. The innovation indicators of the Yangtze River Delta urban agglomeration are relatively uniform and have an important foundation for high-quality innovation and development [16]. The Chengdu Chongqing urban agglomeration tops the list of the five urban agglomerations for the innovation process in terms of invention authorization, patent authorization, and patent application. In several areas, including human resources, innovation capacity, and innovation input-output, it is fairly balanced. As seen in Figure 4, the international exchange cooperation platform introduces and puts into practice externally great innovation knowledge to support the improvement of innovation accomplishments.

Figure 4 shows that, among the five urban agglomerations, the urban area in the middle of the Yangtze River has the lowest number of workers and the lowest contribution to the R&D industry. There are no core cities in the area because of the wide disparity in inventive skills and the low degree of innovation and development, such as scientific research level. Therefore, to promote innovation and coordinated growth, the urban agglomerations in the middle reaches of the Yangtze River must take advantage of the new pattern of double circulation and must absorb outside knowledge and top talent through the huge circulation. [17].

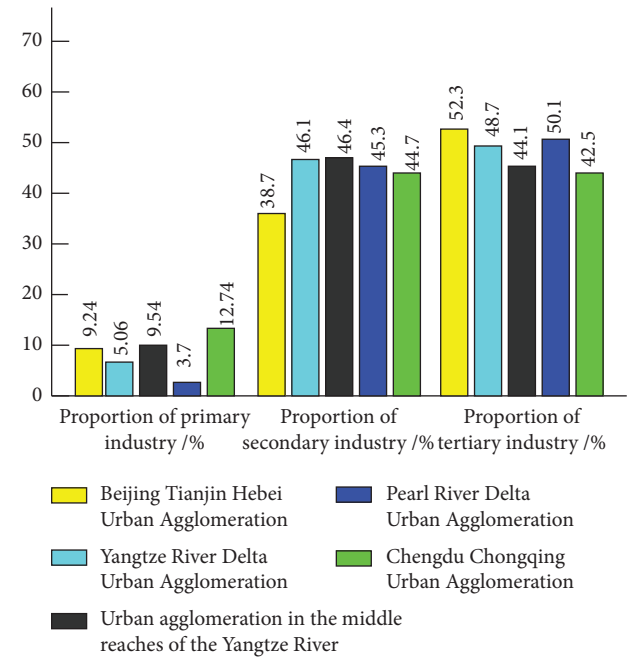

Figure 2: Proportion of industrial structure types of the five major urban agglomerations in China.

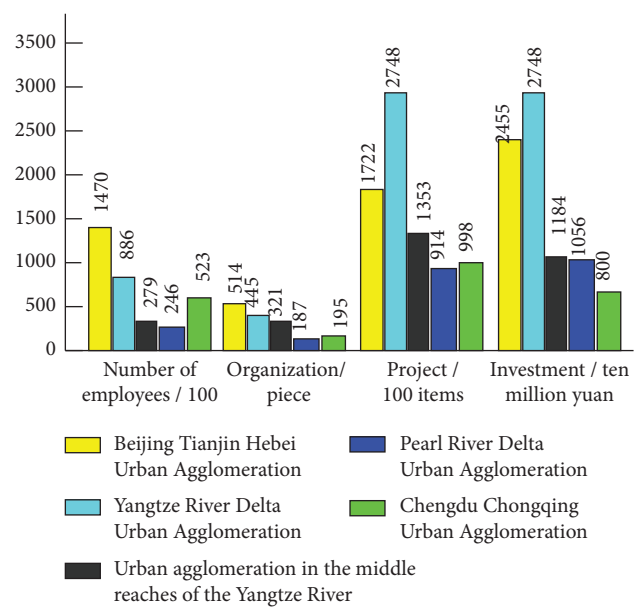

Figure 3: Statistics of the R&D industry development in the five urban agglomerations of China.

3.2. Model Building. The relationship between innovative technology and economic development can be represented as

$$\mathrm{eco}_{i,t} = \alpha_1 + \mathrm{aeff}_{i,t} + \beta_{i,t} X_{i,t} + \varepsilon_{i,t}. \quad (1)$$

In equation (1), $\mathrm{eco}_{i,t}$ represents the economic development level of the city i in the t-th year, $\mathrm{eff}_{i,t}$ represents the efficiency of technological innovation in the city i in the t-th year, $X_{i,t}$ represents the controlled variable, and a represents

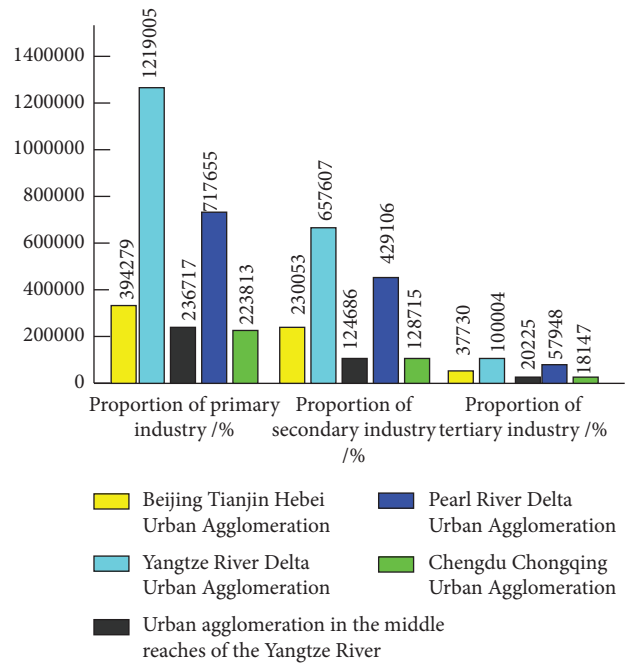

Figure 4: Statistics of innovation achievements in the five urban agglomerations in China.

the total effect of technological innovation on the economic development level.

The relationship between technological innovation and digital economy development is

$$de_{i,t} = \alpha_2 + \mathrm{beff}_{i.t} + \gamma_{i,t} X_{i,t} + \varepsilon_{i,t}. \quad (2)$$

In equation (2), $de_{i.t}$ represents the level of digital economic development of the city i in the t-th year and b represents the effect of independent variables on intermediary variables.

The relationship between digital economic development and regional economic development is as follows:

$$\mathrm{eco}_{i.t} = \alpha_3 + \lambda\, de_{i,t} + \Phi_{i,t} X_{i,t} + \varepsilon_{i,t}. \quad (3)$$

In equation (3), λ the coefficient represents the impact of digital economic development on regional economic development.

The intermediary effect of the digital economy can be verified as

$$\mathrm{eco}_{i.t} = \alpha_4 + \mathrm{ceff}_{i,t} + \mathrm{d\,de}_{i,t} + \Psi_{i,t} X_{i,t} + \varepsilon_{i,t}. \quad (4)$$

In equation (4), c represents the effect of technological innovation on economic development after adding intermediary variables and d represents the effect of digital economic development on the economic development level [18].

4. Analysis of the IIoT's Multiagent Innovation Economy's Development Path

To get accurate results and influence the growth of the innovative economy, it is crucial to pick certain economic

development-related data, preprocess the economic data, and apply data analysis and mining because the economic study of innovation is reliant on technology from earlier data. The novel economic data are mined and analyzed using the Microsoft time series approach, and economic indicators are forecasted. The essential data of the prediction indicators are mined and examined using the clustering technique.

4.1. Microsoft Time Series Method. The historical time points can be used to calculate the autoregression in a specific time t to obtain the predicted value of the current time. Considering n previous time points, the functional relationship of t at the current time point can be obtained as follows:

$$X_t = a_1 X_{t-1} + a_2 X_{t-2} + \cdots + a_n X_{t-n} + \varepsilon_t. \tag{5}$$

In equation (5), X_t represents the predicted value at a time t, a_i represents the coefficient of autoregression at a time i, and ε_t represents the threshold, and the values are from 0 to 1.

The row and column allowed algorithm is produced by converting the various time series of innovative economic development into many events using the autoregressive time series approach. According to the prior value, the computed value is acquired at a specific time and the mean value of time series and observation time series is established and the autoregressive coefficient is minimized [19].

4.2. Microsoft Clustering. Microsoft's clustering technique must be used to identify the grouping from the economic development data if the suitable grouping of innovation and economic development data are not immediately apparent.

The expectation maximization technique is used in the data clustering algorithm to distribute the cases to the data clustering. For the database d containing m elements and D continuous attributes, let each case $\in D$, and the probability expansion calculation of the cluster $h = 1, 2, \cdots, k$ to which x belongs can be expressed as

$$w_h^j(x) = \frac{\omega_h^j \times f_h\left(x \,\middle|\, \mu_h^j \times \sum_h^j\right)}{\sum_i \omega_i^j \times f_i\left(x \,\middle|\, \mu_i^j \times \sum_i^j\right)}. \tag{6}$$

In equation (6), ω_h^j represents the weight of aggregation h in the innovation economy database, f_h represents the function of the density of h aggregation components, and μ_h^j represents the j-dimensional vector composed in aggregation h.

We then update the mixed model parameter value and insert the acquired element probability structure into the model as shown

$$w_h^{j+1} = \sum_{x \in D} w_h^j(x). \tag{7}$$

A hypothetical function $\Phi|w_k, \mu_k, \sum_k|$ is used to construct a discriminant of functional relationships.

$$L(\Phi) = \sum_{x \in D} \log \langle \sum_{h=1}^{k} w_h \times f_h\left(x, \mu_k, \sum_k\right)\rangle. \tag{8}$$

When the model result satisfies $|L(\Phi^j) - L(\Phi^{j+1})| \leq \varepsilon$ If $j \leftarrow j + 1$, then we calculate the probability value of the other case [20].

The category of an object is determined using the expectation-maximization approach by calculating its probability. To get the standard deviation and mean deviation, the method treats any dimension as a bell curve [21]. A point's computation probability is classified into a certain class when it falls within the bell curve. The research on the trajectory of an innovative economy based on data mining in IIoT is finished through the aforementioned approach.

5. Experimental Results

To evaluate the performance of the innovation economy development path research based on data mining for IIoT proposed in this study, simulation experiments are carried out. Table 2 shows the experimental parameter settings.

The data clustering results of creative economic development data utilizing the data clustering technique proposed in this study and the multilevel distributed clustering approach are compared in Figures 5 and 6.

The analysis results of the data on innovative economic development using the clustering method proposed in this study are shown in Figures 5 and 6, respectively. The analysis results of the data on innovative economic development using the multilevel distributed clustering method are also shown in Figures 5 and 6. When the data on innovative economic development are clustered using the multilevel distributed clustering approach, the clustering impact is highly dispersed, which makes it difficult to effectively raise the level of innovative economic development, as can be observed by comparing Figures 5 and 6. The clustering impact is better and the stability of data mining is increased when the clustering approach described in this study is applied to cluster the innovative economic development data. The experimental findings demonstrate the effectiveness of the strategy proposed in this research in enhancing the capacity for creativity and economic growth.

Table 3 shows the comparison of the multilevel distributed clustering approach with the methods recommended in this research for data mining speed for innovative economic development for IIoT.

The five experimental data in Table 3 show that the speed of data mining for innovative economic development for IIoT using the multilevel distributed clustering method is maintained at 9.22 s, while the speed of data mining for innovative economic development using the method proposed in this study is maintained at 1.38 s. By contrasting the two approaches, the proposed approach requires less time for data mining than the multilevel distributed clustering approach. The outcomes of the experiments demonstrate that the proposed approach performs better.

Table 2: Settings for experimental parameters.

Experimental parameters	Data settings
Operating system	Windows 10
CPU	PIII/1gup
Database	MySQL database
Memory	16G
Simulation platform	MATLAB 2020

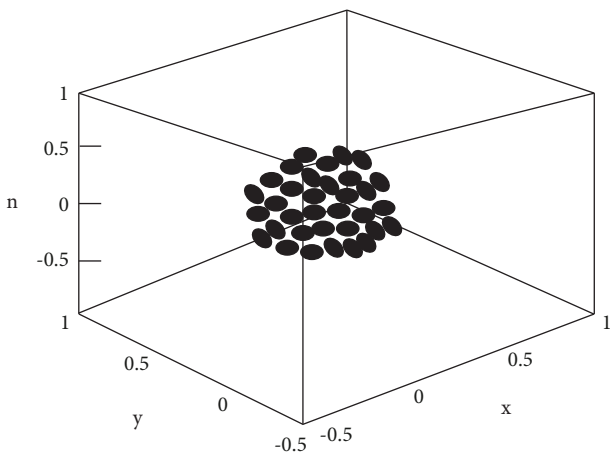

Figure 5: Clustering effect of innovative economic development data of the clustering method proposed in this study.

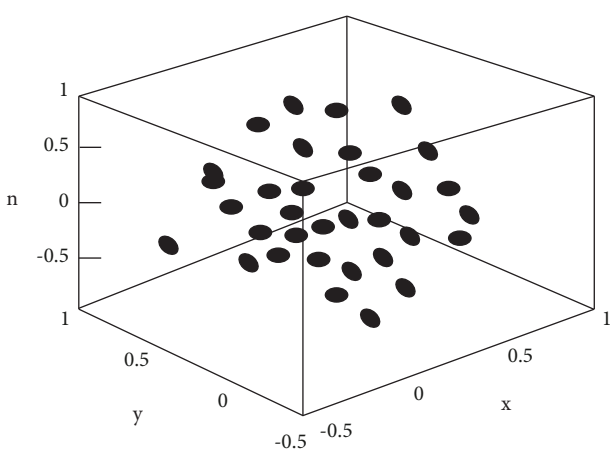

Figure 6: Clustering effect of the multilevel distributed clustering method on innovative economic development data.

Table 3: Comparison of data mining speed of innovative economic development by different methods.

Number of experiments	The clustering method used in this study/s	The multilevel distributed clustering method/s
1	1.3	8.9
2	1.4	9.2
3	1.5	9.6
4	1.4	9.1
5	1.3	9.3

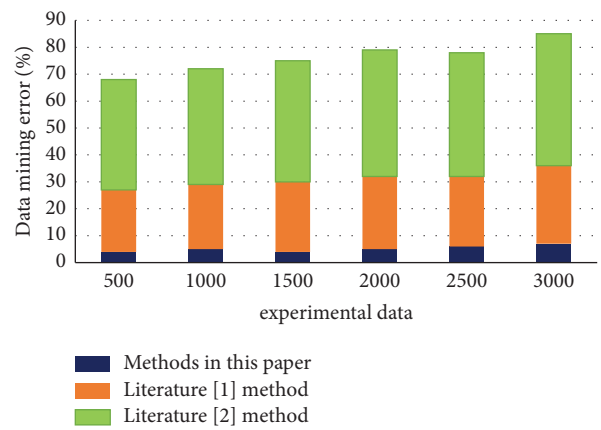

Figure 7: Comparison of data mining errors of the innovative economic development by different methods.

Figure 7 compares the approaches proposed in this article and literature [1, 2], to examine the data mining inefficiency of innovative economic development for IIoT.

The analysis of Figure 7 shows that the data mining error has remained steady at around 20% with the gradual expansion of experimental data when the approach suggested in literature [1] is applied to extract the data of innovative economic development. The data mining error has been maintained at around 40% with the steady expansion of experimental data when the approach provided in literature [2] is employed to dig the data of innovative economic development. The data mining error remained consistent below 10% while utilizing the approach proposed in this work to explore the data of creative economic development as the experimental data had been gradually increased. The experimental results demonstrated the effectiveness of the strategy proposed in this research for data mining of creative economic growth in the field of IIoT. The justification is that the method proposed in this study introduces the Microsoft time series algorithm and the expectation-maximization algorithm to conduct data mining of innovative economic development, using IIoT which can successfully reduce the error of data mining and the clustering mining performance has significant advantages.

6. Conclusion

The industrial sectors frequently use the concept "industrial internet of things" to refer to the IoT's industrial subset. The industrial internet of things has the potential to enhance productivity, improve analytics, and change the workplace. Innovative Economics, an emerging area of economics in the IIoT, combines the investigation of technology, knowledge, and entrepreneurship with an emphasis on innovation. A crucial strategic decision to redefine the new path of economic growth and strengthen the nation's global competitiveness is the new pattern of twofold circulation using IIoT. China's scientific and technical innovation needs to meet new criteria because it enters the next stage of its historical growth after the construction of a new double-cycle pattern. This study is specifically based on the pattern and perspective

of global strategy, and it analyzes the development path of the innovative economy against the new pattern of the double cycle and uses data mining technology to cluster the development data of the innovative economy so as to improve the industrial innovation capability in the field of IIoT. This study's observations keep a sharp focus on innovation and development to get around technical challenges in crucial areas such as national defense and military affairs and advance fundamental science and technology and establishes a new dynamic and double-cycle pattern with technological advancement to support the high-quality development of the social economy through innovation in science and technology using IIoT.

Data Availability

Data are available upon reasonable request from the corresponding author.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Analyzing the Coordinated Relationship between Logistics and Economy Using the Internet of Things in Fujian Province

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The Internet of Things (IoT) is a new method of doing things that have turned traditional lives into high technology. The improvements of IoT include smart economies, smart homes, pollution control, energy efficiency, smart transportation, and intelligence in the capacity. This technology is especially crucial in smart logistics, which is a generator of country and business efficiency and is critical to economic progress. Unfortunately, the current logistics business continues to suffer from high prices and low effectiveness. The advancement of intelligent logistics provides the potential to address these issues. In addition, IoT can generate vast amounts of data and investigate the intricate links between the transactions reflected by these data with the use of a variety of mathematical analytic methods. These characteristics are beneficial to the advancement of intelligent logistics. In this paper, we present a complete overview of IoT technologies used in smart logistics. Initially, the relevant work and IoT-based level of the growth of the logistics sector from a low-carbon viewpoint are presented. Then, we outline the technological solutions for IoT in intelligent logistics. During the experimental work, it selects a technique for estimating carbon emissions to compute the total carbon emissions of the logistics industry in eight provinces in the north and south. The carbon productivity and carbon emission characteristics of China's logistics industry are then examined. In addition, it calculates the carbon emission efficiency of Fuzhou's regional logistics industry based on the BCC model. Secondly, the coordination degree model of the composite system is used to analyze the coordination degree between the low-carbon economic system and the logistics industry level in Fujian Province. Furthermore, it selects the index of the logistics subsystem and the index of the low-carbon economic development subsystem to measure the coupling and coordination effect between logistics manufacturing and the low-carbon economy in Fujian Province.

1. Introduction

In the present era of the Internet, the importance and application of the Internet of Things (IoT) technology are rapidly increasing as it can connect all objects including nonelectronic objects. These objects can be integrated into network nodes through verifiable bar codes, and components are utilized to gather their physical position such as invested capital, operating status, the person responsible, and other information into the Internet technological design in real time. Furthermore, with the fast development of wireless communication systems, IoT is quickly acquiring ground in the situations of new wireless telecommunications [1]. The concept of IoT is continually developing, from an initial focus on machine-to-machine connections and applications to widespread data gathering. That is, the Internet of Things has generated seas of data, and the intricate linkages between the activities recorded by this data may be studied in real time using various mathematical analytic methods. The most important application of IoT is in logistics and the economy.

The logistics economic system is a fundamental economic model that is based on the logistics business, encompassing composite materials transactions and distribution, resource usage processing firms, logistics management, distribution, and other enterprises [2]. It is essential

for economic development and a driver of country and corporate efficiency [3]. However, due to the complexity of supply networks and high labor expenses, logistical costs are still relatively high. According to the 30th Annual Status of Logistic Report from the Council of Supply Chain Management Specialists, the United States, one of the most efficient nations in terms of logistics, spent $1.65 trillion on logistics in 2018, an increase of 11.5% from the previous year and almost 8.1% of the country's $21.0 trillion GDP. In contrast, logistics expenses in the least effective nations can reach 25.2% of GDP. High shipping costs will have an impact on efficiency.

Nowadays, every country in the world pays enough attention to climate warming. China is the first developing country in the globe and a superpower in greenhouse gas emissions. Because the ecological environment in China is not ideal, to achieve the goal of sustainable growth, the domestic government has used many means [4]. The Chinese government declared in the 13th Five-Year Plan that green development should be realized by including resource conservation and environmental preservation in national policy. Furthermore, it was also declared that the circular economy is continuously encouraged by building low-carbon, harmonic, and safe energy systems and zero-carbon emission project pilot work should be implemented [5]. The low-carbon economy emerged as a result of many crises, such as rising greenhouse gas emissions and energy shortages. The British government issued The Future of Our Energy: Creating a Low-Carbon Economy in 2003, which defined a low-carbon economy [6]. Using the ideals of sustainable development, the low-carbon economy uses the least amount of energy, pollutants, and emissions to raise the economic level. Furthermore, by upgrading industrial systems, creating renewable energy, scientific and technical innovation, minimizing the consumption of energy such as oil and natural gas, and reducing gas emissions, we may achieve greater environmental and economic growth [7].

Certainly, IoT will be important in the deployment of smart logistics [8], which will fundamentally alter the way logistical operations are conducted and the structure of the economy. Unfortunately, numerous topics, such as relevant situations, present challenges, and possible trends, remain to be examined during the procedure of making IoT-based intelligent logistics a reality. This work is conducted to help those who are interested in the development and improvement of this domain. In addition, from the perspective of Fujian's low-carbon economic subsystem, the proposed synergy degree shows that it is in a moderate stage from 2015 to 2017, which is entering a high stage after 2018. Besides, from the perspective of the property development subsystem, the value of the coordination factor of the property development subsystem continues to rise after 2017 and the value of the coordination factor of the property development subsystem has reached 0.803 in 2020, indicating that the property development in this province is stable.

The innovations of this paper are as follows: (1) This paper examines the coordination linkages between logistics and the economy in Fujian Province using Internet of Things (IoT) technology, outlining the focuses and shortcomings of IoT-based smart logistics. (2) From the perspective of consumption of energy, carbon release, production of carbon, carbon emission per capita, economic efficiency index, and emission of carbon productivity of logistics manufacturing, this research work discusses the level of growth of China's logistics manufacturing. Following that, the amount of low-carbon economic development in various provinces is examined in terms of carbon emissions and economic growth efficiency. Carbon emission intensity is chosen as a proxy for the amount of low-carbon financial development on this premise. The Eviews 6.0 program is used to conduct an empirical examination of the link between logistics manufacturing expansion and low-carbon financial growth. (3) Based on the connection concept, this article establishes the coordinated development index scheme of the logistics manufacturing and low-carbon economy, uses the coupled coordinated development model to measure the coordinated development status of the logistics manufacturing and low-carbon economy in some provinces of China from 2015 to 2020, and formulates strategies to promote the low-carbon growth of the coupled system according to the results of the coupled coordinated development.

This paper consists of 6 sections, wherein Section 2 highlights the contributions of other researchers and scholars. Section 3 is based on the IoT-based development status of the logistics industry from a low-carbon perspective. Section 4 discusses our methodology for measuring carbon emission efficiency. The results obtained during the suggested methodology and their analysis is offered in Section 5. Lastly, Section 6 concludes our study effort in the last section.

2. Related Work

A new logistical and economic standard has effectively modified management concepts and creative management approaches to guarantee that the conventional logistics business can live and expand in a competitive market. The IoT, as a novel creation of the age, has given promise to the logistics business [9]. The early study of [10] discovered that IoT technology has offered unusual development chances to the logistics business and efficiently pushed the growth of the conventional logistics sector into a contemporary, popular, and forward-thinking development. The author of [11] claimed that the IoT is significant information technology in the modern generation, indicating the beginning of a new age of information. Furthermore, an early study in [12] discovered that IoT technology efficiently interconnects things with objects. The Internet is critical expertise that facilitates its successful development and delay. It spreads the sharing of knowledge to the trade of objects. The rise of IoT skills is seen as the 3rd wave in IT, as it incorporates IT into everyday life. The primary goal for NG and Wakenshaw in establishing a communications network is to maintain and regulate commodities while improving administration quality and efficiency [13]. According to the researcher in [14], to build a successful Internet of things, communications equipment, primarily infrared detectors, GPS wearable

sensors, and similar devices must be connected to the network. However, the study in [15] discovered that for the administration of commodities, the IoT system must do the following 3 phases: Firstly, discover the items and categorize them. Secondly, using smart recognition devices, the article characteristics are examined, and the information received is transformed. Thirdly, we accurately communicate the item data to the network, transmit the data to the regulator center through the Internet, and administer the goods centrally. Employing smart recognition technology, detecting, classifying, and transmitting item information, and storing the data in the information organization scheme enable items to communicate and recognize each other's requirements.

In addition to the foregoing, the low-carbon economy is governed by the philosophy of maintainable growth. It can reduce consumption of traditional high-carbon energy sources such as coal and petroleum, as well as greenhouse gas releases, by utilizing system innovation, scientific and technological research, industrial transformation, and new energy promotion to achieve a win-win economic model of social-economic development and environmental protection. Compared with a traditional economy, the low-carbon economy can promote economic level, optimize environmental quality, reduce energy consumption, and reduce emissions in the growth procedure. The emergence of a low-carbon economy is a research area and a hot topic of concern for all countries. The continuous growth of the low-carbon economy has caused China's economy to face new difficulties and opportunities, prompting China to transform into a low-carbon economy and substantially reduce greenhouse gas emissions to achieve sustainable economic growth [16, 17]. Therefore, how to decrease carbon dioxide releases and promote the growth of a low-carbon economy has become a significant issue of concern to different countries around the world. China is at a critical stage of economic improvement and environmental improvement. We need to solve the problems such as the transformation of the economic growth rate, the change of economic growth momentum, the optimization of the economic system, and the increasing energy consumption [18]. The scale of the domestic logistics market has reached more than 300 trillion yuan in 2020. The rapid growth of the service industry is the key to the domestic economic system, and the logistics industry is the focus of the national economic level [19]. Due to the continuous development of the logistics industry, the environmental pollution problems in China are becoming more and more obvious. The domestic logistics industry has brought about increased energy consumption and emission. The growth of the domestic logistics industry begins to show a clear mismatch between resources and industries. Low resource utilization, backward scientific and technological level, and a large number of pollutants discharged all cause haze or bad weather in most areas of China. In the process of reducing carbon emissions and promoting long-term economic growth, the logistics industry needs to vigorously carry out emission reduction work [20, 21]. Therefore, facing the continuous development of energy conservation and emission reduction, the logistics industry has become the key to energy preservation and release decrease in the macrobackground of low-carbon economic growth. It is essential to change the growing power of the logistics industry and promote the growth of the green economy. The process of China's growth is based on the low-carbon economy, focusing on the economic development mode of low pollution and low consumption of energy.

3. IoT-Based Development Status of the Logistics Industry from Low-Carbon Perspective

3.1. The Architecture of IoT for the Growth of the Logistics Industry. The IoT architecture is composed of five significant layers such as perception, network, middleware, application, and business as depicted in Figure 1. Among these layers, the perception layer comprises physical components like sensors, RFID tags, barcodes, and other physical items linked to the IoT system, which resides at the lowest of IoT design. This equipment gathers information and sends it to the network layer. This layer helps as a conduit for transferring data from the perception layer to the data dispensation scheme. This data transfer may use whatever wireless or wired means, including 4G, wireless fidelity, and Bluetooth. The middleware layer is the following level layer, which has the primary accountability to process data obtained from the network layer and decide things using the outcomes of interconnected devices. This processed data can be used by the application layer for global distant access. While the business layer sits on top of the framework, it aids in the regulation of the larger IoT scheme and applications. The business layer visualizes the data and information obtained from the application layer and uses this knowledge to determine future aims and strategies. Furthermore, IoT designs may be tailored to specific requirements and application domains [22]. Besides a layered basis, the IoT scheme is made up of numerous functional blocks that allow diverse IoT processes such as sensing, identification, recognition, management, and administration [23].

There are various major functional units in charge of I/O activities, connection concerns, computing, audio/video management, and storage and retrieval. This complete functional block integrates an actual IoT arrangement, which is serious for good performance. Though numerous reference schemes have been presented with practical standards, they are still far from the basic system required for worldwide IoT. As a result, an appropriate infrastructure that can meet the global IoT demands must yet be created. Figure 2 depicts the basic functioning framework of the IoT system. This diagram depicts the Internet of Things reliance on certain application characteristics. Gateways of IoT play a significant part in IoT networks because they allow connectivity among IoT servers and devices associated with various applications [24].

3.2. Total Energy Consumption Analysis of the Logistics Industry. The market size of China's logistics industry is 300.1 trillion yuan in 2020. In 2015, the proportion of the logistics industry in China's gross domestic product was

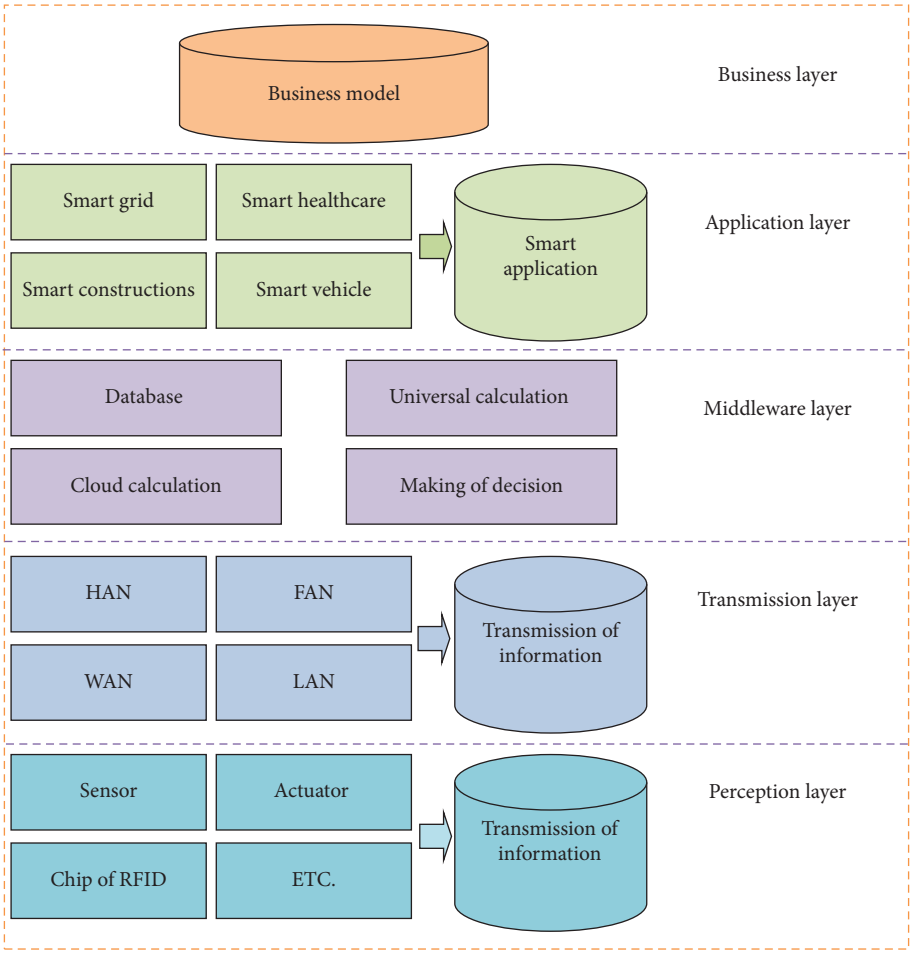

Figure 1: Five-layer architecture of IoT-based development of the logistics industry.

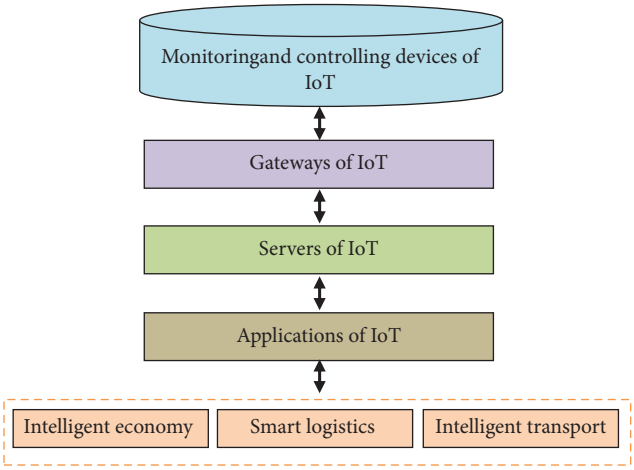

Figure 2: The basic functioning framework of the IoT system.

7.0%, while in 2020 it rose to 7.5%. At the same time, the logistics industry is the key industry of domestic energy consumption. Today, the logistics business is characterized by low energy usage and high emissions. With the macro-environment of lowering carbon emissions and growing economic level, it is extremely difficult for the logistics industry to minimize carbon emissions. As a result, the energy consumption faced by the domestic logistics business is investigated using the overall energy consumption and growing level of the logistics industry. Figure 3 depicts a comparison of a description of changes in overall energy consumption and the logistics industry's growth rate from 2015 to 2020.

Figure 4 shows the comparison of the description of changes in energy consumption of the logistics industry and tertiary industry from 2015 to 2020. From this figure, we can see that the energy consumption of China's logistics industry and the third industry is increasing substantially. During the period 2015–2020, the energy consumption of the logistics industry and the third industry increased slowly. After that, the energy consumption of the logistics industry and the third industry increased rapidly, increasing by 91.21 million tons and 31.57 million tons, respectively, compared with 2015.

3.3. Total Carbon Emission Analysis of the Logistics Industry. After referring to other theoretical conclusions computed in (1), this research employs the IPCC approach to finish the measurement of carbon emissions. According to this equation, we can get the carbon emissions of China's logistics industry over the years. According to the carbon

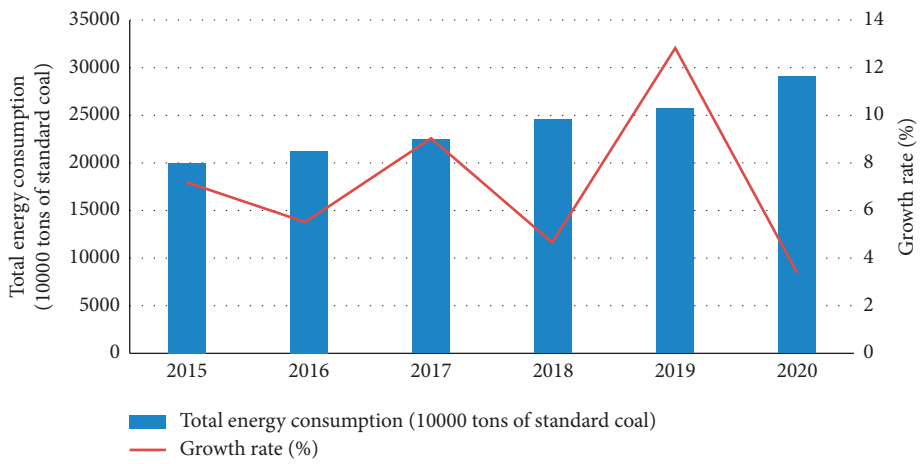

Figure 3: Description of changes in total energy consumption and growth rate of the logistics industry from 2015 to 2020.

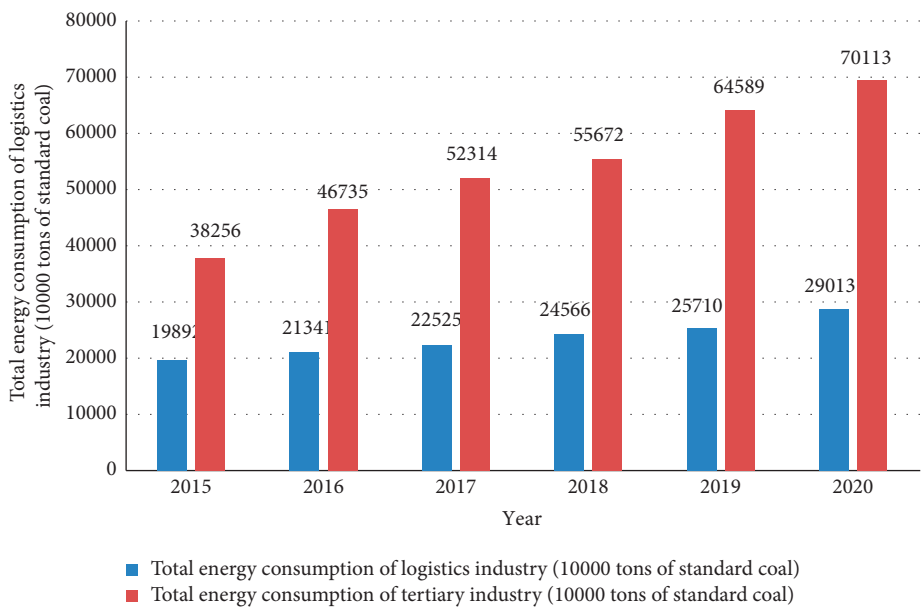

Figure 4: Description of changes in energy consumption of the logistics industry and tertiary industry from 2015 to 2020.

emission statistics published by the logistics industry shown in Figure 5, the total carbon emission of China's logistics industry in the previous two years ranges from 17.45 million tons to 18.113 million tons, indicating that the logistics sector's carbon emission level is not excessive. From 2015 onwards, the carbon emission of the logistics industry has shown a rapid rise to 2019, which reached 124.58 million tons in 2015 and 174.52 million tons in 2019. From 2019 to 2010, the logistics industry has shown a steady upward trend, the rising speed is lower than before, which means that the domestic logistics industry has brought a lot of carbon dioxide in the process of rising. However, in 2015, China's environmental management departments studied the air pollution problem in depth and introduced measures such as Prevention and Control of Air Pollution in Key Areas to reduce the number of carbon emissions. This makes the domestic logistics industry develop towards the direction of low carbon.

4. Estimation Method of Carbon Emission Rate and Modeling of Coordination Degree

4.1. Carbon Emission Estimation Methods. There are no corresponding statistical methods and standards for carbon emissions in China, and only the amount of carbon emissions can be roughly estimated. Most researchers use the measured method, IPCC method, and so on in the process of measuring carbon emissions. The IPCC method calculates the carbon emissions based on the National Greenhouse Gas Inventory Guidelines. This method has the characteristics of easy data acquisition and wide application. Therefore, this research work uses the IPCC technique to complete the

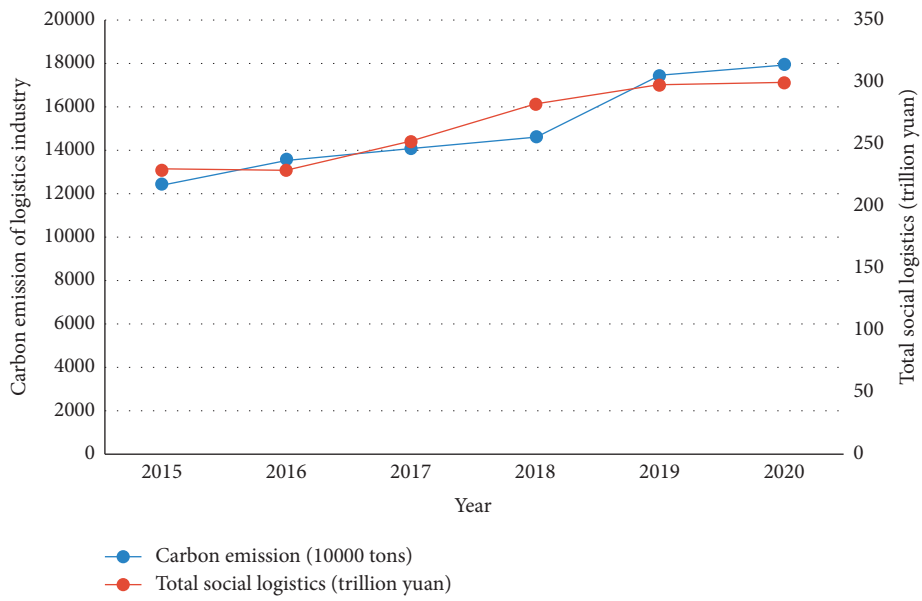

Figure 5: Change trend of the logistics industry value and carbon emissions from 2015 to 2020.

measurement of carbon releases [25] after referring to other theoretical results. The detailed calculation formulas are shown in

$$C^t = \sum_{i=1}^{n} E_i^t \theta_t \delta_i. \tag{1}$$

In the previous equation, C^t is the actual total carbon release of logistics in phase t area. However, E_i^t is the i in phase t, including nine types of energy consumption, such as gasoline, crude oil, coke, and raw coal. In addition, θ_i is the corresponding reference coefficient of the resource consumption transformed into standard coal. Finally, δ_i is the actual carbon emission index of the ith resource.

4.2. Carbon Productivity Measurement Method. Kaya and coworkers developed the term carbon productivity, which refers to the average production per unit of CO_2 GDP. This metric measures the economic advantages provided by each unit of CO_2 emissions. The intensity of CO_2 emissions per unit and carbon have a negative connection. Carbon intensity decreases as carbon productivity increases, and carbon intensity decreases when carbon productivity improves [26]. The following shows the calculation formula:

$$\text{carbon productivity} = \frac{\text{output value}}{\text{CO}_2\text{emissions}}. \tag{2}$$

4.3. Method for Measuring Carbon Emission Efficiency. Many researchers study the actual efficiency of the logistics industry by analyzing the actual effect of carbon emission methods. The carbon emission rate refers to the highest output efficiency that can be obtained when the district obtains a fixed output value with the lowest input or maintains the input based on the existing scientific and technological capacity, which reflects the technical level. At present, the most commonly applicable DEA models are CCR, BCC, etc., while the CCR model refers to a DEA model that takes the ratio of actual output to an input of a decision-making unit as the target, takes the actual efficiency coefficient of each decision-making unit with the target as the limiting condition, and designs a stable return and scale.

In addition, BCC model is based on the CCR model plus $\sum_{k=1}^{N} \lambda_k = 1$, and a DEA model with variable return and scale is designed. Considering the existing relevant literature, the BCC model in DEA is selected as the model to predict the effect of CO_2 emission technology.

If there are n decision-making units in total, these decision-making units have corresponding s outputs and m inputs, with Y_i representing output and X_i representing input. Then, the BCC model can be expressed in

$$\text{Min}\left[\theta_{i0} - \varepsilon\left(e^T s^+ + e^T s^-\right)\right],$$
$$s.t \left\{ \begin{array}{c} \sum_{i=1}^{N} x_i \lambda_i + s^- = \theta_{i0} x_{i0} \\ \sum_{i=1}^{N} y_i \lambda_i - s^+ = y_{i0} \\ \sum_{i=1}^{N} \lambda_i = 1, \lambda_i \geq 0, i = 1, 2, \ldots, n \\ s^+ \geq 0, s^- \geq 0 \end{array} \right\}. \tag{3}$$

In the previous equation, $X_i = (x_{1i}, x_{2i}, \ldots, x_{ki})^T$, $Y_i = (x_{1i}, x_{2i}, \ldots, x_{ri})^T$, x_i represents input variables, and y_i represents output variables. In addition, $y_{ri} > 0$ represents the rth output in the ith decision-making unit. In addition, $x_{ki} > 0$ represents the kth input in the ith decision-making unit. Similarly, s^+ and s^- represent relaxation variables, θ_{i0} represents the corresponding competence value of the decision-making component, e^T is the row vector of the unit, and λ is the weight vector.

4.4. Models of Coordination Degree between the Logistics Industry System and Low-Carbon Economic Development System. The common models used in the analysis of synergistic relationships, that is, coupled coordination models, can conduct quantitative analysis [27] based on space and time. However, coupled coordination models are facing the problem of difficulty in centralizing subjective and objective assignments. This paper optimizes the models, builds a composite model based on ordinal variables, further simplifies the system, and completes the measurement of system coordination degree. It also provides an efficient way to study the relationships and rules between different elements in a composite system [28]. Therefore, this model is used to study the synergistic relationship between Fuzhou's low-carbon economy and the logistics industry.

According to the results of synergy theory, sequence variables directly affect the speed of system evolution. Ordinal variables can be divided into fast and slow variables. Slow-order variables essentially affect whether the system evolves from disorder to order. Composite systems can be considered as $S = \{S_1, S_2, \ldots, S_p\}$.

This paper studies the low-carbon economic system S_2 and the regional logistics system S_1. If the corresponding order variable of the subsystem is $h_j = \{h_{j1}, h_{j2}, \ldots, h_{jn}\}$; in addition, $n \geq 1$, $\alpha_{ji} \leq h_{ji} \leq \beta_{ji} (i = 1, 2, \ldots, n)$, and α_{ji} and β_{ji} are the upper and lower limits of the order variable component h_{ji} to ensure the smooth operation of the system. If the subsystem can be divided into two types: if the value of $h_{j1}, h_{j2,} \ldots, h_{jk}$, $h_{ji}h_{ji}$ is higher and the degree of order in the system will be greater, and on the contrary, the degree of order in the system will be lower, so the index is positive; if $h_{jk+1}, \cdots, h_{jn}$ value is large, the degree of order in the system will be smaller, and on the contrary, it will be larger. Such indicators represent negative indicators. The corresponding order model of the subsystem evaluation index obtained in this way is presented in

$$\mu_j(h_{ji}) = \begin{cases} \dfrac{h_{ji} - \alpha_{ji}}{\beta_{ji} - \alpha_{ji}} i \in (1, k), \\ \\ \dfrac{\beta_{ji} - h_{ji}}{\beta_{ji} - \alpha_{ji}} i \in (k+1, n). \end{cases} \tag{4}$$

By definition in the above equation, $\mu_j(h_{ji}) \in [0, 1]$; the greater the value, the higher the order degree of the order variable, and the greater the contribution of the order variable to the order degree of the system. Integration may be used to determine the geometric average approach, which is used to get the subsystem order degree in

$$\mu_j = (h_j) \sqrt[n]{\prod_{I=1}^{n} \mu_j(h_j)}, j=1,2. \tag{5}$$

In the previous equation, $\mu_j(h_{ji}) \in [0, 1]$ represents the greater the value and the greater the order degree of the subsystem.

In the process of evaluating the coordination degree of composite system, the order degree between different subsystems is analyzed again from the dynamic perspective. If the subsystem is located at t_0, the corresponding order degree value is $\mu_j^0(h_j) j = 1, 2, \cdots, k$. If the initial value of the subsystem is t_1, then its order degree is $\mu_j^1(h_j) j = 1, 2, \cdots, k$. The coordination degree of the combination of a low-carbon economy and regional logistics in this period can be determined as C.

$$C = \omega \sqrt[n]{\mu_j^1(h_j) - \mu_j^0(h_j)}. \tag{6}$$

According to the previous equation, the value range of the total coordination scheduling C of the composite system is [−1, 1]. The larger its value is, the higher the degree of coordinated development of regional logistics and the low-carbon economy composite system is, and vice versa.

5. Results and Analysis

5.1. Index Design and Data Source. In this paper, sustainable development is taken as the research entry point to build a composite system, in which the subsystems are divided into a low-carbon economy and regional logistics. In the process of index design, it is necessary to carry out index design according to the conclusion of the mechanism analysis. As can be seen from Figure 6, all systems are carried out from four dimensions in the process of designing indicators, and to ensure that the indicators are scientific enough, the theoretical results of previous researchers are referred to in the process of selecting indicators [29].

The four aspects of infrastructure, norms and regulations, scientific and technical innovation, and industrial scale are used as entry points in the process of picking system indicators for the regional logistics subsystem. The research theoretical achievements of [30, 31] are used as a reference in the process of selecting system indicators for the low-carbon economy subsystem and the four dimensions of energy consumption, scientific and technological power, economic composition, and the social public are taken as entry points.

5.2. Carbon Productivity Analysis. The concept of carbon production is the carbon releases caused by each unit of GDP increase. The role of this indicator is to evaluate the value and competence of carbon releases, and it can also directly reflect whether the driving force of economic development comes from high-energy consumption businesses. Therefore, in the process of analyzing the carbon emissions of the regional logistics industry, the paper takes carbon productivity as the key index, selects four provinces in the South and north of China, and calculates according to publicity (2). The results are shown in Figure 7.

It can be observed from the data in the figure that there is a certain difference in the carbon productivity of the logistics industry in the southern and northern provinces from 2015 to 2020, which fluctuates from 6700 yuan/ton of coal to 21000 yuan/ton of coal. Due to the reciprocal relationship between the emission intensity of unit CO_2 and carbon productivity, the carbon emission of Guangxi, Liaoning, Heilongjiang, and other provinces has also increased rapidly under the background of the rapid development of the logistics industry. This shows that the above provinces promote the development of the logistics industry by relying on

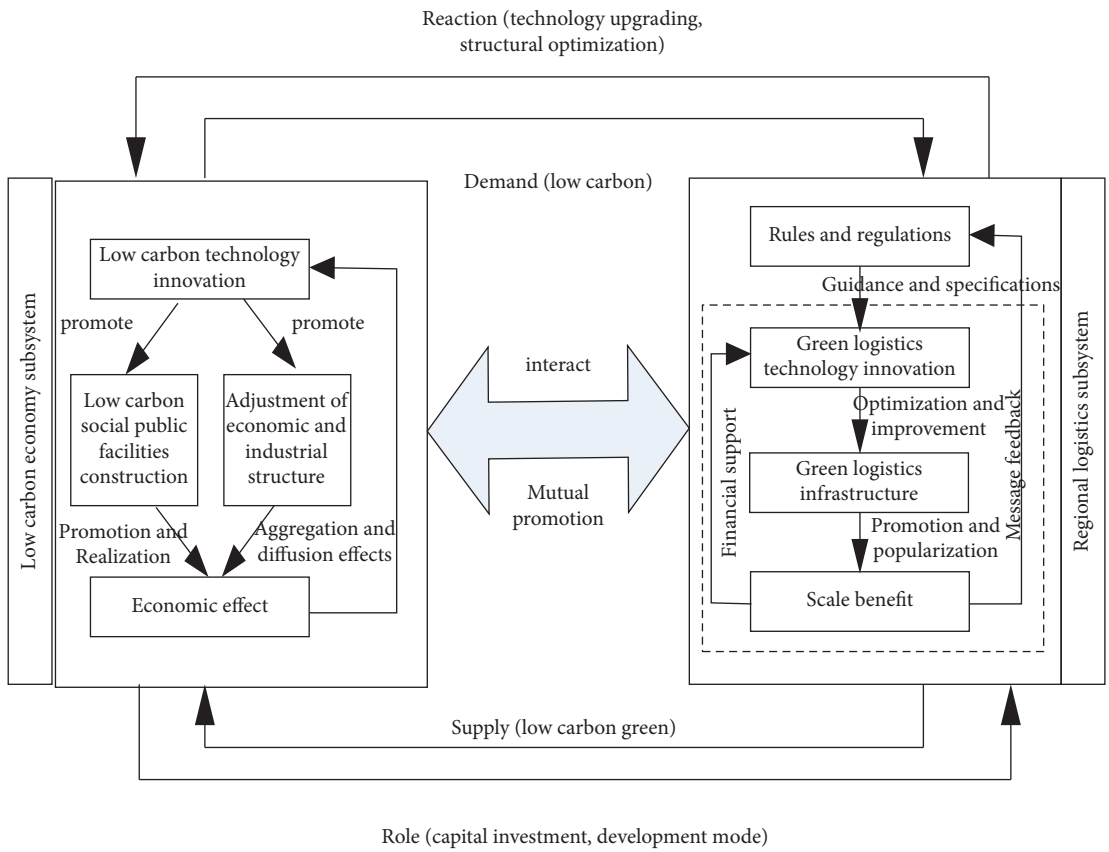

Figure 6: Mechanism analysis of low carbon economic system and regional logistics development system.

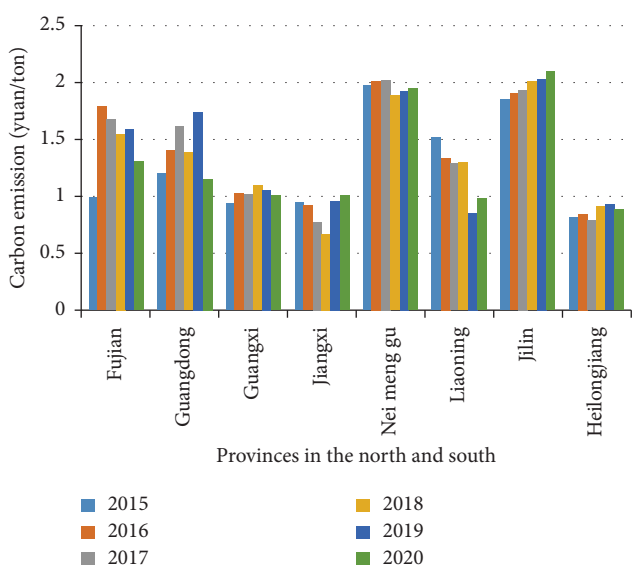

Figure 7: Carbon productivity of the logistics industry in four provinces in North and South China from 2015 to 2020 (unit: 10000 yuan/ton of coal).

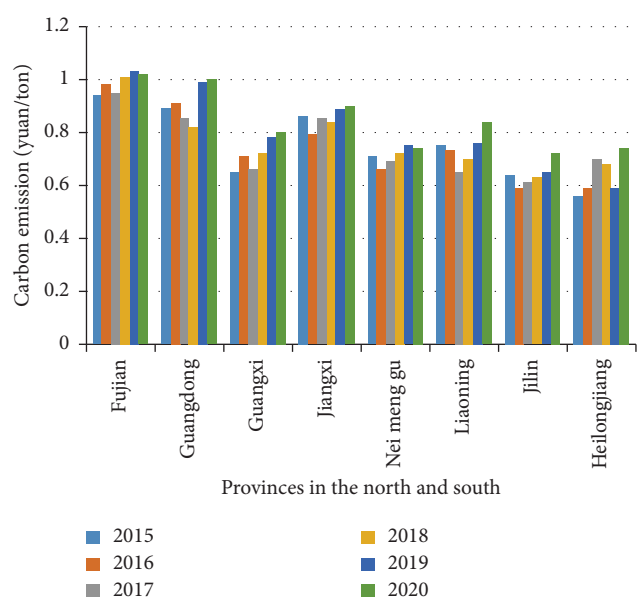

Figure 8: Statistics of carbon emission competence of the logistics industry in various provinces.

energy consumption to expand economic development, which belongs to a resource-based economic growth mode. Other provinces can effectively use resources, science and technology, and other factors to adjust the logistics industry to achieve the low-carbon development of the local regional logistics industry.

5.3. Carbon Emission Efficiency Calculation of the Logistics Industry. This paper uses deap2.1 software to solve the formula given in (3) to calculate the carbon emission efficiency of the logistics industry in four southern and four

Table 1: Data statistics of coordination degree of the composite system in Fujian Province.

Year	Coordination degree of the composite system	Coordination degree of the low-carbon economy subsystem	Coordination degree of the regional logistics subsystem
2015	0.401	0.601	0.559
2016	0.391	0.711	0.521
2017	0.499	0.754	0.610
2018	0.614	0.798	0.704
2019	0.695	0.815	0.782
2020	0.798	0.901	0.803

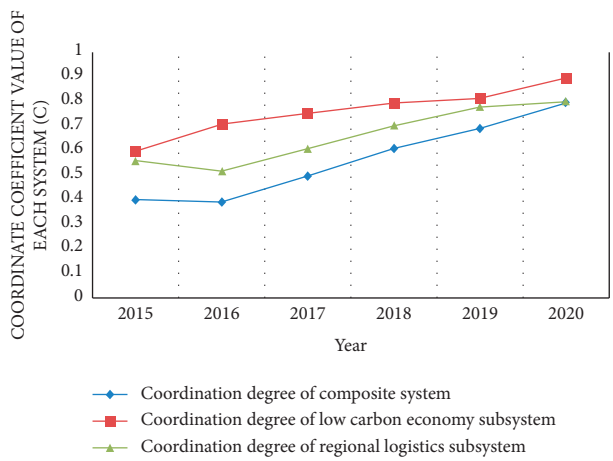

Figure 9: Description of the change trend of system coordination degree.

northern provinces in China from 2015 to 2020. The comparison among the statistics of carbon release efficiency of the logistics manufacturing in various provinces is shown in Figure 8.

The data in the figure shows that the carbon emission efficiency of the logistics industry has changed in 2020, with the efficiency value of Fujian and Guangdong being 1, which is at the forefront of production, while the carbon release competence of the logistics industry in other provinces has also increased significantly, between 0.59 and 0.84, but it has not reached the forefront of production, indicating that there is great room for improvement in the carbon emission efficiency of the logistics industry in these provinces.

5.4. Analysis on the Coordinated Growth Structure of Regional Logistics and Low-Carbon Economy in Fujian Province. Based on the 2016 data, the data after standardization by SPSS software is entered into equation (6). Besides, the coordination degree of the low-carbon economy subsystem, regional logistics subsystem and coordination degree of the composite system of coordinated development of regional logistics and low-carbon economy is calculated. Table 1 displays the unique coordination degree data statistics of the Fujian composite system.

Figure 9 compares descriptions of the evolving trend of system coordination degree. When combined with Figure 9 and Table 1, these three coordination degrees have demonstrated a continuous increase trend from 2015 to 2020, indicating a positive association between Fujian's low-carbon economy and the logistics industry in recent years.

From the results of the figure, it is clear that in 2020, the low-carbon economy subsystem has a coordination degree of 0.901. The regional logistics subsystem has a coordination degree of 0.803. The composite system shows a coordination degree of 0.798. From the above data, we can see that there is a high coordination degree between Fujian's low-carbon economy and regional logistics. In terms of coordination level, considering the scope of coordination and the actual situation, the above three will develop from the previous junior high school-level coordination to a high degree of coordination in 2020.

6. Conclusions

Recent advances in IoT have attracted the attention of developers and researchers all around the world. IoT developers and experts are collaborating to expand the innovation on a big scale and serve society to the greatest extent feasible. Unfortunately, advancements are only achievable if we take into account the different challenges and inadequacies in the current technical techniques. This article investigates the carbon emissions from 2015 to 2020 to examine the coordination links between logistics and the economy in Fujian Province using Internet of Things (IoT) technology. From 2015 to 2020, the carbon emissions and output value of the logistics industry have been rising, which means that during this stage, the domestic logistics industry is driven by high energy consumption in the process of promoting the growth of the logistics industry. The carbon emission efficiency of favorable economic circumstances along the eastern coast ranges between 0.7 and 1. At the same time, the northern provinces with weak economic conditions have an efficiency of 0.59 to 0.87. This leads to the conclusion that the carbon emission efficiency of various locations of the logistics business in the South and North is quite diverse, and there are significant disparities. The majority of coastal locations have low-carbon emission efficiency, whereas other places have high carbon emission efficiency. The synergy of the low-carbon economy subsystem in Fujian Province is in the medium stage from 2015 to 2017 and is just entering the high stage after 2018, showing that the low-carbon economy in Fujian Province is developing steadily. In 2016, the regional logistics subsystem at Fujian Province was in the medium stage, and the coordination coefficient value was near 0.666,

which remained high after 2017. It demonstrates that the development of Fujian Province's regional logistics economy has been generally stable in the last five years, with a pattern of continuous expansion.

Data Availability

Datasets are available on reasonable request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interests.

Acknowledgments

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Research Article

The Performance Evaluation Model of Hotel Green Human Resources Based on Internet of Things and Fuzzy Theory

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The Internet of Things (IoT) is influencing national centers of excellence as well as businesses' approaches to development and how they generate and exploit opportunities in day-to-day hotel activities. The IoT is revolutionary and will transform how human resources are created and managed, necessitating a fresh and adaptable strategy for human resource development. The promise of the IoT is that each device will have a unique means of identifying itself and will be addressable, allowing any object to be connected. This will present a new difficulty to how green human resource development in hotels is conducted. Besides, environmental protection has emerged as the most pressing problem in world politics. Green problems are widely acknowledged as a fundamental source of development. Due to increased customer awareness, the hotel service sector has advanced in terms of quality of services as green marketing has evolved into a crucial instrument for sustainable business approaches. Green marketing strategies are being implemented by businesses to improve company success. In order to improve the adaptive performance assessment capacity of hotel green human resources, this research proposes a performance evaluation model of hotel green human resources based on the Internet of Things and fuzzy theory. It develops a large data analysis model of hotel green human resource performance by statistically quantitatively assessing the constraint parameters of hotel green human resource performance assessment. It extracts the entropy characteristic amount of hotel green human resource performance big data to make the best choice and assessment of hotel green human resource performance by green hotel maximum economic benefit evaluation and fuzzy decision technique. Furthermore, it builds an expert system analysis model for evaluating the hotel green human resource performance. Adaptive optimization of hotel green human resource performance evaluation is carried out by the fuzzy theory adaptive learning algorithm, and the optimization strategy of the hotel green human supply performance evaluation model is realized by similarity characteristic parameter estimation and fuzzy multidimensional parameter constraint. The simulation results show that the performance evaluation of hotel green human resources with this method has high accuracy and good confidence level, which improves the performance evaluation efficiency of hotel green human resources.

1. Introduction

The Internet had a rapid influence on our lives and work since its inception in the early 1990s. People are facing another generation of Internet services that will have a significant influence on how we work and live. This phenomenon, widely referred to as the Internet of Things, refers to an environment in which data creation is the rule of the day. Each human contact, either with living or nonliving objects, produces some sort of data, transforming the workplace into a data-driven environment. The changing technological phase challenges forecasts of human interaction and also how work is done. The Internet of Things can fundamentally alter how we engage with our environment. The human resource management green hotel is in a unique position to train the staff for this modern style of working and to make use of the enormous data provided by the IoT. It can significantly alter our interactions with our environment.

At present, China's big environment is the continuous development of a socialist market economy and the deepening of system reform. These rapid changes have taken place in many aspects, such as the economy, politics, and

culture [1]. The rapid update of knowledge and the huge amount of online information data have brought many opportunities along with challenges to enterprises. In the daily operation of enterprises, it is necessary to have funds, personnel, equipment, and other elements. At present, more and more enterprises begin to attach importance to human resources and develop them into basic competitiveness. Under the current background, enterprises can do a good job in "selecting, hiring, educating, and retaining talents," and the potential of employees is constantly stimulated [2]. Then, in the unpredictable market competition, enterprises will always maintain a sustained and stable advantage. The elements of contemporary human resource management have changed, and the labor force of enterprise employees is no longer one of them. Therefore, it can be said that it has become a precious resource in the overall development of enterprises. If enterprises gain the upper hand from human resources, they will gain a competitive advantage [3]. The most difficult problem for corporate managers these days is figuring out how to improve enterprise human resource management. As we all know, human resource management is very important to the growth of enterprises [4]. "People are the primary productive force." How to stimulate people's subjective initiative becomes the first thing, which is the foundation of enterprise strategic construction and cultural construction. How to achieve successful human resource management, which aims to raise employee productivity and skill levels, allows them to fully fulfill their responsibilities, allowing everyone to play to their full potential in a fitting position and, ultimately, achieves corporate goals. In the performance evaluation of hotel green human resources, it is necessary to build the performance evaluation model of hotel green human resources. In addition, it needs to be combined with the allocation of hotel green human resources and improves the performance management and dynamic allocation ability of hotel green human resources through potential development and comprehensive scheduling [5].

In general, hotel green human resource performance evaluation refers to the organic collocation and combination of ready-made (existing) hotel green human resources with other production components in a certain method, structure, and amount proportion based on specified economic objectives. The performance allocation of hotel green human resources is a key link in the overall chain of human resource management, and it is a subject that must be considered when entering the usage stage after human resource training and development [6]. The performance development of hotel green human resources is only the first development of human potential and sometimes focuses on individuals. The allocation of human resources is the second development of human potential, focusing on the development of overall potential, which is a higher level, more complex, and more important development. Modern scientific methodology inspires people; the structure is reasonable, and the function is positive. On the contrary, it has a negative effect. Therefore, even if every individual member has a high quality and if the allocation of human resources among green human resources groups in the hotel is unreasonable, it will backfire and have the opposite effect. Therefore, managers should not only pay attention to how to effectively develop individual potential but also pay enough attention to the optimal allocation of group human resources. Only in this way can a good overall effect be achieved. At present, the evaluation methods of hotel green human resources performance management mainly include quantitative regression analysis, autocorrelation fusion analysis, and association rule analysis. The fuzzy association rule set of hotel green human resources performance management evaluation is constructed, and the evaluation and prediction model of hotel green human resources performance management is established by analyzing and forecasting the hotel green human resources performance data. However, the traditional methods are not intelligent and accurate [7].

In view of the above problems, this article puts forward a performance evaluation model of hotel green human resources based on the IoT and fuzzy theory and through quantitative management of hotel green human resources performance, it accelerates the transformation of hotel's human resources management from pure functional management to information management.

1.1. Key Innovations. The key innovations of this article are as follows:

(1) First, this research article established the big data enquiry model of hotel green human resource and analyzes the constraint parameters of hotel green human resource performance evaluation by the statistical quantitative analysis method by extracting the entropy characteristic quantity of hotel green human resource performance big data [8].

(2) Second, it makes the optimal decision and evaluation of hotel green human resource performance evaluation by the methods of maximizing economic benefit evaluation and fuzzy decision. In addition, it establishes the expert system analysis model of hotel green human resource performance evaluation. Adaptive optimization of hotel green human resource performance evaluation is carried out by the fuzzy theory adaptive learning algorithm, and the optimization layout of hotel green human supply performance evaluation design is realized by similarity characteristic parameter estimation and fuzzy multidimensional parameter constraint.

(3) Finally, it performs several simulation tests, which show the superior performance of this method in improving the reliability of hotel green human resources performance evaluation.

The test of the sections in this article is organized as follows: The selected material and methodology for the performance evaluation model of hotel green human resources based on fuzzy theory can be explained in Section 2. Section 3 will emphasize the recommended hotel green human resource performance model optimization. Section 4 of this work is based on the simulation and analytical results. Finally, in Section 5 of the document, this article is ended.

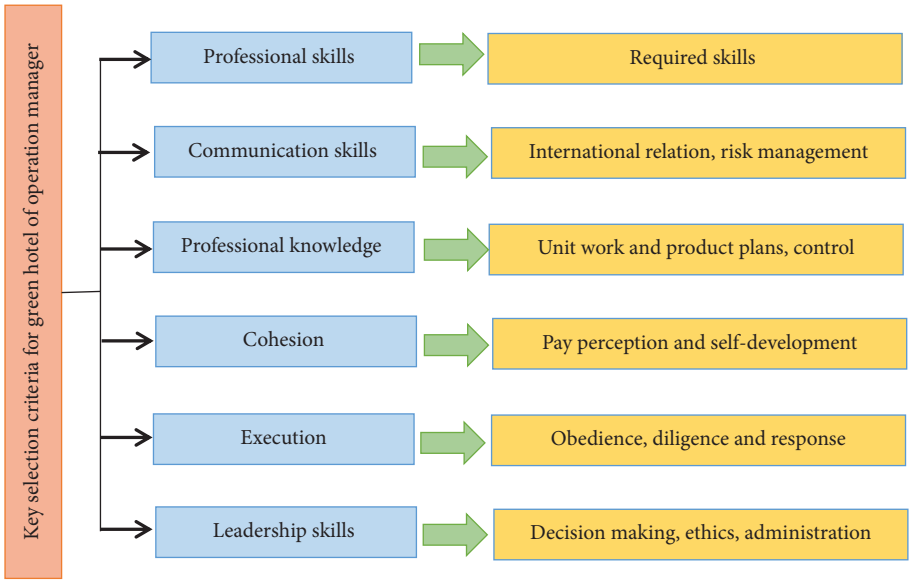

Figure 1: The key selection criteria for green hotel of operation managers.

2. Materials and Methodology

2.1. The Internet of Things (IoT) and Hotel Green Human Resources Operation. The Internet of Things (IoT) enables users to manage and improve internet-connected appliances and electronic devices. Sensors are employed in hotels to capture physical strength data from real-time settings and turn it into machine-readable representations that may be readily transmitted into other data formats. The Internet of Things is claimed to be a system for transforming an object into a light object that can be accessed and collected in real time. It might be seen as the capacity to regulate and monitor resource-related behavior. Hotel resources may be remotely controlled and regulated by implementing RF identification, smart sensors, smart wearable, scanners, barcodes, and so on. This situation is frequently employed in hotel lights and bedroom air conditioning units. Hotel staff is more satisfied once the Internet of Things (IoT) is deployed to or incorporated into hotel facilities. Smart tags have been widely employed in IoT-based services. Hotel personnel can gain hotel access or other varied security features by using smart tags. The indications used to measure the IoT are as follows: information technology employed by hotels in real time, tourism-related information technology is commonly accessible, IoT technology is customizable to hotel room temperature, and IoT technology is flexible to hotel lighting.

2.1.1. Hotel Green Human Resources. Nowadays, human resource innovation is usually recognized. As a critical indicator, it is regarded as the very first resource for the knowledge-based economy that may be employed to measure a global power. Green human resource management (GHRM) is a new area of practice in human resource management that stems from environmental thought, environmental situation, and resources and contributes significantly to sustainability [9]. Human resource management remains a reasonably prominent issue in hotel environment protection. Furthermore, green human resources development and the requirement for operation managers in any business are so crucial that their orientation and performances must match the expectations and needs of the firm. In a word, the position of the operation manager is critical to every organization.

Human resources are the foundation of every successful business, and the GRHM ideas of green management motivations and creative asset protection have far-reaching implications for societal responsibility and organizational productivity [10]. Green "management models" fosters employee environmental understanding. If employees get a green concept, they would intentionally utilize sophisticated technology in their "working practices" of manufacturing and company activity to decrease wastage and use of materials and aim to limit the usage of electricity and water energy. To achieve the objective of sustainable resource use and social progress, GRHM emphasizes efficiency, waste reduction, enhancing workplace engagement behaviors, harmonizing work-life interactions, and boosting employee satisfaction and productivity [11]. Figure 1 shows the key selection criteria for green hotel of operation manager.

2.2. Quantitative Fusion Feature Clustering of Absolute Salary and Relative Salary of Hotel's Human Resources Performance

2.2.1. Hotel Green Human Resources Performance Statistics Analysis. In order to realize the performance model of hotel green human resources based on fuzzy theory and speed up the transformation of hotel human resources management from pure function organization to data organization [12], this work uses the statistical investigation method of hotel green human resources performance to carry out information fusion and obtains the analysis model of big data of hotel green human resources performance statistics. The

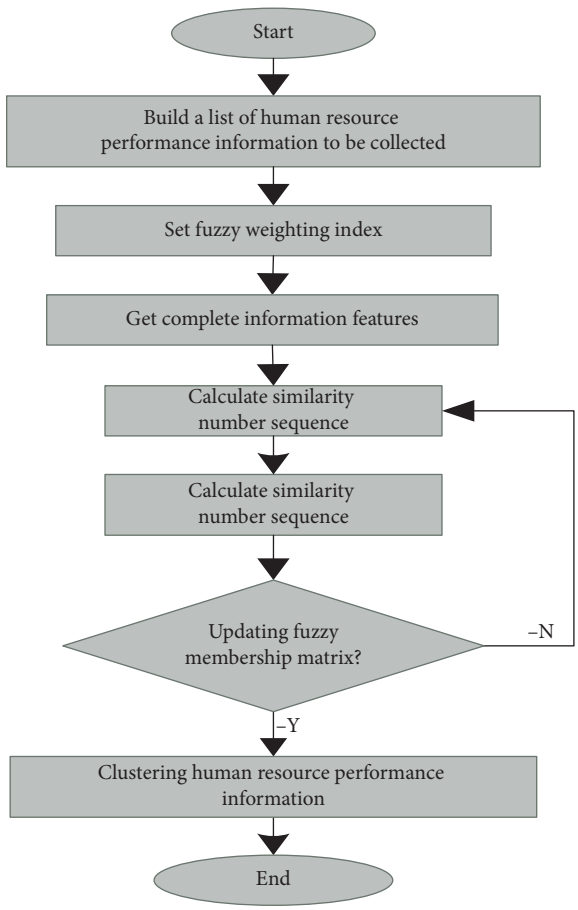

Figure 2: Fuzzy sampling process of hotel green human resources performance.

specific fuzzy information sampling process is shown in Figure 2.

This article assesses how well sampling techniques provide the relevant knowledge by using fuzzy means as the data-mining tool. The efficacy is demonstrated in terms of sampling information generalizability of the results as well as the correctness and mistakes of sampled data sets when applied to the fuzzy clustering method. Using the fuzzy information sampling method, the sample data of hotel green human resources performance are presented as follows:

$$\begin{aligned} &\min_{\{T_{r1},T_{r2}\}} \operatorname{Tr}\left\{T_{r1}T_{r1}^{H} + T_{r2}T_{r2}^{H}\right\}, \\ &\text{s.t.} \quad \begin{aligned} &\widehat{R}_{r1}(T_{r1}) + \widehat{R}_{r2}(T_{r2}) \geq R^{mac}\left(W_1^0, W_2^0\right), \\ &\widehat{R}_{rj}\left(T_{rj}\right) = \overline{R}_{ir}\left(W_i^0\right). \end{aligned} \end{aligned} \tag{1}$$

The optimum closed constancy analysis technique is utilized to examine the service performance features in the process of hotel's human resource management. The issue of hotel human resource management is an optimum closed stability analysis model, and the ideal feature capacity of hotel human resource management presentation is presented as T_{ij}. The fuzzy subspace fusion clustering method is used to obtain the decision function of hotel green human resource performance. The optimal quantity of characteristic of hotel's human resource management presentation can be obtained using the following equation:

$$p_{rj}(k) = \left(\frac{1}{\mu_i} - \frac{\sigma_j(k)^2}{\left|\omega_{rj}(k)\right|^2}\right)^+, \quad k = 1, \cdots, r_{rj}. \tag{2}$$

When $i = 1$, μ_i represents the recruitment parameter in terms of employee value appraisal, recruiting, training, and performance management, as determined by convex optimization combination analysis. Hotel green human resource performance prediction rules have been used to define the probability of the existence or lack of a circumstance and aid in evaluating hotel green resource performance. The forecast rule function of hotel green human supply presentation model is obtained by the following equation:

$$p_{ri}(k) = \left(\frac{1}{\mu_j'} - \frac{\sigma_i(k)^2}{\left|\omega_{ri}(k)\right|^2}\right)^+, \quad k = 1, \cdots, r_{ri}. \tag{3}$$

From the age point of view, there are 21 hotel employees under 20 years, 178 employees aged 20–30 years, 79 employees aged 30–40 years, 40 employees aged 40–50 years, and 74 employees aged over 50 years. It can be seen from this that the age of hotel employees is concentrated in 20–30 years, and they are young on the whole. The similarity component can be calculated using the following equation:

$$\begin{aligned} &\sum_{k=1}^{r_{ri}} \log\left(1 + \left(\frac{1}{\mu_j'}\frac{\left|\omega_{ri}(k)\right|^2}{\sigma_i(k)^2} - 1\right)^+\right) + \overline{R}_{ir}\left(\mathbf{W}_i^0\right) \\ &= R^{mac}\left(\mathbf{W}_1^0, \mathbf{W}_2^0\right). \end{aligned} \tag{4}$$

Based on information clustering and characteristic optimization sampling, the fuzzy membership characteristic solution $1/\mu_i \leq 1/\mu_m < 1/\lambda_0 < 1/\mu_j$ of hotel green human resources performance management is obtained using (56), which satisfy μ_j''.

$$\begin{aligned} &\sum_{k=1}^{r_{ri}} \log\left(1 + \left(\frac{1}{\mu_j''}\frac{\left|\omega_{ri}(k)\right|^2}{\sigma_i(k)^2} - 1\right)^+\right) \geq R^{mac}\left(\mathbf{W}_1^0, \mathbf{W}_2^0\right) \\ &\qquad -\overline{R}_{ir}\left(\mathbf{W}_i^0\right), \end{aligned} \tag{5}$$

$$\sum_{k=1}^{r_{ri}} \left(\frac{1}{\mu_j''} - \frac{\sigma_i(k)^2}{\left|\omega_{ri}(k)\right|^2}\right)^+ \leq P_r - \sum_{k=1}^{r_{rj}} \left(\frac{1}{\mu_i} - \frac{\sigma_j(k)^2}{\left|\omega_{rj}(k)\right|^2}\right)^+. \tag{6}$$

From the above equation, we get the optimal value of Pij (K), which builds the identification of parameter and descriptive variable design of hotel green human resource performance management. It combines the fusion degree analysis technique of descriptive variables and regulator variables, making the analysis of regression of hotel green human resource performance management. Furthermore, it analyzes statistical data on hotel green human resource performance using phase space combination features [13]. The specific process is shown in Figure 3.

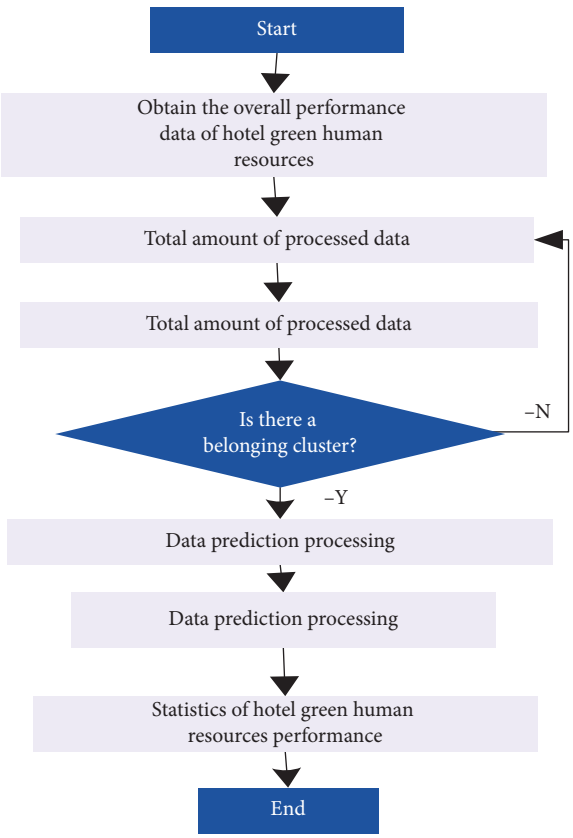

Figure 3: Analysis process of performance statistics of hotel green human resources.

2.2.2. Information Fusion Clustering. Information fusion clustering can divide a data set into different classes or clusters according to specific criteria so that the similarity of data objects in the same cluster is as great as possible. At the same time, the differences of data objects that are not in the same cluster are as large as possible, which is convenient to obtain the optimal strategy. We divide the data space into grid cells, map data object sets into grid cells, and calculate the density of each cell. According to the preset threshold, each grid unit is judged as a high-density unit, and grid units with sufficient density form clusters. Assume a model for each cluster and determine the best fit of the data to the specified model. The hotel's human resource organization and facility presentation tracking are carried out as part of the ideal plan. The function of cost-of-service performance organization is built. The statistical feature quantity of a hotel's human resource performance is derived by multidimensional feature iteration. Furthermore, the threshold distribution at which the cost function reaches the lower limit is calculated as $V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x) - \lambda(1-\mu)/1-\beta$.

The logistic model is a mathematical model that represents the probability of one event occurring by making the events logarithmic chances a linear model of one or more relationships between the independent variable. Regression examination is employed in regression analysis to estimate the parameters of a regression analysis. The logistic regression approach has been used to represent the functional connection among one or more explanatory factors and a binary answer parameter. The corresponding weights of variables are determined using logistic regression, and the cost function is categorized by offset. Using the multidimensional feature parameter decomposition method [14], the information fusion parameter matching template function of the hotel's human resource management performance is derived, as shown in the following equation:

$$V^*_{\beta,\vec{0}^k}(x+1) - V^*_{\beta,\vec{0}^k}(x) \geq V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x+1) - V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x) - \frac{\lambda(1-\mu)}{1-\beta}. \tag{7}$$

The above equation can be defined as follows:

$$LB(x) = V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x+1) - V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x) - \frac{\lambda(1-\mu)}{1-\beta}. \tag{8}$$

Several industries employ clustering analysis, including market research, pattern identification, data processing, and image analysis. Clustering can also assist hotel green human resources and marketers in identifying unique groupings within their client base. They can also categorize their consumer groups depending on their purchase habits. The convergence requirement is satisfied as per (9) based on the clustering function of hotel human resource management performance fusion that was obtained above.

$$V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x+2) - V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x+1) \geq V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x+1) - V_{\beta,\vec{0}^k}^{\tilde{\pi}}(x). \tag{9}$$

In the above equation, it can be seen that $LB(x)$ is a nondecreasing function. The deep learning method is used to perform performance management and dynamic planning of green hotel human resources management services, and the planning equation is given as follows:

$$\begin{aligned} &\mu\left(V^*_{\beta,\vec{0}^k}(x) - V^*_{\beta,\vec{0}^k}(x-1)\right) \\ &+(1-\mu)\left(V^*_{\beta,\vec{0}^k}(x+1) - V^*_{\beta,\vec{0}^k}(x)\right) \\ &\geq \mu \mathrm{LB}(x-1) + (1-\mu)\mathrm{LB}(x). \end{aligned} \tag{10}$$

The fuzzy programming equation of dynamic characteristic analysis of performance evaluation of green hotel's human resource management is written as per the following equation:

$$\mu \mathrm{LB}(x-1) + (1-\mu)\mathrm{LB}(x) - \frac{1-\mu}{\beta}. \tag{11}$$

Because $LB(x)$ is a nondecreasing function, the planning model of hotel human resource management service performance information fusion satisfies the following:

$$\lim_{x \longrightarrow N}\left(\mu \mathrm{LB}(x-1) + (1-\mu)\mathrm{LB}(x) - \frac{1-\mu}{1-\beta}\right) > 0. \tag{12}$$

Then, there is a value x_{Th}, when $x > x_{Th}$, there is a sample condition of hotel green human resource performance decision, as calculated in the following equation:

$$\mu \mathrm{LB}(x-1) + (1-\mu)\mathrm{LB}(x) - \left.\frac{1-\mu}{1-\beta}\right|_{x>x_{Th}} > 0. \tag{13}$$

While $x > \max(k, x_{Th})$, by adopting the multidimensional grouping method, the statistical characteristic quantity of hotel's human resource management service performance decision is obtained as per the following equation:

$$0 < \Delta L < 1 + \frac{\lambda_2}{L}. \tag{14}$$

The statistical package for the social sciences (SPSS) is a software suite used for statistical data analysis. Even though the term SPSS refers to its original application in the social sciences, it has now moved into other data industries. The SPSS18.0 numerical examination technique is used, and the sample regression examination design of hotel green human resource performance management is established. The ambiguity of assistant decision-making of hotel green human resource performance management is obtained as per the following equation:

$$R^{bc}(\mathbf{T}_{r1}, \mathbf{T}_{r2}) = R^{bc}_{r1}(\mathbf{T}_{r1}) + R^{bc}_{r2}(\mathbf{T}_{r2}). \tag{15}$$

Whenever the value of regression analysis of hotel green human resource performance management satisfies $\sum_{i=1}^{m} a_i$ and the quantitative regression characteristic distribution variable of hotel green human resource performance management is $X_{ij}(i = 1, 2 \cdots, m; j = 1, 2, \cdots, n)$, the learning rate of hotel's human resource management service performance information fusion can be written as per the following equation:

$$R^{tw} = \min\left\{R^{mac}(\mathbf{W}_1, \mathbf{W}_2), R^{bc}(\mathbf{T}_{r1}, \mathbf{T}_{r2})\right\}. \tag{16}$$

The fuzzy analysis model of salary data of hotel green human resources management is constructed, and the fair scheduling and adaptive equilibrium game of salary distribution in hotel green human resources management are carried out by using the quantitative fusion feature clustering method of absolute salary and relative salary [5].

3. Hotel Green Human Resource Performance Model Optimization

3.1. IoT-Based Hotel Green Human Resources Performance Characteristics Extraction. The IoT can offer an accurate image of hotel clients' difficulties linked to misunderstandings and inconsistencies encountered immediately at the hotel site. Hotel personnel comprehend this circumstance better since they have access to precise data that allows them to build dialogue and correctly grasp consumer requests. Hotels that follow environmental friendly procedures will increase client satisfaction and encourage them to return. As a result, it urges hotel staff to commit to and act in environmentally friendly ways. Hotels may develop green staff behavior to manage green hotels. Hotels can be built when workers can use ecologically friendly information from their actions and behavior. Staff can reuse items, decrease product pollution, and recover materials as part of practical actions connected to green employee behavior indicators. They can effectively reduce usage by using fewer polluting items and switching to or using more ecologically friendly products. The process of converting garbage into new resources or goods is known as recycling.

Sigma Assessment Systems is a test development and administration company that creates and administers a wide range of exams. This test includes their suite of personality tests and additional tests used for preemployment personality assessment. Sigma personality assessments are prominent preemployment personality assessments that are frequently utilized and distributed. Sigma test criterion is to assume that a group of test data only contains random errors, calculate and process them to get the standard deviation, and determine an interval according to a certain probability. It is considered that any error beyond this interval is not the random error but the gross error, and the data containing this error should be rejected. The Sigma test criterion is used for quantitative evaluation and reliability analysis of hotel green human resource performance management, and the parameter analysis model of hotel green human resource performance management effect evaluation is obtained [15]. The feature quantity of the theme model of hotel green human resource information is extracted, and the fuzzy query and optimization control of hotel green human resource performance management is carried out by using an in-depth query method. The stable solution of the assistant decision equation of hotel green human resource performance management is obtained by sampling the value of hotel green human resource performance characteristics, which is given in the following equation:

$$\mathrm{E}[\tilde{e}_{sk}] = 0 \forall s = 1, \cdots, n, k = 1, \cdots, p, \tag{17}$$

$$\mathrm{E}[\tilde{e}_{s1k1}\tilde{e}_{s2k2}] = \begin{cases} \dfrac{m}{p}\sigma_s^2 \\ 0 \end{cases}. \tag{18}$$

In the above equation, α, β, γ, and ρ represent the order of a, b, c, and d in the decision-making sequence of hotel green human resources performance management. The planning equations of hotel green human resource presentation organization will comprise $2^k \times (N+1)$ equations, and the state space density technique will be adopted to make the result of hotel green human resource performance organization issues simpler. The multidimensional feature prediction method is adopted to obtain the decision-making optimization function, calculated using the following equation:

$$
\begin{aligned}
V^*_{\beta,\vec{i}^k}(q(n-k)) &= V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)\right)\\
&= \left(P_{\vec{0}^k}B\right)\left(q(n-k)+o\left(\vec{i}^k\right)\right)\\
&\quad+\beta\left(\left(P_0V^*_{\beta,\vec{0}^k}\right)\left(q(n-k)+o\left(\vec{i}^k\right)\right)\right)\\
&\quad+\beta\lambda\min\left\{0,\mu V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)\right)+(1-\mu)V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)+1\right)\right.\\
&\quad\left.-\left(\mu V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)-1\right)-(1-\mu)V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)\right)\right)-\frac{1-\mu}{\beta}\right\}\\
&= \left(P_{\vec{0}^k}B\right)\left(q(n-k)+o\left(\vec{i}^k\right)\right)\\
&\quad+\beta\left(\left(P_0V^*_{\beta,\vec{0}^k}\right)\left(q(n-k)+o\left(\vec{i}^k\right)\right)\right)\\
&\quad+\beta\lambda\min\left\{0,\mu\left(V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)\right)-V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)-1\right)\right)\right.\\
&\quad\left.+(1-\mu)\left(V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)+1\right)-V^*_{\beta,\vec{0}^k}\left(q(n-k)+o\left(\vec{i}^k\right)\right)\right)-\frac{1-\mu}{\beta}\right\}.
\end{aligned}
\tag{19}
$$

The method of maximizing economic benefits and fuzzy decision-making of green hotels is adopted to optimize the decision-making and evaluation of hotel green human resources performance evaluation. The expert system analysis model of hotel green human resources performance evaluation is established [16]. The specific model is shown in Figure 4.

The adaptive optimization of hotel green human resources performance evaluation is carried out by using the fuzzy theory adaptive learning algorithm, so that $x = q(n-k) + o(\vec{i}^k)$, considering the situation $q(n-k) \geq k$. The equation of dynamic programming of hotel green human resources performance prediction can be written as follows:

$$
\begin{aligned}
V^*_{\beta,\vec{0}^k}(x) &= \left(P_{\vec{0}^k}B\right)(x)+\beta\left(P_0V^*_{\beta,\vec{0}^k}\right)(x)\\
&\quad+\beta\lambda\min\left\{0,\mu\left(V^*_{\beta,\vec{0}^k}(x)-V^*_{\beta,\vec{0}^k}(x-1)+(1-\mu)\left(V^*_{\beta,\vec{0}^k}(x+1)-V^*_{\beta,\vec{0}^k}(x)\right)-\frac{1-\mu}{\beta}\right)\right\}.
\end{aligned}
\tag{20}
$$

According to the above equation, under the state of $q(n-k) \geq k$, after feature breakdown, it is originated that there are N variables in the forecasting of performance of hotel green human resources. These are simple from $2^k \times (N+1)$ measurement to x measurement such as $x = q(n-k) \leq N + o(\vec{i}^k)$.

As per aforementioned investigation, a feature removal design of hotel green human resources performance is proven by making data decisions and planning as per the feature extraction results. The benefit degree analysis model of hotel green human resources performance management effect is constructed. In addition, the statistical mathematical analysis model of hotel green human resources performance management effect evaluation is obtained by combining the social and economic benefit evaluation [17].

3.2. Performance Evaluation and Prediction of Green Human Resources in Hotels. The deep inquiry method is adopted to carry out fuzzy inquiry and optimization control of hotel green human resources performance management. The QPS interface and user count are used to determine the best optimization strategy. The MySQL feature can be utilized for query optimization in systems with a low user base and a

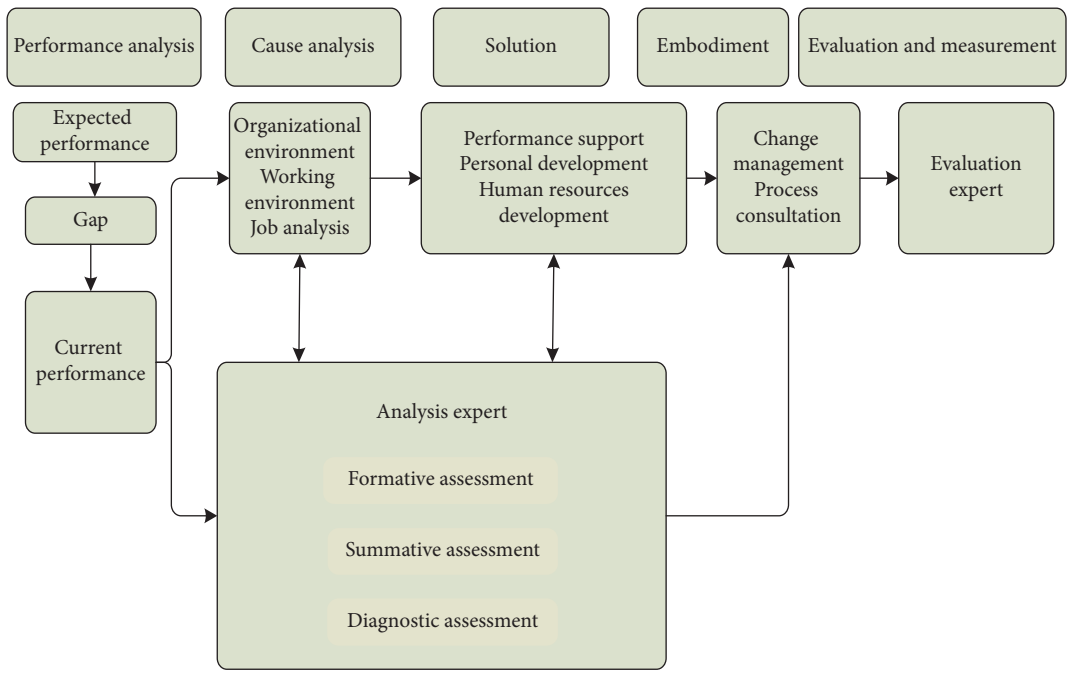

Figure 4: The expert system analysis model of hotel green human resource performance evaluation.

B-end focus. The performance data of hotel green human resources are searched according to the index, and the data information is filtered according to the fuzzy query criteria, using MySQL to improve fuzzy matching. The hotel green human resources performance filtering operation is placed in the storage engine layer, which filters out unnecessary data in advance and reduces the IO overhead caused by unnecessary data being scanned. When evaluating and forecasting the performance of hotel green human resources, it can reduce the reading of data from the storage engine layer by the service layer, thus providing the overall performance of the database and realizing optimal control. All characteristic solutions of satisfy$R^{mac}(\mathbf{W}_1, \mathbf{W}_2) \geq R^{bc}(\mathbf{T}_{r1}^0, \mathbf{T}_{r2}^0)$. The characteristic variables μ_1, μ_2, and μ_m of hotel green human resource performance decision make the optimization problem of assistant decision-making of hotel green human resource performance management meet the results given in the following equations:

$$\sum_{k=1}^{r_{r2}} \log\left(1 + \left(\frac{1}{\mu_1}\frac{|\omega_{r2}(k)|^2}{\sigma_2(k)^2} - 1\right)^+\right) = R_{1r}^-\left(\mathbf{W}_1^0\right),$$
$$\sum_{k=1}^{r_{r1}} \log\left(1 + \left(\frac{1}{\mu_2}\frac{|\omega_{r1}(k)|^2}{\sigma_1(k)^2} - 1\right)^+\right) = R_{2r}^-\left(\mathbf{W}_2^0\right),$$
$$\sum_i \sum_{k=1}^{r_{ri}} \log\left(1 + \left(\frac{1}{\mu_m}\frac{|\omega_{ri}(k)|^2}{\sigma_i(k)^2} - 1\right)^+\right) = R^{mac}\left(\mathbf{W}_1^0, \mathbf{W}_2^0\right). \tag{21}$$

From the constraints of 2 controlling variables, the weight of adaptive $W_e = (\omega_j^{(e)}, 0)$ of hotel green human resources performance management is obtained, and the statistical index distribution set is established. The specific distribution content is shown in Figure 5.

In the statistical index distribution set, the index set $E_k \in E(k = 1, 2, \cdots, t)$ of hotel green human resources performance management is obtained. Information fusion is a technique that integrates and improves the gathering, display, and internal relationships of many forms of data. The hotel green human resources performance management is realized through multidimensional information fusion technology. In addition, the number, distribution, and structure of human resources are predicted. This prediction can be obtained using prediction function, which is represented by $1/\mu_m < \max\{1/\mu_1, 1/\mu_2\}$. The statistical test method between groups is adopted to analyze the autocorrelation of various variables of hotel green human resources performance management effect and to realize performance evaluation. The optimization algorithm implementation process is shown in Figure 6.

4. Simulation and Result Analysis

In order to verify the application performance of this method in the service performance optimization management of hotel green human resources, the simulation test analysis is carried out. The number of nodes sampled for hotel green human resources information is $N = 6822$, the number of statistical samples is 200, the test set of hotel green human resources performance information samples is 250, the data packet transmission rate is $v_\alpha \in [0, 2]$(m)/s, and the related parameter settings are presented in Table 1.

According to the above parameter settings, the hotel green human resource performance management and

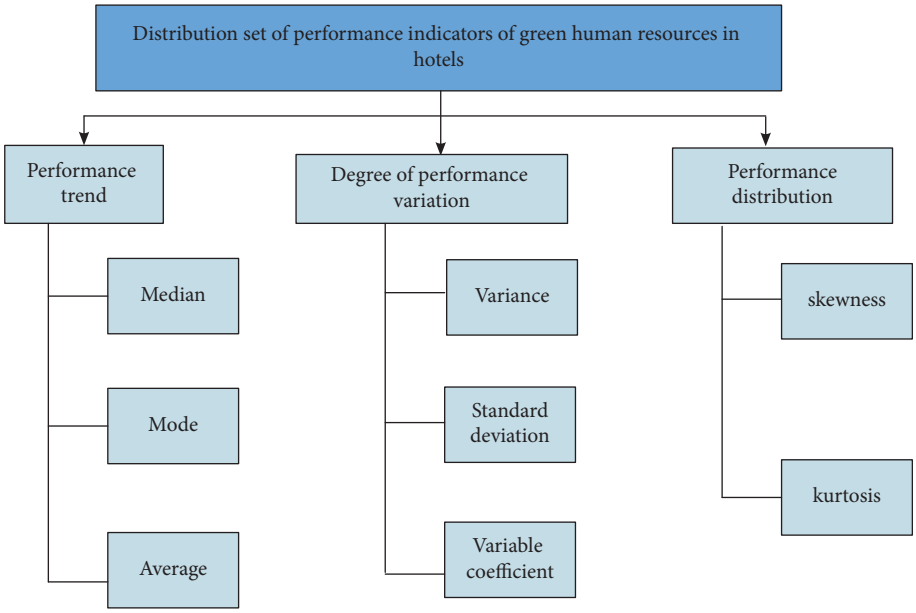

Figure 5: The distribution set of hotel green human resources performance management.

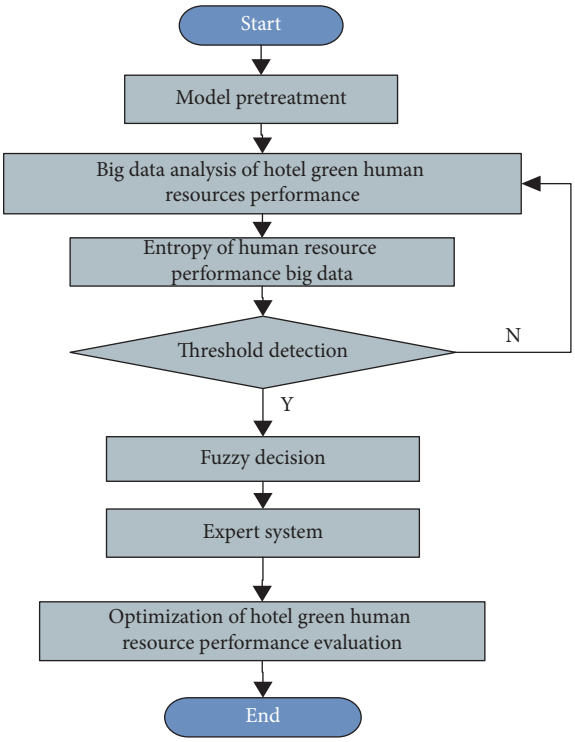

Figure 6: Algorithm implementation process.

decision-making are carried out. The distribution of big data in human resource management and service performance configuration is shown in Figure 7.

According to the data sample in the above figure, the fuzzy query and optimization control of hotel green human resources performance management are carried out by using the in-depth query method. The service performance sample data fusion is realized by multidimensional information fusion technology. The results are shown in Figure 8.

According to the examination of the preceding figure, this approach may successfully implement statistical analysis and performance prediction. Furthermore, to increase service performance integration and information identification data warehousing, online analytical processing and decision support technology may be utilized in human resource management. The accuracy of performance prediction is tested, and the comparison results are shown in Figure 8. This figure illustrates the suggested method's performance accuracy to other researchers. According to this figure, the accuracy of recommended, reference [3], reference [5], and reference [6] in 100 trials is 0.899, 0.823, 0.823, and 0.723, respectively. The accuracy of recommended, reference [3], reference [5], and reference [6] for 200 tests is 0.932, 0.885, 0.856, and 0.797, respectively. The accuracy of recommended, reference [3], reference [5], and reference [6] for 300 experiments is 0.999, 0.899, 0.889, and 0.803, respectively. In simple words, from the analysis of this figure, it can be seen that the method in this article has high accuracy and good statistical analysis ability for hotel green human resources performance prediction.

Figure 9 compares the performance parameters and principal components of characteristics. According to this figure, test object 15 has the greatest performance parameter of 0.404, while test object 9 has the lowest performance value of 0.404. Similarly, test object 10 has the greatest number of primary component characteristics, whereas test object 7 has the lowest. Comparison of the performance parameters and principal components of characteristics is shown in Figure 10.

Table 1: Performance configuration parameters of hotel green human resources.

Test object	Sample number	Salary grade	Performance parameters	Principal component characteristics
1	4137	2.443	0.355	0.434
2	4128	1.231	0.374	0.432
3	4201	1.361	0.350	0.450
4	4199	4.611	0.338	0.450
5	4143	1.742	0.377	0.436
6	4088	0.005	0.388	0.422
7	4066	2.379	0.389	0.417
8	4108	2.855	0.387	0.427
9	4146	3.812	0.332	0.436
10	4286	1.872	0.366	0.471
11	4148	2.605	0.340	0.437
12	4219	1.170	0.369	0.455
13	4096	2.480	0.351	0.424
14	4087	4.320	0.359	0.422
15	4213	2.138	0.404	0.453

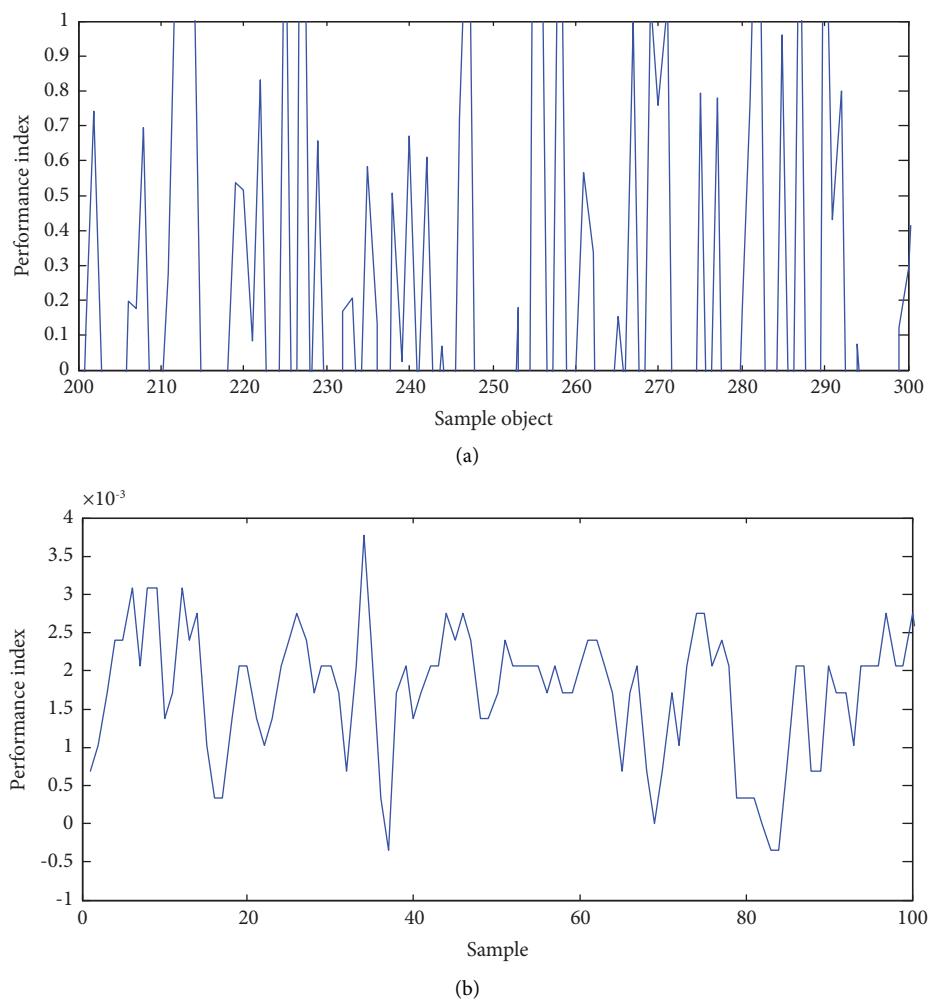

Figure 7: Results of statistical analysis of data. (a) Test samples. (b) Training samples.

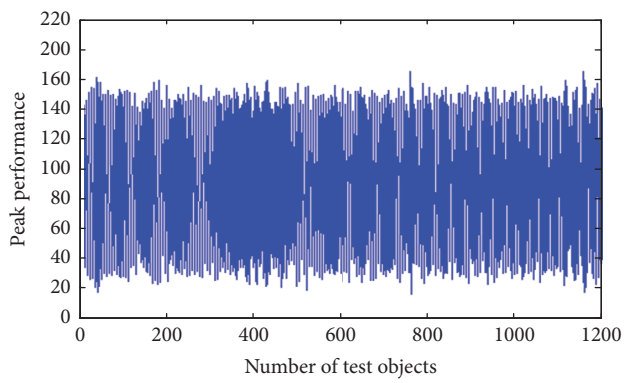

Figure 8: Data fusion decision results.

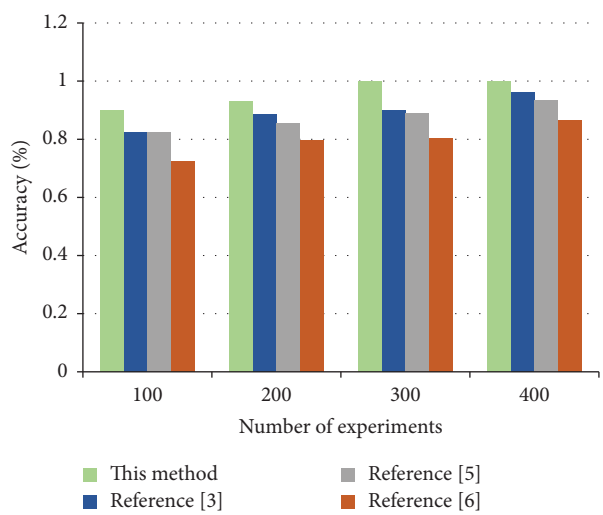

Figure 9: Comparison of performance prediction accuracy of hotel green human resources.

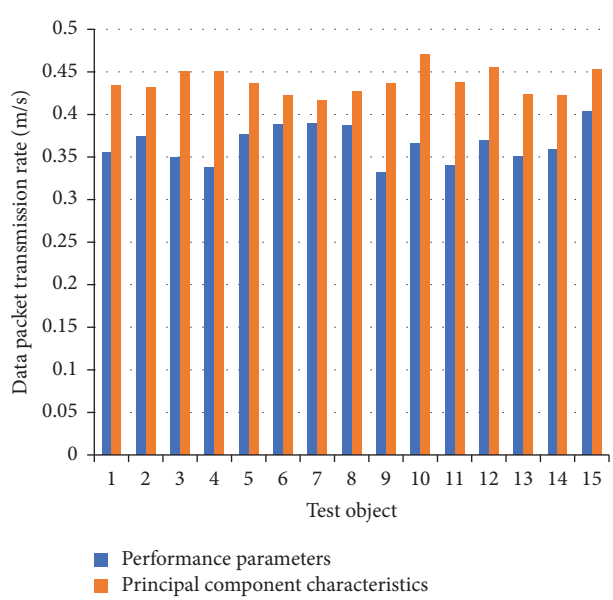

Figure 10: Comparison of the performance parameters and principal components of characteristics.

5. Conclusions

The growth of the Internet of Things is undeniable and unstoppable. The Internet of Things (IoT) is revolutionary and has been motivated by social demands and economic possibilities via demand-pull and supplier push. It is made possible by several strands of technological innovation and application development in various fields, including hotel and human resource management. Therefore, this article proposes a performance model of hotel green human resources based on fuzzy theory to accelerate the transformation of hotel's human resource management from pure functional management to information management and achieve the optimal allocation of hotel green human resource management. The fuzzy analysis model of salary data of hotel green human resource management is constructed. The quantitative fusion feature clustering method of absolute salary and relative salary is adopted to make fair scheduling and adaptive equilibrium game of salary distribution in hotel green human resource management. The sample data of hotel green human resource performance is obtained by the fuzzy information sampling method, and the information fusion parameter matching template function of hotel's human resource management performance is obtained by the multidimensional feature parameter decomposition method. The fuzzy analysis model of salary data of hotel green human resources management is constructed, and the quantitative fusion feature clustering method of absolute salary and relative salary is adopted. The analysis shows that the application of the hotel green human resource performance management system in hotel green human resource management is helpful to analyze the service performance law of human resources in complex data. It provides data support and optimizes the management process in combination with the characteristics of hotel green management.

Data Availability

The data used to support the findings of this article are available from the author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Research Article

Improved Matrix Multiplication by Changing Loop Order

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Matrix multiplication has been implemented in various programming languages, and improved performance has been reported in many articles under various settings. Matrix multiplication is of paramount interest to machine learning, a lightweight matrix-based key management protocol for IoT networks, animation, and so on. There has always been a need and an interest for improved performance in terms of algorithm implementation. In this work, the authors compared the run times of matrix multiplication in popular languages such as C++, Java, and Python. This analysis showed that Python's implementation was poor while Java was relatively slower compared to the C++ implementation. All the aforementioned languages use a row-major scheme, and hence, there are many cache misses encountered when implemented through simple looping. In contrast, the authors show that by changing the loop order, more performance gains are possible. Moreover, we evaluated the performance of matrix multiplication by comparing the execution time under various loop settings. The authors observed tremendous performance gains due to better spatial locality. In addition, the authors also implemented a parallel version of the same algorithm using OpenMP with eight logical cores and achieved a speed-up of seven times compared to the serial implementation.

1. Introduction

With the emergence of smart devices in many application areas, such as healthcare, location-based services, and self-driving vehicles heavily depends on the efficient processing of data produced by these devices. Processing such data are very challenging, especially when data is produced in zettabytes. On the other hand, the performance of an application is no more linearly linked to the processor clock frequency as it was a norm until 2004, where doubling the system speed would roughly result in a 50% performance gain. However, in 2004, the chip manufacturers encountered a "Power Wall" and faced fundamental constraints in power delivery and heat dissipation. "Power Wall" refers to the difficulty of scaling the performance of computing chips and systems due to fundamental constraints imposed by physics. This limitation on increasing processor frequency introduced the era of multicore computing, where multiple cores run an application in parallel for better performance. Multicore systems and even low-end small devices such as tablets and smartphones, which have two or more cores, currently dominate the computing domain. On the other hand, writing algorithms to fully exploit these multicore systems remains a challenging task.

With multicore systems, personal computers today offer the computation power of supercomputers. Such speed provides many prospects for performing computationally extensive operations. To exploit this facility, several serial applications present the opportunity to write parallel versions, especially in applications where it is of principal interest to exploit the potential parallelism in the application. This trend of parallel processing theoretically shows linear performance gains with an increased number of processors at an abstract level and excellent performance when run as a parallel system. However, not all code can run in parallel and, hence, serial parts seriously limit the system performance. Unlike serial counterparts where performance is measured through complexity analysis, the performance of parallel systems is evaluated through Amdahl's or Gustafson's laws [1, 2].

Traditionally, until 2002, the majority of computer systems had one processor, and accordingly, sequential

algorithms were developed. Today, the latest computers, which consist of multiple processing elements (either multiple CPU cores or GPU), are more powerful due to multiple processing units. Understandable serial codes are slow as they need to process the instructions one by one, in contrast to a parallel execution where multiple instructions are processed simultaneously. The performance of many serial programs can be improved by exploiting the parallel architectures, which can be in terms of loop reorder, pipelining, and speculation, and so on. It is worth noting that not every program can be converted in parallel, and there are cases where the parallel version exhibits poor performance compared to the serial version. With the latest computing architecture and parallel languages, tremendous improvements have been reported for machine learning, AI, a lightweight matrix-based key management protocol for IoT networks, graphics, computational photography, and computer vision by exploiting parallelization [3–7].

Benefits such as power efficiency, resource pooling, cost reduction, system availability, and improved computational power can be obtained with cloud computing infrastructure. All such benefits attract computer scientists, systems engineers, the research community, and high-performance computing (HPC) customers to the cloud domain. On the other hand, HPC programs often use a large number of processors to lower the run times of tasks. An issue with such processors is synchronization, in addition to communication overheads. It has been reported in [3] that shifting an HPC application to the cloud environment can negatively impact the aforementioned difficulties and even introduce additional issues of virtualization, multitenancy, network latency, and so forth.

In this paper, we limit our analysis to a multicore system by observing the program behavior and changing loop orderings [4–7]. We apply a parallel construct for matrix multiplication to gain better performance. In this work, we study the following:

The impact of loop reordering on performance

Parallel implementation under OpenMP framework to illustrate the speed-up obtained through parallelism

The remaining part of this paper is divided into four sections as. In the background Section, we discuss the groundwork, followed by an explanation of the row and column major order of data in the memory in the impact of row-major programming constructs Section. We discuss the behavior of matrix multiplication for a square matrix by changing the loop ordering. In the Discussion Section, we provide the parallel version of the code and discuss the experimental results. The paper then offers a conclusion as the last section.

2. Background

Until the beginning of the 21st century, advances in technology would simply be considered an increase in the clock speed. Naturally, the software would effectively "speed-up" automatically over time because of running faster processors. The clock speed of microprocessors increased exponentially through the 1990s and beyond, but after 2004, it reached a limit due to physics, and the clock speed is now limited by power consumption/heat dissipation. With little improvement in clock speed, such performance gain convenience is no longer an option for software engineers.

As a solution to lower power consumption, the dynamic voltage scaling concept was introduced in CMOS technologies. The literature shows that the relationship between frequency and voltage in modern processors [8] can be written as: $E = P * T$, where "E" denotes the power consumption, "P" represents the average power, and "T" is the time taken for this average power.

Today, advances in technology mean increased parallelism and not enhanced clock speed. Thus, exploiting such parallelism is one of the outstanding challenges of modern computer science.

The parallel programming and parallelization of the tasks are done for the main purpose of allowing tasks to be executed at the same time by utilizing multiple computer resources and multiple cores on the same CPU. This process is very critical, especially for large-scale projects where speed is needed. Parallel programming is making its way into various domains, ranging from drug discovery to data analytics to the animation industry. All these applications are computation intensive and traditional sequential code becomes inefficient. However, just increasing the number of processors does not always guarantee performance gains and depends on the nature of the problem to be parallelized. Parallel implementation is prone to overheads such as: task start-up, time, synchronization, SATA communications, and software overhead imposed by parallel languages, libraries, operating system, and so on. When a parallel code is developed, these factors need to be considered carefully.

In the parallel programming literature, a massive parallel system means that the hardware of a given parallel system is comprised of many processing elements, and currently, the largest parallel computers include processing components in the range of hundreds of thousands to millions. Similarly, embarrassing parallel applications refer to a set of applications where independent tasks can run simultaneously and there exists very little to no need for coordination between the tasks. Another term that is used in the parallel programming domain is "scalability," which points to a parallel system's ability to demonstrate an adequate increase in parallel speed-up. Such a situation is understandable with the addition of more resources. Factors that contribute to scalability include algorithms, overheads, hardware, the characteristics of a program, and so forth. In parallel programming, efficiency is defined as the amount of work needed to be done, while "performance" points to how fast an algorithm can finish a particular work. A faster implementation is not necessarily an efficient one, where efficiency points to the full exploitation of available hardware resources.

In a program running on a parallel system, it is possible that some instructions need to be accomplished in sequence. This sequential execution has a limiting factor on program speed-up such that even adding more processors may not make the program run any faster. For instance, if a program

takes 20 minutes to finish using a serial code with one thread, and when the 5 minute portion of the code cannot be made parallel, the remaining 15 minutes of processing can be written as parallel code. In such situations, irrespective of how many threads are devoted to the parallelized execution of this program, the minimum execution time cannot be less than 15 minutes. For such evaluation of a program in the parallel computing domain, Amdahl's law [1] is used and can be represented as follows:

$$S = 1/((1 - p) + p/speed), \quad (1)$$

where S shows the theoretical speed-up of the execution, speed represents the speed-up of the part of the task that benefits from improved system resources, and P is the proportion of the execution time that the part benefiting from the improved resources originally occupied.

One of the most important criteria in parallel computing is to actually measure how much faster a parallel algorithm runs with respect to the best sequential one. This measure is known as "speed-up." In other words, speed-up is the gain in speed made by a parallel execution compared to a sequential execution. Any program that results in higher speed is not necessarily efficient. The efficiency of a program is described as using p processors, or how effectively all system hardware elements are being utilized. If the efficiency is 1.0, then it is the maximum theoretical efficiency and shows the optimal usage of computational resources available for execution. If speed-up is not greater than linear, the efficiency will be less than or equal to 1.0, and this is normally the situation in practical cases.

In computer science, matrix multiplication is of great interest to many application areas, and a lot of work has been done in this regard in the literature [3, 9–23]. It has been shown that the number of processes does not necessarily result in performance gain. Recently, the authors in [3] measured the speed-up and efficiency of a matrix multiplication benchmark running on Amazon EC2. Their experiment shows why the performance of HPC applications on the cloud is not predictable due to the shared resources and multitenant environment of the cloud [3]. Various improvements in matrix multiplication have been discussed in the literature [16, 24, 25], and further gains are possible using GPUs [26–29]. Recently, for more secure communication between these IoT devices, the authors in [30] extended the work by proposing a lightweight matrix-based key management protocol for IoT networks.

OpenMP is an open specification for multiprocessing and offers a standard API for defining multithreaded, shared-memory programs [31]. The OpenMP high-level API consists of 80% preprocessor (compiler) directives, 19% library calls, and around 1% of environment variables. This framework presents the fork-join model of parallel execution. OpenMP is an API that is portable, supports threading, and can work with shared-memory programming specifications with "light" syntax. It is to be noted that the exact behavior depends on the OpenMP implementation and the number of threads. OpenMP is an advanced API and works for both C and C++; and it requires compiler support. Since a program can have serial and parallel sections, OpenMP allows a programmer to separate a program into serial regions and parallel regions, hide stack management, and provide synchronization constructs. As a potential drawback, OpenMP cannot detect dependencies in the code nor guarantee speed-up. In addition, it cannot provide freedom from data races, and it is the responsibility of the programmer to avoid such cases.

3. Impact of Row-Major Programming Constructs

In the computer science domain, two methods exist for storing multidimensional arrays, such as matrices, in linear storage and in random access memory. They are called column-major and row-major orders. These methods are different in the way in which elements are stored contiguously in the memory. In column-major order, elements are arranged consecutively along the column, while elements are arranged consecutively along the row under row-major sequence. Python, C, C++, Objective-C, and Java implement the column-major order when storing elements in memory, while FORTRAN, MATLAB, Julia, and Pascal use the column-major order.

In row-major order, elements are placed in memory as shown in Table 1, where the entire row is placed at one location in the memory, ignoring the cache line size such that there are multiple rows of the matrix. Table 2 represents the representation of the elements of Matrix C in cache, where a minimal block of data is transferred between the memory and the cache in a better algorithm, and the entire block of memory is placed in the cache line i.e., the word length and block length are of the same size in this paper. We then study the effect of spatial locality on program performance.

We name the first Matrix A, the second B; the product of Matrixes A and B is stored in Matrix C, as shown in Figure 1. It can be seen that under the *j, k, i* loop ordering, the program takes the longest due to poor placements of elements in memory. In Figure 2, we can see B has excellent spatial locality, but the code is dominated by two other Matrices A and C, where the placement is poor and, hence, the program shows worse case behavior when implanted in C, C++, Python, or Java.

As an alternative, we implemented the program as follows, written in C++ in Figure 3. We can now visualize the memory layout in Figure 4, where Matrix B offers poor, Matrix A offers good, while Matrix C presents the best spatial locality for the elements. In Figure 4, it can be seen that for Matrix C, the elements are placed n elements apart, and that is why there is a miss, which takes more time for the system to load the value. For Matrix B, it is relatively closer, as only a desired number of steps are taken, but for Matrix C, only one location is updated, and hence, it offers an excellent spatial locality. This program improves the performance by a factor of three when the matrix is of dimension 4096 and implemented in C++.

We then rewrote the code and adjusted the loop order (see Figure 5). This arrangement did not affect the correctness of the program. The aim of this arrangement was to

Table 1: Matrix representation and placement in memory with row-major order.

Row 1			
Row 2			
Row 3			
...			
Row n			
Memory:	Row 1	Row 2	Row 3

Table 2: Representation of elements of Matrix C in cache.

Matrix C				Cache line
C [0][0]	C [0][1]	C [0][2]	C [0][n]	Cache line-0
C [1][0]	C [1][1]	C [1][2]	C [1][n]	Cache line-1
C [2][0]	C [2][1]	C [2][2]	C [2][n]	Cache line-2
...	...	...	...	...
C [n][0]	C [n][1]	C [n][2]	C [n][n]	Cache line-n

```
For (j=0; j<n; j++){
        For (k=0;k<n; k++){
                For (i=0; i<n; i++){
                C[i][j]=A[i][k]*B[k][j];}}}
```

Figure 1: Matrix multiplication with orders *j*, *k*, and *i*.

obtain a better spatial locality, as the program takes much less time compared to the counterpart implements. The corresponding spatial locality for Figure 5 is shown in Figure 6. It can be seen that since Matrixes C and B offer good spatial locality, Matrix A has excellent spatial locality, and hence, this arrangement surpasses its other counterparts in performance. Theoretically, the code shown in Figure 5 is approximately 14 times faster than the one implemented in Figure 2 due to better spatial locality. This arrangement favors row-major languages, while it will hurt the performance of column-major languages due to the inappropriate memory layout of array elements.

4. Discussion

This experiment was conducted on Windows 10 and the system information is shown in Table 3. The complexity of the program is $2n^3$, where *n* represents the loop iterations. Our analysis shows that Python's implementation is poor in all three languages. While Java is relatively slow compared to the C++ implementation. This study is limited to matric multiplication and test programs written in C++. Java and Python to perform matrix-matrix multiplication as follows:

(i) Dimensions of each matrix are n×n and the elements/values of the matrix are of type double.

(ii) Populate each matrix with randomly generated values, etc.

(iii) Add the necessary code to measure the time taken by the matrix-matrix multiplication.

(iv) Observe the behavior of loop reordering.

(v) Evaluate the performance gains with parallel implementation in OpenMP.

We first ran sequential versions of the program while changing the matrix size *n* from 500 to 2500 in steps of 500. We recorded the time to perform matrix-matrix multiplication for each execution. It is worth noting that interpreters can easily support high-level programming features [5]. This is due to the flexibility with which the interpreter reads, interprets, and performs each program statement and updates the machine state. However, the features of dynamic code alteration come at the cost of performance loss. This is why Python is the slowest in this class. While Python is interpreted, Java overcomes this drawback with a just-in-time compiler feature. Since C++ is compiled, it presents the best performance. In Table 4, we show our results where the runtime for C++, Java, and Python is extracted for a matrix starting from size 500 to 2500.

The just-in-time compiler of Java can recover some of the performance lost by interpretation. In Java, when the code is executed for the first time, it is interpreted first. Interestingly, the system keeps information about how often various pieces of code are executed. Whenever a piece of code executes frequently, the code is compiled to machine code in real time, and the next executions of that code use the more efficient compiled version [3].

We further studied the behavior of C++ by changing the loop order. In matric multiplication, there exist combinations where changing the order of the loops will not affect the correctness of the program. In the following experiment, we showed such combinations and provided the performance of the code (see Table 5). In all the aforementioned three programming languages, matrices were placed in row-major order. It is worth mentioning that the matrix size was the same for all experiments under C++, Java, and Python, while the time varied significantly due to the arrangements of the matrix elements in the memory. As discussed earlier, the poor arrangement of elements results in more cache misses and thus the program takes more time, while an excellent arrangement guarantees improved performance. The parallel version of the code is shown in Figure 7, where pragma "omp parallel for" is used. When this code runs on real hardware, the number of threads, which depends on the hardware and operating system, becomes of interest for performance. In Figure 7, we did not specify the number of threads, but the code can run on any system where more threads will definitely enhance the execution of the code significantly.

The results show the improvement of code in C++ over Java and Python. In our last experiment, we extracted results for a parallel code written in C++. We used the pragma "# pragma omp parallel for" in the parallel implementation of the code. The parallel matrix multiplication program with the support of OpenMP, shows a noticeable gain in speed-up for varying matrix sizes. Through our analysis, we conclude that the row-major policy is better for the matrix multiplication using the loop ordering *i, k, j*. It is worth noting that although *i, j, k* order is the natural one and easy to

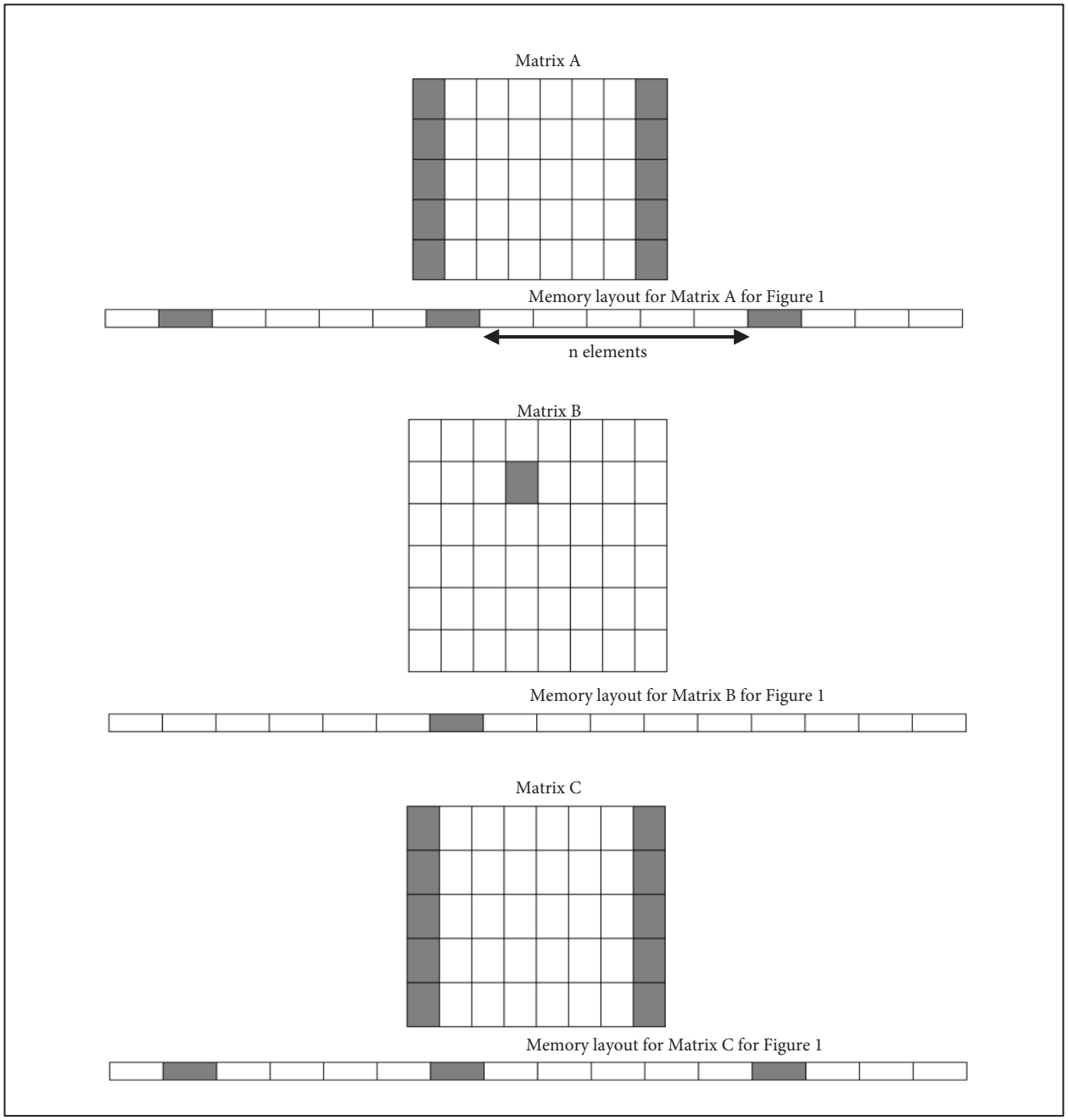

Figure 2: Spatial locality of Matrixes A, B, and C++ using *j*, *k*, and *i* ordering.

```
For (i=0; i<n; i++){
        For (j=0;j<n; j++){
                For (k=0; k<n; k++){
                        C[i][j]=A[i][k]*B[k][j];}}}
```

Figure 3: Matrix multiplication with orders *i*, *j*, and *k*.

understand, it results in poor memory layout, and therefore, the performance is poor. The order *i, k, j* places the data in such a way that the cache hit is increased, and thus, more gains are observed. Considering the *i, k, j* order as the most suitable looping order, we recommend this strategy for improved performance, irrespective of serial and parallel versions. We show our results for both serial and parallel implementation in Table 6. Hence, we implemented the best serial code, which was *i, k, j* ordering, and hence, the results were superior.

After implementing the code using the OpenMP framework, it is observed that the execution time of the parallel version is approximately seven times better than the execution time of the serial one, and thus, an improvement of around seven times has been obtained. It is worth noting

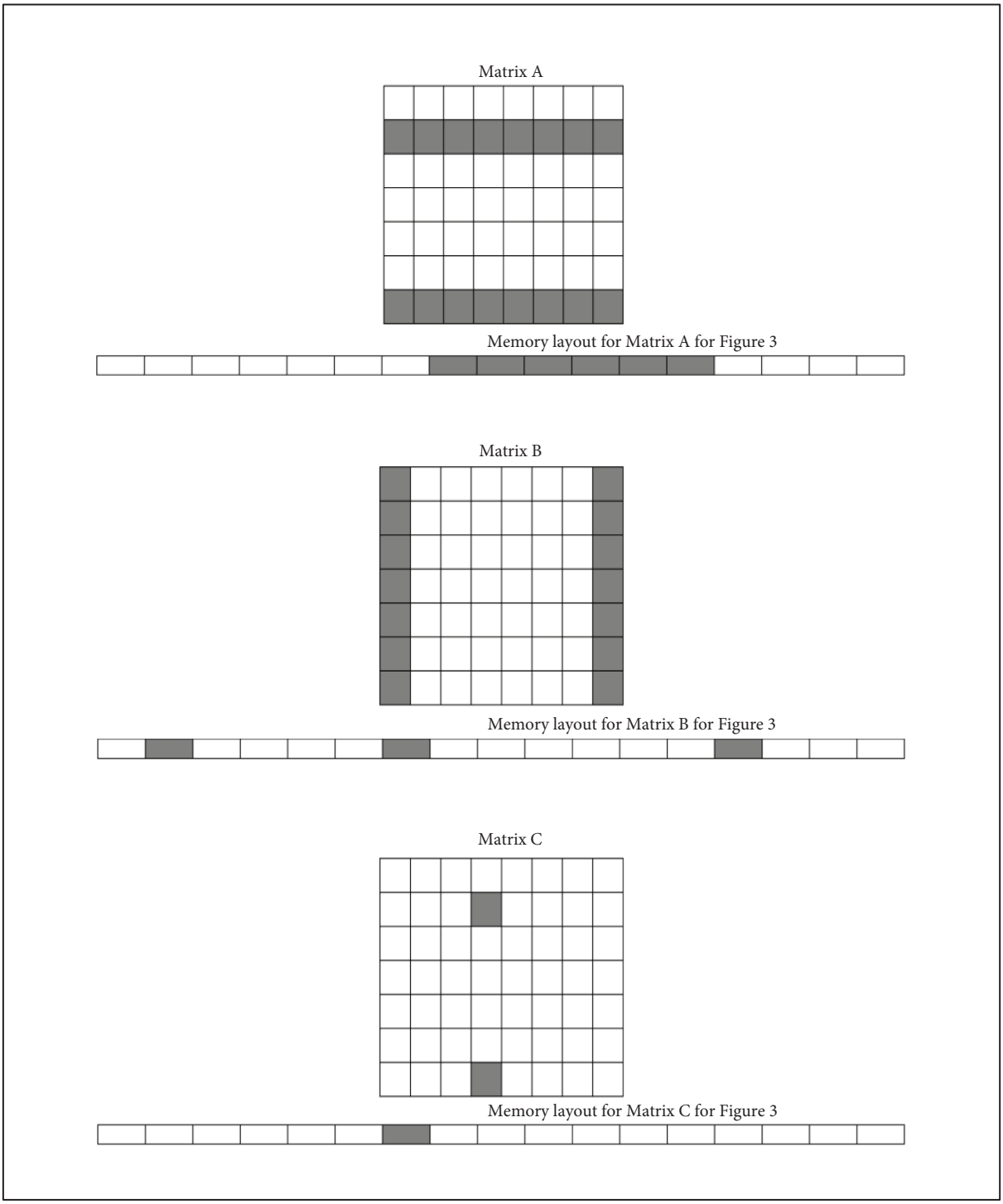

Figure 4: Spatial locality of Matrixes A, B, and C using *i*, *j*, and *k* ordering.

```
For (i=0; i<n; i++){
        For (k=0;k<n; k++){
                For (j=0; j<n; j++){
                        C[i][j]=A[i][k]*B[k][j];}}}
```

Figure 5: Matrix multiplication with orders *i*, *k*, and *j*.

that the efficiency is achieved mainly due to the algorithm, while the system performance depends on the data structure. It can be noted that the performance is not linear in our experimentation, and this is understandable. In theory, the speed should be eight times faster as we have eight cores on the system, but since there are communication, synchronization, etc., overheads involved, and speed-up is not linear,

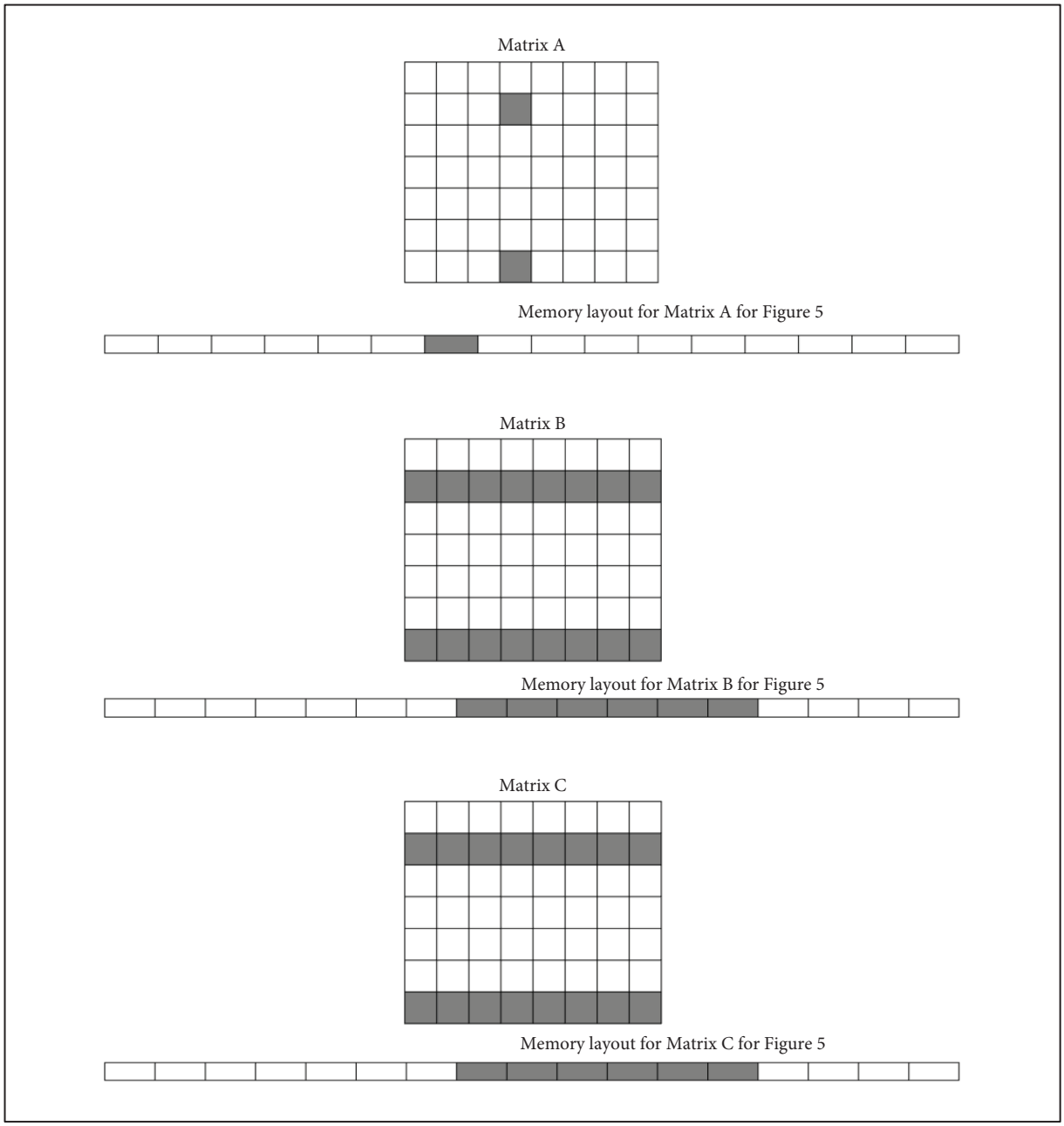

Figure 6: Spatial locality of Matrixes A, B, and C using *i*, *k*, and *j* ordering.

Table 3: Experimental setup.

Item	Specification
Processor	Intel ® core (TM) i7-8650U
Installed memory (RAM)	16 GB
System type	64- Bit operating system
Base speed	2.11 GHz
Cores	8
Logical processors	16
Virtualization	Enabled
Cache (L1, L2, and L3)	256 KB, 1 MB, and 8 MB

Table 4: Results extracted by changing row and columns using serial code.

N	Loop order (i is the outermost loop)	Time taken (seconds)		
		C++ (serial code)	Java (serial code)	Python (serial code)
500	*i, j, k*	0.312	0.324	2.345
1000	*i, j, k*	2.334	3.932	5.456
1500	*i, j, k*	10.881	16.245	23.453
2000	*i, j, k*	37.382	43.88	122.304
2500	*i, j, k*	97.293	124.593	566.452

Table 5: Results of serial code by changing loop order.

N	Loop order	Time (in seconds)		
		C++ (serial code)	Java (serial code)	Python (serial code)
1000	*j, k, i*	5.436	11.492	27.342
1000	*i, j, k*	2.334	3.932	15.456
1000	*i, k, j*	0.802	1.803	5.453
1500	*j, k, i*	7.532	18.432	43.345
1500	*i, j, k*	10.881	16.245	23.453
1500	*i, k, j*	1.342	5.352	8.345

```
# pragma omp parallel for private (tid)

For (i=0; i<n; i++){
        tid = omp_get_thread_num();
        For (k=0;k<n; k++){
                For (j=0; j<n; j++){
                        C[i][j]=A[i][k]*B[k][j];}}}
```

Figure 7: Parallel implementation of matrix multiplication in OpenMP.

Table 6: Parallel code matrix-matrix multiplication in C/C++.

N	C++ (serial code) [i, k, j]	C/C++ (parallel code) [i, k, j]
500	0.4378	0.093
1000	2.815	0.456
1500	20.814	2.845
2000	40.748	8.102
2500	115.456	16.324

a seven-time improvement is still achieved with parallel implementation using *i, k,* and *j* orders.

5. Conclusions

We implemented matrix multiplication for row-major order languages and observed that C++ is more efficient in terms of runtime. The performance gap in programming languages, such as C++, Java, and Python, is due to the use of interpreters and compilers. Since C++ becomes compiled to machine language, it is the fastest. As a workout solution, the just-in-time feature of Java makes it faster than Python for matrix multiplication. We observed that the layout of elements in the memory has a large impact on the computational cost of a program. The parallel implementation of C++ is obtained in a speed-up of a factor of 7.0. As a future work, it will be interesting to extend this work to implement applications such as chess, binary decision diagrams, and logistic regression, and so on.

Data Availability

Data will be made available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Research on Machine Translation Method of English-Chinese Long Sentences Based on Fuzzy Semantic Optimization

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The machine translation of English-Chinese long sentences is out of order under the constraint of the mixed corpus. In order to improve the accuracy of machine translation of English-Chinese long sentences, a machine translation method based on fuzzy semantic optimization is proposed. By adopting the method of systematic semantic configuration structure fusion, the ontology mapping model of the English-Chinese long sentence subject list under the constraint of the mixed corpus is constructed. In the distribution structure space of English-Chinese long sentences under the constraint of the mixed corpus, the method of extracting the best semantic relevance and analyzing the concept tree of context semantic mapping is adopted to mine the dynamic features of the subject list of English-Chinese long sentence translation under the constraint of the mixed corpus. In the intrinsic distribution sequence of semantic mapping between concepts, the fuzzy semantic combination features of English-Chinese long sentences under the constraint of the mixed corpus are extracted. The distribution results of word knowledge priority selection sequence, the automatic translation of English-Chinese long sentences under the constraint of the mixed corpus is realized by scheduling a grammatical error correction task list. According to the simulation results, machine translation of long English-Chinese sentences under the restriction of mixed corpora is capable of good semantic configuration. The degree of linguistic structural similarity between English and Chinese is great, which enhances the automatic translation capacity of English-Chinese long sentences under the limitation of the mixed corpus.

1. Introduction

The syntactic causal structure of English-Chinese lengthy sentences is constrained by the mixed corpus [1], and the causative action and causative consequence are reflected by various lexical forms. The causative meaning of this kind of causative structure is not determined by causative verbs but by the result of the interaction between verbs in English-Chinese long sentences and other components in the structure under the constraint of the mixed corpus. As a result, verbs in English-Chinese long sentences under the constraint of the mixed corpus can be pure causative verbs, causative verbs with specific lexical meanings, and noncausative verbs, but they all have causative meanings after entering the corresponding sentence patterns, expressing the causative process in transitivity system. Events can express different process types in a transitivity system, and the process is caused by a causative external force and the combination of the two forms causative action process, semantic relationship process of English-Chinese translation of long sentences under the constraint of the causative mixed corpus, causative psychological process, etc.

According to the feature distribution and phase space feature distribution of English-Chinese long sentences under the constraint of the mixed corpus, a fusion model of English-Chinese long sentences under the constraint of the mixed corpus is established. Combined with the information feature extraction results of English-Chinese long sentences under the constraint of the mixed corpus, the automatic translation of English-Chinese long sentences under the constraint of the mixed corpus is realized. It is of great significance to study the translation methods of English-Chinese long sentences under the constraint of the mixed

corpus to improve the accuracy of machine translation of English-Chinese long sentences.

Generative grammar overcomes the fact that generative semantics stays in the research of the meaning of causative verbs. The primary focus of the causative study is on the development and modification of causal structures with the intention of examining the degree to which form and language are universal. The explanatory capacity of its generalised one-sentence rule has several limits, and it does not pay enough attention to the pragmatic and semantic qualities of causal structures. Generally speaking, generative linguistics has carried out some research on the causative structure, but the description of syntactic and semantic features of the structure is not thorough and systematic. Automatic translation of English-Chinese long sentences under the constraint of the mixed corpus is based on optimized clustering and feature fusion analysis of data. Among the traditional methods, machine translation methods of English-Chinese long sentences [2, 3] under the constraint of the mixed corpus mainly include machine translation method of English-Chinese long sentences under the constraint of the mixed corpus based on correlation degree feature analysis, resource dynamic translation method of PCA principal component analysis [4], and machine translation method of English-Chinese long sentences under the constraint of mixed corpus of K-means fusion clustering [5]. Statistical feature extraction and autocorrelation feature detection are used to realize machine translation of English-Chinese long sentences under the constraint of the mixed corpus. However, the traditional method of machine translation of English-Chinese long sentences under the constraint of the mixed corpus has poor adaptability and weak feature recognition ability.

To solve the above problems, a machine translation method of English-Chinese long sentences under the constraint of fuzzy semantic optimization mixed corpus is proposed. Ontology is a discipline of philosophy that deals with the study of many things that exist in the world. Its primary objective is to categorise all of the things that exist. From the perspective of computer science, ontology is a specification of a conception. In this sense, ontologies aim to characterise concepts already present in a domain and relate them based on those concepts' traits [6]. Firstly, the ontology mapping model of English-Chinese long sentences under the constraint of the mixed corpus is constructed by the method of systematic semantic configuration and structure fusion, and the semantic mapping between concepts is in the intrinsic distribution sequence. Then, the fuzzy semantic combination feature quantity of English-Chinese long sentences under the constraint of the mixed corpus is extracted. According to the distribution result of the word knowledge priority selection sequence, the automatic translation of English-Chinese long sentences under the constraint of the mixed corpus is realized by scheduling the grammatical error correction task list. Finally, the simulation analysis shows the superior performance of this method in improving the machine translation ability of English-Chinese long sentences under the constraint of the mixed corpus.

2. Concept Tree Model of Upper and Lower Semantic Mapping of Machine Translation

2.1. Machine Thesaurus Construction. In order to optimize the machine translation of English-Chinese long sentences under the constraint of the mixed corpus, the natural semantic processing method [7] is adopted to construct the subject word list of English-Chinese long sentence machine translation under the constraint of the mixed corpus. By combining structural information with ontology mapping, the graph model parameters for English-Chinese long phrase machine translation under the restriction of mixed corpus are established. Figure 1 illustrates how semantic editing is used to create the topic word list for English-Chinese long sentence machine translation under the restriction of mixed corpus.

According to the keyword list distribution of English-Chinese long sentence machine translation restricted by the mixed corpus shown in Figure 1, using the data enhancement method of error correction model back translation, the training samples of machine translation are as follows:

$$D = \left\{S_{i,j}(t), T_{i,j}(t), U_{i,j}(t)\right\}, \tag{1}$$

where in, $S_{i,j}(t)$ represents the correlation dimension [8] of the word context of English-Chinese long sentence machine translation under the constraint of the mixed corpus, $T_{i,j}(t)$ represents the similarity propagation graph model of English-Chinese long sentence machine translation under the constraint of the mixed corpus, and $U_{i,j}(t)$ represents the fuzzy similarity feature quantity (correlation) of English-Chinese long sentence machine translation under the constraint of the mixed corpus [8]. $O = \{C, H^C, R, I, A\}$ is defined as a five-tuple ontology structure model of English-Chinese long sentence machine translation under the constraint of the mixed corpus. The data enhancement model parameters of English-Chinese long sentence machine translation under the constraint of the mixed corpus are constructed by using an ontology mapping method, and the output of neurogrammatical error correction is as follows:

$$S_{i,j}(t) = \frac{p_{i,j}(t) - sp_{i,j}(t)}{p_{i,j}(t)}. \tag{2}$$

For the basic unit of knowledge storage of semantic ontology in machine translation, the following correction vector set representing semantic ambiguity in the process of machine translation of English-Chinese long sentences under the constraint of the mixed corpus is calculated and expressed as follows:

$$T_{i,j}(t) = \frac{\left|p_{i,j}(t) - \Delta p(t)\right|}{p_{i,j}(t)}, \tag{3}$$

where in, $U_{i,j}(t)$ is used to define the frequent item sets [9, 10] of semantic autocorrelation in machine translation of English-Chinese long sentences under the constraint of the mixed corpus, and ontology integration is used to exchange knowledge and search keyword information in the

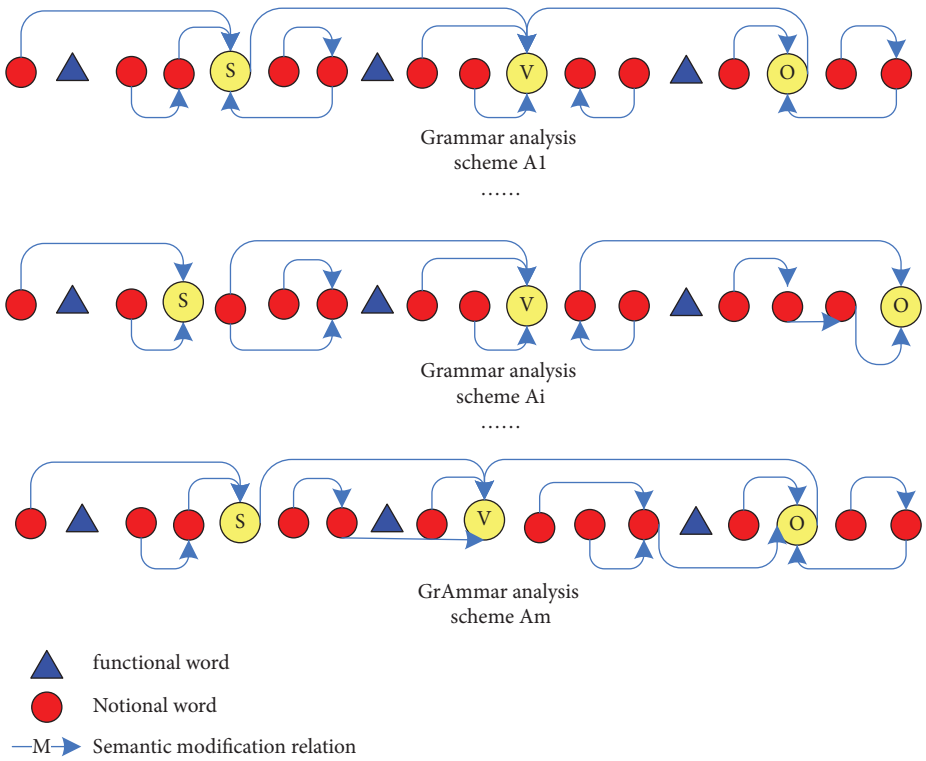

Figure 1: List of keywords in machine translation of English-Chinese long sentences under the constraint of the mixed corpus.

translation process so as to realize the correlation analysis measure of machine translation of English-Chinese long sentences under the constraint of the mixed corpus, and its calculation formula is as follows:

$$U_{i,j}(t) = \exp\left[-b\left[z_i(t) - z_j(t)\right]^2\right], \tag{4}$$

where in, $p_{i,j}(t)$ is the semantic similarity of machine translation of English-Chinese long sentences under the constraint of mixed corpus; $sp_{i,j}(t)$ is the multistrategy similarity in machine translation of English-Chinese long sentences under the constraint of the mixed corpus; $\Delta p(t)$ combines the reference values for the Bayesian network model [11] of English-Chinese long sentence machine translation under the constraint of the mixed corpus; $z_i(t)$ and $z_j(t)$ respectively represent ontology mapping of machine translation thesaurus. According to the above analysis, the overall structure model of machine translation of English-Chinese long sentences under the constraint of the mixed corpus is shown in Figure 2.

2.2. Concept Tree of Context Semantic Mapping of Machine Translation. The establishment of semantic mapping between machine translation ontologies of English-Chinese long sentences under the constraint of the mixed corpus needs to consider the context relationship of machine translation. The context mapping method is used to construct the concept tree model of machine translation. The multi-fuzzy semantic automatic judgment is performed via model. The big data fusion cluster analysis method is used to realize dynamic resource reorganisation and feature screening control [12]. The phase space distribution structure model of English-Chinese long sentences under the constraint of the mixed corpus is constructed. By using the method of fuzziness detection, the characteristic scalar time series of English-Chinese long sentences under the constraint of the mixed corpus is $x(t)$, $t = 0, 1, \cdots, n-1$. Given the numerical attribute and classification attribute feature quantity of English-Chinese long sentences under the constraint of the mixed corpus, the distribution sequence of fuzzy association rules [13] of English-Chinese long sentences under the constraint of the mixed corpus is $x_1, x_2, \cdots x_n \in C^m$ (m-dimensional complex space). In the fuzzy clustering center, the sparsity feature points of English-Chinese long sentences under the constraint of the mixed corpus are $P_i = (p_{i1}, p_{i2}, \cdots p_{iD})$, where

$$j \in N_i(k), N_i(k) = \left\{\left\|x_j(k) - x_i(k)\right\| < r_d(k)\right\}. \tag{5}$$

In the distributed subspace of English-Chinese long sentences under the constraint of the mixed corpus, considering the relevance of resource attributes, the fuzzy set [14] of English-Chinese long sentences under the constraint of the mixed corpus is obtained by the method of fuzzy association rules scheduling, and the semantic correlation function of grammar analysis with the largest semantic correlation of English-Chinese long sentences under the constraint of the mixed corpus is obtained as follows:

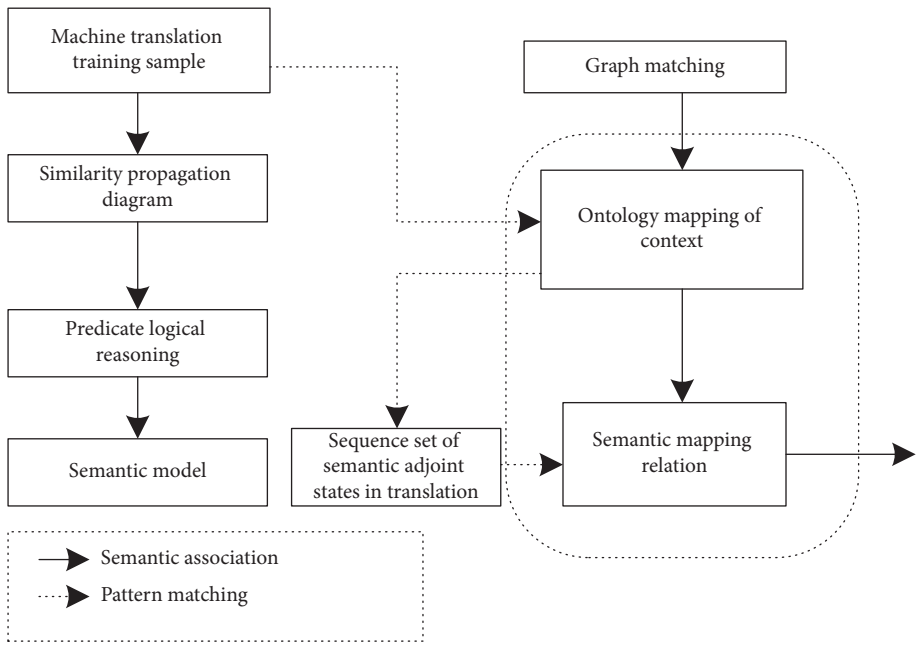

Figure 2: Structure model of machine translation of English-Chinese long sentences under the constraint of the mixed corpus.

$$f(k) = \begin{cases} f(k-1) - \dfrac{1}{n}, & 1 \le k < n, \\ 1, & k = n. \end{cases} \tag{6}$$

The decision tree Wi of residual data segmentation is constructed under the mixed corpus constraint by weighting the semantic modification target between two words of English-Chinese long phrases. Under the I-th grammar analysis scheme, the concept set [15] of context semantic mapping of English-Chinese long sentence allocation semantic tree vocabulary semantic library under the constraint of the mixed corpus can be recorded as follows:

$$D''_{i,j}(t_{n+1}) = \frac{D'_{i,j}(t_{n+1}) + f(n) D'_{i,j}(t_n)}{2}. \tag{7}$$

Under the constraint of the mixed corpus, the main features of prepositional function words in English-Chinese translation are extracted as follows:

$$f_{Ai} = K_{SVO} * (match(S,V) + match(O,V)) + \sum_{i=1}^{n} match(W_i, W_{Gi}). \tag{8}$$

The fuzzy clustering [16, 17] of English-Chinese long sentences under the mixed corpus of the i-th classification attribute is taken, the quantitative regression analysis results of English-Chinese long sentences under the mixed corpus is obtained, and the semantic similarity at time T and time T+1 is analyzed, finds all clauses, and calculates the maximum semantic relevance of English-Chinese long sentences under the mixed corpus as follows:

$$I_{i,j}(t) = \frac{\sum D''_{i,k}(t) D''_{k,j}(t)}{\sum D''_{i,k}(t)}. \tag{9}$$

In the context of semantic mapping of English-Chinese long sentence translation under the constraint of the mixed corpus, the simple semantic unit of English-Chinese long sentence attribute under the constraint of the premixed corpus is expressed as follows:

$$\widehat{S}_w = \sum_{i=1}^{c} p_i 1/n_i \sum_{k=1}^{n_i} \left[\left(\vec{X}_k^{(i)} - \vec{m}_i \right) \left(\vec{X}_k^{(i)} - \vec{m}_i \right)^T \right]. \tag{10}$$

The binary structure feature distribution set of English-Chinese long sentences constrained by the mixed corpus is established in the virtual database, and the context semantic mapping features of simple semantic units of English-Chinese long sentences constrained by the mixed corpus are arranged in descending order as follows:

$$S\left(\vec{X}_1\right) \ge S\left(\vec{X}_2\right) \ge \cdots \ge s\left(\vec{X}_l\right). \tag{11}$$

The conceptual tree structure model of context semantic mapping for machine translation of English-Chinese long sentences under the constraint of the mixed corpus is obtained by different boundary division schemes, as shown in Figure 3.

In Figure 3, the target attribute values of the semantic modification of English-Chinese long sentences are mapped into the semantic mapping idea tree, and the fuzziness of sentences is automatically assessed. In the experimental process, the dynamic feature mining of the subject word list in English-Chinese long sentence translation under the constraint of the mixed corpus is realized by the methods of extracting the best semantic relevance

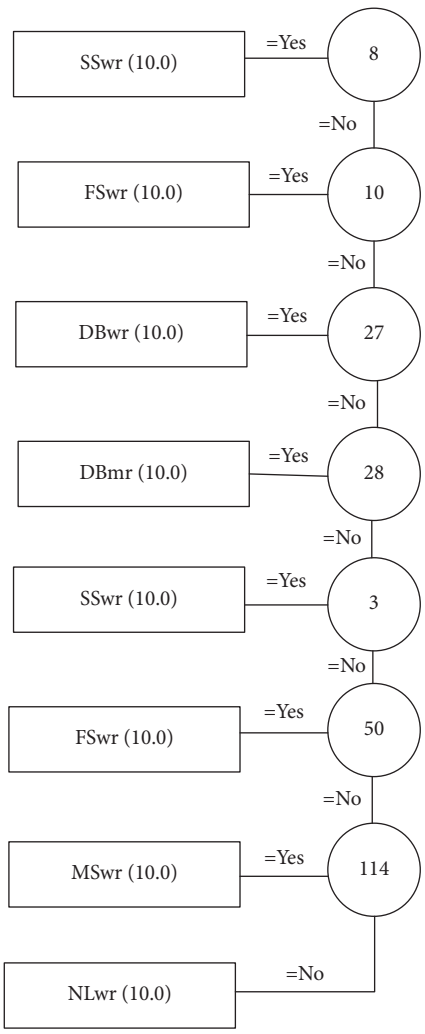

Figure 3: Conceptual tree structure of context semantic mapping of English-Chinese long sentences under the constraint of the mixed corpus.

and analyzing the concept tree of contextual semantic mapping. In the intrinsic distribution sequence of semantic mapping between concepts, the high-order spectrum of English-Chinese long sentences constrained by the mixed corpus is extracted, and it is transformed into the progressive semantic feature analysis of simple semantic units and the adaptive adjoint tracking recognition [18, 19] of machine translation. According to a microlevel analysis of the semantic components of English and Chinese causative resultative constructions, the semantic properties of English and Chinese causative semantic elements are relatively similar, but the syntactic units that reflect the semantic components are different. The sorts of transitivity processes, semantic configuration structure, and syntactic functions of English and Chinese causative resultants are found to differ significantly on a macro level when the functional semantic syntax of these resultants is examined. English only expresses the causative process but lacks the causative action process and the causative psychological process, which is related to the nature of syntactic units that embody English and Chinese causative results. After semantic analysis and machine translation modification in the C4.5 decision tree, the schematic diagram of the process of converting long sentences into short sentences is shown in Figure 4.

3. Realization of Machine Translation of Long Sentences

3.1. Rule Reduction of Machine Translation of Long Sentences from English to Chinese. In the distribution structure space of English-Chinese long sentences under the constraint of the mixed corpus, the method of extracting the best semantic relevance and analyzing the concept tree of context semantic mapping is adopted to mine the dynamic features of the keyword list in English-Chinese long sentence translation under the constraint of the mixed corpus. In the intrinsic distribution sequence of semantic mapping between concepts, a fuzzy semantic feature extraction model of text information is established. The reduction rule function of machine translation of English-Chinese long sentences under the constraint of the mixed corpus is described as follows:

$$\begin{aligned} x(2k+1) &= (x(2k)+x(2k+2))*a+x(2k+1)x(2k) \\ &= (x(2k-1)+x(2k+1))*b+x(2k)x(2k+1) \\ &= (x(2k)+x(2k+2))*c+x(2k+1)x(2k) \\ &= (x(2k-1)+x(2k+1))*d+x(2k). \end{aligned} \tag{12}$$

The English-Chinese long phrase machine translation feature decomposition formula is expressed as an S, V, and O decomposition operation after numerous iterations of target clause creation. The maximum spanning tree matrix A of each simple semantic is then calculated, which is a real matrix of SD. English-Chinese double object structure includes double-name structure and dative structure, which is set as the target clause, with M-order orthogonal semantic reduction rule matrix U and N-order orthogonal matrix V. After SVM decomposition, the weight of English-Chinese long sentence machine translation under the constraint of the mixed corpus is determined.

$$\begin{aligned} A &= \mathrm{USV}' = U\begin{pmatrix} \sum & 0 \\ 0 & 0 \end{pmatrix}V', U*U' = I, V*V' = I \\ \sum &= \mathrm{diag}(\sigma_1,\sigma_2,\sigma_r)\sigma_1 \geq \sigma_2 \geq \cdots \geq \sigma_r > 0, \end{aligned} \tag{13}$$

where, A is $m \times n$ matrix, $A*A'$ and $A'*A$ are the square root of information fuzzy semantic feature extraction in the lexical-semantic calculation of English-Chinese long sentences under the constraint of the mixed corpus. The rule information set of English-Chinese long sentence translation under the constraint of the mixed corpus is described as follows:

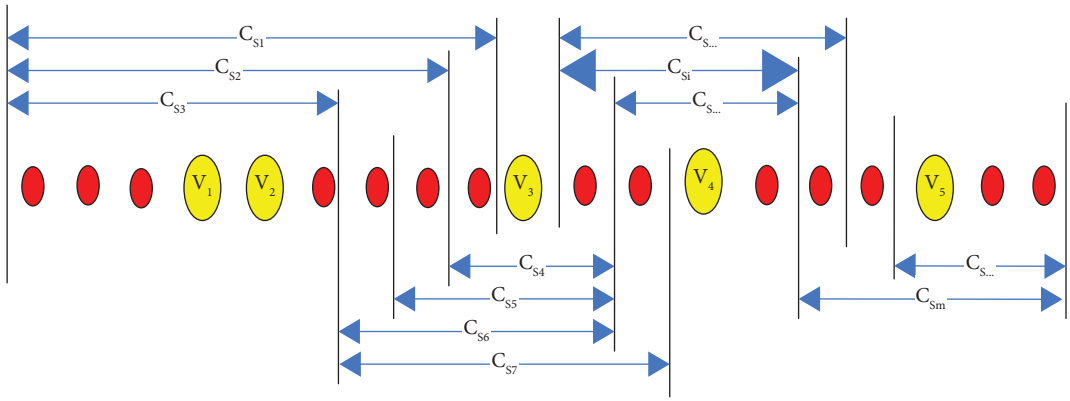

Figure 4: Schematic diagram of the process of converting long sentences into short sentences.

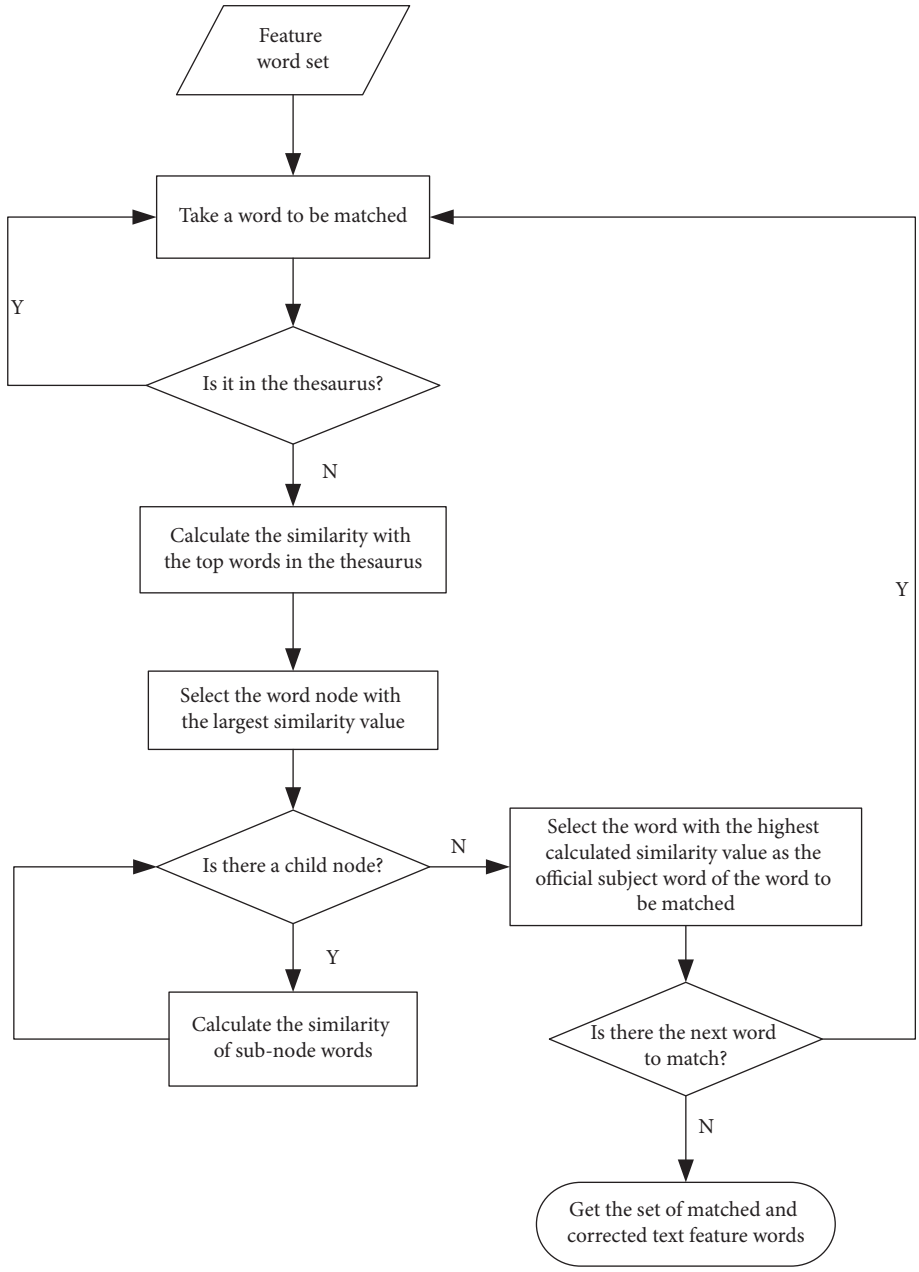

Figure 5: The process of machine translation of English-Chinese long sentences under the constraint of the mixed corpus.

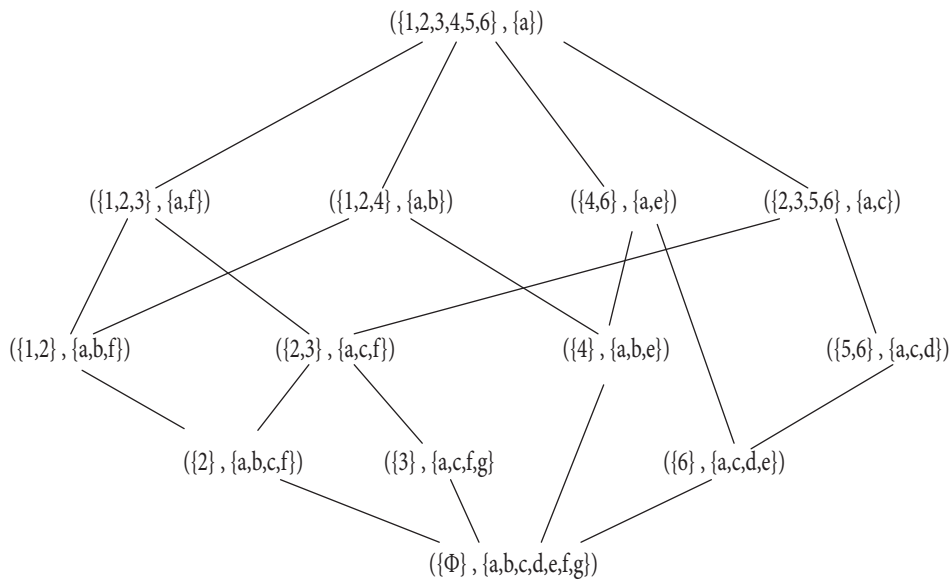

Figure 6: Parameter setting of concept tree of context semantic mapping.

$$u(t) = A(t)\exp\left[j\theta(t)\right] = A(t)\exp\left[-j2\pi K\ln\left(1-\frac{t}{t_0}\right)\right], \tag{14}$$

wherein, $A(t)$ is the envelope amplitude of vocabulary meaning of English-Chinese long sentences under the constraint of the mixed corpus. According to the multi-transformation method, the maximum utility fitness function of English-Chinese long sentences under the constraint of the mixed corpus is calculated. According to unsupervised machine learning, the information fusion scheduling model of English-Chinese long sentences under the constraint of the mixed corpus is s_h^w, and the global optimal solution $E(T_k^w - \xi_k^w(\omega) \mid T_k^w \geq \xi_k^w(\omega))$ of dynamic attribute translation of English-Chinese long sentences under the constraint of each mixed corpus can be expressed as follows:

$$f_i(t) = \frac{1}{2\pi}\frac{\mathrm{d}\theta}{\mathrm{d}t} = \frac{K}{t_0 - t}. \tag{15}$$

The attributive clauses of machine translation are summed up, the best grammar analysis is carried out, and the reduction rule function of English-Chinese long sentences under the constraint of the mixed corpus is constructed as follows:

$$u_a(t) = \frac{1}{\sqrt{a}}A\left(\frac{t}{a}\right)\exp\left[-j2\pi K\ln\left(1-\frac{t}{at_0}\right)\right]. \tag{16}$$

The fuzzy semantic combination features of English-Chinese long sentences are extracted under the constraint of the mixed corpus, and the rule reduction output of machine translation of English-Chinese long sentences is as follows:

$$f_{i,a}(t) = \frac{K}{at_0 - t} = \frac{K}{t_0 - \left[t + (1-a)t_0\right]}. \tag{17}$$

Binary structure combination control is adopted, $\tau^* = (1-a)t_0$ is adopted, and the reduction output of English-Chinese long sentence machine translation is restricted by the mixed corpus.

$$f_{i,a}(t) = f_i\left(t + \tau^*\right). \tag{18}$$

In the intrinsic distribution sequence of semantic mapping between concepts, the fuzzy semantic combination feature quantity of English-Chinese long sentences constrained by the mixed corpus is extracted. According to the distribution result of word knowledge priority selection sequence, multifuzzy semantic automatic judgment is made to provide accurate information input basis.

3.2. Step Description of English-Chinese Translation of Long Sentences under the Constraint of the Mixed Corpus. The fuzzy semantic feature [20] decomposition of English-Chinese long sentences under the constraint of the mixed corpus is described as follows:

(1) According to the thesaurus of multi-fuzzy semantic object set O of English-Chinese long sentences under the constraint of the mixed corpus, the concept subset clauses of English-Chinese long sentence translation under the constraint of the mixed corpus are obtained.

(2) Select clauses of dynamic matching words in English-Chinese long sentences under the constraint of the mixed corpus for S, V, and O decomposition and determine reasonable weights to obtain several simple main sentence units of multi-fuzzy semantics in English-Chinese long sentence translation under the constraint of the mixed corpus.

(3) Calculate the semantic correlation values of common attributes of fuzzy semantic feature units of English-Chinese long sentences under the constraint of the

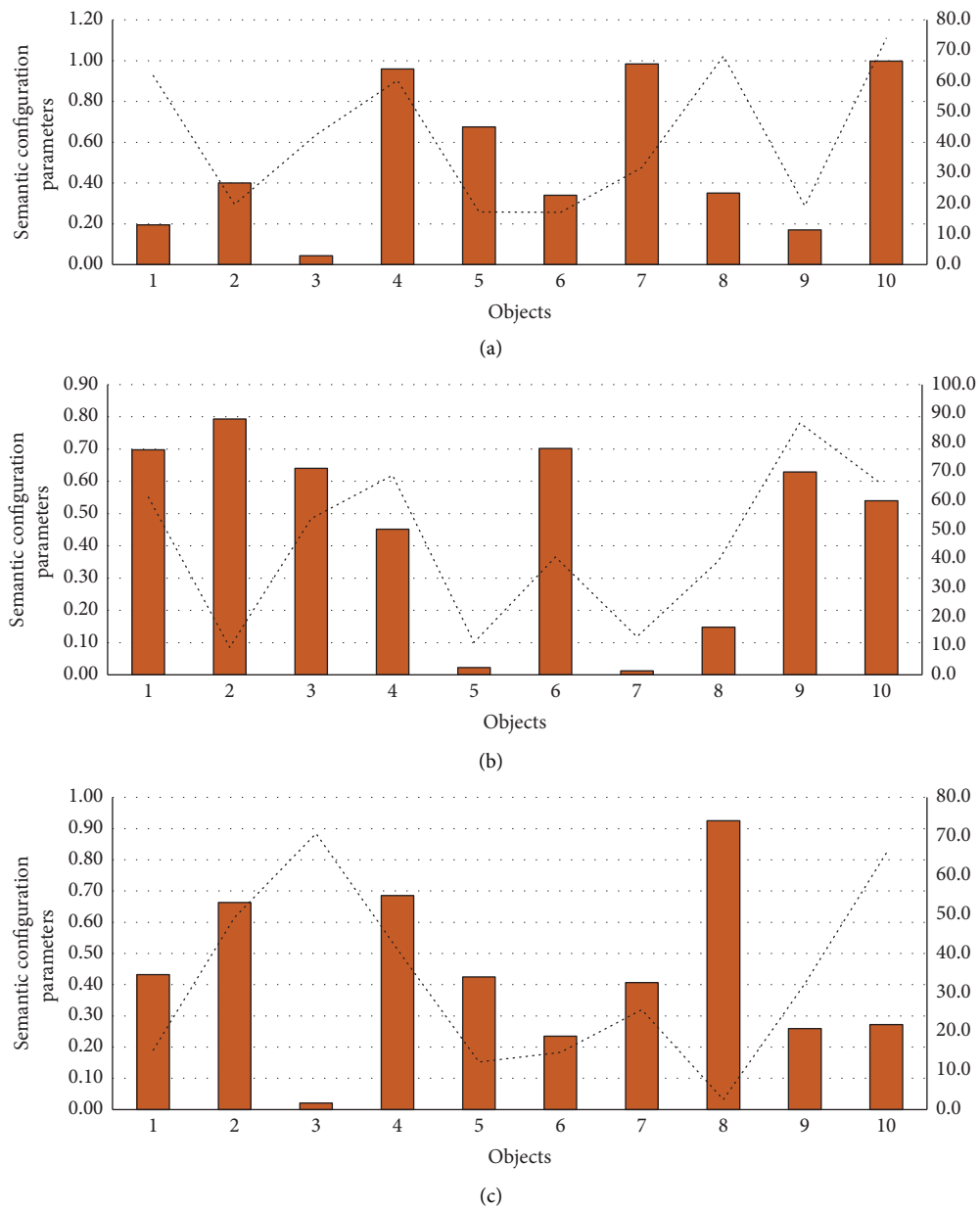

Figure 7: The results of semantic linear fitting of English-Chinese long sentences under the constraint of the mixed corpus. (a) Corpus A. (b) Corpus B. (c) Corpus C.

mixed corpus, and define the fuzzy semantics of English-Chinese long sentence translation under the constraint of the mixed corpus as g(I): = {*o* O| A I, *o* R A}.

(4) Automatically judging and searching according to the topmost node in the subject word list of English-Chinese long sentences under the constraint of the mixed corpus and calculating the characteristic word value of the object set O of the concept tree of English-Chinese long sentences under the constraint of the mixed corpus.

(5) Reduce the matched and corrected text to a vocabulary. For the concept sets *o* O, A A of English-Chinese long sentences restricted by the mixed corpus, if the convergence conditions are met, the machine translation results obtained are fuzzy, so go back to step 2 and redefine the basic units of the thesaurus; otherwise, go to the next step.

(6) According to the matching algorithm of the subject word list of English-Chinese long sentences under the constraint of the mixed corpus, the multi-fuzzy semantic automatic judgment of machine translation [21] of English-Chinese long sentences under the constraint of the mixed corpus is realized, and the corresponding best grammar analysis result is obtained.

(7) Adjust the headings (predicates) of English-Chinese long sentences under the constraint of the mixed

corpus, automatically register and judge the fuzzy semantics of English-Chinese long sentences under the constraint of the mixed corpus, and get the weight coefficient KS of English-Chinese long sentences under the constraint of the mixed corpus and make an experimental comparative analysis.

According to the above analysis, the flow chart of machine translation of English-Chinese long sentences under the constraint of the mixed corpus is shown in Figure 5.

4. Experimental Test Analysis

The programming language JAVA 1.5.4 is used as the programming software for multi-fuzzy semantic analysis and judgment programming in machine translation, and the development environment is Eclipse 3.4.2. Under the constraint of the tested mixed corpus, the machine translation of English-Chinese long sentences comes from the position-TAg1 text database, and the information attribute set consisting of A, B, C, and D4 semantic features is obtained by selecting $k = 4$. Set the dimension of spatial dynamic distribution of English-Chinese long sentences under the constraint of the mixed corpus as 12, the sample size of English-Chinese long sentences under the constraint of the mixed corpus as 1200, the training set as 100, the iteration times of fuzzy clustering of English-Chinese long sentences under the constraint of the mixed corpus as 300, and use ICTCLAS2015 machine translation software for batch Chinese-English machine translation. The number of characteristic words $(1'', 1') = (\{1, 4\}, \{a, r, f\})$, $(1'', 2') = (\{2\}, \{a, c, d, e\})$ in machine translation of English-Chinese long sentences under the constraint of the mixed corpus, and the concept tree of context semantic mapping of English-Chinese long sentences under the constraint of the mixed corpus is set. Parameter setting of concept tree of context semantic mapping is shown in Figure 6.

According to the above simulation environment and parameter settings, the multi-fuzzy semantic automatic judgment of machine translation of English-Chinese long sentences under the constraint of the mixed corpus is carried out, and the results of semantic linear fitting of English-Chinese long sentences under the constraint of the mixed corpus are shown in Figure 7.

The analysis of Figure 7 shows that, when limited by a mixed corpus, machine translation of English-Chinese long sentences has a strong semantic allocation capacity. The matching degree of English-Chinese language structure types is discovered using the results of the linear fitting of English-Chinese long sentences with the mixed corpus constraints. By using this method and traditional methods, the comparison results of semantic matching degree of machine translation of English-Chinese long sentences under the constraint of the mixed corpus are shown in Figure 8.

Analysis of the simulation results in Figure 8 shows that the semantic matching degree of English-Chinese long sentence machine translation under the constraint of the mixed corpus is high, and the feature registration rate of context semantic mapping is greatly improved, which is superior and improves the accuracy of English-Chinese long sentence machine translation under the constraint of the mixed corpus [20].

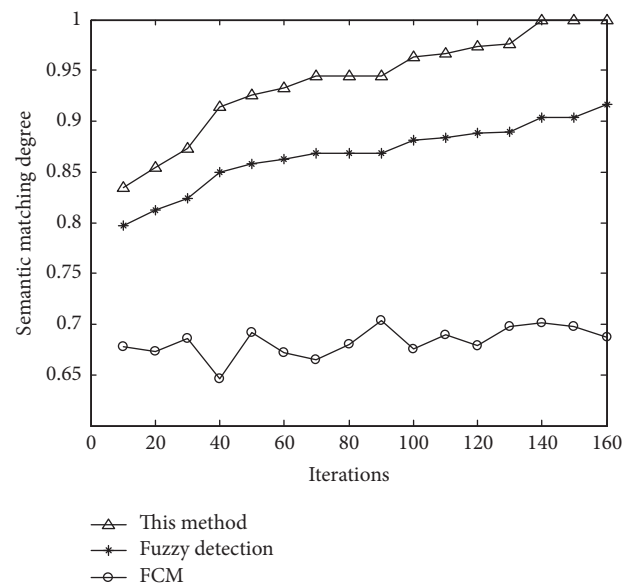

Figure 8: Comparison of feature registration rates of semantic mapping.

5. Conclusions

In this paper, a machine translation method of English-Chinese long sentences based on fuzzy semantic optimization is proposed. The English-Chinese long sentence subject list ontology mapping model is created under the restriction of the mixed corpus by using the method of systematic semantic configuration structure fusion. In the distribution structure space of English-Chinese long sentences under the constraint of the mixed corpus, the method of extracting the best semantic relevance and analyzing the concept tree of context semantic mapping is adopted to mine the dynamic features of the subject list of English-Chinese long sentence translation under the constraint of the mixed corpus. In the intrinsic distribution sequence of semantic mapping between concepts, the fuzzy semantic combination features of English-Chinese long sentences under the constraint of the mixed corpus are extracted, and according to the distribution results of word knowledge priority selection sequence, the automatic translation of English-Chinese long sentences under the constraint of the mixed corpus is realized by scheduling grammatical error correction task list. The simulation results show that the semantic configuration ability of machine translation of English-Chinese long sentences under the constraint of the mixed corpus is good, and the matching degree between English and Chinese language structures is high, which improves the automatic translation ability of English-Chinese long sentences under the constraint of the mixed corpus. This method has a good application value in the design of machine translation software for English-Chinese long sentences under the constraint of the mixed corpus [22].

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Application of Experiential Education Based on Modern Teaching Concept in College Management

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Experiential teaching is based on modern teaching approaches, including the construction of knowledge, the generation of emotion, and the development of ability through students' personal experiences. Compared with traditional teaching, it has characteristics of autonomy, practice, and interaction. This is conducive to promote students' autonomous learning, speeding up the transfer of knowledge and experience, and improving students' personal comprehensive ability. There are various forms of experiential teaching methods in management teaching, but they should be selected reasonably according to the teaching contents. In the actual application of experiential teaching, teachers should carefully design teaching plans, pay attention to comments and summaries, and ensure the unity of theoretical teaching and experiential learning. This research work investigates experiential teaching based on modern teaching concepts and explores three application mechanisms of the experiential teaching method in the first stage. In the second stage, it proposes an algorithm to evaluate the promotion of experiential education based on modern teaching concepts in college management. The proposed algorithm is named improved gray wolf optimization-Back Propagation (IGWO-BP). IGWO balances the full search and the local search through a nonlinear convergence factor and makes the leadership gray wolf dynamically guide the population forward through a variable proportional weight. Then, IGWO is used to optimize the BP network to improve evaluation accuracy and convergence speed. Compared with the state-of-the-art machine learning methods, the proposed mechanism achieves the highest accuracy of 94.6% and an F1 score of 91.3%.

1. Introduction

The traditional teaching method of management is dominated by teachers' classroom teaching, which has obvious shortcomings. The creation of the teaching situation is to reproduce the actual things or the relevant background of the knowledge expressed in the book in an intuitive way. According to the management situation created by the teacher's oral language, it is difficult to stimulate a desire to learn with emotion; it is limited to the rote memorization of words. The experiential teaching mode with modern teaching concepts attaches great importance to the dominant position, and it emphasizes students' classroom participation and emotional experience, which is conducive to the realization of the teaching goal of cultivating strong practical ability in management. There are a variety of formative approaches that can be used to enhance the student experience in the actual teaching of management courses. This is of great significance for cultivating management talents that are needed by enterprises, have high comprehensive ability, and can solve practical problems of enterprise management [1–5].

Experiential teaching based on the modern teaching concept is to present the teaching knowledge by creating a realistic situation according to self-knowledge as well as learning rules in the teaching process and apply the complex and abstract theoretical knowledge and skills to practice. This enables students to gain insight into the process, lighten their own experience into experience, and have a deeper understanding and understanding of knowledge. Experiential teaching attaches importance to students' comprehension of learning content, attaches importance to learning methods, promotes rational learning knowledge and skills, and creates healthy personality charm. Its purpose is to enable students to improve their management awareness and management ability [6–10].

First, experiential teaching can stimulate interest and improve innovative ability. Experiential teaching not only emphasizes the active participation of students to stimulate interest but also emphasizes teachers guide students to understand society and enter society through various practical activities. In experiential teaching activities, students experience theoretical knowledge through active participation, which in turn drives students' learning enthusiasm and initiative. Expanding students' theoretical knowledge will stimulate students' creativity. In the teaching process, students' autonomy will be exercised, an atmosphere of independent thinking will be created, and students will be encouraged to use their own thinking to complete the entire teaching activity. Secondly, experiential teaching can improve the rigor of teaching content and conform to the nature of the discipline. Management is a multi-disciplinary interdisciplinary course with strong practicality, and it is particularly important to highlight its practicality. Experiential teaching mode is based on theoretical knowledge, appropriately introducing cutting-edge knowledge to broaden students' knowledge, and through experiential teaching, let students enter the society. This allows students to create teaching situations by actively observing, comparing, and summarizing destinations, enabling them to experience knowledge happily and actively and to construct and enrich their own knowledge structures in all aspects. This is an effective teaching model that enhances students' learning initiative by interacting with the team. As the international community communicates with teachers, they make correct assessments and revisions to their own assumptions, thereby improving the rigor of teaching content. Finally, experiential teaching can improve the scientific nature of teaching methods and meet cognitive needs. Different from the traditional method, experiential teaching emphasizes interaction and pays attention to the whole process of teaching. Through teacher guidance and student practice, the theoretical knowledge is integrated into social practice; students can melt, absorb and experience theoretical knowledge in the classroom through multimedia cases, social practice investigation, project practice, and other experience methods. The core of experiential teaching: Applying experiential learning in management disciplines to other aspects of learning and life not only satisfies students' thirst for knowledge but also expands students' knowledge skills and social skills. With the rapid development of the Internet today, college students, as the mainstream group of network applications, have undergone profound changes in their knowledge sources. In the experiential teaching method, teachers no longer simply impart theoretical knowledge but need to guide students to think deeply, help students find problems, and analyze problems and try to solve them. It is also in line with the cognitive needs of contemporary college students to experience and verify knowledge through their own perception and cognition [11–15].

Experiential teaching methods in management require the features of autonomy, practice, and interaction. It is needed to promote students' autonomous learning to speed up the transfer of knowledge and experience. There are various methods for experiential teaching methods in management teaching, but there exists no proper mechanism for selecting a reasonable method according to the teaching contents. This research work will investigate and propose a mechanism named improved gray wolf optimization back propagation (IGWO-BP). IGWO-BP is used to evaluate the quality impact of experiential education based on modern teaching concepts in university management.

2. Related Work

Joshi et al. [16] define the concept of experiential teaching, which is an educational concept and method that guides students to actively participate in accordance with students' cognition to cultivate students' healthy personalities. According to Laditka & Houck [17], experiential teaching is the introduction or development of distinct situations and atmospheres in the teaching process to adapt to and awaken students' emotional experiences in accordance with the teaching content. Teaching knowledge quickly and correctly helps students absorb it while also promoting an approach that helps students develop their psychological processes in an integrated manner. Rocha [18] pointed out that experiential teaching means that teachers obtain professional growth and maturity through the experience of teaching. Developing in experience: experience is the best way and means for the development of the main body of students. For the purpose of achieving a predetermined educational goal, Koutsoukos et al. [19] believe in experiential education as an educational approach that enables students to gain understanding and construct knowledge through the use of personal experience. Sojka & Fish [20] believe that experiential teaching cannot be simply defined as a teaching mode or teaching method. In addition, it is also an innovative teaching idea that promotes the all-round development of students' personal qualities and is an internal basic requirement for implementing the value concept of quality education. Experiential teaching not only is concerned with how much knowledge is acquired in teaching but also pays attention to the development of various qualities such as individuality and innovation. Beausoleil-Morrison [21] believes that experiential teaching is not simply imparting knowledge or simply doing small experiments but a more complex practical experience. This requires teachers to create a more reasonable situation so that students can be immersed and experienced. Different knowledge requires different teaching situations. Teachers can activate the classroom atmosphere and guide students to learn independently through group discussions, simulated situations, and other methods. Chiu et al. [22] propose that it is easy to forget what is said from the mouths of others, but it is usually memorable and more emotional than what one has experienced. If experiential teaching wants to play a better role, it is significant to notice the fact that created situation must be consistent with the actual life and cognitive laws of students so that they can be immersed in it faster and better. Hill [23] pointed out that the characteristics of experiential teaching mainly include respecting the uniqueness of life, understanding the generative nature of life, being kind to the

autonomy of life, caring for the integrity of life, and integrating the truth, the good and the beautiful.

Berte & Jones [24] believe that experiential teaching transforms the teacher as the main body in the past into the student as the main body. The teacher is no longer a pure knowledge lecturer but plays the role of classroom designer, guide, and inspiration. Experiential teaching is rooted in real life and concerned about the emotional experience of students during the whole learning process; students can deeply appreciate the meaning of learning. Experiential teaching emphasizes that students actively participate in teaching. By participating in the formation process of understanding knowledge, they can generate corresponding emotions and exercise their own abilities. Mason & Arshed [25] pointed out that experiential teaching allows students to experience knowledge in the process of experiencing a teaching situation, and obtain corresponding emotional and value experiences, so as to improve the effectiveness of teaching. The direct purpose of using experiential teaching in the classroom is to improve the effectiveness of teaching activities. Dawes [26] pointed out that the characteristics of experiential teaching, from the perspective of the subject, have experience, subjectivity, and individual differences. From the process point of view, it has generative, meaningful, silent, and interactive interaction. From the point of view of purpose, it has life development, emotional purpose, and life practice. In terms of form, it is open. Wilsey et al. [27] believe that experience brings learners intuitive perception, and individuals have differences in the same experience activities, and there are corresponding emotional expressions. Dailey et al. [28] believe that this teaching form reflects the subject's own personal experience and a new interaction process. The whole teaching activity is realized in the corresponding situation, and students form a certain emotional response after experiencing the object. Kotval [29] pointed out that experiential teaching is conducive to promoting students' positive emotions, ensuring students' subject status, cultivating students' innovative spirit and practical ability, and is a good way to improve students' learning effectiveness. Fan et al. [30] studied the necessity of experiential teaching based on the importance of experience. In the literature [31, 32], various methods have been used which can equally likely be used for improving teaching quality in an educational environment. It believes that experience is the basic way of human survival and development, and only through this comprehensive psychological activity will the memory be profound. Jarmon et al. pointed out that experiential teaching requires high comprehensive ability and knowledge of teachers, and most teachers currently do not have such ability.

Autonomy, practice, and interaction are important features of experiential teaching methods in management. It is desired to promote students' autonomous learning to speed up the transfer of knowledge and experience. In the literature, there are various techniques to handle experiential teaching methods in management teaching, but there exists no proper mechanism for selecting or suggesting the best method according to the teaching contents. This research work investigates experiential teaching methods in management teaching and proposes a mechanism named improved gray wolf optimization-back propagation (IGWO-BP). IGWO-BP is used to improve the quality impact of experiential education based on modern teaching concepts in university management.

3. Method

First, this work analyzes the meaning of experiential teaching with modern teaching concepts and summarizes and analyzes three application methods of experiential teaching method. Secondly, this work proposes an IGWO-BP algorithm to evaluate the promotion of experiential education based on modern teaching concepts in college management.

3.1. Application and Construction of Experiential Teaching Method. The application methods of experiential teaching method used in this work include situational simulation teaching method, case teaching method, and management game method. The scenario simulation teaching method is based on students' traditional knowledge and experience as the basis of new knowledge. It breaks traditional thinking and constructs a new knowledge system by deliberately creating an atmosphere and situation of management activities. This is based on students' knowledge points to discuss and explore a certain management theory, collect cases and related materials from practice, and formulate situational simulation experiments suitable for students. This enables students to use vivid teaching simulation of situational simulation experiments. In the teaching simulation, students can play different roles so that their personalities can be developed to the greatest extent, and they can better guide them to explore the ideas of knowledge in practice so as to stimulate students to have a strong interest in learning. It applies social management activities to the classroom, allowing students to have a larger operating space and increasing their interest in learning. Case teaching is with the construction of students' awareness of the situation, taking students as the main body; teachers should play a good auxiliary and guiding role. This allows students to collect data and conduct careful analysis and practical verification of it. Then conduct active discussions, and make practical and effective expressions based on their own subjective consciousness and knowledge, and experience. Management game method is also an important part of experiential teaching, which is mainly a teaching method through game-based teaching thinking mode. The management game method effectively introduces some relative elements in the game into the teaching, which enables the students to learn methods in the game mode. In a sense, the management game method is a new teaching method. The whole process is similar to a game, which requires a series of processes, from game preparation and theoretical learning to practical operation. While taking students as the main body, teachers need to be responsible for guiding and supervising the whole process of game organization and game maintenance management. This method improves interest in teaching and deepens comprehensive understanding.

Management, as a discipline that focuses on practice and application, aims to cultivate managers with comprehensive qualities such as communication ability, collaboration ability, and innovation ability. After a relaxed and pleasant classroom, students may only have fragmented memories of their theoretical knowledge of management. The design of management experiential teaching mode needs to take the basic teaching content as the main line, rely on the existing teaching resources, and use a variety of teaching forms to design a multi-directional interactive teaching plan. The first is the design of teaching goals. The design of teaching goals of experiential teaching emphasizes the motivation of students to learn independently through simulation of scenarios, role-playing, participation in games, and events inside and outside the school. The second is an organization of teaching resources. In order to promote the experiential teaching method, teachers must provide students with many resources for students to explore and learn independently based on the progress of the course and their understanding ability of students. At the same time, the specific tasks of each chapter are arranged to ensure that each student can participate prepared and confidently in the specific implementation process. The last is the design of teaching evaluation. The scientific evaluation system is the baton. Each learning activity should have specific and clear evaluation indicators and evaluation standards. Self-evaluation and mutual evaluation are combined, and teachers analyze the evaluation results in the classroom. On the one hand, the weak links of students can be found and then targeted fir improvement On the other hand, teachers can also evaluate the teaching effect accordingly and adjust the teaching content and methods in time.

3.2. BP Network and GWO Algorithm. According to the connecting method of neurons, ANNs can be split into feedforward and feedback neural networks. ANNs can also be divided into unsupervised and supervised. A back propagation (BP) network is a kind of artificial neural network. Error back-propagation is used to train the multilayer feedforward neural network. In addition to being one of the most extensively used neural networks, it is a tutor learning neural network. There are three layers in a BP network: an input layer, a hidden layer, and an output layer. Kolmogorov's theorem states that when the number of nodes in the hidden layer is large enough, a three-layer BP neural network can approximate any nonlinear continuous function with any degree of precision across an infinite set. The basic structure of the three-layer network is demonstrated in Figure 1.

The activation function of the hidden layer adopts the sigmoid function. The value range of input is negative infinity to positive infinity, and the output range after activation is (0, 1). The function has very good symmetry; when the input exceeds a certain range, the function value will be insensitive to the input.

$$\text{Sigmoid}(x) = \frac{1}{(1 + \exp\ (-x))}. \tag{1}$$

The forward propagation process of BP can be summarized as the following formula:

$$\begin{aligned} a_j &= f\left(\sum_i w_{ji} x_i + b_j\right), \\ y_k &= \sum_j w_{kj} a_j + b_k. \end{aligned} \tag{2}$$

The error function needs to be defined in the back-propagation of BP

$$E = \sum_m \sum_n \left(y_n^m - o_n^m\right)^2. \tag{3}$$

The back-propagation weight and threshold update process are

$$\begin{aligned} w_{\text{new}} &= w - \eta \Delta w, \\ b_{\text{new}} &= b - \eta \Delta b. \end{aligned} \tag{4}$$

The standard BP network adjusts the weights and thresholds for the hidden layer and output layer according to the gradient descent algorithm, and its derivation process has strong reliability and versatility. Although the BP network has strong nonlinear mapping ability, high self-learning ability, and adaptive ability, it still has some limitations. The number of iterations and the final weights and thresholds vary greatly between different training. The training of the network relies on randomness and is prone to local minima. As the number of iterations increases, the convergence efficiency becomes slower, the network structure is difficult to determine, and the generalization ability is relatively poor.

The setting of the initial weights and thresholds of the BP network has a great influence on the convergence and convergence speed of the network. In the design of the BP network, the initial weights and thresholds are randomly initialized. Inappropriate values may cause the network to fall into a local optimum and fail to converge to the global optimum. The gray wolf algorithm has the advantages of simple operation and few parameters, so the gray wolf algorithm can be used to optimize the initial weights and thresholds of the BP network. Use the optimized initial weights and thresholds to train the BP network to improve the performance of the network.

GWO is an optimization search method inspired by the prey activity of gray wolves, so it belongs to a meta-heuristic algorithm. It simulates the social hierarchy mechanism and hunting behavior of gray wolf groups in nature. The GWO algorithm is a relatively new intelligent algorithm with advantages over other algorithms, such as simple structure, few parameters, and strong operability. In addition, it has strong global search ability, strong convergence performance, and easy implementation, and it can be easily combined with other algorithms to obtain better optimization performance. The mathematical model of the gray wolf algorithm can be divided into four parts, which simulate the behavior of wolf group hierarchy, tracking prey, surrounding prey, and attacking prey, respectively.

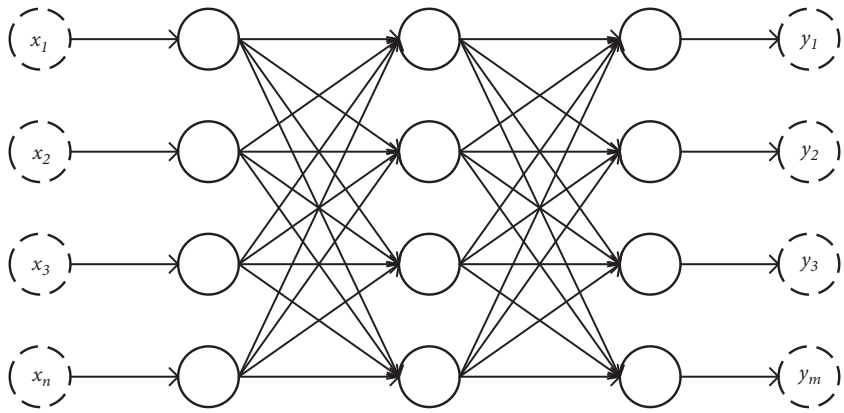

Figure 1: Back propagation (BP) network.

The gray wolf strictly abides by a social domination hierarchy. When designing the gray wolf algorithm, the gray wolf hierarchy is first simulated. According to the fitness value of each gray wolf, gray wolves can be divided into four levels. Mathematically simulate the process of surrounding the prey as

$$\begin{aligned} A &= 2ar_1 - a, \\ C &= 2r_2, \\ D &= \left|Cx_p(t) - x_i(t)\right|, \\ x_i(t+1) &= x_p(t) - AD, \\ a &= 2 - \frac{2t}{t_{\max}}. \end{aligned} \tag{5}$$

To simulate the hunting activities of gray wolves, it is assumed that the three solutions are more able to obtain potential information on the location of the prey. After each gray wolf is updated, the fitness value of each gray wolf is calculated, and the three solutions with the smallest fitness value so far are selected as the current wolf position. The next generation of gray wolves uses the three solutions as the traction to update the position of the individual.

$$\begin{aligned} x_1 &= x_\alpha - A_1\left|C_1 x_a - x_i\right|, \\ x_2 &= x_\beta - A_2\left|C_2 x_\beta - x_i\right|, \\ x_3 &= x_\delta - A_3\left|C_3 x_\delta - x_i\right|, \\ x_i(t+1) &= \frac{(x_1 + x_2 + x_3)}{3}. \end{aligned} \tag{6}$$

3.3. IGWO-BP Algorithm. GWO is gaining popularity as a new form of swarm intelligence optimization algorithm because of its simplicity in parameter configuration and superior optimization results. Although it has the advantage of being simple to fall into a local optimum in the later stages, it also has the disadvantage of being sluggish to convergence, like other swarm intelligence optimization algorithms. This work balances global search and local search through a nonlinear control parameter (NLCP) strategy and dynamically guides the population forward through a variable proportional weight (VPW) to speed up the algorithm convergence speed and avoid local optimum.

In the swarm intelligence optimization algorithm, it is very important to coordinate the global search and the local search. Global search means that the swarm needs to explore a wider search area to avoid the algorithm getting stuck in a local optimum. The local search means performing a fine search on some areas of the population, which has a great influence on convergence speed. Only when the swarm intelligence optimization algorithm can coordinate global search and local development well can it have better robustness and faster convergence speed.

The parameter A of the GWO algorithm is important in coordinating global search and local search. The value of parameter A changes as the control parameter a changes. Parameter a decreases linearly from 2 to 0, but the convergence process of the gray wolf algorithm is not linear. Therefore, this linear control strategy cannot fully reflect the actual convergence process. Inspired by the decreasing inertia weight factor of the PSO algorithm, this work proposes a nonlinear control parameter strategy.

$$a = a_1 - \frac{(a_1 - a_2)t^2}{T_{\max}^2}. \tag{7}$$

Compared with the original linear decline, the control parameters change nonlinearly. In the early stage, its decreasing speed becomes slower, which can increase the global search ability and avoid falling into local optimum. In the later stage, the decrement speed of this parameter is accelerated, which can speed up the algorithm optimization speed. This can effectively balance the global search and the local search.

In the design of the gray wolf algorithm, three gray wolves with the smallest fitness up to the current iteration

number are selected by the size of the fitness. They had the same amount of guidance during the location update process, but in practice, the first group was the leader of the gray wolf population, while the other two wolves were helping the first group make decisions. Therefore, updating the position by the same weight ratio cannot reflect the leadership degree among the gray wolves. In this paper, the fitness scale is calculated as a variable proportional weight of the position update equation, and a new variable proportional weight is formed by combining the proportional weight based on the step size Euclidean distance. Through this mechanism, the gray wolf in the leadership can dynamically guide the gray wolf forward, improve optimization performance, speed up the convergence speed, and prevent the algorithm from falling into local optimum.

$$\begin{aligned}
w_{a1} &= \frac{\left[f(x_\alpha) + f(x_\beta) + f(x_\delta)\right]}{f(x_\alpha)}, \\
w_{b1} &= \frac{\left[f(x_\alpha) + f(x_\beta) + f(x_\delta)\right]}{f(x_\beta)}, \\
w_{c1} &= \frac{\left[f(x_\alpha) + f(x_\beta) + f(x_\delta)\right]}{f(x_\delta)}, \\
w_{a2} &= \frac{|x_1|}{\left(\mathrm{sum}\left(|x_1|, |x_2|, |x_3|\right)\right)}, \\
w_{b2} &= \frac{|x_2|}{\left(\mathrm{sum}\left(|x_1|, |x_2|, |x_3|\right)\right)}, \\
w_{c2} &= \frac{|x_3|}{\left(\mathrm{sum}\left(|x_1|, |x_2|, |x_3|\right)\right)}, \\
w_1 &= \frac{w_{a1}w_{a2}}{\mathrm{sum}\left(w_{a1}w_{a2}, w_{b1}w_{b2}, w_{c1}w_{c2}\right)}, \\
w_2 &= \frac{w_{b1}w_{b2}}{\mathrm{sum}\left(w_{a1}w_{a2}, w_{b1}w_{b2}, w_{c1}w_{c2}\right)}, \\
w_3 &= \frac{w_{c1}w_{c2}}{\mathrm{sum}\left(w_{a1}w_{a2}, w_{b1}w_{b2}, w_{c1}w_{c2}\right)}, \\
x_i &= w_1x_1 + w_2x_2 + w_3x_3.
\end{aligned} \tag{8}$$

Finally, the improved GWO algorithm is applied to BP network optimization to construct the IGWO-BP network. Applying IGWO-BP to evaluate the quality impact of experiential education based on modern teaching concepts in university management. The process of IGWO-BP is illustrated in Figure 2.

4. Experiment

4.1. Evaluation of IGWO-BP. This work used IGWO-BP to evaluate the quality of university management after using experiential education with modern teaching concepts. First, collect the corresponding data sets. The datasets used in this work come from the databases of various universities and contain a total of 92,760 samples, of which 60,387 are training samples, and the rest are test samples. The input features of each sample are shown in Table 1, and the corresponding labels are the corresponding evaluation quality.

Firstly, the training process of IGWO-BP is analyzed. This work shows the change of training loss during the training process, as demonstrated in Figure 3.

During the first 100 iterations, the network loss drops significantly. After 100 iterations, the network loss no longer decreases significantly, at which time IGWO-BP converges.

This work compares IGWO-BO with other methods, including decision tree, SVM, and RBF. The accuracy and F1 score of the four strategies are demonstrated in Table 2.

Compared with the other three machine learning methods, IGWO-BP achieves the highest accuracy and F1 score of 94.6% and 91.3%, respectively. Compared with the RBF network, it has increased by 2.4% and 2.6%, respectively.

Compared with the traditional GWO algorithm, the proposed IGWO uses the NLCP strategy for optimization. To verify the reliability of the NLCP strategy, the accuracy and F1 score are compared without and when the strategy is used, and the results are demonstrated in Figure 4.

Compared with not using NLCP, after embedding this strategy, IGWP-BP can obtain 1.7% accuracy and 1.8% F1 score promotion. This corroborates the feasibility of using the NLCP strategy.

Compared with the traditional GWO algorithm, the proposed IGWO uses the VPW strategy for optimization. To verify the reliability of the VPW strategy, the accuracy and F1 score are compared without and when the strategy is used, and the results are demonstrated in Figure 5.

Compared with not using VPW, after embedding this strategy, IGWP-BP can obtain 2.1% accuracy and 1.9% F1 score promotion. This corroborates the feasibility of using the VPW strategy.

Finally, in order to verify the correctness of using IGWO to optimize the BP network, the performances of BP, GWO-BP and IGWO-BP are compared, respectively, and the results are demonstrated in Table 3.

The accuracy and F1 score corresponding to the BP network is the lowest. When GWO is introduced to optimize BP, the two performance indicators can be improved to a certain extent. When the GWO algorithm is further improved, the highest performance can be obtained.

4.2. Evaluation of Experiential Education. This section compares whether the quality of management education in colleges and universities has been improved after using the experiential education method based on modern teaching concepts (MCCEE). The indicators compared in this work are the eight (08) indicators mentioned in Table 1, and the detailed experimental results are demonstrated in Figure 6.

From the experimental results of Figure 6, it can be seen that after using the experiential education method based on

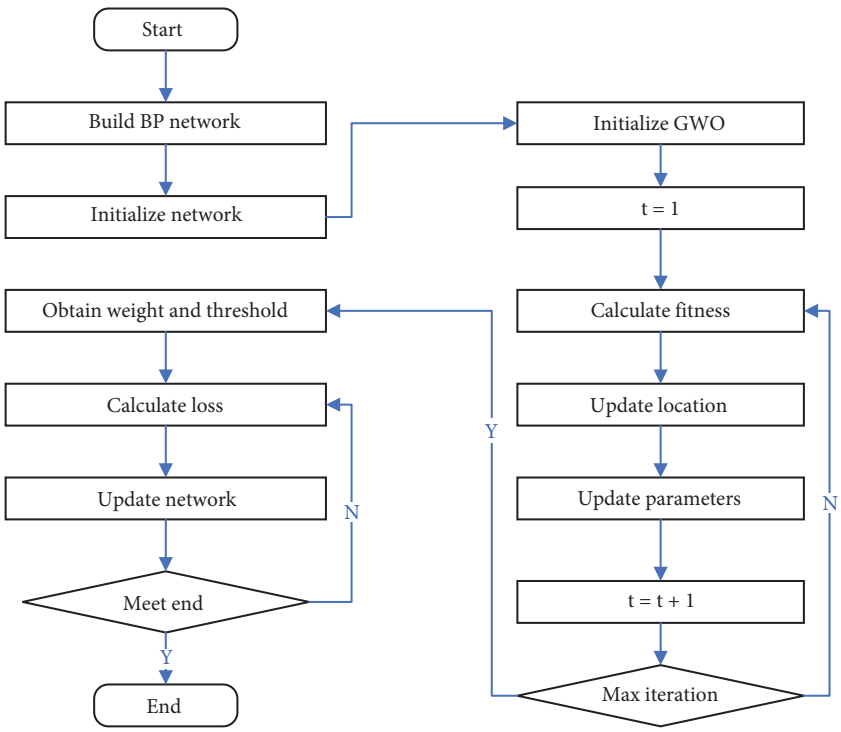

Figure 2: IGWO-BP pipeline.

Table 1: Feature information of the used data.

Index	Feature
x_1	Teaching attitude
x_2	Teaching content
x_3	Class order
x_4	Education resource
x_5	Experimental content
x_6	Homework assignment
x_7	Teacher-student interaction
x_8	Test score

Table 2: Method comparison result.

Method	Accuracy	F1 score
Decision tree	87.3	85.8
SVM	89.5	87.2
RBF	92.2	88.7
IGWO-BP	94.6	91.3

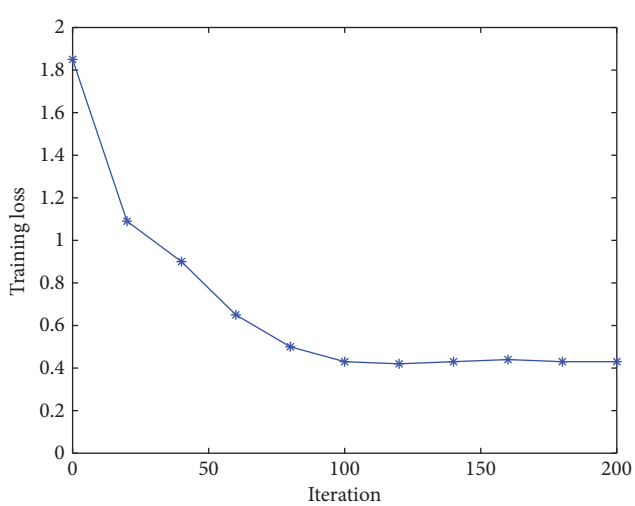

Figure 3: Training loss of IGWO-BP.

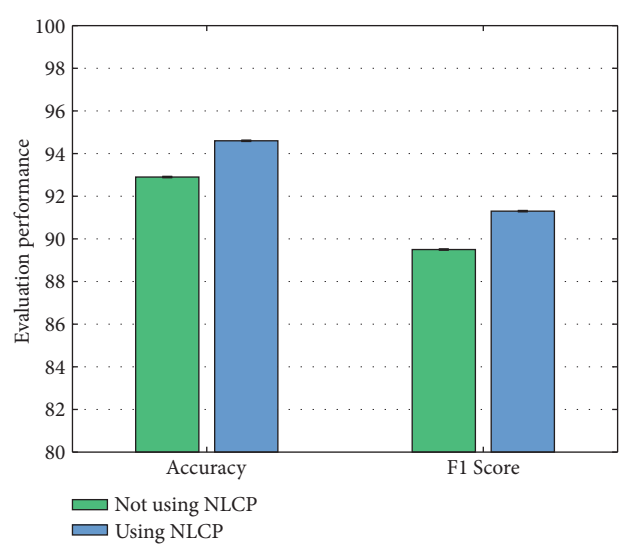

Figure 4: Comparison of using NLCP and without NLCP.

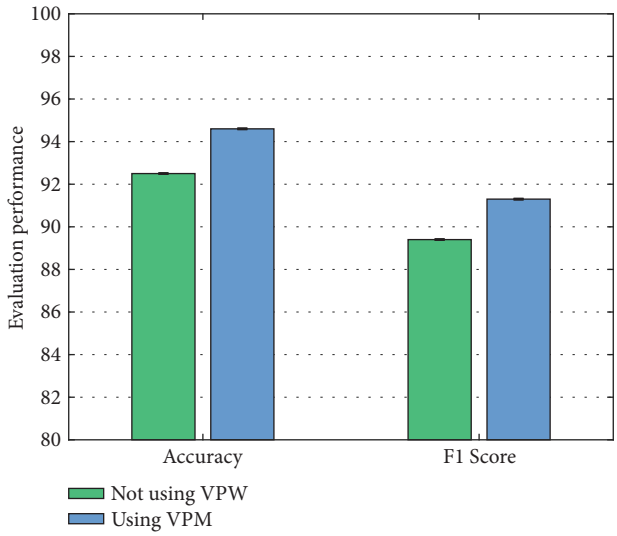

Figure 5: Comparison of using VPW and without VPW.

Table 3: Comparison of three different BP methods.

Method	Accuracy	F1 score
BP	90.2	87.8
GWO-BP	91.8	88.6
IGWO-BP	94.6	91.3

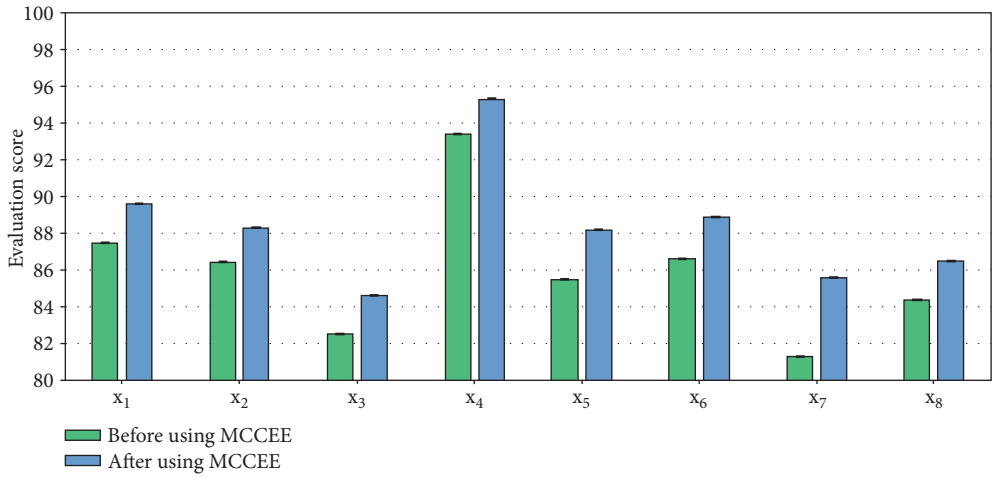

Figure 6: Evaluation of using MCCEE for the indicators.

modern teaching concepts, the quality of management education in universities has improved accordingly. This verifies the feasibility of applying experiential education based on modern teaching concepts to management education in colleges and universities proposed in this work.

5. Conclusion

Management tells students that management refers to the process of integrating the resources of the organization and achieving the established goals of the organization through the execution of functions such as planning, organization, leadership, and control under a specific environment. The experiential teaching method is a creative teaching method under modern education and teaching concept, which aims to stimulate intrinsic interest in learning through teaching experience. Today, emphasizing the cultivation of personal comprehensive ability, the experiential teaching method is gradually replacing the traditional teaching method. This allows students to realize the cultivation of the dominant

position in the classroom in the process of active learning. In fact, combining passive reception of knowledge with active perception is an important means for universities to improve the teaching effect of management. First of all, this work analyzes the meaning of experiential teaching based on modern teaching concepts and summarizes and analyzes three application methods of experiential teaching method. Secondly, this work proposes the IGWO-BP algorithm to evaluate the promotion of experiential education based on modern teaching concepts in college management. The algorithm first improves GWO to propose IGWO, which balances full search and local search through a nonlinear convergence factor and dynamically guides the population forward through a variable proportional weight. Then, IGWO is used to optimize the BP network to improve evaluation accuracy and convergence speed. Finally, this work analyzes that after the use of experiential teaching based on modern teaching concepts, the management teaching effect on students has been significantly improved.

Data Availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Automatic Recognition and Repair System of Mural Image Cracks Based on Cloud Edge Computing and Digitization

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Mural painting is the art on the wall, it is the painting that people draw on the wall, it is one of the earliest forms of painting in human history, and it is also an accessory part of the building. The decorative and beautifying functions of murals make them an important aspect of environmental art. Cloud edge computing is a combination of cloud computing and edge computing, that fully absorbs the advantages of both cloud computing and edge computing and maximizes their advantages. In this study, based on cloud edge computing and digital technology, the automatic identification and repair system of fresco image cracks is studied. Image segmentation techniques have been proposed in this study, using 60 murals in three regions as experimental objects. Through experimental analysis, it is found that the traditional pine poise treatment method takes the shortest repair time. However, for a specific image, it is difficult to guarantee the quality of its restoration. The mural image in area A was repaired with the conventional pine pitch repair method, which took 113.01 seconds, and the subjective evaluation was 69 points. Using the repair method described in this study to repair, it takes 127.38 seconds, and its subjective evaluation score is the highest, which is 87 points. The experimental results have shown that the cloud edge computing method and digital technology have had a certain positive effect on the identification and repair system of fresco image cracks.

1. Introduction

As one of the types of cultural relics, frescoes represent the production and living conditions of the society at that time in the form of pictures by the ancients and are an important basis for scholars to study ancient civilizations. Due to factors such as geological activities and human damage, the painted murals have been damaged in various forms such as cracks, fading, and oxidation, and these damaged murals continue to be repaired, but traditional handicraft techniques find it difficult to complete such difficult task. Using computer technology to digitally repair damaged murals, on the one hand, the damaged murals can be repaired in time, and on the other hand, it is also helpful for the virtual display of the murals. For the problem of damaged murals, traditional manual techniques were used to restore them in the past. However, due to the lack of talent, it is difficult to restore a large number of cultural relics in a short period of time. Therefore, the innovation of this study is to use the cloud edge computing method and digital technology to perform image processing on the fresco crack image, automatically identify the crack type, and perform image repair.

The advent of the digital age has greatly facilitated work and life. This study has carried out a comprehensive study of cloud edge computing methods, digital technology, and mural crack identification and repair systems. The innovation of this study is using image processing technology,

noise processing of mural images, and research on image threshold segmentation. Therefore, the role of cloud edge computing methods and digital technology in fresco crack identification research is effective. To a certain extent, it can save manpower and material resources and speed up the restoration of murals.

2. Related Work

With the expansion of human activities, various murals have been discovered. Affected by various natural factors and human activities, the frescoes have problems such as cracks and damages, which need to be identified and repaired using technology. Many scholars have conducted research on this. Wang has proposed using the needs of users in daily life to discuss ways to expand image access points. Due to the advanced Internet and digital technology, as well as the characteristics of the younger generation, images have been searched and used extensively [1]. Patayon and Crisostomo have proposed to develop an automatic identification system for abaca bunchy top disease using different deep learning models [2]. Conforto et al. have proposed a robot-assisted treatment method and have used an automatic identification system to identify the patient's disease type, which has assisted doctors to make better treatment plans [3]. Mu and Yue have proposed to classify and grade the image degradation of security signs, trying to break the limitation of real-time image recognition [4]. Chen et al. have proposed the establishment of a comprehensive prediction model, which has integrated the medical imaging features of patients and has purposefully identified and classified the disease types of patients [5]. The above studies have applied automatic recognition and repair systems to various fields of research, but few have used automatic recognition systems for crack recognition in mural images.

In recent years, cloud edge computing methods have continued to develop, and digital technologies have also been popularized. Scholars from all walks of life have used cloud edge computing methods and digital technologies to conduct research on various academic issues. Chen and Wang have argued that nonintrusive load monitoring can infer the operating status of equipment and its energy consumption by analyzing energy data collected from monitoring equipment. With the rapid increase in the number and types of electrical loads, the traditional way of uploading all energy data to the cloud faces huge challenges [6]. Xu et al. have believed that cloud edge computing already has powerful real-time information collection capabilities and has played a vital role in providing diversified services. It works by transferring the collected information to a centralized, resource-intensive cloud platform for service implementation [7]. Taleb et al. have considered multiaccess edge computing as a platform designed to converge telecom and IT services to provide cloud computing at the edge of the radio access network [8]. Ogino et al. have proposed a flexible multiagent-based IoT edge computing architecture for balancing cloud global and edge local optimization and optimizing the roles of cloud servers and edge servers [9]. Esposito et al. have considered that one of the advantages of connecting edge computing and cloud computing is to achieve high throughput with real-time processing to ensure data durability [10]. The above research is a good analysis and application of cloud edge computing, but the field of application rarely involves the identification of cracks in mural images.

3. Recognition and Repair Method for Cracks in Mural Images under Cloud Edge Computing and Digitization

3.1. Crack Identification and Repair of Mural Images. Murals are the precious historical and cultural heritage of human beings and an important means of reflecting ancient civilizations and have high artistic value. Due to their existence, the ancient murals have various problems with cracks and damage, and it is necessary to use the current technology to repair the murals [11]. As shown in Figure 1, it is an image of an ancient mural.

The problems with murals are mainly cracks, falling off, fading, and herpes [12, 13]. With the passage of time, the damage from the strokes will be more serious, so the protection of the murals is imminent. As shown in Figure 2, it is a common problem in murals.

According to relevant information, most of the ancient murals appeared in ancient temples, as shown in Figure 3.

It can be seen from Figure 3 that the above images are murals taken at Jueshan Temple, Kaihua Temple, Sansheng Temple, and Yanshan Temple, respectively.

3.2. Cloud Edge Computing Methods and Digital Technologies. The digitization of cultural relics integrates modern information technology for the protection of cultural relics, and as a new development trend, the digitization of cultural relics is also used by cultural relics protection units around the world [14]. Based on the cloud edge computing method and digital technology, this study uses image preprocessing technology to study the problem of fresco cracks [15]. As shown in Figure 4, it is an introduction diagram for the image preprocessing system.

Image processing is to process the information collected by the image acquisition system. Due to the influence of various factors, the collected information may have certain problems [16, 17]. Moreover, because of the huge number of crack images in murals, in order to extract information quickly, it is necessary to denoise the images first.

Noise introduction: in the process of generation, transmission, and storage, images are prone to noise [18]. This study selects the most common Gaussian noise and salt and pepper noise for analysis.

3.2.1. Gaussian Noise. If Gaussian noise is regarded as a variable in the image, the probability density function formula of noise is as follows [19]. Gaussian function means

Figure 1: Ancient mural image.

Figure 2: Frequently asked questions about murals.

that the probability density function of the modified noise obeys a normal distribution:

$$Q(m) = \frac{1}{\sqrt{2\pi}\alpha} e^{-(m-\nu)^2/(2\alpha^2)}, \tag{1}$$

where m is a variable, ν represents the expected value of m, α represents the standard deviation of m, and α^2 represents the variance of m.

3.2.2. Salt and Pepper Noise. This noise is caused by the photoelectric conversion process of image sensors and other devices and appears as irregular and dark dots in grayscale images [20]. If salt and pepper noise is used as a variable, the probability density function formula for noise is as follows:

$$Q(m) = \begin{cases} Q_a & m = a \\ Q_b & m = b \\ 0 & \text{others} \end{cases}, \tag{2}$$

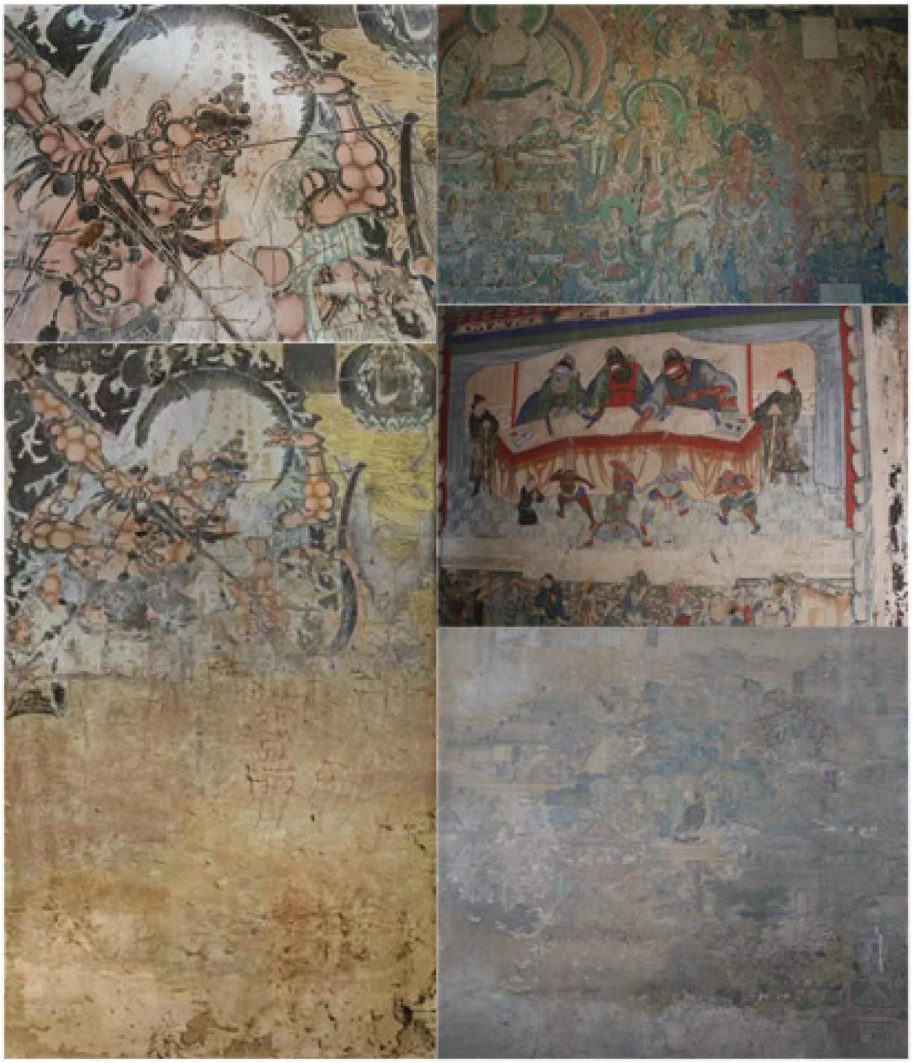

Figure 3: Ancient murals in the temple.

where $0 \leq Q_a \leq 1$ and $0 \leq Q_b \leq 1$. Usually, the pulse value of salt and pepper noise is divided into positive and negative numbers, and the pulse intensity is much larger than that of the image signal, so an image is always numerically converted to the maximum value, that is, pure black or pure white. For noise processing, denoising is required. There are many denoising methods. This study mainly introduces three denoising methods: mean filter, median filter, and Wiener filter [21]. It is as follows.

3.2.3. Mean Filtering. It is because the original pixel in the image and the surrounding pixels are related, but the noise does not have this correlation [22]. Therefore, this property can be used to replace the gray value of the target pixel with the gray value of the pixel in the field, thereby achieving the purpose of reducing sharp noise [23]. As shown in Figure 5, it is a graph of the mean filter model.

The formula is as follows:

$$f(m,n) = \frac{1}{X} \sum_{x,y \in R} g(m,n), \tag{3}$$

where $g(m,n)$ represents the gray value of the original image pixel, $f(m,n)$ represents the gray value of the processed image pixel, and $x * y$ represents the field window size.

3.2.4. Median Filtering. It sorts all the pixels in the field according to the gray value and takes the gray median value to replace the gray value of the target pixel [24]. The characteristics of this method are similar to those of the mean filter; that is, the substitute index is replaced by the median value. This method is simple and convenient to calculate, but the phenomenon of image blurring will also occur. The specific formula is as follows:

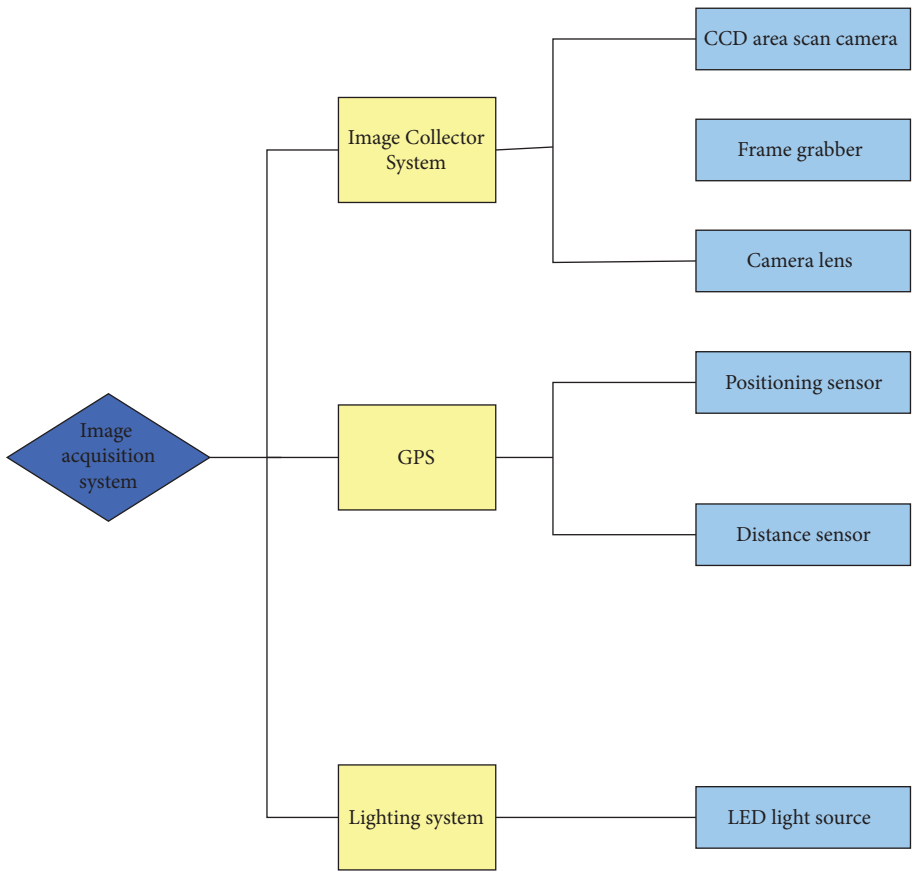

Figure 4: Introduction to the image preprocessing system.

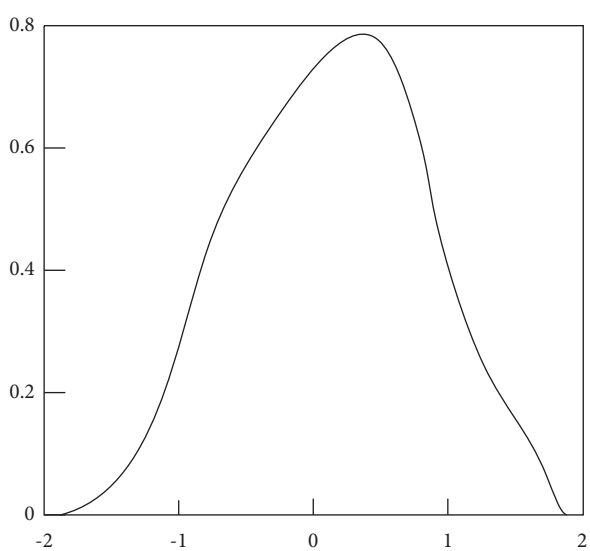

Figure 5: Mean filter model diagram.

$$f(m,n) = \mathrm{med}\{g(m_1,n_1), g(m_X,n_X)\}, \quad (4)$$

where $g(m,n)$ represents the gray value of the original pixel, $f(m,n)$ represents the gray value of the processed image pixel, and X represents the number of pixels in the field.

3.2.5. Wiener Filtering. Wiener filtering is an optimal filtering method using the minimum mean square error criterion under stationary conditions. Its central idea is to find an optimal linear filter that minimizes the value of the mean square error [25]. As shown in Figure 6, it is a diagram of the Wiener filter model.

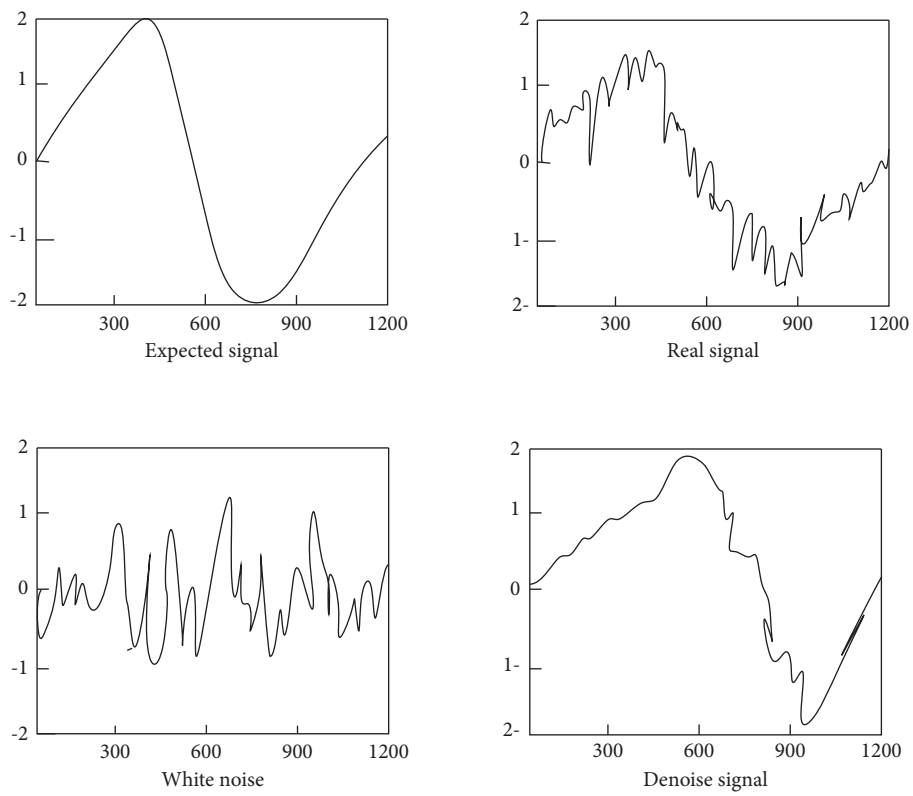

Figure 6: Wiener filter model diagram.

Its formula is as follows:

$$\nu = \frac{1}{X \times Y} \sum_{m,n \in R} g(m,n),$$

$$\alpha^2 = \frac{1}{X \times Y} \sum_{m,n \in R} (g(m,n) - \nu)^2, \tag{5}$$

$$f(m,n) = \nu + \frac{\alpha^2 - z^2}{\alpha^2} (g(m,n) - \nu),$$

where g (m, n) represents the original image pixel gray value, f (m, n) represents the processed image pixel gray value, v represents the average gray value of the pixel in the field, α^2 represents the grayscale variance of pixels in the field, and α^2 represents the overall grayscale variance of the image. According to the formula of Wiener filtering, it can be seen that this method can change with the local variance of the image. When the local variance increases, a weaker smoothing process will be performed. Stronger smoothing is performed when the local variance is reduced [26]. For crack images, the smaller the gray variance of the background, the larger the gray variance of the edge region of the crack, so Wiener filtering can fully preserve edge information under a smooth background.

Image threshold segmentation research: a binary image refers to an image with only two gray levels of 0 and 1, that is, a black and white image. The process of converting a multigray level image into a binary image is called image segmentation. Image segmentation has two methods: edge detection and region similarity.

In segmentation based on regional similarity, threshold segmentation has been widely used in practice due to its simple operation and strong practicability. Threshold segmentation mainly selects a threshold and uses the threshold to segment the image. The formula is as follows:

$$f(m,n) = \begin{cases} 0, & g(m,n) < T \\ 1, & g(m,n) \geq T \end{cases}, \tag{6}$$

where $g(m,n)$ represents the pixel gray value of the original image, $f(m,n)$ represents the processed image gray value, and T represents the threshold. It can be seen from the formula that when the gray value of the pixel in the image is lower than the set threshold, the gray value will be redefined as 0. That becomes the black point. When the gray value of the pixel point of the image is higher than the set threshold, the gray value is redefined as 1, that is, the white point. As shown in Figure 7, images with different thresholds are segmented.

A threshold is selected to segment all pixels of the entire image. Under the dynamic threshold, different thresholds should be selected at different positions for segmentation. The following is an introduction to several commonly used image algorithms.

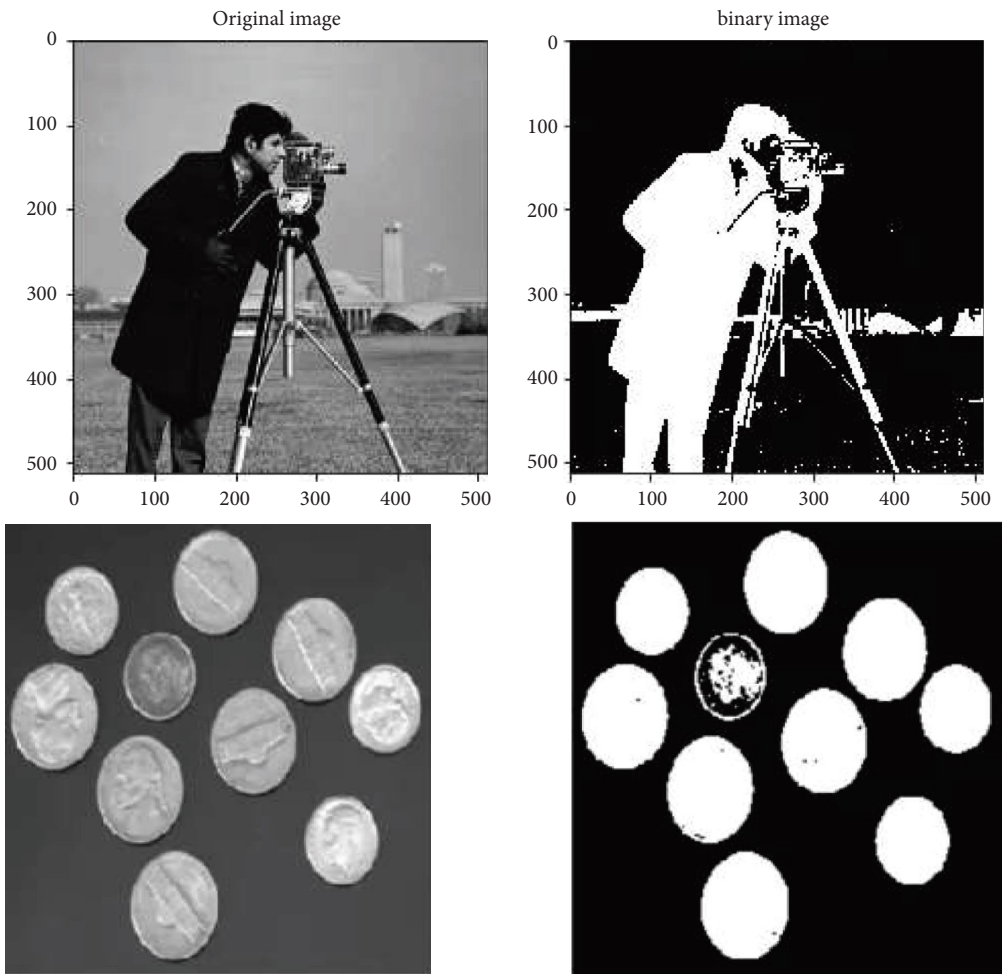

Figure 7: Segmentation of images with different thresholds.

(1) Maximum Entropy Method. Entropy indicates that an information source is uncertain and reflects the amount of information in the image. When the amount of information in the image is larger, the entropy of the image will also increase.

Suppose that an image size is $X \times Y$, the gray level is 0~K, the number of pixels with gray level i in the image is Y_i, and the ratio of each gray level in the image is

$$Q_i = \frac{Y_i}{X \times Y}, i = 0, 1, 2, K, \qquad \sum_{i=0}^{K} Q_i = 1, \tag{7}$$

where Q_i represents the probability that each gray level accounts for the entire image.

Set the initial threshold T, and divide the image into two parts a, b, where a represents the image of the target area and b is the image of the background area; then,

$$\begin{aligned} H_a(T) &= -\sum_{i=1}^{T} \frac{Q_i}{Q_a} \log \frac{Q_i}{Q_a}, \\ H_b(T) &= -\sum_{i=1}^{T} \frac{Q_i}{Q_b} \log \frac{Q_i}{Q_b} = -\sum_{i=1+T}^{T} \frac{Q_i}{1-Q_a} \log \frac{Q_i}{1-Q_a}, \\ Q_a &= \sum_{i=0}^{T} Q_i, Q_b \\ H(T) &= H_a(T) + H_b(T), \\ H(T') &= \max H(T), \end{aligned} \tag{8}$$

where $H_a(T)$ represents the entropy of area a, $H_b(T)$ represents the entropy of area b, $H(T)$ is the sum of the entropy of area a and area b, and T' represents the optimal threshold.

(2) Maximum Interclass Method. The maximum interclass method refers to considering the image as two parts, namely, the background and the target, using variance to represent the difference between the background and the target, and

finding an optimal threshold to maximize the interclass variance in this part.

Assuming that the size of the image is $X \times Y$, the gray level is 0~K, and the number of pixels whose gray level is i in the image is N_i; then, the probability that each gray level occupies the entire image is

$$Q_i = \frac{N_i}{X \times Y}, i = 0, 1, 2, K, \quad \sum_{i=0}^{K} Q_i = 1. \tag{9}$$

Set the initial threshold and divide the image into two parts, a and b; then,

$$Q_a = \sum_{i=0}^{T} Q_i, Q_b = \sum_{i=T+1}^{T} Q_i, \quad \nu_0 = \sum_{i=0}^{T} iQ_i, \nu_a = \sum_{i=0}^{T} i\frac{Q_i}{Q_a}, \nu_b = \sum_{i=T+1}^{T} i\frac{Q_i}{Q_b}, \tag{10}$$

where Q_a represents the probability that the pixels in the area a occupy the entire image, Q_b represents the probability that the pixels in the area b occupy the entire image, ν_0 is the grayscale mean of the entire image, ν_0 is the grayscale mean of the area a, and ν_0 is the grayscale mean of the area b.

The formula for the between-class variance α^2 is

$$\alpha^2 = Q_a(\nu_a - \nu_0)^2 + Q_b(\nu_b - \nu_0)^2. \tag{11}$$

The maximum interclass method is to select the best threshold, T', to maximize the interclass variance, and its formula is

$$\alpha^2(T') == \max \alpha^2(T). \tag{12}$$

The maximum between-class method is usually used in the case where the target and the background of the image are quite different.

In the case where the variance value of the target and the background is not much different, the maximum between-class method makes it difficult to obtain a better segmentation method.

4. Experimental on Crack Identification and Repair in Mural Images

4.1. Experimental Results of Crack Identification and Repair in Mural Images. For the automatic identification and repair system of fresco image cracks, this study mainly conducts a statistical analysis of the problems of ancient frescoes. Twenty murals in three regions of A, B, and C were selected as the research objects. Due to the differences in natural conditions such as climate, the murals in the three regions were damaged differently. Details are as follows.

4.1.1. Problems with Murals. Due to the influence of natural factors, the frescoes in the three regions have different degrees of problems, the most important of which are cracks, fading, and damage. The specific situation is shown in Figure 8.

As can be seen from Figure 8, among the 20 murals in area A, 19 murals have cracks, 10 murals have faded, and 4 murals have broken and missing pieces. In area B, 3 frescoes have cracks, 7 frescoes have fading problems, and 13 frescoes are found to be missing pieces. In Area C, 15 murals have cracks, 13 have faded, and 18 have missing blocks. From these data, it can be seen that some of the murals in the three regions may have more problems, such as cracks, missing pieces, and fading problems.

It can be found from the figure that the murals in areas A and B have fewer problems than the murals in area C. However, due to the difference in climatic factors between A and B, the problems of murals in the two places take on opposite forms. Among them, area A has a high temperature and a dry climate all year round, so the air humidity is low, and the walls of the murals are dry and easy to crack, so the murals have more cracks and fading. Area B is rainy all year round, and the climate is humid. The walls of the murals are wet, so the walls are easy to peel off, and there are cases of missing pieces and damage. However, due to the extreme climatic conditions in the C area, the dry season and the rainy season are distinct, the dry season is hot and dry, and the rainy season is also hot and rainy, which leads to more problems with the murals in the C area. The problems of cracks, missing blocks, and fading are more serious than those in the other two areas. This shows that climatic factors will affect the state of the murals.

4.1.2. The Time When the Murals Existed. Due to the existence of ancient murals for too long, it will also cause problems such as damage to the murals. The specific situation is shown in Figure 9.

It can be seen from Figure 9 that most of the murals in area A have a history of over 1000 years, and some murals are less than 1,000 years old. Among them, there is one under 500 years old, accounting for only 5%. There are 2 pictures from 500 to 1000, accounting for 10%. There are 17 murals over 1000 years old, accounting for as high as 85%; it also reflects from the side that region A has a long history and human activities occurred earlier. Most of the frescoes in area B are more than a thousand years old. Among them, there are 2 murals under 500 years old, accounting for 10%. There are 3 murals from 500 to 1000, accounting for 15%. There are 15 murals over a thousand years old, accounting for 75%. This also shows that the historical civilization of the B region is relatively long. Among the murals in area B, there is 1 mural with horizontal cracks, 3 with vertical cracks, 2 with shedding, and 2 with massive cracks. Compared with the mural history of the other two regions, the history of the murals in the C area is relatively short. Among them, there are no murals under 500 years old, 18 murals are 500 to 1000 years old, accounting for 60%, and 2 murals are more than 1000 years old, accounting for 20%. This shows that the

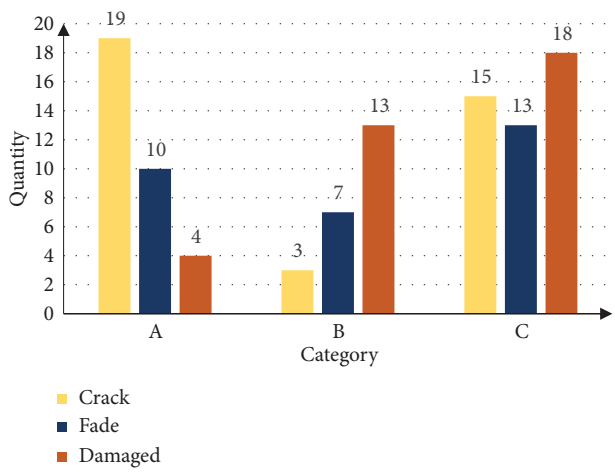

Figure 8: Problems with murals in three regions.

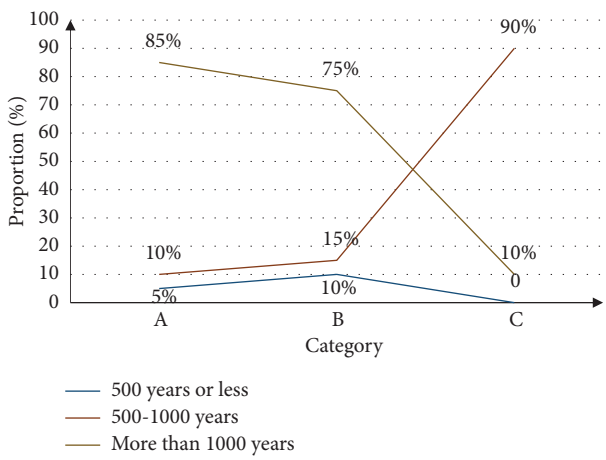

Figure 9: How long did the frescoes exist?.

frescoes in the C area mainly appeared 500 years ago, when there were frequent human activities in the area. It can be seen that the appearance time of the murals can also understand the time when the local historical civilization appeared. Due to the existence of murals for too long, it will also lead to various problems with murals.

4.1.3. The Form of Cracks in the Frescoes. This paper mainly studies the identification and repair system of fresco cracks. This study conducts experiments on different cracks since the appearance of cracks is usually accompanied by problems such as wall peeling and water seepage. The specific crack form is shown in Figure 10.

It can be seen from Figure 10 that there are cracks in the murals in the three areas. Among them, there are many cracks in the murals of A and C. There are 19 murals with horizontal cracks in the murals in Area A. There are 12 frescoes with longitudinal cracks. There are 9 cases of falling off. There are 15 frescoes with blocky cracks. Among the murals in Area C, there are 13 murals with horizontal cracks, 14 with longitudinal cracks, 11 with falling off, and 15 with

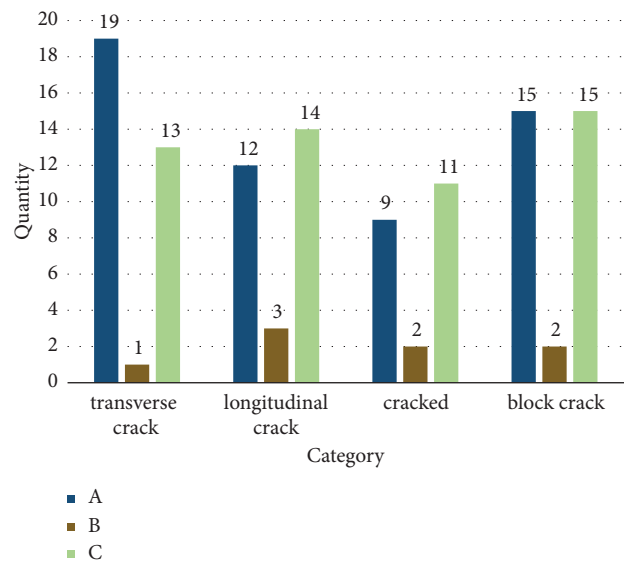

Figure 10: The fresco appears in the form of cracks.

massive cracks. Cracks in different directions and shapes are due to local geological activities, human activities, climate, and other factors that cause different degrees of cracks in the murals.

In order to facilitate comparison, a representative mural was selected from each of the three regions for comparative analysis, and the restoration time and various restoration indicators of the crack image of the mural are listed in a table, as shown in Table 1.

It can be seen from Table 1 that the number of repaired pixels in the repaired image is directly related to the repair time. The more pixels to be repaired, the longer the repair time. The number of repaired pixels can reflect that the search range of the sample block affects the repairing time, and the ratio of repaired pixels to total pixels can also reflect the difficulty of image repairing. The frequency of replication of the samples can reflect the complexity of the cracks in the frescoes to be repaired. The ratio of Poisson processing times to sample replication times is an important comparison parameter. It can be seen from Table 1 that the restoration time of the three murals is calculated in seconds, which is an acceptable restoration time length. The proportion of repaired pixels to total pixels is 3.6%, 7.7%, and 21%, respectively. Different proportions indicate that the difficulty of repairing will also be different. The repairing is achieved for three sets of images to be repaired with different proportions, which shows the effectiveness of the repairing method in this study. In the three groups of experiments, the number of Poisson processing accounted for about 25% of the total number of sample replications, which indicates that the Poisson processed method repaired only the initial outermost sample block as expected. In the field of image restoration, there is still no clear definition of the restoration effect. In the past restoration process, the peak signal-to-noise ratio is often used. Because the object removal experiment does not have known images as a comparison benchmark, which makes the metric difficult to calculate

Table 1: The repair metrics of the algorithm in this study.

	A	B	C
Repair time (s)	131.39	198.62	98.29
Fix pixel (per)	3568	6629	12656
Total pixels (per)	97415	97314	61438
Sample replication times (times)	125	211	221
Number of Poisson treatments (times)	22	47	38

accurately, this kind of experiment cannot be applied to the inpainting experiment. This experiment uses a subjective evaluation strategy; that is, the experimenter evaluates the repaired images without knowing the repaired area.

It can be seen from Table 2 that this experiment has achieved relatively good results in terms of restoration time and restoration quality. The traditional loose poise processing method takes the shortest restoration time, but for a specific image, it is difficult to guarantee the restoration quality. As can be seen from Table 2, the frescoes in area A were repaired by the conventional pine poise repair method, which took 113.01 seconds and the subjective evaluation was 69 points, while the restoration using the Criminisi repair method took 139.45 seconds and the subjective evaluation was 83 points. Using the repair method in this study to repair, it only takes 127.38 seconds and its subjective evaluation score is the highest, which is 87 points. Although the repair method in this study takes a long time, it can guarantee the quality of its repair. The mural image in area B was repaired with the conventional pine poise repair method, which took 186.66 seconds and the subjective evaluation score was 65 points, while the restoration using the Criminisi repair method took 221.06 seconds and the subjective evaluation score was 69 points. The repair method in this study was used. To repair, it takes 193.12 seconds to use, and the subjective evaluation score is as high as 83 points. To sum up, the repair method described in this study has obvious advantages in repair effect compared with other repair methods, and its evaluation score and repair quality are both high.

It can be seen from Table 3 that image inpainting can be used for image compression, but since the inpainting principle of image inpainting technology is to use the correlation of the image itself, the prerequisite for applying image inpainting technology to image compression is that the image content has a certain correlation. If the correlation of the image is large, a larger compression ratio can be obtained, but if the image itself is an image with less correlation and more complex cracks, the compression ratio will be reduced accordingly. For example, the fresco images in area C have more complex cracks, and the compression ratio will be lower than the compression ratio of the murals in areas A and B. Among the compression ratios of the mural images in the three regions, the highest compression ratio is the mural image in Region A, whose ratio is less than 5 : 1. The compression ratios obtained in the mural images in the three regions are the maximum values obtained under the premise that the restoration algorithm studied in this paper can be restored, and the existing restoration algorithms have made it difficult to complete the restoration task. Theoretically speaking, with the development of image inpainting technology, a higher compression ratio can be obtained under the condition that the new inpainting technology has more powerful inpainting capabilities.

4.2. Improve the Experimental Scheme of Crack Identification and Repair in Mural Images. According to the above analysis, the cloud edge computing method and digital technology are perfectly combined with the research on the fresco crack identification and repair system. The idea of identifying, analyzing, and repairing cracks in frescoes with digital technology has greatly facilitated scholars' research on this project. However, because the learning on digital technology and cloud edge algorithms is not deep and complete enough, the experiments in this study still have some defects, which need to be improved. The details are as follows. First, in the three regions of A, B, and C as the experimental objects, the selected sample size is not enough, and the number of samples needs to be increased to ensure the accuracy of the experimental results. Second, in the experiment, only the Criminisi repair method and the loose Pois repair method were selected as the comparison methods. It is recommended to add several types of repair algorithms, and the results obtained will be different, and the reliability will also increase. Criminisi repair method is difficult to ensure the repair quality of the edge with a strong structure, and the phenomenon of structural disconnection may occur. The loose Pois repair method also has certain defects. Since the size of the sample block is fixed, the repair process is not flexible enough, and error repair may occur.

5. Discussion

With the development of Internet technology, it has become the daily work of experts and technicians to use computer technology to restore the treasures of cultural relics that were difficult to restore manually in the past. In this study, the identification and repair system of fresco cracks has been studied by combining cloud edge computing methods with digital technology. There are still several problems in the research process of this study. (1) The repair algorithm in this study is not perfect, the repair time is too high, and the subjective evaluation score is too low. (2) For more complex cracks, the repair technology in this study is difficult to completely repair and it is difficult to completely repair them. (3) The experimental subjects selected in this study are too few, the number of comparable samples is small, and the reliability of the experimental results is not high. In this regard, there is still a long way to go to completely repair the cracks in the murals using computer technology.

This study is devoted to the research based on cloud edge computing methods and digital technology in various fields and applied to the analysis of mural crack repair technology. A new attempt has been made in the study of fresco crack identification and repair systems. Through the case study, it is shown that this study reflects the effectiveness of the cloud edge computing method and digital technology in the analysis of the mural crack repair system.

Table 2: Comparison of repair evaluation and repair time.

		Regular Poisson processing fix	Criminisi repair	How to fix this article
A	Subjective evaluation (score/total score)	69/100	83/100	87/100
	Repair time (s)	113.01	139.45	127.38
B	Subjective evaluation (number of approvals/samples)	65/100	69/100	83/100
	Repair time (s)	186.66	221.06	193.12
C	Subjective evaluation (score/total score)	54/100	77/100	89/100
	Repair time (s)	91.24	111.43	98.21

Table 3: Comparison of compression repair schemes.

	Original size (KB)	Size after compression (KB)	Compression ratio (%)	AIEI model PSNR (dB)	CDD model PSNR (dB)	The method of this paper PSNR (dB)
A	67	16	21.09	26.3	25.4	27.3
B	67	15.8	21.88	31.3	28.7	35.2
C	87	27.3	33.73	31.6	27.9	32.3

6. Conclusions

This study has taken digital technology as the main analysis technology and has taken 20 murals in three regions A, B, and C as the research objects. Statistical analysis has been carried out on the problems of each mural, and the cloud edge computing method and digital technology have been used to classify them and identify the shape of the cracks in the mural. Through the case study, it has been concluded that factors such as temperature, humidity, precipitation, geological activity, and time can cause various problems such as cracks and fading of murals. The higher the image compression technology and the higher the image compression ratio, the higher the completeness of image restoration. The length of image restoration time does not guarantee the quality of image restoration. To sum up, the research on the fresco crack identification and repair system needs more in-depth and systematic analysis. The research in this study is only based on image pixels, recognition time, and image compression technology. The research of fresco crack repair based on cloud edge computing methods and digital technology has been a popular research object among experts and scholars from all walks of life in recent years, and further research is needed at present.

Data Availability

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declare that they have no conflicts of interest with any financial organizations regarding the material reported in this study.

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Research Article

Modeling Method of Intelligent Scoring for Solfeggio Training Based on Deep Learning

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In the solfeggio training, melody model singing is an important part of auditory training. Reasonable and effective model singing training is of great significance to train the singer's hearing. So, the level of model singing also reflects the level of the singer's solfeggio to a certain extent. The correct model singing score will help students to master their own real melody model singing level and help students to better improve their solfeggio skills. However, the melody model singing training scoring system that has been developed has low accuracy and needs to be improved. In order to improve the accuracy of the intelligent scoring results of melody model singing training, this paper used deep learning technology to study the intelligent scoring method of melody model singing training. This paper first extracted the features of songs, then collected a large number of song features, trained the existing feature data, and established an intelligent scoring model for melody model singing training. Then, the students' model songs and standard songs were used as two inputs, and the similarity of the characteristics of the two songs was analyzed; then, the score results of the model songs were obtained. The validity of this research should be verified by a comparative experiment. The research results showed that the melody model singing training intelligent scoring model, established by deep learning technology, has a higher accuracy rate, and the accuracy rate was increased by 6.82% compared with the original scoring model, indicating the research has practical significance.

1. Introduction

Model singing training can effectively improve the trainer's musical hearing ability and effectively improve the trainer's auditory discrimination ability and pitch perception ability, prompting them to continuously enhance their singing skills, and model singing training scoring is an important part of it. With the wide application of artificial intelligence and the popularization of the Internet and smartphones, the problem of intelligent scoring of melody model singing training is more and more worthy of in-depth study. At present, although there has been preliminary exploration on the intelligent scoring of melody model singing training, these scoring systems have low accuracy and have not achieved satisfactory results. In order to further improve the scoring accuracy of the melody model singing training intelligent scoring system, this study attempted to use deep learning technology to develop the melody model singing training intelligent scoring system.

At present, there are many research studies on solfeggio. Debevc et al. conducted an experiment to examine the effectiveness of an interactive mobile app mySolfeggio in solfeggio learning. Experimental results showed that students show higher scores in musical interval and rhythm accuracy when using the mobile app [1]. Based on dynamic teaching theory and teaching practice, Maofang constructed a dynamic teaching mode of solfeggio class to meet the needs of talent training in basic music education and improve the teaching effect of solfeggio class [2]. Aycan has developed a vocal training system based on bona exercises by examining vocal exercises adapted to rhythmic pronunciation exercises in the classroom. The research results showed that bona exercises play an important role in solfeggio training [3]. Ding conducted research on SIFT-based audio processing technology. The experimental results showed that the introduction of digital multimedia music production technology in music solfeggio teaching could not only make the teaching form vivid, standardize the teaching process, and

enrich the teaching content but also improve the quality of teaching and promote students' enthusiasm and interest in learning [4]. Ying analyzed and compared the effect of CAT technology in the auxiliary teaching system of solfeggio and ear training and the difference with the original traditional teaching. The results showed that more than 60% of the students are satisfied with the cat technology learning assistance system [5]. Although there are many studies on solfeggio training, there are few studies on melody model singing training in solfeggio training, and the research on intelligent scoring of melody model singing training has not yet achieved satisfactory results.

Due to their advantages in feature extraction, deep learning techniques are widely used. Geert investigated the use of deep learning for image classification, object detection, segmentation, registration, and other tasks, having brief overview of research in each application area [6]. Shen et al. introduced the fundamentals of deep learning methods and reviewed their success in image registration, anatomy, cellular structure detection, tissue segmentation, computer-aided disease diagnosis, and prognosis [7]. Kermany et al. has built a deep learning framework-based diagnostic tool to screen patients for common treatable blinding retinal diseases; the study of which can help speed up diagnosis and referral for these treatable diseases [8]. Rajkumar et al. proposed a representation of the patient's complete raw EHR records based on the Fast Healthcare Interoperability Resource (FHIR) format, and studies have demonstrated that deep learning methods using this representation can accurately predict multiple medical events from multiple centers [9]. Sinha et al. demonstrated that deep neural networks (DNNs) can be trained to solve the inverse problem in computational imaging, given a raw intensity image recorded at a certain distance, training a DNN to recover phase objects [10]. Although deep learning technology is widely used, no one has studied the application of deep learning technology in melody model singing training scoring.

In this paper, the Mel sound spectrum was used as the sound spectrum feature to extract song features; then, the existing feature data were trained to build a melody model singing intelligent scoring model based on the convolutional neural network. The feature similarity between them was used to score analog songs. In the experimental part, 10 subjects were selected to sing a Chinese song, an English song, a German song, and a pure music through a man-machine comparison experiment to verify the melody model using deep learning technology and the effectiveness of singing and training smart scoring models [11].

2. Intelligent Scoring of the Melody Model Singing Training Based on Deep Learning

Model singing mainly refers to imitating the rhythm or music sung. If people want to intelligently analyze the training of melody model singing, they must first extract the features of the model singing songs and then establish an intelligent scoring model for melody model singing based on deep learning. The task of the scoring model is to match the songs sung by the students with the standard songs, calculate the similarity between them, and then output the corresponding scores to achieve automatic scoring [12]. The basic process of melody model singing training scoring is shown in Figure 1.

2.1. Feature Extraction. For the two songs that need to be matched, feature extraction is to extract some salient features from them. The song melody features mainly include four feature vectors of pitch, length, speed, and dynamics [13, 14].

2.1.1. Pitch. The physical characteristic that corresponds to the pitch is the frequency of vibration. The higher the vibration frequency, the higher the sound and vice versa. F is defined as a function for evaluating the pitch attribute of a song. Assuming that there are $m\,(m \geq 1)$ tracks in the current song, the pitch features of each track are extracted for correlation extraction, and the pitch feature vector x_f is determined according to the relevant attributes of the main track. Setting the pitch feature value of the song is to match the song to $p_i\,(x_f)$ and $i = [1, 2, ..., n]$, then:

$$f\left(x_f\right) = Max\left(p_i\right). \tag{1}$$

2.1.2. Sound Length. The sound length represents the duration of the note. In the identification of the pitch length, the pitch attribute is mainly determined according to the length of its duration. In order to measure the sound length characteristics of the song, the value of the sound length evaluation function g for:

$$g\left(x_g\right) = \begin{cases} long, x_g \geq x_{switch}, \\ short, x_g < x_{switch}. \end{cases} \tag{2}$$

According to formula (2), the length and duration of each note can be determined, so that the properties of each note length of the whole song can be determined accordingly.

2.1.3. Speed. Tempo refers to the speed of the music beat. The beat characteristics of each piece are certain, and the tempo characteristics can be directly obtained.

2.1.4. Strength. The information that reflects the strength of the note is mainly contained in the data bytes in the note-off and note-on events. The strength is reflected in the numerical range of 0–127.

In this paper, the Mel spectrum is selected as the feature of the spectrum, and the extraction process of the Mel spectrum is shown in Figure 2 [15].

First, it is necessary to perform a short-time Fourier transform on the sound signal of the music. Then, the Mel scale is used to transform the frequency on the amplitude spectrum. Then, the amplitude is converted by the Mel filter and the result is the Mel spectrum representation of each frame; then, the corresponding Mel spectrum is obtained by

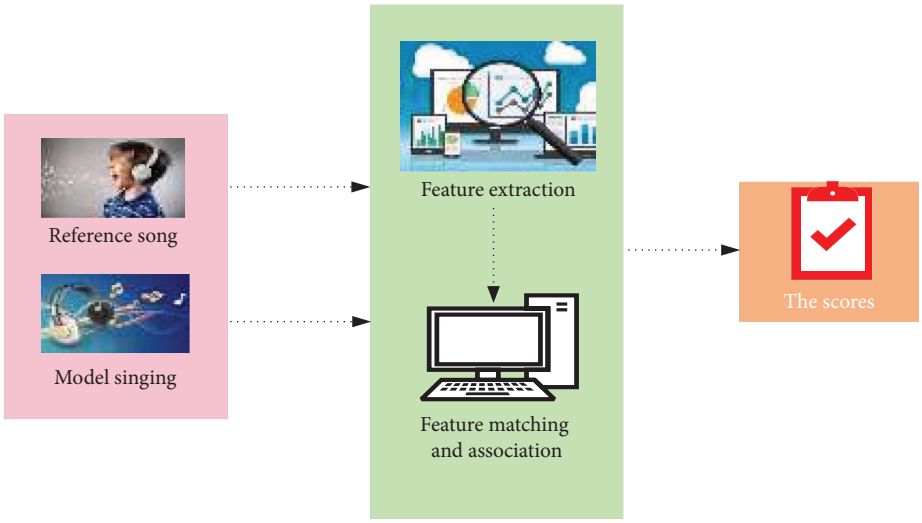

Figure 1: Melody singing training basic process of scoring.

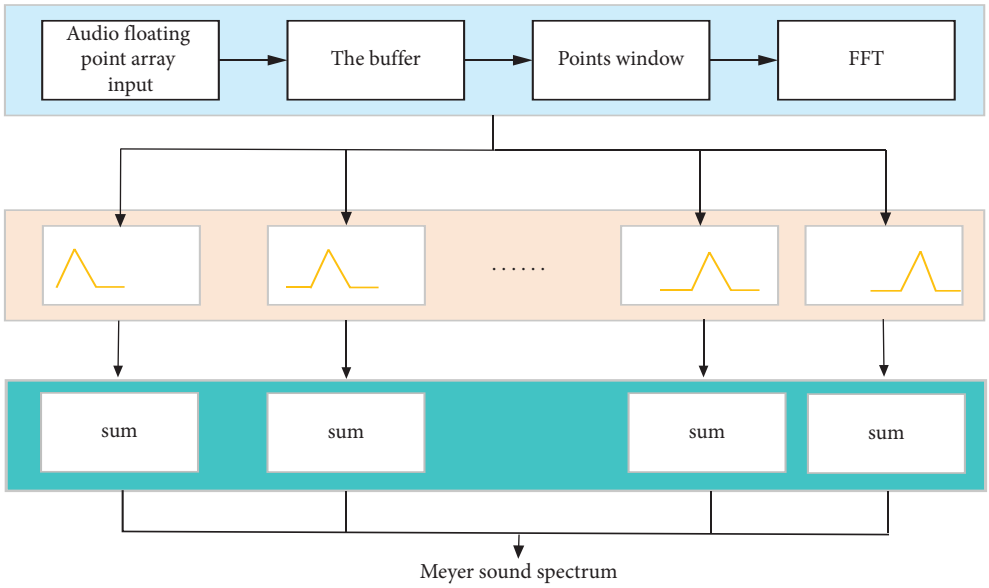

Figure 2: Song feature extraction process.

piecing together the spectrum within the analysis window length.

2.2. Scoring Model. Currently, the most widely used deep learning model is the convolutional neural network (CNN) [16]. A convolutional neural network is a special kind of the multilayer perceptron or feedforward neural network. The feature of local connection and weight sharing, in which a large number of neurons are organized in a certain way and respond to overlapping areas in the field of vision. A standard convolutional neural network generally consists of an input layer, alternating convolutional layers (also called detection layers) and pooling layers (also called down-sampling layers), a fully connected layer, and an output layer. The convolution kernel generally needs to be trained, but it can sometimes be fixed [17]. The convolutional neural network model is shown in Figure 3.

This paper attempted to use a convolutional neural network to intelligently score students' melody model singing training. The scoring model first collected a large number of song features, trained the existing feature data through a neural network, and built a melody model singing intelligent scoring model based on the convolutional neural network. The student model songs and standard songs were taken as two inputs and sent to the same neural network structure for processing, and two corresponding high-level representations were obtained. These two high-level representations were calculated by the similarity calculation of the upper layer of structured network, and the obtained similarity features were adjusted by a fully connected layer, so as to obtain the predicted score of the analog song in the actual

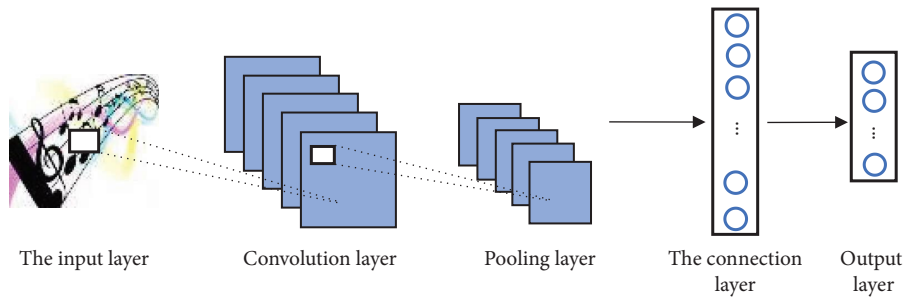

Figure 3: Convolution neural network model.

situation and output it. As the score of students' melody model singing, automatic scoring was realized [18].

2.2.1. Convolutional Layer. In the convolution layer, there are usually multiple learnable convolution kernels. The output feature graph of the previous layer can be obtained by convolution operation with the convolution kernel, that is, dot product between the input item and the convolution kernel. Each output feature map may be a combination of values convolved with multiple input feature maps [19]. The calculation of the output value a_j^l of the jth unit of the convolutional layer L is as follows:

$$a_j^l = f\left(b_j^l + \sum_{i \epsilon M_j^l} a_j^{l-1} * k_{ij}^l\right). \tag{3}$$

2.2.2. Pooling Layer. Pooling layers usually appear after convolutional layers, the two alternate with each other, and each convolutional layer has a one-to-one correspondence with a pooling layer [20]. The calculation formula of the activation value a_j^l in the pooling layer L is as follows:

$$a_j^l = f\left(b_j^l + \beta_j^l down\left(a_j^{l-1}, M^l\right)\right). \tag{4}$$

Among them, down (.) indicates the pooling function, b_j^l is the bias, β_j^l is the multiplier residual, and M^l indicates that the size of the pooling box used in the first layer is $M^l * M^l$.

2.2.3. Fully Connected Layer. The raw output of layer L is as follows:

$$z^{(l)} = \omega^{(l)} \bullet a^{(l-1)} + b^{(l)}. \tag{5}$$

The output of this layer after activation by function f is as follows:

$$a^{(l-1)} = f\left(z^{(l)}\right). \tag{6}$$

The original output error δ of the $L-1$ layer can be inversely obtained from the output error of the L layer as follows:

$$\delta^{(l-1)} = \left(\left(\omega^{(l)}\right)^T \delta_{fc}^{(l)}\right) \bullet f'\left(z^{(l-1)}\right). \tag{7}$$

The gradient of the parameter can be calculated from the pre-activation output error of this layer and the post-activation output of the previous layer:

$$\begin{aligned} \nabla_{W(l)} Loss\,(W, b; x, y) &= \delta^{(l)}\left(a^{(l-1)}\right)^T, \\ \nabla_{b(l)} Loss\,(W, b; x, y) &= \delta^{(l)}. \end{aligned} \tag{8}$$

2.2.4. Pooling Layer Backpropagation. For the max-pooling layer (max-pooling), due to the pooling process, only the max value element is sampled in each group of data blocks (block) of the output matrix, so the gradient of each data block, the max value element is 1, and the other elements do not participate in error propagation and the gradient is 0. In order to allow the error δ of the maximum pooling layer to be correctly transmitted back, during max-pooling processing, the position index of the max value of each data block at each depth of the input data needs to be saved after sampling and reused directly during backpropagation [21]. The backpropagation of the error by the pooling layer can be expressed as follows:

$$\delta^{(l-1)} = upsample\left(\delta^{(l)} \bullet f'\left(z^{(l-1)}\right)\right). \tag{9}$$

2.2.5. Convolutional Layer Backpropagation. When strides is 1, on an input channel, the convolutional layer error δ transfer of a filter is expressed as follows:

$$\delta_{i,j}^{(l-1)} = \frac{\partial Loss^{(l)}}{\partial a_{i,j}{}^{(l-1)}} \frac{\partial a_{i,j}{}^{(l-1)}}{\partial z_{i,j}{}^{(l-1)}}. \tag{10}$$

Among them,

$$\frac{\partial Loss^{(l)}}{\partial a_{i,j}{}^{(l-1)}} = \delta^{(l)} * rot180^o\left(W^{(l)}\right). \tag{11}$$

Expanding to item-by-item accumulation:

$$\frac{\partial Loss^{(l)}}{\partial a_{i,j}{}^{(l-1)}} = \sum_{r=0}^{R-1} \sum_{c=0}^{C-1} \omega_{r,c}^{(l)} \delta_{i-r,j-c}^{(l)}. \tag{12}$$

The data block elements of δ correspond to the elements of filter W in reverse order and then calculate the dot product.

$$\frac{\partial a_{i,j}^{(l-1)}}{\partial z_{i,j}^{(l-1)}} = f'\left(z_{i,j}^{(l-1)}\right). \tag{13}$$

Putting the two parts together, then

$$\delta_{i,j}^{(l-1)} = \sum_{r=0}^{R-1}\sum_{c=0}^{C-1} \omega_{r,c}^{(l)} \delta_{i-r,j-c}^{(l)} f'\left(z_{i,j}^{(l-1)}\right), \tag{14}$$

or written in a cross-correlation form:

$$\delta^{(l-1)} = \delta^{(l)} * rot180^{o}\left(W^{(l)} \bullet f'\left(z^{(l-1)}\right)\right). \tag{15}$$

After processing formula (15), we obtain as follows:

$$\frac{\partial Loss}{\partial \omega^{(l)}} = a^{(l-1)} * \delta^{(l)}. \tag{16}$$

Expanding to item-by-item accumulation:

$$\frac{\partial Loss}{\partial \omega^{(l)}} = \sum_{r=0}^{R-1}\sum_{c=0}^{C-1} \delta_{r,c}^{(l)} a_{i+r,j+c}^{(l-1)}. \tag{17}$$

Calculating the weight parameter gradient of the filter as follows:

$$\frac{\partial Loss}{\partial \omega^{(l)}} = \frac{\partial Loss}{\partial z^{(l)}} \frac{\partial z^{(l)}}{\partial \omega^{(l)}}. \tag{18}$$

Calculating the bias gradient of the filter:

There are convolution kernels with D filters and there are also D bias item gradients. The bias item gradient of this convolution kernel in order d is the sum of the elements of the network layer error tensor δ on the component matrix of d:

$$\frac{\partial Loss^{(l)}}{\partial b_d^{(l)}} = \frac{\partial Loss^{(l)}}{\partial z_d^{(l)}} \frac{\partial z_d^{(l)}}{\partial b_d^{(l)}} = \sum_i \sum_j \delta_{d,i,j}^{(l)}. \tag{19}$$

3. Intelligent Scoring Experiment of Melody Model Singing Training

A man-machine comparison experiment was carried out to test the scoring effect of the melody model singing intelligent scoring system after using the deep learning technology [22]. 10 subjects were selected to sing a Chinese song, an English song, a German song, and pure music. The human graders were professional music teachers. The machine grading system included the automatic grading model established in this paper and two other automatic grading models [23]. The automatic grading model established in this paper was recorded as Model 1, and the other two automatic grading models were recorded as Model 2, 3. To set the full score of 10 points, the subjects' model singing results were scored; then, the difference between the human-computer scores was calculated, and the data were analyzed.

3.1. Chinese Songs. Manual scoring and three scoring models were used to score the Chinese song model singing results of the subjects, and data analysis was performed on the scoring results, as shown in Figure 4.

Because the scoring algorithms of the 3 scoring systems were different, the scoring results were different. From the scoring results, it could be seen that the scoring results of Model 1 and Model 3 were lower than those of the manual raters, and the scoring results of Model 2 were higher than those of the manual raters. In the manual scoring results, 8 people were higher than the passing line, with an average score of 7.4 points, and the pass rate was 80%. The scoring results of Model 1 were 0.4–0.8 points lower than the manual scoring results, and 6 people were higher than the passing line, with an average score of 6.79 points, and the passing rate was 60%. The scoring results of Model 2 are 0.7–1.4 points higher than the manual scoring results, with an average score of 8.46 points. 10 people were above the pass line, and the pass rate was 100%. The scoring results of Model 3 were 0.9–1.3 points lower than the manual scoring results and 6 people were higher than the passing line, with an average score of 6.25, and the passing rate was 60%. Among them, the average disparity between the Model 1 marking consequence and the factitious marking consequence was 0.61 points, the average disparity between the Model 2 marking consequence and the factitious marking consequence was 1 point, and the disparity difference between the Model 3 marking consequence and the factitious marking consequence was 1.15 points. The comparison of the results showed that the automatic scoring model established in this paper was more accurate in the scoring results of Chinese songs.

3.2. English Songs. It is necessary to use manual scoring and three scoring models to score the English song model singing results of the subjects and to perform data analysis on the scoring results, as shown in Figure 5.

There were 6 people who are above the pass line in the manual scoring results, with an average score of 6.62 points, and a pass rate of 60%. The scoring results of Model 1 were 0.5–0.8 points lower than the manual scoring results, and 6 people were higher than the passing line, with an average score of 6 points, and the passing rate was 60%. The scoring results of Model 2 were 0.9–1.5 points higher than the manual scoring results, and 10 people were higher than the passing line, with an average score of 7.8 points, and the passing rate was 100%. The scoring results of Model 3 were 0.8–1.2 points lower than the manual scoring results, and 4 people were higher than the passing line, with an average score of 5.58, and the passing rate was 40%. Among them, the average disparity between the Model 1 marking consequence and the factitious marking consequence was 0.62 points, the average disparity between the Model 2 marking consequence and the factitious marking consequence was 1.18 point, and the disparity difference between the Model 3 marking consequence and the factitious marking consequence was 1.04 points. The comparison of the results showed that the automatic scoring model established in this paper was more accurate in the scoring results of English songs.

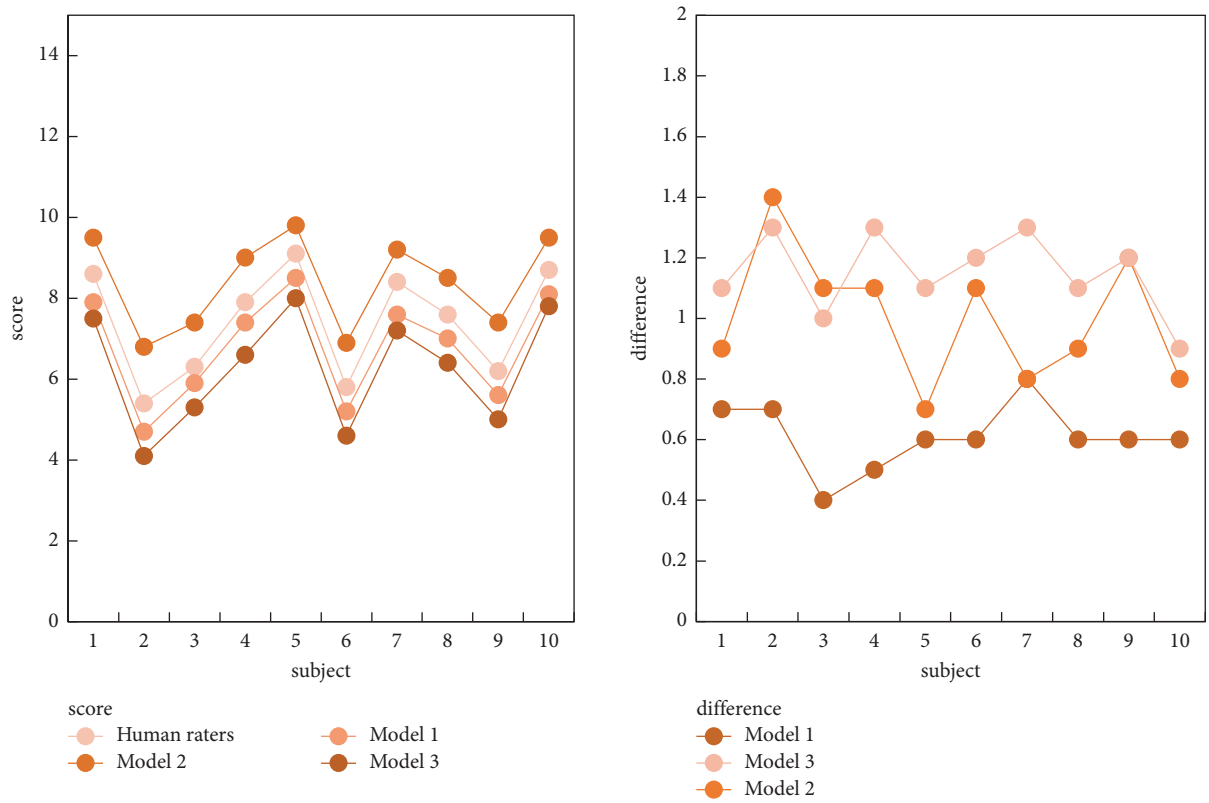

Figure 4: The result of the Chinese song singing rating.

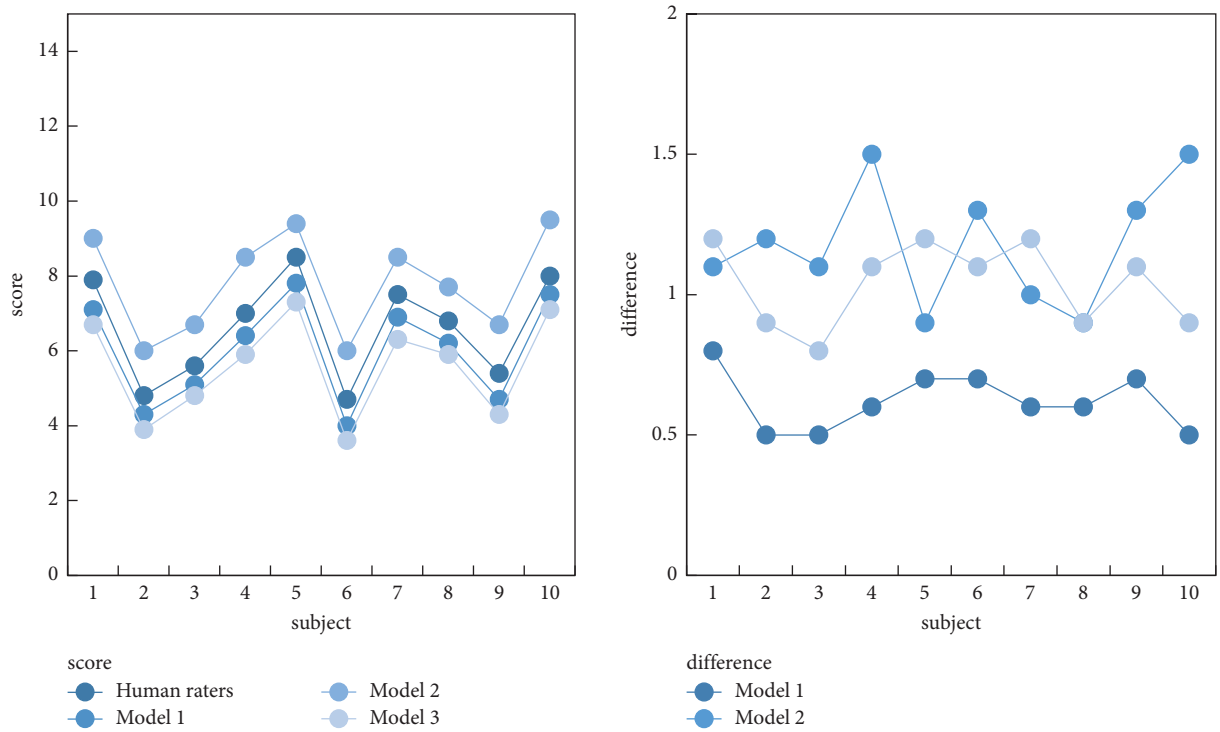

Figure 5: The result of the English song singing rating.

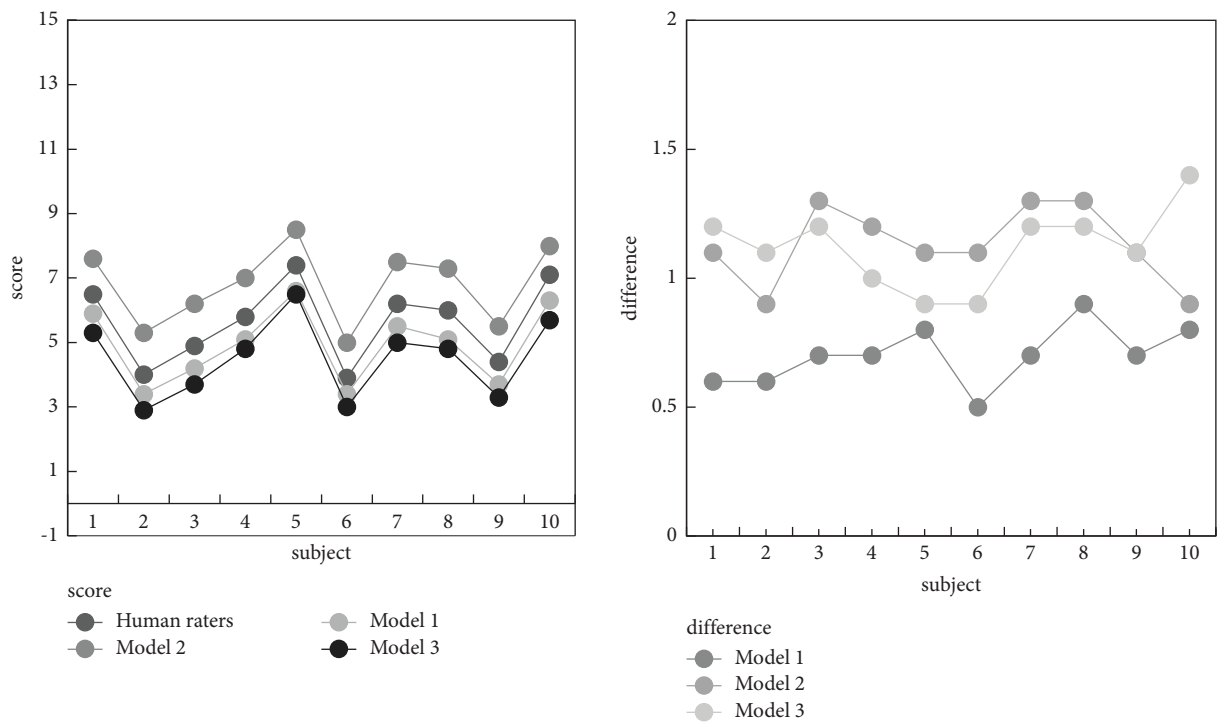

Figure 6: The result of the German song singing rating.

3.3. German Songs. Manual scoring and three scoring models were used to score the German song model singing results of the subjects, and data analysis was performed on the scoring results, as shown in Figure 6.

In the manual scoring results, 5 people were higher than the passing line, with an average score of 5.62, and the passing rate was 50%. The scoring results of Model 1 were 0.5–0.9 points lower than the manual scoring results, and 2 people were higher than the passing line, with an average score of 4.92 points, and the passing rate was 20%. The scoring results of Model 2 were 0.9–1.3 points higher than the manual scoring results, and 7 people were higher than the passing line, with an average score of 6.79 points, and the passing rate was 70%. The scoring results of Model 3 were 0.9–1.4 points lower than the manual scoring results, and 1 person was higher than the passing line, with an average score of 4.5 points, and the passing rate was 10%. Among them, the average disparity between the model 1 marking consequence and the factitious marking consequence was 0.7 points, the average disparity between the model 2 marking consequence and the factitious marking consequence was 1.13 point, and the disparity difference between the model 3 marking consequence and the factitious marking consequence was 1.12 points. The comparison of the results showed that the automatic scoring model established in this paper was more accurate in the scoring results of German songs.

3.4. Pure Music. It is necessary to use manual scoring and three scoring models to score the pure music song model singing results of the subjects and perform data analysis on the scoring results, as shown in Figure 7.

In the manual scoring results, 8 people were higher than the passing line, with an average score of 7.22, and the passing rate was 80%. The scoring results of Model 1 were 0.4–0.8 points lower than the manual scoring results, and 6 people were higher than the passing line, with an average score of 6.64 points, and the passing rate was 60%. The scoring results of Model 2 were 0.9–1.4 points higher than the manual scoring results, and 10 people were higher than the passing line, with an average score of 8.4 points, and the passing rate was 100%. The scoring results of Model 3 were 0.8–1.3 points lower than the manual scoring results, and 6 people were higher than the passing line, with an average score of 6.19 points, and the passing rate was 60%. Among them, the average disparity between the Model 1 marking consequence and the factitious marking consequence was 0.58 points, the average disparity between the Model 2 marking consequence and the factitious marking consequence was 1.18 point, and the disparity difference between the model 3 marking consequence and the factitious marking consequence was 1.03 points. The comparison of the results showed that the automatic scoring model established in this paper had more accurate scoring results in pure music.

3.5. Comprehensive Analysis. The data of the four evaluation results are summarized, and the intelligent scoring effect of the three systems is comprehensively analyzed. The data are shown in Table 1.

The average difference between the evaluation results of the four songs of Model 1 and the manual evaluation results was 0.63 points, and the accuracy rate was 90.66%. The accuracy rate of this scoring model was relatively high. The

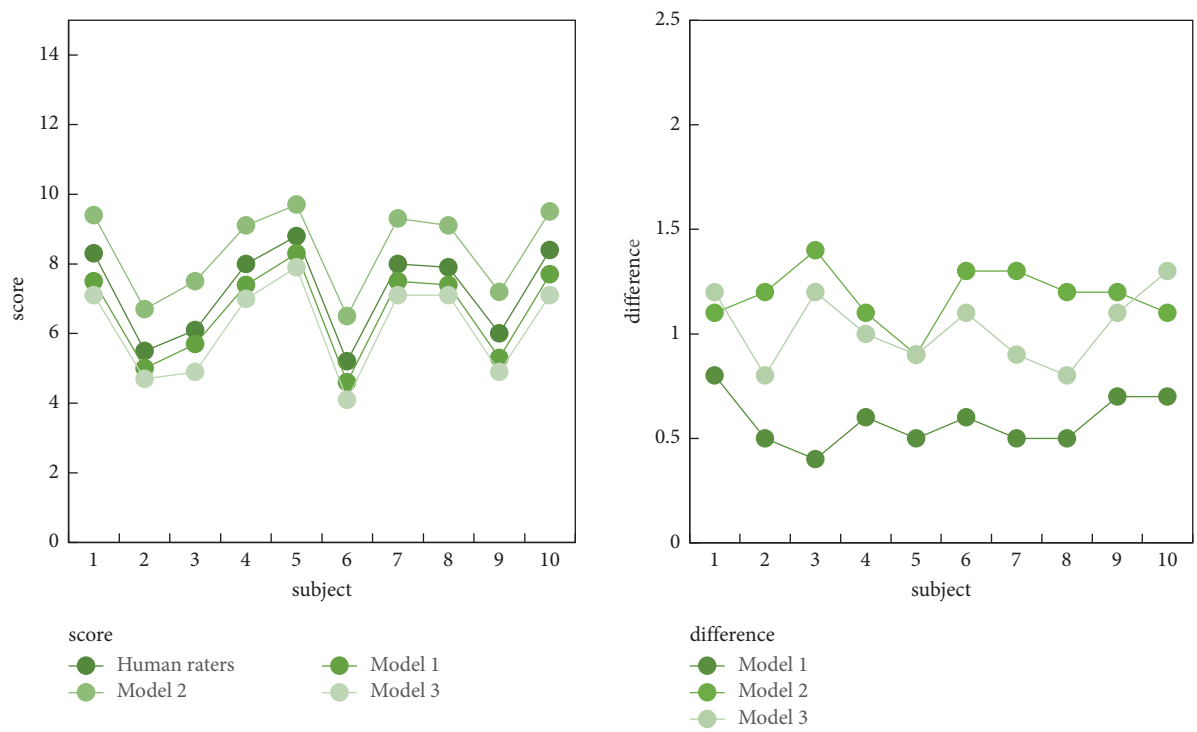

Figure 7: The result of the pure music song rating.

Table 1: Summary of evaluation system data.

Model	The average difference	Accuracy (%)
Model 1	0.63	90.66
Model 2	1.12	82.9
Model 3	1.09	83.84

average difference between the evaluation results of the four songs of Model 2 and the manual evaluation results was 1.12 points, and the accuracy rate was 82.9%. The average difference between the evaluation results of the four songs of Model 3 and the manual evaluation results was 1.09 points, and the accuracy rate was 83.84%. Comparing the data, it could be seen that compared with Model 2 and Model 3, the melody model singing intelligent scoring result of Model 1 had a higher accuracy and was closer to the real scoring result. Compared with the original melody model singing intelligent scoring system, the accuracy of the automatic scoring model established in this paper was increased by 6.82%, indicating that the research had certain feasibility.

4. Experimental Discussion

This paper used deep learning technology to study the intelligent scoring modeling method of solfeggio training in ear melody model singing training. The research results were as follows:

(1) It was necessary to extract the features of the melody model singing according to the Mel sound spectrum and then build a melody model singing intelligent scoring model based on the convolutional neural network. It could predict the score of the analog song and output it, realize automatic scoring, and enhance the scoring effect.

(2) A man-machine comparison experiment was carried out. The human graders are professional music teachers, and the machine grading system includes the automatic grading model established in this article and the other two automatic grading models to test the scoring effect of the melody-model singing intelligent scoring system after using the deep learning technology. The experimental results showed that the accuracy of the automatic scoring model established in this paper was 90.66%, and the accuracy of the other two automatic scoring models was 82.9% and 83.84% when evaluating the results of Chinese songs, English songs, German songs, and pure music, indicating that the automatic scoring models established in this paper had a higher accuracy, and the accuracy was increased by 6.82%, which was closer to the manual scoring results.

5. Conclusion

Based on deep learning technology, this paper constructs an intelligent scoring model for melody model singing training. First, the Mel map is used as the sound spectrum feature to extract song features; then, a large number of song features are collected, and the feature data are trained to build a scoring model. By comparing the feature similarity between the model song and the standard song, the score of the model song can be obtained. The man-machine comparison

experiment shows that the melody model singing training scoring model established by deep learning technology has a higher accuracy. Compared with the original melody model singing intelligent scoring system, the accuracy of the automatic scoring model established in this paper is increased by 6.82%. It shows that the research study has certain feasibility.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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Research Article

The Interactive Relationship between Rural Ecotourism Development and New Rural Construction under the Background of Internet

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Rural ecotourism is of great significance to the construction of new countryside, including promoting rural social progress, adjusting agricultural industrial structure, and increasing farmers' income. Starting with the basic concepts of rural ecotourism and new rural construction, this study compares and analyzes the development background and main characteristics of rural ecotourism at home and abroad and evaluates the development of rural ecotourism based on the Internet. This study takes Shahe City in Hebei Province as an example to develop rural ecotourism in the new rural construction and analyzes its tourism development status combined with the Internet+. Combined with its development orientation and basic conditions, this study summarizes the main measures for the development of rural ecotourism in Shahe City, Hebei Province, in order to improve the effectiveness of new rural construction. The results showed that the income of Shahe tourism increased by 31.5%, and the income of outbound tourism increased by 8.9%. This shows that the new rural construction can promote the development of rural ecotourism, increase the passenger flow, and improve the per capita income. The new rural construction and rural ecotourism development complement each other.

1. Introduction

Rural areas have specific natural landscape and socioeconomic conditions, which refer to the places where workers mainly engaged in agricultural production live in concentrated communities, and are different from cities and towns where people engaged in agriculture live. The village is a regional spatial system. One of the manifestations of the village is land use. At present, most villages are close to residential areas, with large areas and low population density, and they are basically rural forest land. There are many ways to use land. Land use methods mainly include agricultural land, construction land, and unused land. The distance between the cities is relatively small, and the residents' activities and ways of thinking are coordinated with the space, which have become an important feature of the system. In recent years, urban-rural integration has been accelerated, and the boundaries between urban and rural areas have been clearly blurred. How to define the concept of urban and rural areas has always been an eternal topic that experts and scholars pay attention to. They try to explain their different views and make different interpretations at different levels in the countryside.

Rural ecotourism plays an important role in promoting social progress in rural areas, adjusting the structure of agricultural industry, and increasing farmers' income, and there is huge room for development [1]. The prerequisite for the development of rural ecotourism is to rely on the current large-scale construction of new rural areas to avoid waste of investment and damage the agricultural ecological environment, leading to barren farmland and failure of farmers' investment. Exploiting ideas and improving social and economic benefits and ecological benefits have an effective role in promoting the steady progress of the construction of a new countryside. These measures are inseparable from a certain degree of scientific and technical support. With the

rapid development of information technology and the arrival of the big data era, the development mode of the Internet+ has penetrated into all aspects of people's lives. According to statistics, nearly 200 districts and towns have actively carried out the activities of building and piloting smart cities. Driven by the wave of the Internet+ traditional industry model, China's agricultural informatization is bound to usher in a new climax.

Generally speaking, rural ecotourism has many different definitions. In foreign countries, some scholars believe that rural ecotourism is a form of tourism. It is a variety of leisure activities carried out in rural environments such as farms or pastures and provides accommodation, catering, and other services for tourists. Other scholars believe that rural ecotourism involves multilevel tourism activities, not only agriculture but also natural ecology, such as walking, cycling, rock climbing, adventure, hunting, and fishing, and some are also related to regional and folk customs. Sex, education, culture, and traditional tourism. Some experts and scholars believe that tourism activities carried out in the rural environment belong to rural ecotourism, and its publicity point and focus should be on rural scenery. Many scholars have carried out the basic ideas of planning and formulating rural ecotourism. Zhen et al. [2], taking Hutou village as an example, analyzed the basic ideas and key points of rural ecotourism planning from the perspectives of tourism resources, development goals, planning and construction priorities, and tourism resources protection and achieved the goal of building a beautiful village [3]. The impact of rural ecotourism on the economy, society, culture, and environment in the desert area of Dhbala Shirkooh village, Yazd Province, Iran, was investigated. Kristin [4] discussed how Lebanon's ecotourism attractions and excursions present a spatial narrative, which is characterized by the desire to build a comprehensive country that connects rural and urban areas on different ecological terrains. Nihayah [5] evaluated data based on field surveys and questionnaires through SWOT analysis (strengths, weaknesses, opportunities, and threats) and showed that the appropriate strategy of the tourist village is a reversal strategy, which means that the village's internal problems must be minimized for a change. Seize market opportunities, restore infrastructure, and take advantage of the diversity of the ecosystem [6]. The new countryside construction plan should follow the principles of "production development, well-off life, rural civilization, clean countryside, and democratic management," analyze the basic ideas of new countryside construction and development, and then summarize the connotation and elements of the concept of rural landscape. It can be found that many related research studies on new rural construction are at the theoretical level, without combining the current era background and scientific and technological background. Therefore, this paper is innovative in the method and discusses the interactive relationship between rural ecotourism development and new rural construction in the context of the Internet based on the characteristics of the times.

The construction of new countryside will drive the overall development of the village, including tourism, and the effective construction of tourist attractions in the village will promote the development of tourism economy. Based on the above research, this article starts with the basic concept of rural ecotourism and the construction of new countryside, comparatively analyzes the development, background, and main characteristics of rural ecotourism at home and abroad, and evaluates the development of rural ecotourism in China. Second, it analyzes the relationship between rural ecotourism and the construction of a new countryside and discusses the significance of developing rural ecotourism for the construction of a new socialist countryside from multiple angles and levels. Third, taking the development of rural ecotourism in Shahe City, Hebei Province, in the construction of new rural areas as an example, the current situation and analysis of tourism development are analyzed. According to its development orientation and basic conditions, the development of rural ecotourism in Shahe City, Hebei Province, is summarized. The main measures and effects to promote the construction of a new countryside. Data show that Shahe tourism revenue increased by 31.5% year-on-year, and income from receiving foreign tourists rose by 8.9%. Finally, some suggestions are made for the development of rural ecotourism and new rural construction in China. It is pointed out that the development of rural ecotourism needs to adhere to government leadership, pay attention to brand building, launch excellent rural ecotourism demonstration bases, implement differentiated competition, and strengthen the overall level of services. To develop a new rural construction, we must establish a government-assisted platform that is people-oriented; planning units take the initiative to grasp the source of the design, identify entry points and strengthen publicity, increase education in rural areas, and cultivate backup talents for new rural construction. The research contents are shown in Table 1.

As can be seen from Table 1, the first chapter is introduction; the second chapter is relevant theoretical explanation; the third chapter is about making a case study according to the situation in Hebei Province; the fourth chapter is about summarizing and discussing the new rural construction; and the fifth chapter is conclusion.

2. The Proposed Method

2.1. New Rural Construction Theory

2.1.1. Connotation of New Rural Construction. China is one of the largest agricultural nations in the world. According to the data released by the National Bureau of Statistics in 2019, we can see that the total rural population in China is 72.135 million, which is nearly half of the total population of the country. At present, China has a large rural population base, a large gap between urban and rural areas, and backward infrastructure. The "three rural issues" are still the most important issues in the process of social development. The construction of a new socialist countryside and measures formulated by the state are important strategies for promoting rural economic development in an orderly manner. The construction of a new socialist countryside refers to the

Table 1: Research situation table.

1	Introduce
2	Relevant theoretical explanation
3	Make a case study according to the situation in Hebei Province.
4	Summarize and discuss the new rural construction
5	Conclusion

economic, political, cultural, and social construction of the countryside in accordance with the requirements of the new era under the socialist system and finally to realize the construction of the countryside into economic prosperity, perfect facilities, beautiful environment, and civilization, the goal of a harmonious new socialist countryside.

2.1.2. Basic Requirements for New Rural Construction. The construction of a new countryside must pay attention to the five aspects of "production development, ample living, civilized villages, tidy villages, and democratic management." The production development optimizes the agricultural structure and develops the characteristic agricultural economy to promote the farmers to live a prosperous life. Only after living a prosperous life, can we improve various mechanisms to help farmers generate income again and begin to pay attention to village civilization, do a good job in the construction of rural spiritual civilization, and create a harmonious and stable countryside. At the same time, we should also pay attention to the cleanliness of villages, using green energy to keep the environment clean. The most important thing is to manage people's livelihood, strengthen grassroots democratic autonomy, and reshape the government's power over farmers. These five aspects are mutually reinforcing and closely linked. Figure 1 shows the five basic requirements for new rural construction and their overview.

Production development is to continue to optimize the agricultural structure, develop a characteristic agricultural economy, and cultivate new points for increasing production and income in rural areas. We must continue to promote industrialization, scale, standardization, and intensification and cultivate leading agricultural enterprises with market competitiveness. We must increase investment and investment efforts to form a new agricultural industry and then promote the construction of a higher-level and higher-quality new countryside.

Ample life means perfecting various mechanisms, helping farmers generate income and increasing income, adjusting land ownership relations, and implementing a land transfer system to enable large-scale land management. It is necessary to reimprove the governance of agricultural population, improve labor relations, and reform the household registration system. We must make every effort to safeguard the legitimate rights and interests of farmers, maintain fairness and justice, actively improve farmers' production and living conditions, rationalize the distribution relationship, improve the basic insurance system to help farmers resist risks, and increase efforts to reduce the burden on farmers, so that farmers fully enjoy dividends from the results of tax reform.

Country-style civilization is to pay close attention to the construction of rural spiritual civilization and create a harmonious and stable countryside. We must oppose unscientific, uncivilized, and unruly life concepts, resolve the contradiction between material civilization and spiritual civilization in multiple ways, and create a culture that is more in line with rural reality and farmers' needs in terms of content, means, technology, and form. Efforts should be made to educate farmers on forms and policies, protect the rural ecological environment, and ensure the ideologically comprehensive process of building a well-off society.

Villages are clean and tidy, which is to promote the use of green energy, keep the environment tidy, and carry out projects focusing on cleaning. It is necessary to increase capital investment, carry out rural road hardening and transformation, improve the rural environment, and further improve the situation of poor and dirty villages. It is necessary to vigorously promote the use of green energy, reduce the harm to mountain forests and grasslands, and promote the popularization of clean energy such as biogas and natural gas; we must pay attention to the establishment of a multiagent common supervision mechanism and improve the management level and quality through democratic governance to ensure rural ecological civilization.

We must manage democracy, strengthen democratic self-government at the grassroots level, fully respect the autonomy of peasants' self-government subjects, return the power of internal governance to farmers, and further strengthen legal construction and legal education, so that villagers can abide by disciplines, laws, and regulations and build legal countryside. We must simplify administration and decentralize power, regulate the functions of grassroots governments, and make grassroots governments more democratic and legalized when conducting rural governance; we must further strengthen supervision of rural areas, mobilize the enthusiasm of supervision of multiple parties, and maintain the supervision rights of farmers. Channels establish a mechanism for rural complaints and suggestions and strengthen inspections of public security in rural areas, making farmers' lives happier, safer, and more dignified.

2.2. Other Theories

2.2.1. Sustainable Development Theory. Sustainable development is development that does not harm the interests of future generations and can meet the needs of contemporary people. We must emphasise on economic development while paying attention to protecting the environment, ecological protection, and harmonious development of economic development. The mode of coexistence between man and nature has changed from traditional to modern, and attitudes towards nature have gradually changed. The environment and the economy have been balanced. Several principles of sustainable development should be adhered to and summarized into four aspects. Figure 2 shows the four principles of sustainable development theory.

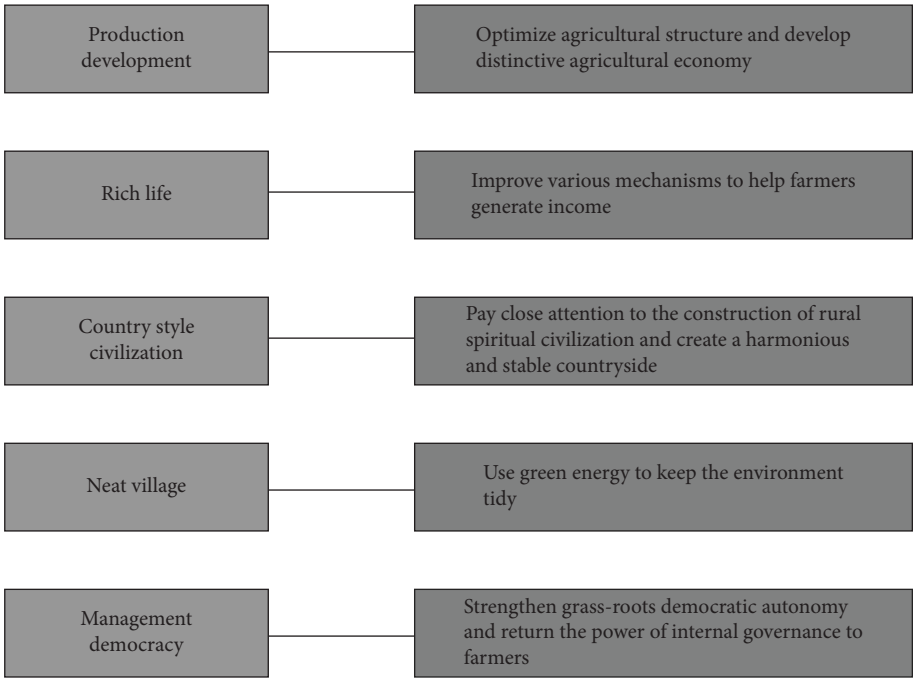

Figure 1: Five basic requirements for new rural construction.

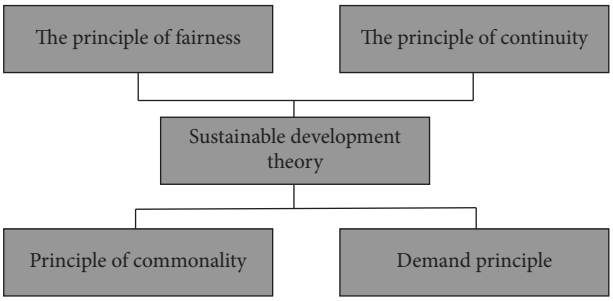

Figure 2: Four aspects of the principles of sustainable development theory.

The principle of fairness: The pursuit of the principle of fairness must be considered from two aspects. The first is that from a vertical perspective, the interests of future generations and the needs of contemporary people need to be respected, and there is no difference and equality between the two. While we develop resources to meet the needs of modern and contemporary times, we must consider the issue of fairness to future generations, and we cannot build the happiness of contemporary generations on the suffering of future generations. Future generations have the same rights as modern people to enjoy Mother Earth. Second, from a horizontal perspective, the power of everyone living in modern and contemporary times is equal, and no one's rights can take precedence over others. Everyone should enjoy all kinds of resources equally and fairly. Distribution of benefits.

Sustainability principle: The earth's bearing capacity is limited. People cannot exceed the earth's bearing range. Exploitation of resources should be moderate and follow a long-term sustainable development situation. Therefore, we cannot accept all production modes that are based on polluting the environment and abusing resources. We should establish low-energy, low-pollution, high-efficiency industries, and production modes. Furthermore, we must use clean energy, promote the protection of the environment and resources, reduce waste, and change. The situation of environmental pollution promotes human and environmental friendly development.

The principle of commonality: The earth is not only the place of one person or of one country but the place where all people and all nations of the world live and develop. Everyone, every organization, and every country have the right to use and develop the resources on the earth. Similarly, the environment of the earth also needs to be maintained by every country, every organization, and everyone. The problems caused by the waste of resources and environmental pollution are global and holistic. We must analyze and respond to the overall concept. While meeting the growing needs of people, we must also properly unite to protect the planet, the beauty of the environment, and make the sustainable use of resources.

Demand principle: it meets everyone's needs and provides better life opportunities. Sustainable development should also follow the principle of demand, which needs not only the needs of the present but also the needs of future generations. We do not compromise the needs of future generations and appropriately meet the needs of contemporary people. The same is true for the development of rural ecotourism. It is necessary to meet the growing needs of people's spiritual civilization, maintain the rural ecological environment and local customs with the concept of sustainable development, and promote rural economic growth and rural social progress.

2.2.2. Governance Theory. Governance theory emphasizes that social governance is common and requires multiple subjects to coordinate and cooperate with each other to play a role and form diversified management [7–9]. Rural ecotourism is a social phenomenon, and its survival and development are also an important content of social governance. Therefore, it is necessary to rely on the theory of governance, give play to the enthusiasm and initiative of various subjects, promote government, enterprises, rural social organizations, farmers, tourists, and other multiparticipants participate in governance, jointly promote and play the active role of governance theory in rural ecotourism planning, development, management, and decision-making, and enjoy the dividends of rural ecotourism to promote economic development and improve people's income and living standards. Moreover, governance must ultimately lead to good governance, so that the relationship between rural economic society and the ecological environment can be straightened out and a sustainable development situation can be formed.

2.2.3. Theory of Tourism Economics. Tourism economics analyzes a contradiction that exists between the supply and demand for tourism products and services. This contradiction runs through the entire process of tourism economic behavior, and it provides an analysis of this economic subject that is different from other economics and different from other sciences [10–12]. The confrontation between the supply and demand of tourism products and services will definitely lead to different economic conditions, as well as various economic relations and contradictory movement laws. Therefore, tourism economics mainly analyzes economic conditions, relationships, and the operating laws of tourism activities. The internal contradiction is between tourism economic activity in tourism demand and supply, and the external conflicts of interest are tourists in the tourism industry, the operator's tourism products, and the government of the destination country or region. Tourists get the most enjoyment and satisfaction from the purchase of tourism products, and people who operate tourism products can get the maximum profits by selling tourism services and products. At the same time, in this process, countries or regions can obtain economic and social benefits [13–15].

2.3. Integration of New Rural Construction and Rural Ecotourism. The interaction between new rural construction and rural ecotourism is the core. The core of the construction of interactive tourism should be based on economic development and expand the precise "urban-rural" development strategy in the composition, so as to experience the connotation of ecology in the process. Therefore, in the new rural construction, we should conduct comprehensive and detailed research on the environment, start from the urban forest coverage, and build ecotourism on the basis of stable economic development. In the process of construction, the local culture of Yiyang City should be integrated into the construction of ecotourism, so as to realize the ingenious combination of vacation and green and highlight the vitality of characteristic tourism.

2.3.1. Relationship between New Rural Construction and Rural Ecotourism. The new rural construction has laid a good social environment for the sustainable development of rural ecotourism. At the same time, it is also changing the concept of rural ecotourism. In the context of the new rural construction, various regions have carried out rural ecotourism construction annual activities in various forms. Displaying local modern agricultural products and special products, exchanging experiences, promoting the production and sales of local agricultural and sideline products, and laying the industrial foundation for the development of rural ecotourism are considered. In order to improve farmers' ability to engage in agricultural and nonagricultural industries, in recent years, the agricultural sector has launched projects such as the "new-type farmers training project," calling on farmers to participate in quality and skill training, which has caused a huge change in the ideological quality and ability structure of rural residents. It also provides a continuous supply of reserve talents for the continuous development of rural ecotourism. Judging from the practice in various places, the rural ecological environment, traffic conditions, and village appearance have changed. Rural infrastructure, ecological environment, production and living conditions, transportation, communication, sanitation, and drinking water conditions have also improved. Of course, it is necessary to achieve comprehensive improvement, we still need a process, and now, we are on the road to deepening development.

The development of rural ecotourism has become a new growth point of the rural economy. Because a large amount of agricultural land was expropriated, a large amount of surplus labor found it difficult to find employment in the rural areas. As a result, they had no choice but to go out to work in cities and increase the pressure on urban employment. However, the development of rural ecotourism has brought employment opportunities and attracted a large number of people. Migrant workers returned to home to engage in service business activities. At the same time as the development of rural material civilization, the development of rural ecotourism has enabled good communication between urban and rural residents, between different nationalities and regions, and even between different countries. Many foreign friends are very close. I like China's rural ecotourism resources, and some of them have married and settled with local villagers and started to engage in business activities. This has greatly strengthened the friendship between people and enabled foreigners to understand China's national conditions, and it is also beneficial to farmers. By having a broad perspective, abandoning old ideas, and changing bad habits, many ethnic regions can not only speak fluent Mandarin but also some foreign languages by developing rural ecotourism.

2.3.2. Significance of Integration and Development of New Rural Construction and Rural Ecotourism. Rural ecotourism plays an important role in promoting social progress, agricultural industrial restructuring, and increasing farmers' income in China's rural areas. There is huge room for

development. The prerequisite for the development of rural ecotourism is to rely on the current large-scale construction of new rural areas, avoid investment waste, destroy the agricultural ecological environment, and lead to barren farmland and farmers' investment failures. Development ideas improve social economic and ecological benefits and have an effective role in promoting the steady progress of new rural construction. Figure 3 shows the significance of rural ecotourism to the construction of a new countryside.

First, one must optimize the structure of the agricultural industry. The economic structure of the local industry has changed with the development of rural ecotourism, and new impetus has been developed in production. With the increase of consumer demand, the related industrial chains such as processing and transportation of local specialty products such as agricultural and sideline products will also be driven.

Second, one must raise the level of farmers' income. Local farmers have become rural ecotourism operators and have achieved good returns. In the development of rural ecotourism, there are many ways and means to resolve employment and increase income. Farmers can earn a good income without going to the city to work, and on the one hand, they can support their families and take care of their wives, children, and parents. They increase their income by working for hours, building hotels, opening restaurants, and selling specialty products and handicrafts. In addition, through the intervention of the government and village committees, they can also participate in the project to increase their dividends.

Third, one must enhance rural cultural connotation. The development of rural ecotourism has brought new information and new ideas. Farmers' desire for cultural knowledge has been further strengthened. The quality of farmers has been affected by foreign tourists, and they have begun to actively learn about culture and technology. Many villagers have also learned Mandarin, foreign languages, and computers; as a result, the overall quality and spiritual civilization of farmers have greatly improved.

Fourth, attach importance to ecological and environmental protection issues. Through digital and advanced means such as information networks, focus on instilling environmental protection knowledge, strengthening environmental awareness, and appropriately using some negative teaching materials to stimulate local farmers' attention towards ecological and environmental protection to better protect their own environmental resources, ecological resources, and cultural resources and strengthen sustainable development in rural areas. Finally, strengthen farmers' initiative and participation. Adhering to the method of democratic management and implementing independent decision-making and democratic decision-making by farmers, such a development of rural ecotourism, can really promote the construction of a new countryside.

3. Experiments

3.1. Basic Situation of Shahe City, Hebei Province. Shahe City is a prefecture-level city in Henan Province. It is close to the Taihang Mountains and is dominated by plains. Shahe is adjacent to Shandong Province to the east, Shanxi Province to the west, Hengshui City and Shijiazhuang City to the north, and Handan City to the south. Shahe City is 185 km long and 80 km wide with a total area of approximately 12364 km^2. There are many mountain peaks, beautiful mountains and clear waters, vast land, fertile land, abundant products, and relatively developed agriculture in the area. Shahe is also rich in resources, including ferrous metals and coal. The traffic in the area of Shahe is very convenient. There are many famous railways passing through, such as Beijing –Kowloon line and Beijing –Guangzhou line. In addition, there are many expressways. Because it is close to the Grand Canal, water transportation is also relatively fast. The Shahe Municipal Government has made great efforts in the integration and optimization of the economic structure, and the economy has reached a new level, and the people's living standards and happiness index have been improved. The tertiary industry, especially the tourism service industry, has made great progress. In 2019, Shahe received 17.139 million domestic tourists, an increase of 22.3%. The income from tourism in Shahe City reached 13.86 billion yuan, an increase of 31.5%. The average amount of money spent per person was 826.3 yuan/person-time, an increase of 58.4 yuan/person-time. Last year, it received 2,488 foreign tourists, an increase of 26.8%, because receiving foreign tourists brought in $ 5.686 million in money income, an increase of 8.9%. The income and living standards of urban and rural residents have improved to a certain extent.

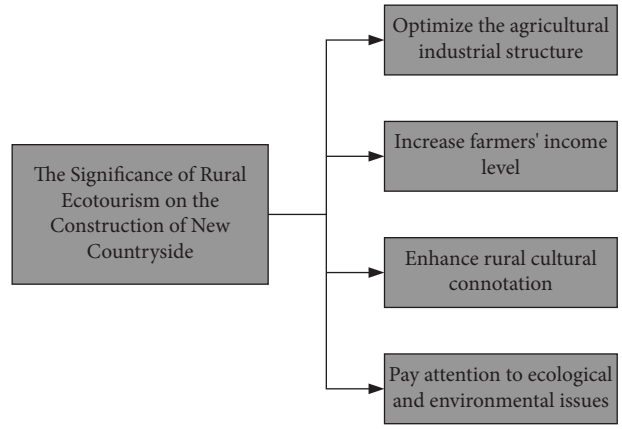

Figure 3: The significance of rural ecotourism to the construction of new countryside.

3.2. Analysis of Integration Development of Rural Ecotourism and New Rural Construction in Shahe City, Hebei Province

3.2.1. Analysis of Development Advantages. The integration of rural ecotourism and new rural construction will promote the common development of both, resulting in a series of advantages, as shown in Figure 4.

It is a very long journey to promote the growth of rural ecotourism and the construction of new countryside. Based on this goal, the author believes that it should be promoted from three aspects.

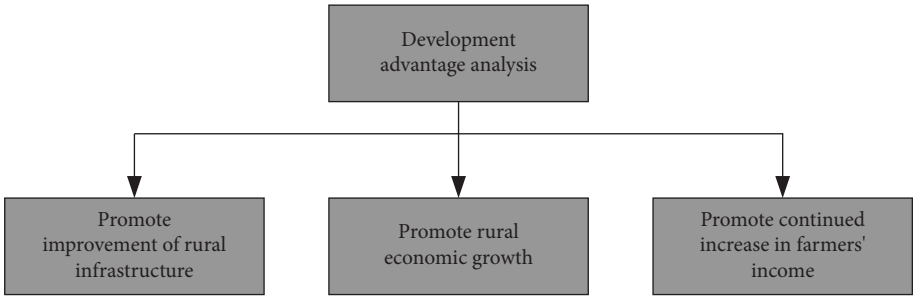

Figure 4: Development advantage analysis.

First, promote the improvement of rural infrastructure. Rural ecotourism has become a driver of rural collective economic growth, which has greatly strengthened farmers' affordability. Village enterprises and farmers also have the conditions and talents to accelerate the development and completion of rural infrastructure construction and have adopted effective measures for a long time. Infrastructure maintenance and supervision. Rural ecotourism promotes the improvement of rural infrastructure and promotes the goal of "clean village appearance."

Second, promote rural economic growth. For a long time, China has still been dominated by the plantation industry, where the rural economy is relatively poor and farmers' income is relatively small. Through the rational and effective integration of tourism and old style agriculture, expand the agricultural production and management boundaries, increase the added value of agricultural products, promote the formation of new industries, promote the integration of the three industries, and catalyze the mutually reinforcing and growing industries. Based on various rural resources, combining rural ecotourism with the vital interests of farmers, and thus starting to promote tourism and agriculture, is a key measure to promote the process of new countryside and to efficiently optimize the rural industrial structure.

Finally, promote the continuous increase of farmers' income. Tourism requires industries with a large labor force and is highly coupled. The World Tourism Organization believes that tourism can bring employment opportunities, create 6–8 labor positions, and greatly increase the supply of employment. Rural ecotourism enables many farmers to use tourism behaviors and their own space, and based on rural natural resources, they can get rich without going out of their homes and exchange space for wealth to achieve nonvirtual employment. According to statistics, serving 100,000 people each year, this rural ecotourism site can place 300 employment opportunities for farmers, bringing higher income to 100 families.

3.2.2. Analysis of Development Disadvantages. Today, Xingtai's rural ecotourism has grown to a certain degree and has achieved excellent results, which is of great benefit to the construction of a new countryside. However, because it is still in the initial stage of development, rural ecotourism not only brings great opportunities but also brings negative impacts on culture, ecology, and concepts.

First, the negative impact on the rural economy. The existence and growth of rural ecotourism has opened up the income difference between farmers. The quality and skills of people are different, as are farmers. Therefore, each farmer gains different benefits in the process of rural ecotourism growth, which has widened the gap between farmers.

Second, the leakage of rural ecotourism is critical, especially in rural areas where the economy is so poor. Economically sound regions can take a variety of measures to respond, such as collective investment and mutual cooperation, and increase their income through equity participation. However, the economically backward regions have dependence on foreign investment and products and bring low income to the localities. They cannot achieve the objective of promoting economic growth, but affect the stability of rural product prices. Urban residents who come to rural ecotourism have relatively good economic conditions and high consumption tolerance. Therefore, they are willing to pay more than the value of commodities to buy tourism products, which will increase animal prices. Therefore, if a large number of tourists enter rural areas, prices will rise, but the income of rural residents has not increased, and high consumption has increased the burden on farmers.

Traditional culture has been eroded. The existence and growth of rural ecotourism can indeed protect the ecology and maintain the environment to a certain extent, but the entry of a large number of tourists will also have a certain impact on culture. For example, some historical and cultural streets, in order to meet the needs of tourists, carry out game halls, movies, and other business activities, as well as matters that are not in harmony with local customs, which distorted the value of rural ecotourism growth. In the long run, it will cause damage to the growth of local rural ecotourism. Figure5

Therefore, while developing the rural tourism economy, we need to pay close attention to the changes of farmers' income and commodity prices as well as the protection of traditional culture. Only in this way can the rural tourism economy develop sustainably.

4. Discussion

4.1. Pilot Work on the Integration of New Rural Construction and Rural Ecotourism. Shahe City has indeed invested a lot of time and energy in the new countryside. It has also implemented pilot projects in some places and has achieved

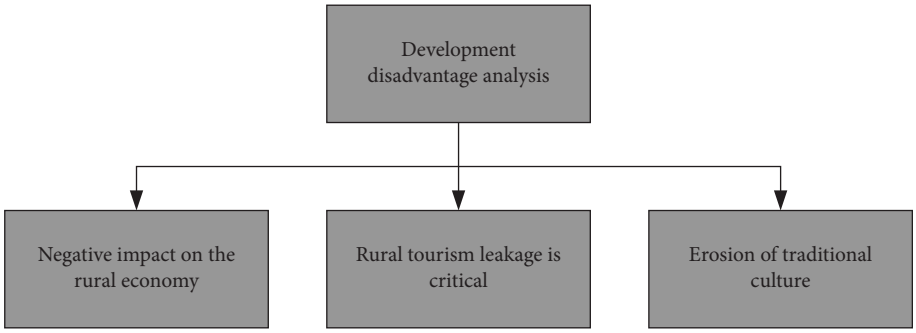

Figure 5: Development disadvantage analysis.

certain results. Table 2 shows some basic conditions of new rural construction in Shahe City. Table 3 shows some of the results achieved by using Shahe City as a new rural construction complex. Figure 6 shows the number of domestic and foreign tourists received by Shahe City in 2019 and 2018. Figure 7 shows that Shahe City's tourism revenue in 2019 is compared with that in 2018.

It can be seen from Figures 6 and 7 that from 2018 to 2019, the number of domestic and foreign tourists and tourism income in Shahe City increased.

4.2. Problems and Countermeasures for the Integration and Development of New Rural Construction and Rural Ecotourism. The promotion mechanism of rural tourism to the construction of new countryside is shown in Figure 8. Xingtai's rural ecotourism has grown to a certain degree and has achieved excellent results, which has great benefits for the construction of a new countryside. However, as a whole, it is still in the initial stage of development and there are still many problems in the integrated development of rural ecotourism and new rural construction. Figure 9 shows four basic issues that arise in the integrated development of rural ecotourism and new rural construction.

Looking at the practice of rural ecotourism at home and abroad, combined with the basic situation of Shahe rural ecotourism development, it can be found that rural ecotourism helps promote the development of "agriculture, rural areas, and farmers," promote rural economic development, increase farmers employment, and improve farmers' quality of life. To better promote the development of rural ecotourism, promote the rural economy, and play a more active role, propose the following countermeasures and suggestions. Figure 10 shows the strategies of the interactive development model of new rural construction and rural ecotourism.

4.2.1. Improve Government Policies for Rural Ecotourism. In order to promote the healthy and orderly development of rural ecotourism, the government needs to play a strong safeguard role, play a leading role, and at the same time, play the role of nongovernmental organizations. The government can increase investment in policies, relax market access, tax incentives, and support policies for tourism operators. At the same time, it can reform infrastructure facilities, increase financial investment, standardize the market system, and increase publicity to address rural tourism development. Bottleneck.

Table 2: Some basic situations of new rural construction in Shahe City.

Change water	286 households	Water improvement rate is 95%
Toilet modification	292 households	95% toilet modification rate
Reroute	230 m	Rerouting rate is 86%
Sewer	1530 m	—
Site hardening	4000 m^2	—
Trash removal	200 t	—
Plant tree	500 trees	85% survival rate

Table 3: Achievements of Shahe new rural construction complex.

Area	2000 acres
Total investment	1.4 billion
Involving farmers	More than 200 households
Involving farmers	More than 800 people
Taoyuan and Liyuan bases	90 acres
Farmhouse	4 homes
New farm house	51 households

Figure 6: Comparison of the number of domestic and foreign tourists received in 2018 and 2019.

4.2.2. Adapt to Local Conditions and Create Special Tourism Products. The key to improving the attractiveness of rural ecotourism is to tap the characteristics of the countryside

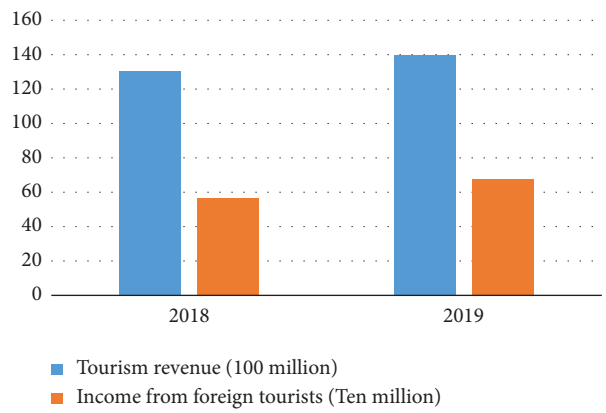

Figure 7: Comparison of tourism revenue in 2018 and 2019.

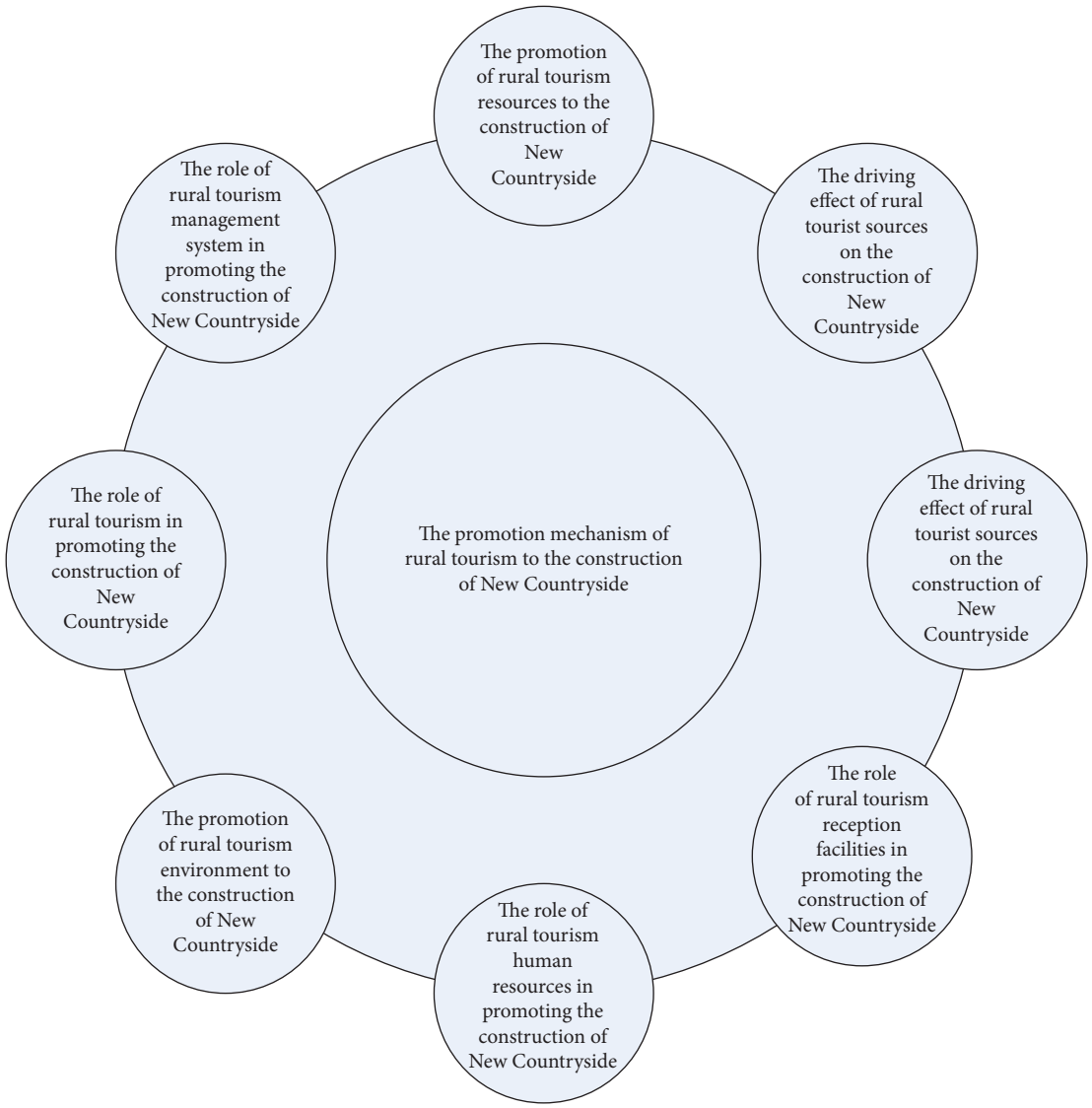

Figure 8: The promotion mechanism of rural tourism to the construction of new countryside.

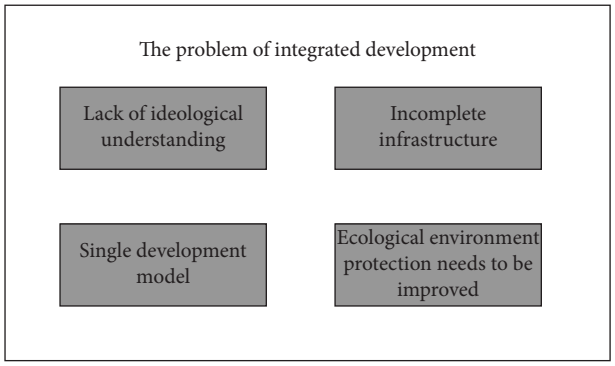

Figure 9: 4 basic issues of integrated development.

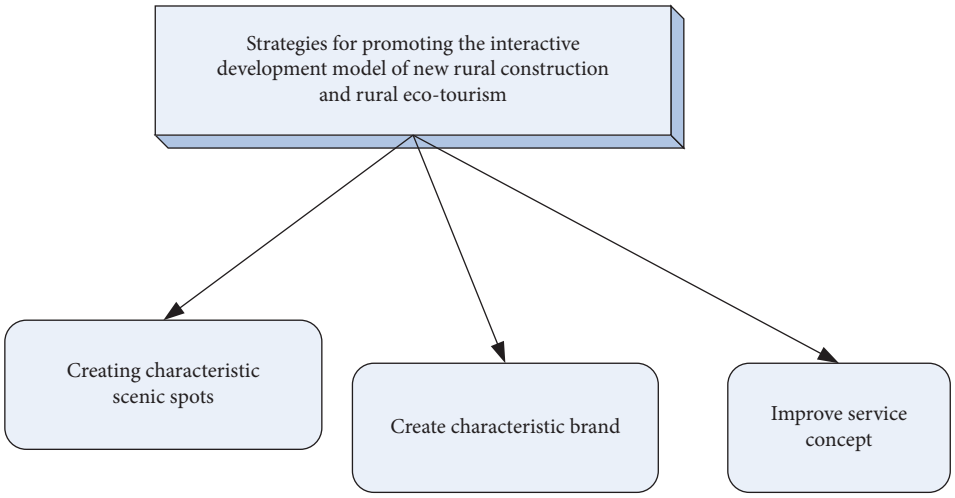

Figure 10: Strategies for promoting the interactive development model of new rural construction and rural ecotourism.

and create unique customs. The most essential local culture of the countryside, rural features, and rural characteristic products are the specific carriers for the development of rural ecotourism. By summarizing the experience of local ethnic style, living customs, and rural ecotourism, it can be found that the theme is concentrated in a typical positioning of industrial products, that is, the theme of experience. The theme of rural ecotourism should show the characteristics of rural ecotourism, according to the needs of the tourism market, highlight the characteristics, and strengthen the theme, in order to satisfy tourists' awareness, feelings, and experiences of cross-cultural differences and enhance the attractiveness of rural ecotourism. In addition, leisure and agricultural tourism operators can establish long-term cooperation mechanisms with travel agencies to maximize their own publicity, strive to expand market influence, and win more customers; in addition, they should also communicate with surrounding small towns activities, establish an information communication platform, learn from each other, and focus on joint marketing.

4.2.3. Strengthen Marketing Efforts. The development of rural ecotourism must adhere to the core principle of sustainable development. However, the construction of rural ecotourism exceeds the environmental carrying capacity, causing environmental pollution, wasting resources, and restricting the balanced development of local economy, society, and ecology. Therefore, the development of rural ecotourism must adhere to the implementation of sustainable development strategies, strictly in accordance with the "green development" concept proposed by the 18th Third Plenary Session, adhere to resource conservation and environmental protection, adhere to sustainable development, resolutely take production and development, and live a wealthy well-developed and ecologically sound development path, accelerating the construction of a resource-saving and environment-friendly society and forming a new social structure.

4.2.4. Regional Linkage and Common Urban and Rural Development. The development of rural ecotourism in China is still in its infancy, low level, and immature. The nature and external effects of its public goods are obvious. Therefore, the development of rural ecotourism needs to rely on local famous scenic spots and linkages with regions. Development of various points should be linked to rural ecotourism and scenic spots, integrate various types of tourism resources, form a component of regional tourism

products, and give play to the linkage effect of regional tourism.

5. Conclusion

Tourism is a developing industry with the development of social economy. Rural ecotourism is a new type of rural development industry that mobilizes the participation of rural villagers, promotes the development of rural industries, increases farmers' income, and can effectively solve the employment problem of rural surplus labor. Improving the quality of life of farmers is of great significance to the construction of a new countryside.

The development of rural ecotourism has effectively solved the problem of farmers entering cities and retaining young adults and some talents. One must promote urbanization, expand rural demand, stimulate consumption growth, and benefit rural areas. Deeper conflict resolution. At the same time, the development of rural ecotourism is also a requirement for building "beautiful villages," attracting more tourists to pay attention to the countryside, and narrowing the gap between urban and rural areas. Promoting the development of rural ecotourism inevitably cannot be realized without the support of science and technology.

This article analyzes the current situation in Shahe District. First, it reviewed the development of rural ecotourism at home and abroad and analyzed the development of rural ecotourism in China. The experimental results show that the income of Shahe tourism increased by 31.5% and the income of outbound tourism increased by 8.9%. In addition, one must combine relevant theories and big data technology to carry out rural ecotourism research in Shahe District. The detailed analysis of the advantages and disadvantages summarizes the current main problems and puts forward specific countermeasures to promote the construction of a new ecotourism countryside based on the current situation.

In the research, although a large number of documents and materials have been consulted, the understanding of rural construction in Xi' an is still not profound. In the analysis of this paper, only the situation in Hebei is analyzed, and there are still some limitations. The authors hope that this situation can be deeply analyzed in the follow-up research.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Application of Digital Interactive Display Design Based on Computer Technology in VR Film

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In order to explore the sustainable development of VR films, the paper analyzes the current situation and problems of the film works and the important role of digital interactive display design in the film, and makes a comprehensive analysis and comparison between traditional display design and digital interactive display design by using statistical methods. Finally, it is concluded that the application of digital interactive display design in VR films not only meets the development needs of the digital industry in the intelligent era but can also improve the interactive experience of VR films. The application of computer technology to the digital integration of VR movies can enhance the visual effect of the movies and more easily resonate with the audience, and it has important strategic significance to promote the economic prosperity of later animation films.

1. Introduction

The development road of VR films contains people's imagination and good wishes for the digitization of computer technology. The characters, actions, behaviors, and reaction modes in VR films can better attract the audience. With the increase of the number of audiences, the immersive performance and interactivity of VR films can enable the audience to better participate in it. The surrealism can fully mobilize the audience's vision, hearing, smell and touch, and complete an interactive process of communication experience. The digital interactive display design application of computer technology provides the audience with a stronger immersive interactive experience in the film, and realizes the seamless connection between the real world and the virtual world. In the panoramic film, the digital display design can achieve the real-time rendering characteristics necessary for interaction, so that the audience can obtain the entertainment experience. This way, to a certain extent, enhances the audience's sense of substitution. It has changed from the previous fixed screen or screen play to a 360° surrounding environment. VR movies and TV are no longer based on the narrative means of traditional movies, but more show an immersive experience. Wang (2022) made an artistic exploration of VR films and an analysis of the possibility of the future, pointing out that people's awareness of the artistic expression of VR films is constantly improving, and VR films have made new artistic exploration and attempts in terms of space composition, time composition, and narrative composition [1]. Li (2021) analyzed the narrative characteristics and narrative structure of VR films under the background of 5 g computer technology. Due to the particularity and versatility of audiovisual, VR films, supported by the hardware of technology, have more released the narrative perspective and fluency [2]. Jiang and Wang (2021) and others studied the problems of weak immersion, poor interaction, and low simulation of the previous film experience, and used deep learning technology to enhance the VR film experience effect. From the perspective of visual center, the visual expression of VR film is emphasized, and the concept of VR film creation based on audience experience and visual guidance is emphasized to realize the interactivity of VR movies [3].

Zhang (2019) pointed out that computer technology has been fully integrated into people's daily life. The improvement of new media and human-computer interaction technology has also stimulated people's interest in digital interactive display design. Under the current big data background and the development status of digital interactive technology, it can bring diversified development in various fields [4]. Yanliang (2022) analyzed the conditions for the generation of immersive experience in digital reading, and provided enlightenment for the development of interactive experience design in the future by creating more immersive experience in digital reading through interactive mode design [5]. This research is about the application of digital interactive display design in VR movies. This research can bring some reference value to this research. Xu and Xu (2022) in the perspective of interactive narrative, from the perspective of analyzing the elements and characteristics of interactive narrative in digital display, constructs the interactive narrative situation and truly conveys it to the audience, so that the audience can receive, understand, and identify with the theme of the display from the sensory organs. The digital interactive display design of interactive narrative can break through the boundaries of time and space and allow the audience to obtain a good experience [6]. In this study, the digital interactive display design of computer technology is applied in VR movies to bring good entertainment experience and physical and mental relaxation to the audience. Yuan and Liu (2022) and others discussed the creative imagination and extensional thinking of sci-fi films as the starting point to positively respond and reflect on the virtual world constructed by digital technology and the emotional experience separated from the body. Various virtual space-time and spectacular images created by digital technology have broadened the audience's vision [7]. Yaqin (2019) analyzed that the integration of virtual reality technology and film has become an important discovery in the development of film art, bringing a brand-new visual experience to the development of film art, and digital interactive display design has created innovations in the creation of plot scenes, line of sight, and characterization [8].

This research analyzes VR movies through digital interactive display design, and promotes the innovation and integration of digital industry and the reconstruction of new business forms from the concept and principle of digital technology interactive display design, it enhances the artistic expression and attraction of the film, breaks through the traditional form of film art expression, and plays a long-term and sustainable role in promoting the innovation of VR film industry.

1.1. Current Situation and Problems of VR Film Works. The development of VR technology in the film is the development of technology and the production of the content of the film itself. The two complement each other. The strong immersive experience of VR films not only has the feeling of immersive but also can better receive the emotional expression conveyed by the films. In the exquisite pictures, the real and detailed actions and realistic three-dimensional effects conquer the audience's senses, so that the audience can get a more shocking experience. The appearance of VR makes the audience immersive in the virtual scene. The appearance of VR technology promotes the audience's audiovisual enjoyment to a new level, Strengthen the environmental perception of the senses. The continuous extension of this technology makes the sensory perception more immersive. The highly virtual feature of VR technology has greatly expanded the possibility of the film to express reality and psychology, and enriched the aesthetic characteristics of the film art. However, it is difficult to shape the space outside the picture in VR films, and the creation method is too limited. The space change in VR scenes is also impossible to complete the space conversion. The disadvantage of immersion is the closeness. In augmented reality, it will gradually fade with the freshness and lose the original charm of the film. The picture output of VR film works has the problem of low-image quality, so the value of VR film works is greatly reduced.

The viewing angle of VR movies is 360°. When watching movies, the audience will put on the VR head display and immediately enter the movie scene. They can enjoy the film and television works in all directions and from multiple angles. From the perspective of audience experience, VR movies improve the visual effect of movies and the immersive feeling of human-computer interaction, which is the top priority of the next film production innovation, it is equipped with virtual reality technology and has the general nature of the technology product, that is, super immersive feeling. No matter how an excellent VR movie is watched, the audience can feel the reality of the scene and the integrity of the plot. A good picture can guide the audience to actively experience, perceive and guess the plot, and guide the audience to appreciate the beauty of the movie picture and realize a comprehensive observation. VR films highlight a future direction of the development of film entertainment. In terms of production content, they create new ideas, explore three-dimensional interactive immersive scene building methods, and VR films do not explore the interactivity of the technology itself, which is a common challenge in the future.

2. Digital Interactive Display Design

2.1. Digital Interactive Display Design Concept. Digital interactive display design uses the computer and network information technology auxiliary tools in the information age to carry out various display activities and achieve the purpose of display. In the digital display design, human-computer interaction is the best form of interaction, language conversion, and information expression. The application of digital interactive display design injects fresh blood into VR movies. This design has the characteristics of simulation. It can not only see six ways in all directions and listen to all directions but also have the feeling of touch, force, and smell. Shan and Li (2020) and others pointed out that in the interactive experience, consciousness materialization is formed, and the integration of different degrees of freedom in the real world and the virtual world is presented,

and once the results are achieved in physical and mental relaxation [9]. In addition, the interactive function of the digital display design is reflected in the personalized behavior mode, which enables the audience to give full play to their own thinking and imagination space in the virtual environment, and at the same time, it can also achieve the purpose of driving the audience's emotions and more closely conform to the physiological needs, so as to bring the audience an unusual and rich real experience and promote them to achieve a good sense of pleasure and satisfaction.

2.2. Principles of Digital Interactive Display Design. The design of digital interactive display needs to be clear about the purpose of the design and cannot be based on personal preferences. The design of interactive display also needs continuous innovation in the form of expression in order to be attractive in the design, have strong expressiveness and appeal, effectively mobilize the audience's multiple senses, and improve the audience's interest. Compared with the traditional display design, the digital interactive display design has stronger design and avant-garde. It is more in line with the favorite way of the audience in the information age. At the same time, the interactive design also represents the development direction of the mode towards the direction of digitization, networking, and intelligence. Digital interactive display design specifically includes digital technology, new media technology, and art performance design. It is created in virtual reality by combining computer technology, so as to respond to a rich three-dimensional virtual world, bring more pleasant and vivid visual experience to the audience, effectively help the audience release pressure in VR movies and feel happy and relaxed when enjoying the movies. Interactive design is convenient for the audience to find their own position in the virtual world and achieve good entertainment effect.

3. The Role of Digital Interactive Display Design in VR Film

Liang (2022) pointed out that under the influence of computer technology, the expression forms of films have also presented diversified styles, and the interactive experience and creativity of films have also undergone major changes. The traditional film plot has gradually changed into the interactive guidance dominated by the audience [10]. Digital display design can not only effectively spread the information that you want to express but also is an effective way to green display and environmental protection display. The use of virtual technology in digital display design can interact with the audience 360°. In VR movies, it can promote the communication of the audience beyond the real space, realize the artistic feeling that cannot be experienced in real life, realize interactive new display design in different time and space, and enhance the subjective initiative of the audience. This interactive characteristic gives the audience a viewing space. The audience explores the sense of extension of the story according to the film's interest points, and closely combines the audience's behavior and cognition in the interaction design to form a common and interactive state. This interaction design is natural and friendly, and it is easy to mention the audience's desire to participate.

Zhang et al. (2020) and others' animation interactive experience and creative design under the background of the digital era have promoted the qualitative development and leap [11]. Xiong and Ming (2022) and others analyzed the design commonality of games and animation in interactive context to explore the characteristics that can be optimized and utilized between them, from surface experience to detailed modeling of animation design [12]. The application of digital interactive display design is a process in which the audience's senses or psychology produce a certain feeling. Psychological curiosity and the surrounding environment will cause different behaviors in the process of perception formation, which is the interaction of senses, behavior, thinking, and psychology. In the aspect of physical induction, the display design is applied to VR movies, and the stimulation content generated in the multimedia environment will be more abundant, with multidimensional experience, bringing new perception to the audience. The human-computer interaction effect has reached the humanized effect in the digital interactive display design, so that each audience has a unique experience.

VR films have not been able to obtain good experience, and they have lost their initial enthusiasm for the former VR films. They need innovation to satisfy the audience's appetite. Interactive display design can deduce the branch plots in the form of movies to meet the audience's inner desire to master the plot direction, and greatly enhance the audience's participation in the story in the interactive way.

4. Simulation Verification

4.1. Comprehensive Analysis of Two Kinds of Display Design. In recent years, the characteristic audiovisual entertainment consumption has been very popular with the broad audience. In order to shoot more works with strong appeal and interest, with the help of computer technology, interactive scenes are designed in the film to change the traditional passive viewing experience. Digital interactive display design and traditional display design can enhance the visual effect and immersive feeling of human-computer interaction in the film from the perspective of audience experience. Now, through comprehensive analysis of two different display designs, the following Table 1 is obtained:

In Table 1, it can be clearly seen from the data in the comprehensive analysis of the two different display designs in the table that the digital interactive display design has higher design effects in VR movies and can bring better visual feast to the audience.

Make the above data into a visual diagram as shown in Figure 1:

As shown in Figure 1, the digital interactive display design is far superior to the traditional interactive display design. It provides computer technology support in user experience design, film structure design, and visual communication design, bringing unique sensory experience to the audience.

Table 1: Comprehensive analysis of two display designs (%).

Group	User experience design	Film structure design	Visual communication design
Digital interactive display design	82.47	83.21	82.57
Traditional display design	60.58	62.15	61.54

is better integrated with the subsequent development of VR

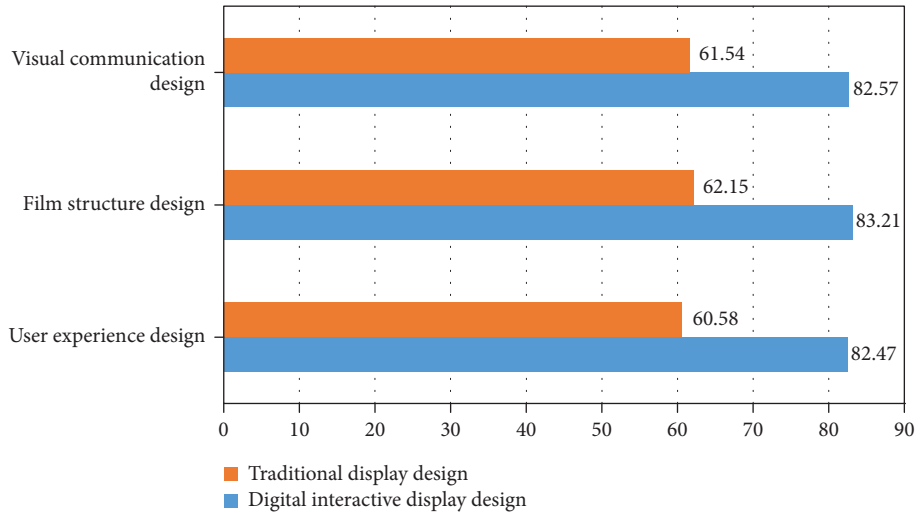

Figure 1: Comprehensive visualization of two display designs (%).

4.2. Performance Effect Comparison of Two Display Designs in VR Movies. The digital display design in VR movies is mainly to convey the hidden details of the movie to the audience and deepen the audience's understanding of the movie, so as to bring a new movie viewing experience in terms of visual touch and hearing. With the help of computer technology, we can establish a good interactive experience between VR movies and audiences, effectively solve the problem of insufficient realism in interactive display design, and increase the interactivity of design and the conceptuality of display design. The performance effects of two different display designs are compared, and Table 2 is obtained:

In Table 2, the comparative analysis of the performance and effect of the two kinds of display design can be concluded that the display design breaks the original movie viewing experience. In consideration of the audience's preference and entertainment sense, it is necessary to strengthen the research and development of innovative interactive display design, and create unique interactive viewing experience with immersion as the core, so as to expand the influence of VR movies.

Make the above data into a visual diagram as shown in Figure 2.

As shown in Figure 2, the performance and effect analysis of the design shown in this study in the development of VR movies are significantly higher than that of the traditional design. From the comparison results, it can be indirectly explained that the digital interactive display design

Table 2: Performance effect comparison of two display designs (%).

Group	Immersive	Interactive	Imaginative
Digital interactive display design	90.25	91.11	92.14
Traditional display design	60.58	63.58	65.43

movies.

4.3. Comparison of Two Display Designs in VR Movies. VR films are changing the narrative mode and creative thinking of films while bringing people a brand-new film viewing experience. The immersive autonomy of the audience brought by VR films can change from spectators in traditional films to participants in VR films, and the experience is also transformed into interactive experience. In VR movies, the interaction mode highlights the theme of the role of the film, the style of the film and the interactive elements between the characters and the audience. Table 3 is obtained by comparing two different display designs in VR movies:

In Table 3, from the comparison and analysis of the data presented by the two kinds of display design in the film, it can be seen that the application of computer interactive design assistant technology in VR film can have more abundant interaction than under the traditional design, the new design of digital display with interactive function has changed the previous linear line of sight, it can more effectively shorten the distance between the characters and the

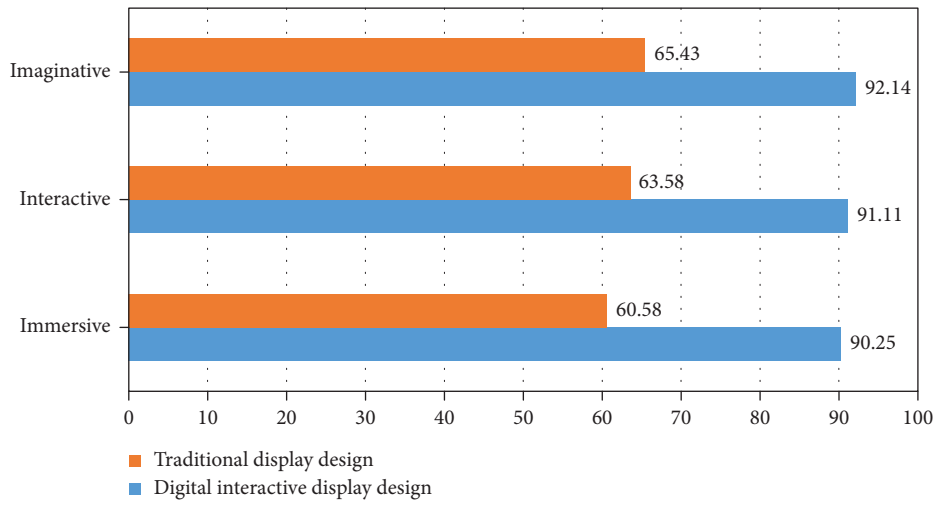

Figure 2: Visual analysis of performance effects of two display designs (%).

Table 3: Comparison of two display designs in the film (%).

Group	The theme of the film works	Interactive elements of characters and audience	The style of the film
Digital interactive display design	85.76	90.55	86.43
Traditional display design	62.75	60.48	65.72

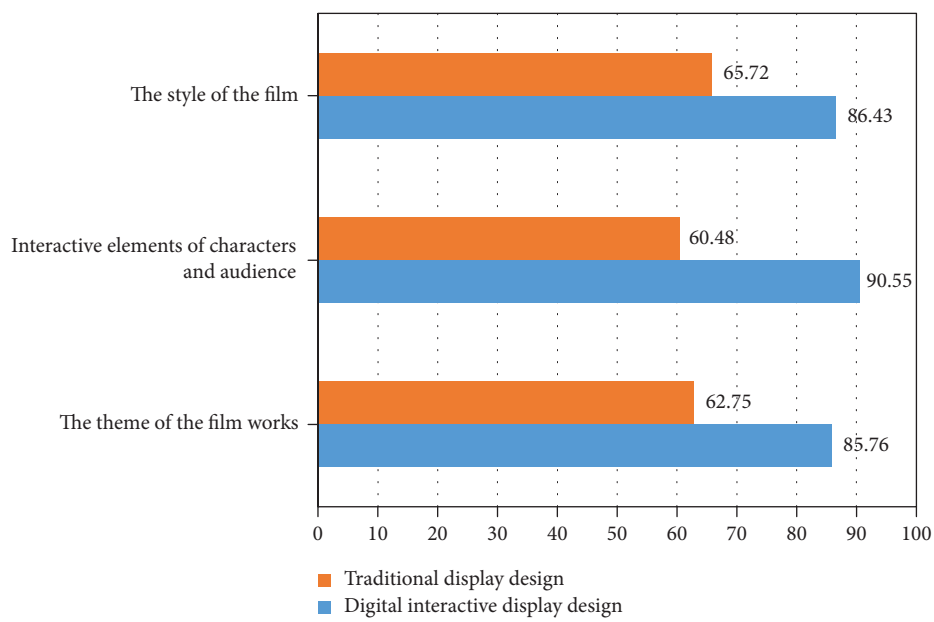

Figure 3: Visual analysis of two display designs in VR movies (%).

audience in interactive movies, making the audience have a more sense of substitution, higher immersion, and better experience.

Make the above data into a visual diagram as shown in Figure 3.

As shown in Figure 3, there is a statistical significance of $T < 10.000$ and $P < 0.05$ between the two kinds of display design data. It can be clearly seen that the comparison between the two groups of data is very different, which indirectly indicates that the digital interactive display design has a certain innovative effect on VR movies.

4.4. Experience Changes of Two Kinds of Display Design to the Audience in VR Movies. The progress of computer technology and the development of art are interrelated. Interactive design allows the audience to actively enter the film, and indirectly guides the audience to find their own sense of existence in the virtual film world, and then get satisfaction

Table 4: Changes in audience experience of two designs in VR movies (%).

Group	Thinking changes	Psychological feelings	Behaviors
Digital interactive display design	89.58	90.43	90.63
Traditional display design	65.13	64.52	60.15

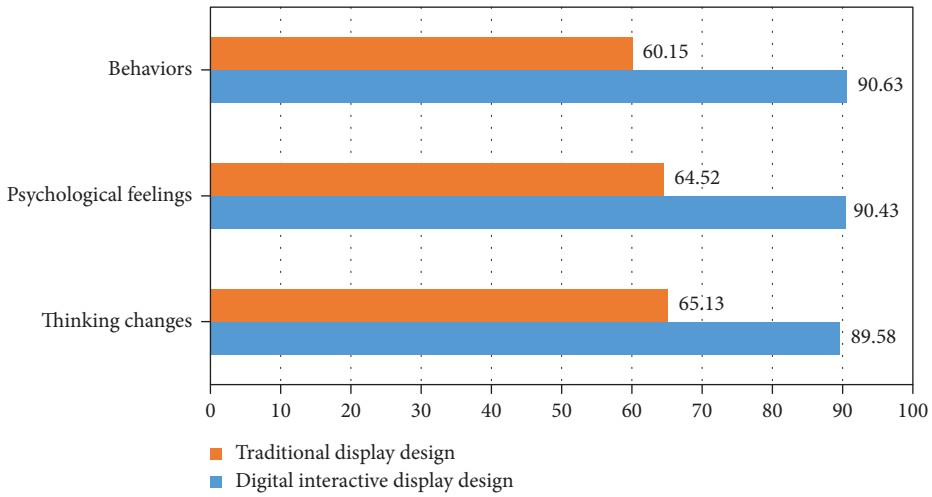

Figure 4: Visualization of audience experience changes by two designs in VR movies (%).

of their own value in the virtual world. Along with the development of the plot, the audience will be guided to produce psychological thinking changes, and different psychological feelings will appear. They will interact with each other in terms of vision, hearing, and touch, and have a strong interaction function in terms of experience. Now, the experience of the audience in the VR film of two different display designs is changed, and the following Table 4 is obtained:

In Table 4, the application of traditional display design in VR movies has no obvious difference in the change range of the audience's experience. The application of interactive design in this study has certain guidance on the psychological changes and thinking changes of the audience during the movie viewing, so that the audience can truly enter the world of movies.

Make the above data into a visual diagram as shown in Figure 4.

As shown in Figure 4, the digital interactive design is obviously superior to the traditional design, which can indirectly show that the design of this study can effectively improve the audience's interest in VR movies, and this interactive design has good interaction with the audience's film viewing experience.

5. Summary

Under the background of the rapid development of digital technology, VR films and TV are rapidly upgraded and updated in the direction of making viewers have a better sense of experience. However, its sense of experience is still at the relatively primary immersive stage, and it is quite lacking in deeper user experience and audience attention guidance. This research is based on the computer technology to explore the application of digital interactive display design in VR movies. Through the comprehensive analysis and performance effect comparison of two different display design applications in VR movies, this paper studies the changes in the audience's thinking, psychological changes, and the changes in the audience's viewing experience, and integrating computer digital interaction technology into VR movies can better increase the immersion of VR movies and make them more realistic with 3D visual and auditory effects. In the digital age, the interactive function display design using computer technology has a positive role and important influence in VR movies. Interactive VR movies and TV will become a new way to break the current deadlock in the upcoming 5G era, it is expected to provide new ideas for the creation and innovation of VR film art in the future.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Disclosure

The authors confirm that the content of the manuscript has not been published or submitted for publication elsewhere.

Conflicts of Interest

There are no potential conflicts of interest in our paper, and all the authors have seen the manuscript and approved to submit.

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Research Article

Multicriteria Recommendation Method of Tourist Routes Based on Tourist Clustering

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A multicriteria recommendation algorithm for tourist routes under the multidimensional expanded spatial grid structure model based on fuzzy C-means clustering of tourist preferences is proposed. The purpose of the proposed structure is to improve the multicriteria intelligent recommendation ability of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle. The multidimensional enlarged spatial grid structure model of the well-known tourist core circle is used to develop the tourist correlation model of travel routes under the restricted sample training. Under the popular traveler core circle's multidimensional enlarged spatial grid structure framework, the mixed kernel use and global kernel use are created to extract the correlation characteristics of tourist route recommendation. Under the multidimensional enlarged spatial grid structure model of the well-known tourist core circle, the adaptive learning of tourist route selection is carried out using the hybrid particle swarm algorithm. To manage the convergence of the suggestion process, maps of logistical chaos are employed, utilizing culture's universalism and ergodicity resources and examining the aesthetic resources along tourism routes. The simulation results demonstrate that the multidimensional extended spatial grid structure model's tourism route information recommendation accuracy is decent, and a solid swarm intelligence junction is observed in this analysis, preventing tourism route recommendations from settling for the local optimal solution and enhancing their intelligence and global stability.

1. Introduction

With the development of tourism, to improve the recommendation level of tourist routes under the multi-dimensional expanded spatial grid structure model of the core circle of popular tourism, to enrich the research content of the destination tourist routes network of the core circle of popular tourism, and to innovate the research perspective of influencing factors. Due to the usual spatial aspects of tourism, it is crucial to understand the network properties of destination tourism routes in order to coordinate the interaction between people and the environment. In the past five years, the academic research on the spatial structure characteristics of tourist route network has gradually increased, but the research scale mainly focuses on the macro scale, while the research on the city scale is less, and the research on the influencing factors is still in the exploratory stage. This paper uses Nanjing as an example to analyse the spatial structure characteristics of city-scale tourist route networks. It does so by using text data from travel notes, and it does so in a novel way by incorporating tourists' emotions into the study of factors that influence tourist route networks. This enriches the research materials of meso-scale tourist route network structures, encourages the integration of emotional geography and tourism disciplines, and offers a fresh viewpoint for both fields. The resource scheduling and tailored recommendations of tourist routes are taken out using the design approach in conjunction with the popular tourist core circle's multidimensional extended spatial grid structure model. Under the multidimensional enlarged spatial grid structure model of the well-known tourist core circle, the resource scheduling capacity of tourist routes and the prospective feature extraction capacity of tourists are increased [1]. According to historical visit records and preferences, personalized resource optimization scheduling is done for complex and diverse online learning resources in

the tourism routes under the multidimensional expanded spatial grid structure model of the popular tourism core circle. This is done to promote knowledge utilisation and improve the ability of the tourism routes to interact dynamically under the multidimensional enlarged spatial grid structure model [2]. Promoting the best design of the tourism routes under the multidimensional enlarged spatial grid structure model of the popular tourism core circle requires a thorough understanding of the personalized intelligent recommendation algorithm for those routes. Sanghoon Kang and Jaskon Vilam analyzed the spatial network structure characteristics of tourist attractions in Seoul, South Korea by using the data of China's Free and Independent Tourists (FIT), and put forward optimization measures. Rosario D'Agata, Lisa Rimon and Sofei Sili analyzed the data of tourists departing from airports and ports in major cities in Sicily, studied the regional spatial network structure, and explored the tourism flow pattern in the region. Manllan and Silin explored the tourism business contact of isolated communities by analyzing the characteristics of tourism route spatial network. Sang-Hyun Lee and Linshoon analyzed the spatial layout of tourist routes in 43 villages in Yang Town and Quan Lam Town, and measured them with concentration indicators, so as to verify the effectiveness of comprehensive rural tourism management. Liu Hongying and Yan Tiantian took the tourist routes as the breakthrough point and used the collected relevant data to study the structural characteristics of the tourism spatial network in the Pan-Beibu Gulf region. Wang Jinying and Wiliion analyzed the geographical distribution of inbound tourist flows in Asia and studied the spatial distribution of tourist routes from Asian countries to China. Zhou Huiling and Wang wuqiang, taking a travel itinerary as a sample, made an in-depth analysis of the characteristics of Hunan's tourism spatial network and put forward targeted plans to optimize traffic routes and build city image. Chen Hao and Chen Mengji studied the spatial network structure characteristics of tourist destinations in the Pearl River Delta region from the macroscopic point of view of urban tourist groups and put forward the idea of optimizing the spatial structure. Intelligent particle swarm algorithms, association rule mining algorithms, data clustering approval algorithms, fuzzy PID recommendation algorithms, etc. The primary ones are found in traditional approaches for personalized recommendation of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circles. According to the multilevel multidimensional expanded spatial grid structure model of the popular tourist core circle, the topological structure of tourist routes is optimized. Considering information distribution and recommendation task features [3–5], a data clustering center for personalized recommendation of tourist routes in the multidimensional expanded spatial grid structure model of popular tourist core circle is established, and the algorithm for recommendation of tourist routes in the multidimensional expanded spatial grid structure model of a popular tourist core circle is designed by using the association rules mining method in order to enhance the tourist routes' ability to express themselves uniquely within the multidimensional enlarged spatial grid structure model of the main tourist core circle. Related literature have designed the recommendation algorithm of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circles and achieved certain research results. The recommendation algorithm of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circles is proposed, taking tourist behaviour value, tourist consumption value, and loyalty of tourist routes under the model as independent variables [3]. The fuzzy decision-making model of tourism route recommendation under the multidimensional expanded spatial grid structure model of popular tourism core circle is established, and the optimization design of tourism route recommendation model under the multidimensional expanded spatial grid structure model of popular tourism core circle is carried out by combining the association mining method. However, the calculation cost of this method is large, and the real-time performance of tourism route recommendations under the multidimensional expanded spatial grid structure model of popular tourism core circle is not good. In [4], on the basis of difference factor evaluation and intelligent PSO, a suggestion and recommendation algorithm for tourist routes under the multidimensional enlarged spatial grid structure model of popular tourist core circle is provided. It is established that tourist routes have synchronous tags under the multidimensional enlarged spatial grid structure model of the well-known tourist core circle, and it is extracted that these tourist routes have linked attribute features from this model. Analyze the relationship between the level of group interaction and the effectiveness of recommendations, and implement personalized travel route recommendations using a multidimensional enlarged spatial grid structure model of a well-liked tourist core circle. The procedure of selecting tourist routes using this technology is not clever on the multidimensional enlarged spatial grid structure model [5].

This research suggests a multicriteria recommendation method for tourist routes based on fuzzy C-means clustering of visitors' preferences within the multidimensional enlarged spatial grid structure model of a well-liked tourist core circle in order to address the aforementioned issues. Firstly, using a small sample of training data, a tourist correlation model of tourist routes is created using a multidimensional expanded spatial grid structure model of a popular tourist core circle. Then, using this model, to extract the correlation properties of the information about the recommended tourist routes, global and hybrid kernel functions are developed. Finally, the multidimensional enlarged spatial grid structure model of the popular tourist core circle is used to carry out adaptive learning of the suggested tourist routes. Then, using logistic chaotic mapping, the suggestion process' convergence is controlled, and the universality and ergodicity of the tourist routes' cultural and scenic resources are examined. The multidimensional expanded spatial grid structure model of the popular tourist core circle is used in conjunction with the gradient algorithm to carry out particle swarm evolution and adaptive optimization of tourist route recommendation, and this results

in the realization of swarm intelligence recommendations of tourist information of tourist routes. Finally, the simulation analysis shows that this method is superior in improving the personalized intelligent recommendation ability of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle.

2. Tourism Route Recommendation Information Model and Associated Feature Extraction

2.1. Recommended Information Transfer Model of Tourist Routes. Under the multidimensional enlarged spatial grid structure model of the popular tourist core circle, a parallel recommendation algorithm is applied. This algorithm is used to obtain prospective presents and mine tourist data in order to accomplish personalized recommendation and feature identification of tourist routes [6]. Under the multidimensional enlarged spatial grid structure model of the well-known tourist core circle, associated components of the tourist route approval data are extracted using a hybrid kernel function and a global kernel function. Self-organizing nonlinear mapping creates the information transmission space for a tourist route under the grid structure model of the multidimensional expansion space of the popular tourism core circle, and the fuzzy decision function of the recommendation information for the tourist route is obtained using a small sample of training data [6]. The recommendation data for a tourist route under the grid structure model of the multidimensional expansion space of a well-known tourist core circle is mapped to high-dimensional feature space using fuzzy decision and intelligent swarm algorithms. Under the multidimensional enlarged spatial grid structure model of the widely used tourist core circle, it is anticipated that the suggested training sample set of tourist routes isΦ: $x \in R^n \longrightarrow F$, where the recommendation model's input vector is personalization factor quantity, $\{(x_1, y_1), (x_2, y_2), \cdots, (x_n, y_n)\}$ is the goal measurement value for individualized advice, and $x_i \in R^n$ is the total sample size. Combined with the algorithm of association rules mining, the actual task of intelligent suggestion of tourist routes under the grid structure model of multidimensional expansion space of popular tourist core circle is obtained as follows:

$$\begin{aligned} &\text{minimize}\,\frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n}\left(\xi_i + \xi_i^*\right) \\ &\text{subjectto}\, y_i - \left(w'\Phi\left(x_i\right) + b\right) \le \varepsilon - \xi_i \\ &\left(w'\Phi\left(x_i\right) + b\right) - y_i \le \varepsilon - \xi_i^* \\ &\xi_i, \xi_i^* \ge 0, i = 1, 2, \cdots, n; C > 0, \end{aligned} \tag{1}$$

wherein ξ_i and ξ_i^* represent the variables in association rules and semantic ontology properties. In order to execute the punishment control of wrong samples, The cost factor for suggestions is based on the algorithm for generalized learning and applied to the process for suggestion method for adaptive learning. The following describes how the particle swarm optimization control is used to produce the difference function of a customized recommendation:

$$f(x) = \sum_{i=1}^{n}\left(\alpha_i - \alpha_i^*\right)K\left(x_i, x_j\right) + b, \tag{2}$$

where α_i and α_i^* are suggested attribute values and how many template categories there, which are symmetric kernel functions satisfying Mercer conditions, and $K(x_i, x_j)$ is the recommended threshold.

Under the multidimensional expanded spatial grid structure model of the popular tourism core circle, to create a hybrid kernel function for tourism route recommendation, each and every information tuple's property course set is produced, and the local kernel function (RBF kernel function) and global kernel function (polynomial kernel function) are employed as controllers of taking decision functions. Its expression is:

$$K_{\min} = \beta K_{\text{poly}} + (1 - \beta)K_{rbf}, \beta \in (0, 1), \tag{3}$$

wherein $K_{\text{poly}} = [(x \cdot x_i) + 1]^2$ represents the kernel function of multidimensional expansion space, and $K_{rbf} = \exp(-\gamma\|x - x_i\|^2)$ displays the RBF kernel function of trust reliability of tourist routes under the grid structure model of multidimensional expansion space of a well-liked tourist core circle. K_{rbf}, is to modify the impact of two kernel functions on the weight coefficient, which is the mixed kernel function as a whole. As a result, the multidimensional expanded spatial grid structure model of the popular tourist core circle is used to construct the information transmission model of tourist route recommendation. Tourist feature mining and personalized recommendation design of tourist routes under this model are carried out by combining the particle swarm optimization method [7].

2.2. Extraction of Correlation Features of Tourist Route Recommendation Information. Correlation properties to extract tourist route useful data is taken under multidimensional extended spatial grid structure model of the popular tourist core circle using building mixed kernel function and global kernel function. Logistic chaotic planning is utilized to achieve convergence control of the commendation procedure [8], where a multidimensional enlarged spatial grid structure model of the widely used tourist core circle is used to get the potential tourist variables of tourism routes, which are represented by four tuples as $\{S_1, S_2, \cdots, S_L\}$, and the following describes the typical extraction conduction control model of customized recommendations:

$$\alpha_{desira}^{i} = \alpha_1 \cdot \frac{\text{Density}_i}{\sum_i \text{Density}_i} + \alpha_2 \frac{AP_i}{AP_{init}}, \tag{4}$$

wherein

$$\begin{cases} \alpha_1 + \alpha_2 = 1, \alpha_1, \alpha_2 \in [0, 1], \\ \alpha_2 = \dfrac{\max_i\left(AP_i\right) - \min_i\left(AP_i\right)}{AP_{init}}. \end{cases} \tag{5}$$

Formulas (4) and (5) represent the sparsity coefficient from the relay node U to the statistical node of tourism route passenger flow under the multi-dimensional extended space grid structure model of the tourism core circle, where $M_i[t_l > M_m \vee M_n, M_m[t_m > M_j, M_n[t_n > M_j,$ represents the scoring variable of tourism route recommendation information, and $(i \neq m \neq n \neq j, a \neq b \neq c)$ represents the average intercommunication information of tourism route tourism feature U under the multidimensional extended space grid structure model of the tourism core circle, where under the constraint control of association rules, we can get the potential correlation characteristics of tourism routes under the multidimensional extended spatial grid structure model of well-known tourism core circle:

$$\varepsilon_t(i,j) = \frac{\alpha_t(i) a_{ij} b_j(o_{t+1}) \beta_{t+1}(j)}{\sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_t(i) a_{ij} b_j(o_{t+1}) \beta_{t+1}(j)}, \tag{6}$$

wherein $|\mathrm{Re}v(u)|$ represents coefficient point set, $\mathrm{Re}v(u)$ represents the number of tourist nodes, a_{ij} represents the tourist scoring measurement information of tourist routes under the multi-dimensional expanded spatial grid structure model of popular tourist core circle, b_j represents mutual information, and $\mathrm{Order}(\mathrm{Re}v(u))$ represents the matching degree of nodes in the communication channel of tourist routes according to their personalized behavior characteristics [9]. In the self-adaptive clustering of group intelligence information of travel routes under the grid structure model of multidimensional expansion space of well-known tourist core circle, association rule constraints and chaotic mapping are combined, and the clustering output is as follows:

$$\begin{aligned} f_{\lg-M}(z) &= \left(f_{\lg}(z), f_{\lg-x}(z), f_{\lg-y}(z)\right), \\ &= \left(f_{\lg}(z), h_x * f_{\lg}(z), h_y * f_{\lg}(z)\right), \end{aligned} \tag{7}$$

$f_{\lg}(z)$ signifies the value of tourist items recommended by tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle, thus obtaining the quadruple expression of correlation feature extraction of tourist routes recommended under the multidimensional expanded spatial grid structure model of popular tourist core circle as follows:

$$\begin{aligned} &\max\left\{\left|Ch(u) - Ch(u) \cap Ch(u_2)\right| + \left|Ch(u) \cap Ch(u_2)\right| \right. \\ &\left. \left|Ch(u_2) - Ch(u) \cap Ch(u_2)\right| + \left|Ch(u) \cap Ch(u_2)\right|\right\}, \\ &= \max\left\{|Ch(u)|, \left|Ch(u_2)\right|\right\} \leq \Delta. \end{aligned} \tag{8}$$

In the above formula, $Ch(u)$ is a representation of the correlation coefficient, and a node that is v placed in the center to achieve multidimensional expansion space reorganization of the core circle of the most well-liked tourist attractions and adaptive feature extraction of customized tourist features.[10].

3. Recommended Algorithm Optimization

3.1. Optimization of Fuzzy C-Means Clustering Algorithm for Tourists' Preferences. An improved design of the multicriteria recommendation algorithm of tourism route under the multidimensional expanded spatial grid structure model of popular tourism core circle is carried out based on the construction to extract correlation features of the information on suggested tourist routes, use a hybrid kernel working and a worldwide kernel working. In this paper, a multicriteria recommendation algorithm for tourism routes under the multidimensional expanded spatial grid structure model of popular tourism core circle based on fuzzy C-means clustering of tourists' preference is proposed [11]. The suggested algorithm is put through its global optimization control while utilizing the chaotic map's advantages of regularity, universality, ergodicity, and initial value sensitivity, and the expression for the logistic map is created:

$$y_i = \mu y_i (1 - y_i), \tag{9}$$

wherein $y_i \in [0, 1]$ is the random number, μ is the group intelligent recommendation control parameter of tourist routes under the grid structure model of multi-dimensional expansion space of popular tourist core circle. Generally, it takes a value of 4, and a fuzzy C-means clustering algorithm of tourist preferences is constructed. It is assumed that in an d-dimensional fuzzy C-means clustering search space of tourist preferences, m represents the population of particles, and $P_i^d(t)\,(i = 1, 2, \cdots, m)$ represents the clustering center of intelligent search particles $P_i^d(t)\,(i = 1, 2, \cdots, m)$ of potential tourist characteristics in the current d dimensional solution space. i represents the current optimization speed of traversal particle $P_{\mathrm{best}}^d(t)$ of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle, representing the best position experienced by particle $G_{\mathrm{best}}^d(t)$ itself, $G_{\mathrm{best}}^d(t)$ represents the optimization extreme value of intelligent recommendation, and $G_{\mathrm{best}}^d(t)$ represents the optimal solution of intelligent personalized recommendation. In each iteration, the global extreme value D and individual extreme value $G_{\mathrm{best}}^d(t)$ of gradient particles are controlled, and the fuzzy C-means clustering optimization expression of tourist preferences of personalized recommendation of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle is obtained as follows:

$$\begin{cases} V_i^d(t+1) = W \cdot V_i^d(t) + C_1 \cdot R_1 \cdot \left(P_{best}^d(t) - P_i^d(t)\right) \\ +C_2 \cdot R_2 \cdot \left(G_{best}^d(t) - P_i^d(t)\right), \\ P_i^d(t+1) = P_i^d(t) + V_i^d(t+1), \end{cases} \tag{10}$$

wherein $V_i^d(t)$, $V_i^d(t+1)$, $P_i^d(t)$, $P_i^d(t+1)$ are the conduction coefficient and correlation dimension feature quantity of tourists' potential feature mining of tourist routes under the multi-dimensional expansion spatial grid structure model of popular tourist core circle at the current moment and the next moment of particle i, respectively; C_1 and C_2 are learning factors, and the value of S is between 25 and 28; R_1 andR_2 are search radius and the global search threshold of fuzzy C-means clustering intelligent optimization which respectively represent the preference of tourists, taking random numbers between [0, 1]; it is inertia

weight, combined with fuzzy C-means clustering optimization of tourists' preference, and adjusts the recommendation process in repeated steps through optimization. In $[W_{\min}, W_{\max}]$ break, the alteration formula of multicriteria suggested tourist routes under the grid structure model of multidimensional expansion space of popular tourist core circle is got as follows:

$$\begin{aligned} W(t+1) &= 4.0W(t)(1-W(t)), \\ W(t) &= W_{\min} + (W_{\max} - W_{\min})W(t), \end{aligned} \tag{11}$$

wherein $[W_{\min}, W_{\max}]$ provide value variety of inertia causes, generally taking [0.5, 0.6].

3.2. Implementation of Multicriteria Recommendation Algorithm for Tourist Routes. Utilizing mixed particle swarm optimizations is utilized for flexible learning of tourist route selection under the grid structure model of the multidimensional expansion space of the well-known tourist core circle [12]. Chaos is brought interested in the optimization of the inertia factor, and logistic chaotic mapping enables the convergence control of the suggestion process. W, search radius R_1 as will as R_2 are introduced in the clustering learning process of tourists' preference fuzzy C-means, and the updated formulation is expressed as follows:

$$R_i(t+1) = 4.0R_i(t)\left(1 - R_i(t)\right), \tag{12}$$

wherein $R_i(t) \in (0,1), i = 1,2$. Apparently from the tourists who are congregating, the fuzzy feature quantity of tourist route allocation is obtained, and chaos is introduced into the learning factors C_1 and C_2. The updated formulation is as follows:

$$\begin{aligned} C_i(t+1), &= 4.0C_i(t)\left(1 - C_i(t)\right), \\ C_i(t), &= C_{\min} + (C_{\max} - C_{\min})C_i(t). \end{aligned} \tag{13}$$

In the formula: $i = 1,2$, $[C_{\min}, C_{\max}]$ shows first group framework using fuzzy C-means clustering optimization to convey tourist preferences. The fitness of the particle is assessed based on its position, and the convergence control is implemented in conjunction with the premature condition, with the convergence control coefficient being defined as follows:

$$\delta^2 = \sum_{i=1}^{m} \frac{F_i - F_{\text{avg}}}{F}, \tag{14}$$

wherein m is the number of particles in the recommended particle swarm of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle, F_i is the adaptability of particles to learn tourists' potential characteristics of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle, F_{avg} is the average fitness of particle swarm, F is the recommended control objective function, and it is used to limit the size, which is expressed as follows:

$$F = \begin{cases} \max\limits_{1 \le i \le m} \left|F_i - F_{\text{avg}}\right|, \max\limits_{1 \le i \le m} \left|F_i - F_{\text{avg}}\right| > 11, \text{other}. \end{cases} \tag{15}$$

If $\delta^2 < \text{H}$ (H is a given constant), the precocious judgment and adaptive processing of tourist feature mining of tourist routes under the multi-dimensional expanded spatial grid structure model of popular tourist core circle are carried out. For the premature particles, gradient reduction method is used to make them jump out of the local optimum. The implementation of this algorithm is described as:

$$\begin{aligned} V_i^d(t+1) &= 4.0V_i^d(t)\left(1 - V_i^d(t)\right), \\ V_i^d(t) &= V_{\min} + (V_{\max} - V_{\min})V_i^d(t), \end{aligned} \tag{16}$$

wherein $[V_{\min}, V_{\max}]$ is the range of particle velocity of self-adaptive recommendation of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle[12]. By means of methods for limited optimization control and connotation rule mining, the revised formula for suggested tourist routes under the multidimensional extended spatial grid structure model of the well-known tourist core circle is as follows:

$$\begin{cases} V_i^d(t+1) = W(t) \cdot V_i^d(t) + C_1(t) \cdot R_1(t) \cdot \left(P_{\text{best}}^d(t) - P_i^d(t)\right) \\ +C_2(t) \cdot R_2(t) \cdot \left(G_{\text{best}}^d(t) - P_i^d(t)\right), \\ P_i^d(t+1) = P_i^d(t) + V_i^d(t+1). \end{cases} \tag{17}$$

In the above formulas, $t = 1, 2, \cdots, T$ and T represent the maximum number of iterations of the population. The logistic chaotic mapping method is used to manage convergence of the suggestion process, and the universality and ergodicity of cultural resources and scenic resources along tourist routes are investigated, and the fitness function of SVM parameters is expressed as follows:

$$F_{\text{fitness}} = \frac{1}{m} \sum_{i=1}^{m} \left(f_i - y_i\right)^2, \tag{18}$$

wherein f_i is the predicted value of the optimal combination of particle swarm, y_i is the actual value of the current free particles, and m is the recommended number of tourist samples of tourist routes under the multidimensional expanded spatial grid structure model of the popular tourist core circle. Calculate the variance of group fitness, and judge whether $\delta^2 < \text{H}$ is established or not. According to the threshold judgment result, judge whether the convergence criterion is satisfied. Combined with the gradient algorithm, the multidimensional expanded spatial grid structure model of the popular tourist core circle is used to carry out particle swarm evolution and adaptive optimization of tourist route recommendations, and this model also allows for the realization of swarm intelligence for the recommendation of tourist routes [13]. At this time, the description of the particle optimization process of multicriteria recommendation of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle is shown in Figure 1.

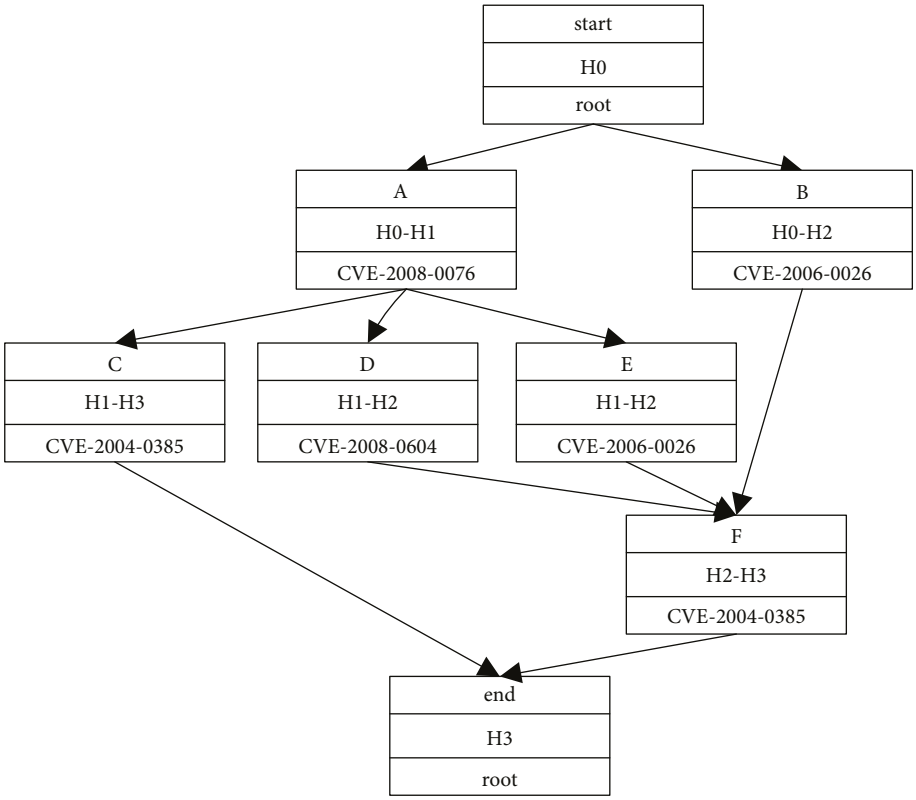

Figure 1: Particle optimization process of multicriteria recommendation for tourist routes.

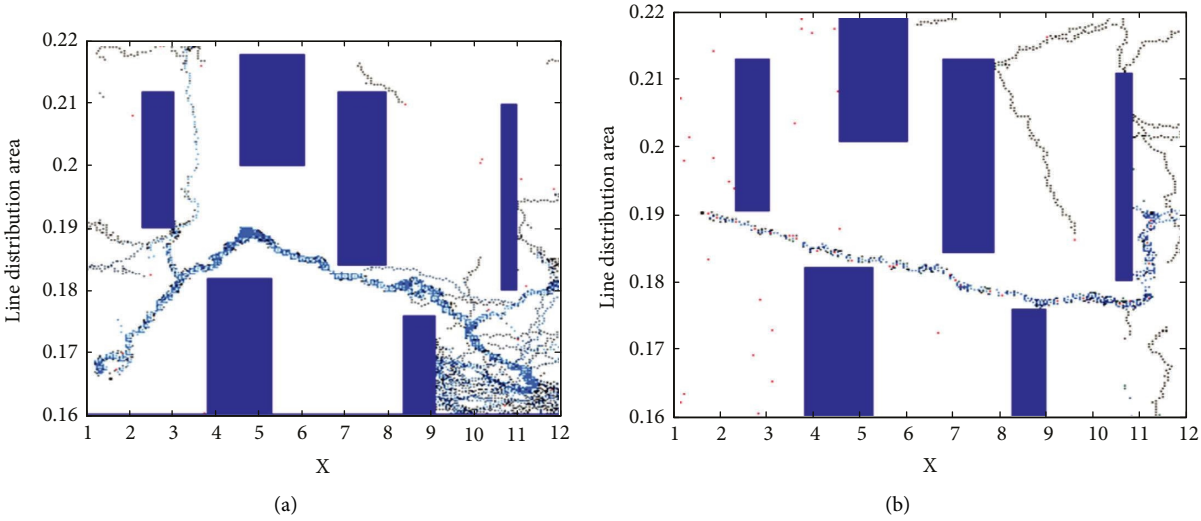

Figure 2: Grid distribution of tourist routes under the multidimensional expanded spatial grid structure model of tourism core circle (a) tourist route A (b) tourist route B.

4. Simulation Experiment and Result Analysis

A simulation experiment was run and expanded upon to confirm the precision and convergence of the suggested strategy. The test set for the experiment was the Book-Crossing data set, and the recommended data for tourist routes under the multi-dimensional employed in the experiment was the network data of Ctrip.com. 2,000 tourists underwent testing. The population size of the cultural resource distribution of the tourist routes is set at 20, the suggested replication period of the tourist lanes is 24 seconds, and the iteration is carried out 1,200 times. The ZDT series test function is the test function for particle swarm optimization. Grid distribution of tourist routes under the multidimensional expanded spatial grid structure model of popular tourist core circle is obtained, as shown in Figure 2.

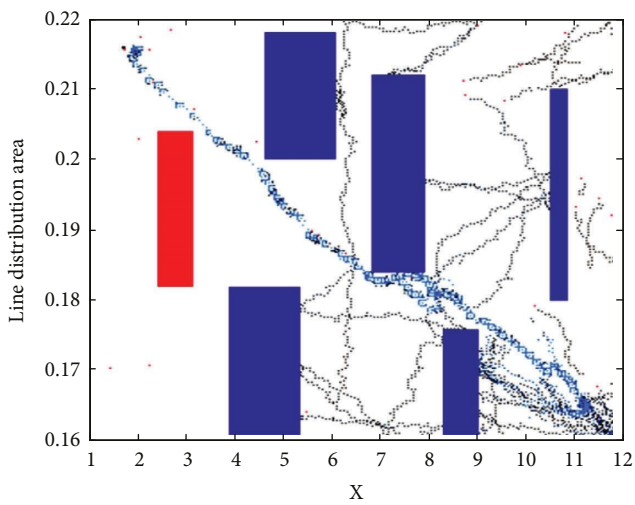

Figure 3: Simulation of the best recommended route for tourist routes.

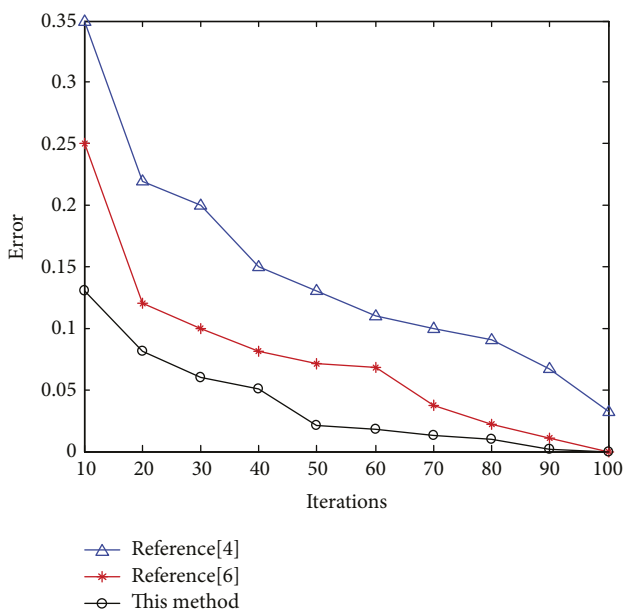

Figure 4: Error comparison of tourist route recommendation.

The adaptive learning of tourist route suggestions under the multidimensional grid structure model is conducted using the grid distribution of tourist routes as the research object. Figure 3 illustrates the best recommended route simulation of tourism routes.

From the analysis of Figure 3, it is well-known that the proposed method's adaptive learning capabilities are strong, and that the demand of its mining of the potential characteristics and tourism traits of tourist routes under the multidimensional expanded spatial grid structure model of well-liked tourist core circle are both favorable. Test the errors of the recommended tourist routes under the spatial grid structure model of the multidimensional extension of the preferred tourist core circle using additional techniques and compare the results. The results are shown in Figure 4. Under the multidimensional enlarged spatial grid structure model of the widely used tourism core circle presented model (this model). The convergence of swarm intelligence optimization is stronger and route information recommendations are more accurate. It is feasible to stop the multidimensional enlarged spatial grid structure model's multicriteria route recommendation process used in the well-known tourism core circle model from choosing a local optimal solution.

5. Conclusion

The multi-dimensional enlarged spatial grid structure model of the well-known tourist core circle is used to present a multi-criteria recommendation method for tourist routes based on fuzzy C-means clustering of visitor preferences. The tourist correlation model of tourist routes is constructed under the multidimensional expanded spatial grid structure model of the popular tourist core circle, and the correlation features of tourist route recommendation data are extracted under this model's multidimensional expanded spatial grid structure. The universality and ergodicity of cultural resources and scenic resources along tourism routes are investigated in order to establish convergence control of the suggestion process. To achieve swarm intelligence in the recommendation of tourist information for tourist routes under the framework of the multi-dimensional enlarged spatial grid structure model of the well-known tourist core circle, the gradient method is coupled with particle swarm optimization and self-adaptive optimization of tourist route suggestion. The study shows that the well-known tourist core circle's multi-criteria route recommendation procedure can avoid finding the best solution locally since the best proposal is one that provides the most accurate route information. The study also shows that the intersection of swarm cleverness optimization is primarily strong, intelligent, and globally stable for tourism route suggestions under the multidimensional enlarged spatial grid structure model. Using the multidimensional enlarged spatial grid structure model of the well-known tourist core circle, it is helpful for personalized learning and intelligent advice on trip itineraries.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

A Personalized Recommendation Method for Ancient Chinese Literary Works Based on a Collaborative Filtering Algorithm

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The works of ancient Chinese literature that rely on Internet technologies are developing quickly. Through mobile phone inspection, ancient Chinese literary masterpieces are becoming more well-known, which encourages readers to read them more regularly. Providers of output literary works are confronted with a conundrum and a challenge, enabling users to quickly discover and attract their own works in the vast body of ancient Chinese literature. Providers of output literature can rely on personalized recommendation technology to find a solution to this issue. The production of works of literature is one of the most significant signs of human civilisation. As Internet technology becomes more widespread, the suggestion of the platform will become a more important factor in determining how the general audience reacts to works of literature. A collaborative filtering (*CF*) algorithm is offered as a method for making the recommendation algorithm for ancient Chinese literature more accurate. The personalized recommendation system's technological support helps to increase the accuracy of recommendations. This system predicts and scores the reading preferences of the readers in a thorough manner, which helps to improve the recommendation's accuracy. It is hoped that the user community will find the analysis and discussion contained in this article to be useful as a reference. The compelling experimental findings show that the recommendation algorithm suggested in this study greatly improves the accuracy of the intelligent recommendation system. These results were found by analyzing the final experimental data.

1. Introduction

Since 1997, Resnick and Varian have been working on the concept of a personalized recommendation system [1–4]. It proposes related product information on the e-commerce platform, according to the actual preferences of users, and it gives users suggestions and guidance. The function of virtual sales significantly simplifies the purchase requirements of users. A comprehensive personalized recommendation system will consist of a number of modules, the most important of which are user behavior records, user data analysis, and recommendation algorithms. These modules will each be responsible for their own unique processing functions. The scope of user information is determined by using the user behavior record, which also assesses the user's preference for similar information. These recommendations are based on the user's online activity, including comments, browsing, time spent on reading, staying on websites, and likings. The relevance of user information recommendations is also assessed using the user behavior record. User data analysis [5–7] involves immediately analyzing the user's activity, determining the user's genuine preferences, and making targeted recommendations for comparable relevant content. The recommendation algorithm serves as the framework upon which the entirety of this process is built, and it is the single most significant component of the system's main technologies in terms of ensuring the correct execution of the process.

Inquiries from clients are processed using technology for information and data retrieval [8–10]. The research on information data retrieval includes two different sorts of technologies. The first is a technology for queries, and the second is a technique for indexes. The second step is to conduct an analysis of the information contained within the resource, after which it is represented to the computer in the form of a data and information structure that it can process.

The first step is to acknowledge the requirements of clients via the user interface. Hence, information data retrieval technology is typically implemented in large-scale database management systems. Nevertheless, these databases are typically unchanging. It is unable to actively provide recommendations for clients and is also unable to uncover other interests held by customers.

In contrast to information retrieval, information filtering considers the requirements of clients over an extended period. Its primary function is to process various forms of textual data. The end goal is to be able to assist clients in processing vast amounts of information. The pursuits and passions of consumers need to inspire the development of this technology. It can be primarily broken down into two categories: the first is based on the technology of filtering content information, and the second is *CF* technology, which combines the characteristics of the information content to be filtered and organically matches the information flow with the customer file and determines the information based on the degree to which it matches. Does the customer derive any benefit from consuming the stream?

Customers work together in this technology to pick out information, which is mostly based on customers who have interests that are comparable to one another, and to make judgments on the information data through the cooperation of these customers. The collaborators are typically consumers' family, friends, coworkers, or other customers who share similar interests. Customers place their trust in these individuals since they recommend information to consumers based on their own personal opinions. The most important advantage of the so-called *CF* technology is that it completes the filtering process after studying client behavior rather than the product itself. People have started to make improvements to *CF* technology by doing ongoing studies and analyses of this technology [11–15]. This has led to the production of a *CF* technology that is automated and intelligent. As a result of the fact that the *CF* technology does not care about the actual content of resources, it is difficult to analyze the content of resources. If you want to use things like music, graphics, videos, or images as resource content, *CF* technology is an excellent option. Consumers are unable to anticipate the recommended content in advance due to the fact that the *CF* technology can uncover resources that have completely diverse appearances in their content. The *CF* technology offers several advantages that cannot be replicated when compared to the traditional methods that were used in the past, and it is also a relatively successful technology that has been employed in personalized recommendation systems up until this point.

The vast majority of existing recommendation systems favour recommending things that have a high likelihood of being bought. They use methods such as data mining, *CF*, and content-based filtering in their operations. After conducting research to determine the flaws in each algorithm, a number of academics came to the conclusion that the existing algorithms had less direct engagement with clients. Many researchers have focused their attention on the combined recommendation algorithm [16–18], which combines a number of different recommendation techniques in order to address the shortcomings of individual recommendation algorithms while also capitalizing on the benefits offered by those algorithms individually. On the other hand, the majority of the study is founded on two different algorithms: *CF* and content-based filtering. Very few scholars have looked into how interactive design might be used to dynamically compose several recommendation methods.

Customers can have better services by using IoT services. It can enable users to acquire information when it is required. The primary idea behind the proposed plan is to provide recommendations to users whose interests are comparable to one another. In other words, the *CF* algorithms first assess a user's preferences based on the behavioral records that the user has kept, and then they generate recommendations based on the preferences of other individuals who share interests that are comparable to the user's own. When it comes to recommended products, *CF* does not have any specific requirements (such as descriptions or metadata). It can deal with a variety of things, such as books, movies, and music. Because of this, it finds widespread use in a variety of commercial applications. According to a survey that was just released by Ref, the recommendation system on Amazon is responsible for more than 30 percent of purchases. Additionally, recommender systems are an essential component of cloud computing.

2. Related Work

The memory-based *CF* algorithm is a type of filtering algorithm that is based on items as well as the thoughts contributed by the user. It begins by choosing collaborative neighbor users who have concepts that are comparable to those of the user, and then it proposes objects and items based on the associated items of the users who are collaborative neighbors. Scoring things, proposing users, anticipating the likely scoring values of users for these items, and screening the benefits and disadvantages according to the scores are all included in this process. It is important to note that the judgment basis of the algorithm will be the score of the item and that the analogy concept will also be reflected here. These two points are important to note. If the features described above are favored by a sizable majority of users who are collaborative neighbours, then it is assumed that the user will similarly value these qualities and any features that are related to them. The ranking system will demand user participation and will automatically prefer items that are comparable.

The memory-based *CF*algorithm [19] and the model-based *CF* method [20] both have distinctive features that distinguish them from one another. The earlier method tends to build a model first (by combining users' surfing, clicks, purchases, and information read), then look for related and cooperative neighbour users. Make a thorough model of the user's preferences, assess that model in light of the data provided by the nearby users, and use that data to anticipate the user's preferences. When the item set is divided up into numerous modules, the module units of the

users who are working together with their neighbors are then categorized according to the user's model, and the user model that best fits the data is chosen. A curated selection of the most relevant modules is used to provide users with content recommendations. This technology has branched out into many different subfields, many of which incorporate the concepts of correlation and comparative analysis in some way. People's aspirations to lead more spiritual lives are growing in tandem with the general rise in the quality of their living conditions, and as a result, libraries have evolved into popular gathering spots for those looking to do so. It is very crucial for individuals to be able to locate the books that they require from among a huge number of books when the technology for wireless mobile network storage has matured to the point where many e-books may be stored in libraries [21–24]. People will have an easier time finding the books they require with the assistance of the library's bibliographic recommendation system, which will lead to a higher rate of resource usage overall. It is for this reason that the development of a library bibliographic recommendation system that has good performance has become an important direction in the field of study concerning libraries.

There is now more interest in location-based recommendations due to improvements in mobile positioning technology. These suggestions can help users find interesting places to visit within a specific distance of where they are right now, as well as propose places to go for food that they would enjoy. In general, information about a user's mobility and spatial location is useful in identifying their preferences. When making recommendations, considering the geographic location of the user can improve speed, as well as give improved scalability to accommodate growing data sizes and latent space dimensions. In general, user behaviors falls somewhere within a predetermined range of possibilities. For instance, when most users consume offline content, they will choose hotels within 50 miles, which demonstrates that user behavior patterns are heavily influenced by geographic regions. This can be seen in the fact that most users will choose hotels within this distance range. Take into account the whereabouts of users across the globe. It is possible to do user portraits with greater accuracy in order to determine user preferences.

The success of the venue recommendation process is heavily dependent on the methods that are utilized to obtain information regarding the user's environment or preferences. However, it is difficult to collect complete knowledge about user preferences, and furthermore, user preferences have a tendency to vary from person to person (i.e., some preferences are common to all users, while others are dynamic and diverse). Venue-based recommendation algorithms [25, 26] typically suggest the most well-known, inexpensive, or conveniently located venues based on a few pieces of contextual information. In addition to taking into account the user's location, it is imperative to also consider the user's other interests and preferences. The preferences of users are influenced by a wide variety of factors, including proximity, familiarity, and overlap in areas of interest [26]. Therefore, it is vital to take into account distance in addition to other criteria of interest that include several dimensions when making individualized recommendations for crowdfunding projects.

In recommender systems, users and goods each have their own unique set of multidimensional characteristics. The degree to which objects and users match up can be improved, as well as the effectiveness of recommendations, by the utilization of multifeature similarity [27]. Therefore, when it comes to financial things found on the Internet, taking into account the multidimensional characteristics of both items and users and matching them can considerably increase the identification of user preferences. Studies that already exist have shown that there is a local bias in the behavior of online investors. This means that investors favor projects that are located in closer proximity to them. This preference of investors violates the limitation of geographical location, and it is a completely different scenario from the suggestion of venue projects. Because of this, a recommendation system that is based on local preferences needs to be reconstructed.

Due to the fact that the majority of consumers only buy a few goods, there is a problem with data sparsity. Utilizing various forms of implicit feedback data, such as the ratings and comments left by customers on online retailers' websites, is one potential answer. One such possibility is to make use of a network graph to determine the overall degree of similarity that exists between users and products.

The location of the user is one of the fundamental features. Other user attributes are diverse. Recommender systems have evolved in recent years to take into consideration the multidimensional features of consumers. However, this type of group recommendation treats users in the same group as if they were all identical, does not include any sort of personalisation, and has a performance that is restricted by the degree to which clustering is accurate.

3. Research Design

The analysis of its working process reveals, as shown in Figure 1, that the user's individual needs are analyzed first and then the relevant information regarding ancient Chinese literary works is extracted from the database. Finally, a portion of the information is preprocessed and categorized, and the classification outcomes are saved in the database. All this is completed prior to the classification results being saved in the database. The next step is to make use of *CF* to determine the degree of similarity between users and works, as well as to mine the relationship between the two. Next, create tailored recommendation association rules, and then ultimately show the results of the recommendations made.

3.1. Data Sources. The source of our data is a database of the ancient Chinese literary works on a domestic literary website. This database contains readers' ratings of the ancient Chinese literary works as well as their comments on these works. Separate the data into a training set and a test set, with the former accounting for eighty percent of the total and the latter for twenty percent.

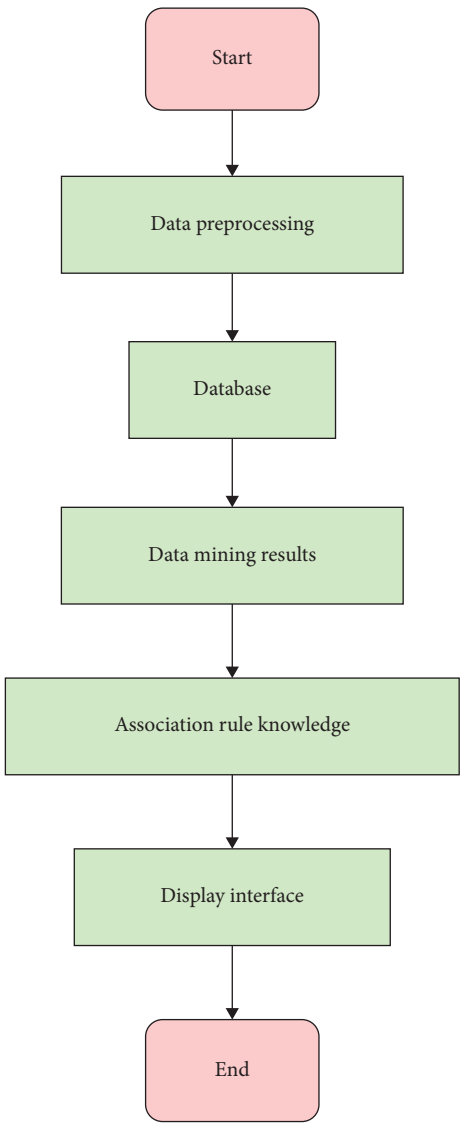

Figure 1: The workflow of a personalized recommendation system.

3.2. CF Algorithm. The *CF* algorithm establishes the relevance of the keywords found in the works of classical literature from the mediaeval times. Currently, a number of methods can be used to determine the keyword weights of literature from the mediaeval and classical periods. This method is more scientific and reasonable when compared to other methods, and it may be used to determine the relative importance of keywords in literary works from the Middle Ages and the classical period. As a result, the focus of this article will be on determining the relative importance of keywords in classical and medieval literary works. The importance of keywords to medieval and classical literary works is represented by the *WF*, which stands for the word frequency of medieval and classical literary works and is used to describe the importance of keywords. The word used to describe the significance of keys around the world is Inverse Document Frequency (*IDF*) of medieval classical literary works. Assuming that there are F keywords in books of medieval and classical literature and that the number of times they appear in books of medieval and classical literature is K, then WF may be represented as a formula, provided that there are F keywords in books of medieval and classical literature.

$$WF = \frac{K}{F}. \tag{1}$$

If we assume that the total number of the ancient Chinese literary works is N, and that the number of ancient Chinese literary works that contain a certain keyword is k, then the information distribution function can be stated as the following formula:

$$IDF = \log_{10}^{N/k+1}. \tag{2}$$

It is possible to determine the keyword weight of the ancient Chinese literary works using this method, and this weight may be stated using the following formula:

$$WF - IDF = WF \times IDF. \tag{3}$$

The keyword weights of the ancient Chinese literary works are used next in order to determine the similarity between the works being compared. h is the number of common keywords that may be found in literary works from ancient China such as A_i and A_j. Since the weights of the kth keyword are ω_{ik} and ω_{jk}, respectively, for the literary works A_i and A_j, the formula for determining the degree of similarity between these two sets of works is as follows:

$$\mathrm{sim}\left(A_i, A_j\right) = \sum_{k=1}^{h} \omega_{ik} \times \omega_{jk}. \tag{4}$$

After that, compute the user's degree of overlap. Numeric and text kinds are both considered user characteristics. Let's call the degree to which the numerical characteristics of user U_i and user U_j are alike $\mathrm{sim}_{n(i,j)}$. The similarity between user U_i and U_j's text attributes is denoted by $\mathrm{sim}_{h(i,j)}$, and the similarity between user attributes is denoted by the following formula:

$$\mathrm{sim}_{a(i,j)} = \mathrm{sim}_{n(i,j)} + \mathrm{sim}_{h(i,j)}. \tag{5}$$

Determine the degree of user activity overlap. The number of dynamic pieces of information that are shared between user U_i and U_j is equal to m, and the weight of the kth dynamic piece of information is denoted by U_{ik} and U_{jk}, respectively. The sim_{ac} model is based on user activity similarities, as shown in the following equation:

$$\mathrm{sim}_{ac(i,j)} = \sum_{k=1}^{m} U_{ik} + U_{jk}. \tag{6}$$

The concept of user similarity refers to two distinct aspects: attribute similarity and activity similarity. The overall degree of overlap between users U_i and U_j can be calculated using the following formula:

$$\mathrm{sim}\left(U_i, U_j\right) = \gamma \mathrm{sim}_{a(i,j)} + \eta \mathrm{sim}_{ac(i,j)}. \tag{7}$$

Determine the degree of association between users and classic works of Chinese literature. If we make the assumption that there are connections between the user U_i and the work A_j, then the formula used to determine the nature of the link between the user U_i and the work A_j is as follows:

$$\mathrm{sim}_{ua} = \sum_{k=1}^{c} R_{ik}. \tag{8}$$

The value that corresponds to the kth connection between U_i and work A_j is denoted by R_{ik} in the formula.

Finally, it comes down to the recommendation rules for the ancient Chinese literary works from the users. The collection of the ancient Chinese literary works should be denoted by the letter $X = \{X_1, X_2, \ldots, X_m\}$, and the collection of transaction records should be denoted by the letter $Y = (y_1, y_2, \ldots, y_n)$. In accordance with the matching tree method, the levels of support and confidence are derived from the following formulas:

$$S(X_i) = \frac{\left|\{y \in Y | X_i \in X\}\right|}{|Y|}, \tag{9}$$

$$\mathrm{Con}\left(X_p \longrightarrow X_q\right) = \frac{S\left(X_p \cup X_q\right)}{S\left(X_p\right)}. \tag{10}$$

The K-Means clustering algorithm is utilized in the process of analyzing the ancient Chinese literary works and classifying them into a set of K categories. The matching rules for the numerous literary works are formed according to the matching tree technique, and the minimal support and minimum confidence are computed after that. Finally, based on the minimal amount of support and minimum amount of confidence, the bibliography is recommended to users.

4. Results

To begin, we stipulate a condition regarding the rating index of the personalized recommendation system's procedure. Early recommendation systems are frequently based on their evaluation of their ability to anticipate whether users will read a certain work of literature or not. As a result, the accuracy rate becomes a crucial measure. Later research concluded that basing the development of recommender systems primarily on accuracy would result in unintended consequences. As an illustration, the accuracy rate will be quite high when it comes to the recommendation of well-known products. Users will still purchase these kinds of products even though they are not recommended. When users promote things to other users who are unfamiliar with but are interested in, they express higher levels of enjoyment. On the other hand, experience has shown that a massive collection of outstanding literary works will significantly affect sales. In order to accomplish this, precision and recall are divided into two separate areas when evaluating recommender systems. In the formulas (11) and (12), which are listed in that order, there are the steps for calculating the two different types of indicators.

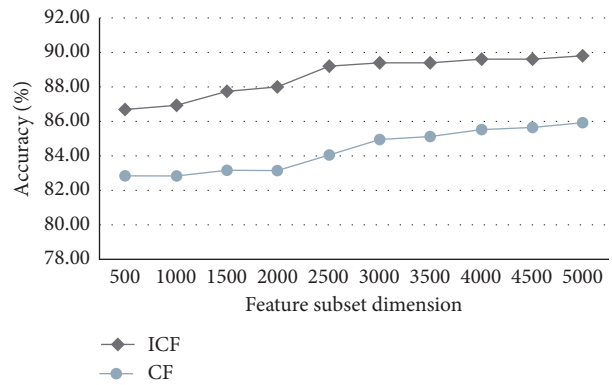

Figure 2: The accuracy of the two algorithms.

$$p = \frac{TP}{TP + FP}, \tag{11}$$

$$r = \frac{TP}{TP + FN}. \tag{12}$$

As can be seen in Figure 2, we evaluate the performance of the improved collaborative filtering algorithm (*ICF*) in contrast to the conventional *CF*. The accuracy of the *ICF* algorithm is substantially higher than that of the *CF* algorithm, as can be seen from the observation figure. This is a major difference between the two algorithms. When the dimension of the feature subset is 500 dimensions, the accuracy of the *ICF* algorithm is higher than that of the *CF* algorithm. When the dimension of the feature subset reaches 4000 dimensions, the accuracy of the two algorithms tends to be stable, and the final accuracy of the *ICF* algorithm is stable. When the dimension of the feature subset is 500 dimensions, the accuracy of the *CF* algorithm is higher than that of the *ICF* algorithm. It is approximately 89.6 percent, but the accuracy of the *CF* algorithm remains relatively constant at approximately 85.8 percent.

Figure 3 displays the recall results obtained using the two different techniques. It has been found that the recall rate of the *ICF* method is greater than that of the *CF* algorithm when the feature subset dimension is set to 500 dimensions. The recall rate of the *ICF* algorithm tends to be stable when the dimension of the feature subset reaches 1500, but the recall rate of the *CF* method is steady when the dimension of the feature subset reaches 3500. The ultimate recall rate of the *ICF* algorithm has been found to be steady at approximately 89.1%, which is higher than the *CF* algorithm's recall rate of 85%.

Figure 4 depicts the outcomes of the calculations for the *F* value performed by the algorithm for the analysis of reader text comments. It is clear from looking at the figure that as the feature subset dimension gets larger, the *F* value of the *ICF* algorithm goes up from 85.9% to 88.7%, and the *F* value of the *CF* method also goes up from 82.5% to 84.7%. When the dimension of the feature subset approaches 3500, the *F* value of the two algorithms has a greater likelihood of being stable. In general, the performance of the *ICF* algorithm is noticeably superior to that of the *CF* method.

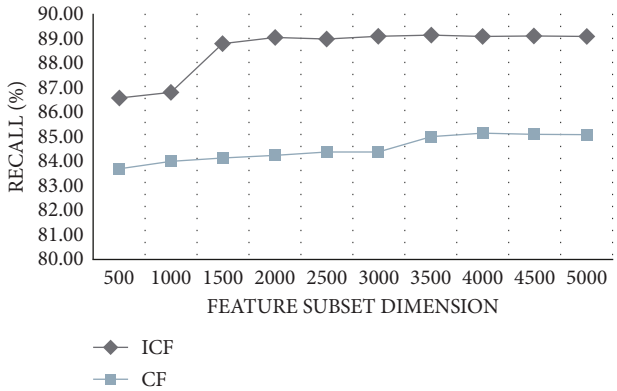

Figure 3: The recall of the two algorithms.

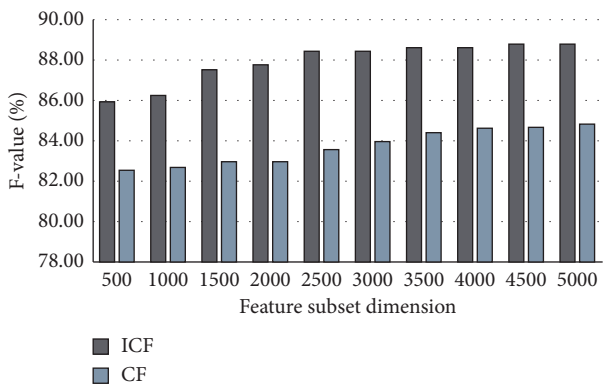

Figure 4: The F value of the two algorithms.

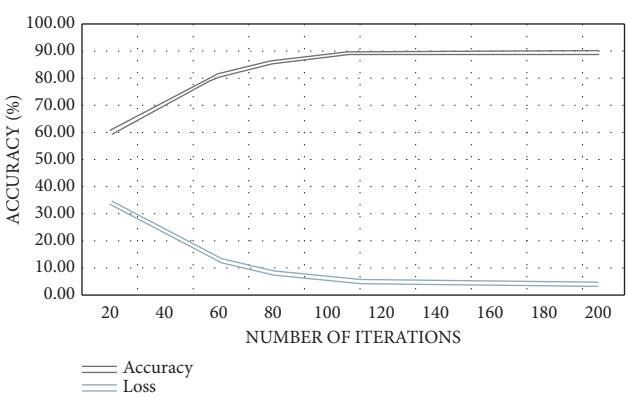

Figure 5: Accuracy and loss as a function of iterations.

As can be seen in Figure 5, both the accuracy and the loss of the *ICF* algorithm shift as more and more rounds are performed. When the number of iterations is close to 120, we can observe that the *ICF* algorithm is getting close to convergent. At this point, both the accuracy and the loss are fluctuating within a relatively small range.

5. Conclusion

We will discuss the *CF* algorithm and the personalized recommendation system, as well as elaborate on the correlation between the two. Our primary focus will be on the structure, classification, advantages, and disadvantages of the personalized recommendation system that is based on the collaborative recommendation algorithm. In addition, we will expand on and introduce the method for improving the algorithm. The classification of model-based filtering algorithms is comparable to that of personalized recommender systems, in that it is user-centric and has similarities to the aforementioned categorization. The *CF* algorithm is the backbone of the system that generates tailored recommendations. Its fundamental premise is that it should be possible to conduct an efficient search for neighbor users who share use'r preferences in a short amount of time, to filter and sort objects according to the preferences of the neighbor users, and to recommend the results of the search to the initial users. It is composed of an offline system and an online system, both of which are connected to one another and work in conjunction with one another. A lack of data, insufficient sample richness, limited system computing capacity, new users, new product interference, and other issues are also present in the process of its development. Improvements can be made, respectively, to the user-led recommendation and the project-guided recommendation systems in response to the issues described above.

We have developed a personalized recommendation algorithm for the ancient Chinese literature that is based on the *ICF* method. This algorithm was created to assist users who are interested in ancient Chinese literature in swiftly locating the literature that best suits their interests. Help more readers get their tailored text while saving time and effort, providing users with a better experience, and giving users more options.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

Declares that he has no conflict of interest.

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Research Article

Design of Hotel Human Interaction System Based on Deep Learning

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This paper designs a hotel human-computer interaction (HCI) system which is based on deep learning. The whole system mainly includes face detection, speech synthesis, and speech recognition. Real time face detection is realized by transplanting the Opencv library into the Android system and combining that with the AdaBoost algorithm. Furthermore, the local speech recognition is realized through the special chip for speech recognition hbr740, while the local speech synthesis is realized through the special chip for speech synthesis syn6288. Subsequently, the massive speech resources are obtained through the network connection into the iFLYTEK's open platform, which can realize online speech recognition, semantic understanding, and speech synthesis. In the data flow phase, we transmit data to the lower computer through the serial port of tiny4412 in order to realize the motion control of the lower computer. This is achieved through the SQLite database for system voice interaction and motion control, which is built through the jar package of the Litepal and POI. Finally, a hybrid voice interaction system is designed combining the local voice interaction with the online voice interaction. Through numerical simulation, the suggested system is tested to verify the feasibility of the hybrid voice interaction scheme. We observed that when the network is in good condition, the speech recognition rate of the whole system reaches as high as 94.67%; while without the network, the speech recognition rate can still reaches up to 84.67%. The attained outcomes demonstrate the superiority of the suggested hybrid system.

1. Introduction

Over the past decade, smart hotels have gradually developed, but they are still in the initial exploring stage. Problems such as high personnel costs, disordered management, and low service quality are emerging in an endless stream in the traditional hotel industry. Technology iteration and intelligent transformation are inevitable. Artificial intelligence, face recognition, voice interaction, and other technologies have applied to the hotel industry. Relying on artificial intelligence, the Internet of things (IoTs), big data, edge, machine learning, cloud computing, and other emerging technologies, the smart hotel has established a smart service system to intelligentize its operation, management, and control and bring users a mild and high-quality service experience. When introducing technologies and hardware such as intelligent devices, intelligent robots, and digitalization, it is also necessary to consider consumer's emotional needs and provide humanized services. The connotation of the smart hotel is people-oriented, focusing on user, combining science and technology with human nature with the aim to optimize the user experience.

The smart hotel can improve hotel management efficiency, intelligently manage hotel equipment and personnel, and reduce equipment failures and personnel errors. Big data may be used to gather and combine occupancy data, and precision marketing can be used to satisfy user. In addition, the smart hotel has implemented remote management, data statistical analysis, energy preservation, CO_2 lessening, low carbon and ecological fortification, independent monitoring and system and module updating, and independent monitoring and upgrading, which has significantly decreased the cost of hotel operation and maintenance.

In the contemporary age, the growth of the Internet and mobile devices has opened up new markets for the traditional hotel industry. Various tourism app hotels have

gradually replaced calling the front desk and booking through the computer network, which not only facilitates consumers but also drives the growth of the tourism economy. Most hotels in China still use the front desk for manual check-in. The room facilities are fixed and the update speed is slow and the check-out procedures are cumbersome. To a large extent, they have been unable to meet the personal needs of customers. In order to improve the user experience, many traditional hotels have gradually started to innovate and introduce new measures in terms of hotel equipment in combination with science and technology. The traditional hotel industry has high training costs, long working hours, redundant personnel and rapid loss, low wages, and no sense of identity, resulting in low work efficiency. Users' data are scattered and privacy is not guaranteed. The selection range of room types is small, which is difficult to meet personalized needs. The mature large hotel group has a huge industrial chain, and it is difficult to quickly update the infrastructure, resulting in slow transformation. Because small and medium-sized hotels only simply decorate and upgrade equipment, they excessively pursue promotion and marketing, neglect service, and do not invest in design from the perspective of users, resulting in a poor experience.

The rapid development of embedded technology, mobile Internet, and artificial intelligence provides the basic support of software and hardware for the hotel service robot. The International Federation of Robotics (IFR) defines fully autonomous or semiautonomous robots that perform useful service activities for human beings but do not engage in production as service robots. In China, the definition of a service robot is relatively narrow, and the fully autonomous or semiautonomous robot that provides necessary services for humans and equipment is called a service robot. Service robots can be distributed into three categories: (i) entertainment service robots, (ii) family service robots, and (iii) professional service robots. Among them, professional service robots are predominantly used in specific places to replace people to complete tasks. Hotel service robots belong to one of them. At present, the labor cost of the hotel industry is high and the turnover rate is high. According to the "big data" platform hotel, the labor cost has been accounting for more than 30% in four of the past six years, and the labor cost is a major expenditure item of the hotel. In addition, the average monthly turnover rate of hotel staff in the past six years has also been around 4%, which has been in a relatively high state [1].

Due to cultural differences in different countries, the development of smart hotels also has its own emphasis. The first unmanned hotel in China, Le Yi's "unmanned smart hotel" has realized the full induction intelligent room, which is completed by the electronic system from the reservation, check-in to check-out [2]. Happy to stay in view of the pain points of the homogenization of traditional hotels and high labor costs, we designed a new "unmanned Hotel" model to reduce costs from the aspects of "de lobby," reducing staffing ratio and increasing online publicity. The most notable feature of the smart home-focused Murano Resort Hotel in Paris, France, is that guests may customize a number of profile settings using the light controller by their bedside. These modes can be adjusted to reflect their own routines and tastes. The Peninsula Hotel in Tokyo, Japan, has the ideal design. Throughout the hotel, there are several buttons with various purposes. By pushing the buttons, users may answer the phone hands-free and learn the weather outside and how to dress for it. In the United States, the Seattle Hotel 1000 includes a full intelligent infrastructure that can accommodate users' demands whenever they arise. China's advancement in smart hotels falls behind that of industrialized nations such as Europe and the United States. Several upscale hotels have started researching low-carbon environmental protection and intelligent information since 2009. Poor user experiences are particularly typical in small and medium-sized hotels because of limited capital expenditures and a lack of knowledge of the usage scenarios for intelligent systems. The majority of international smart hotels engage much in R&D (research and development), create systems that adhere to their own growth and management philosophy, and significantly enhance the quality of life for their guests [3]. The fundamental contributions are as follows:

(1) We design a hotel human-computer interaction system based on deep learning, and the suggested system includes face detection, speech synthesis, speech recognition, and so on,

(2) real time face detection is realized by transplanting the Opencv library to the Android system and combining it with the AdaBoost algorithm in the Opencv library,

(3) the SQLite database for system voice interaction and motion control is built through the jar package of Litepal and POI,

(4) combining local voice interaction with online voice interaction, a hybrid voice interaction system is designed and tested to verify the feasibility of the hybrid voice interaction scheme.

The rest of the paper is structured as follows: in Section 2, we discuss some related work and state-of-the-art mechanisms. In Section 3, several applications of deep learning in hotel human-computer interaction are deliberated. In Section 4, the hotel's human-computer interaction system is validated through simulations and tests. Finally, Section 5 concludes this paper and discusses several key directions in, which the work can be extended in the future.

2. Related Work

At home and abroad, hotels' investment in intelligent voice research and development. In 2011, apple entered the field of intelligent voice with Siri, and vigorously promoted the application of Siri in automotive electronics and other fields. In 2014, Google launched the Android wear project, in which the voice function is an important part [4, 5] and released Google now and Google glass. In 2016, Google integrated Google now and OK Google and launched the voice assistant Google assistant [6]. In 2014, Microsoft released the Xiaobing robot and Cortana (Xiaona) with leisure entertainment and personal assistant functions respectively and integrated the

two. Domestically, on August 1st, 2012, the China voice industry alliance, jointly initiated by 19 enterprises including iFLYTEK, Huawei, Lenovo, China Mobile, China Unicom, and China Telecom, was officially established in Beijing. At present, the voice technology research manufacturers in China are mainly divided into three categories: one is the traditional voice technology manufacturers, such as iFLYTEK, Jietong Huasheng, and Zhongke modular [7, 8]. The second category is the current Internet enterprises, such as Tencent, Alibaba, Baidu, and Sogou, which actively promotes their original Internet business, obtain the original voice technology through cooperation or acquisition, and add their own relevant elements and ideas, making the current voice technology more and more mature. The third is the small and medium-sized companies that are still in the entrepreneurial stage, such as yunzhisheng and sibichi. They only focus on those related to their own business areas, but at present, most of them are involved in the public domain and do not involve the dedicated hotel field [9, 10].

Finding and managing feature interactions that break system requires and thus failures may be difficult. By recasting this issue as a search-based test generation problem, the authors of [11] provide a method to identify feature interaction failures. A hybrid PRNN/KNN algorithm is used to create an improved human voice emotion recognition system [12]. The goal of [13] is to create an articulated language processing method for human-machine interaction-based smart device diagnostics. Although the hybrid CTC/attention ASR system benefits from both CTC and attention architectures during both phases i.e., training and decoding, due to its attention approach, the CTC prefix possibility and bidirectional encoder, however, it is still difficult to employ for streaming speech recognition. The authors of [14] have suggested a truncated CTC prefix probability (T-CTC) to stream its CTC branch and a stable monotonic chunkwise attention (sMoChA) to stream its attention branch. Similar to [15], which offers a guideline for the growth of arti A convolutional neural network (CNN) and recurrent neural network (RNN) technology, the state-of-the-art automatic lip-reading technology, is used to build a speech training system for patients with dysphonia and hearing loss [16]. Using noncooperative game theory and robust optimization, the authors of [17] describe a novel coordinated energy management strategy for hybrid AC/DC distribution systems with microgrid clusters that take into account various market actors. The use of hybrid robust feature extraction approaches for spoken language identification (LID) systems is also presented and encouraged by researchers in [18]. In order to study speech recognition, the researchers in [19] offer an automatic speech recognition (ASR) system, which is, in fact, founded on a few single and/or (potentially) multiple modalities, including audio and electroencephalogram (EEG) inputs. The authors of [20] intend to investigate a novel paradigm of human-computer interaction and conduct an in-depth study on the creation and implementation of intelligent services in the big data environment. This is based on the growing idea of "Hybrid Intelligence."

3. Application of Deep Learning in Hotel Human-Computer Interaction

3.1. Deep Learning. Deep learning is a group of algorithms and a subset of machine learning. It is often referred to as deep structured learning or deep machine learning. Today, deep learning is a big success in the field of algorithms, not only on the Internet and artificial intelligence but also in all major fields in life that can reflect the great changes led by deep learning, such as the most advanced speech recognition, visual object recognition, and other fields. In this paper, we first understand deep learning from some concepts involved in deep learning. Finally, we mainly introduce two kinds of deep learning networks, convolutional neural networks, and cyclic neural networks, which are most widely used in image recognition and language processing [21].

Deep learning is now the most popular technique, and voice recognition and computer vision are the two fields where it performs best. Convolutional neural networks are a common example in computer vision. Convolutional neural networks are a specific kind of deep feedforward network that perform better at generalization than fully connected neural networks and are simpler to train. A color image with three color channels is an example of the type of multidimensional array data that the convolutional neural networks (CNN) are intended to analyze. One-dimensional arrays are used to represent signals and sequences such as speech, two-dimensional arrays are used to depict pictures, and three-dimensional arrays are used to represent video or sound images. Next, we demonstrate how to comprehend convolutional neural networks using a color channel in a color picture. As can be seen in the picture below, the convolutional neural network really consists of many layers, with the essential functions being convolution, pooling, full connections, and recognition. Figure 1 depicts the deep learning architecture.

The following characterizes the hotel human-computer interaction association problem from the four aspects of the hotel human-computer interaction association scene input data, association feature input data, association decision output data, and loss function so as to model the hotel human-computer interaction association problem as a classification and identification problem. The specific modeling methods are as follows:

(1) Based on the hotel human-computer interaction information at time t, the input data of hotel human-computer interaction-related scenes are calculated and constructed. The data have an image data structure. The specific calculation method is as follows:

(a) according to the importance of the information obtained from the hotel human-computer interaction, the hotel customer positions at the time t of the source are sorted internally, and the

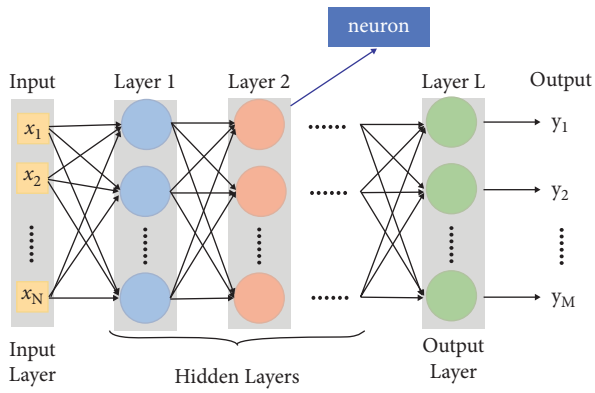

FIGURE 1: The structure of deep learning.

serial number l of each customer in the source is obtained using the following formulas:

$$l = I_s(i), \tag{1}$$

$$i = I_s^{-1}(l). \tag{2}$$

(b) among the guest information sources of different hotels, calculate the distance $\widetilde{\mathbf{C}}_{e,t}$ between any two guests at time t in sequence according to the sequence of the guest serial number and take it as the element in row i and column k to build the input data $\widetilde{\mathbf{C}}_{e,t}$ of the human-computer interaction scene of the associated hotel. The $\widetilde{\mathbf{C}}_{e,t}$ is calculated using the following formula:

$$C_{e,t,l,k} = \sqrt{\left|x^t_{s_1,I^{-1}(t)} - x^t_{s_2,I^{-1}(k)}\right|^2 + \left|y^t_{s_1,I^{-1}(t)} - y^t_{s_2,I^{-1}(k)}\right|^2}. \tag{3}$$

(2) For the human-computer interaction point I of guest location information 1 and the human-computer interaction point J of guest location information 2 to be associated, the statistical distances of the two human-computer interaction points at the location, information sharing point, and internal information sharing are calculated respectively as the associated feature input data $\mathbf{D}_{t,i,j}$, the specific calculation method is mathematically illustrated using the following formula:

$$\begin{aligned}
\mathbf{D}_{i,j} &= \left[\, d_{\mathrm{r}}(i,j) d_{\mathrm{v}}(i,j)(i,j) \,\right]^{\mathrm{T}}, \\
d_{\mathrm{r}}(i,j) &= \frac{\sqrt{1/u \sum_{i=t-u+1}^{t}} \left(\left|x^l_{1,i} - x^l_{2,j}\right|^2 + \left|y^l_{1,i} - y^l_{2,j}\right|^2 \right)}{2\left(\sigma^2_{1,\mathrm{r}} + \sigma^2_{2,\mathrm{r}}\right)}, \\
d_{\mathrm{v}}(i,j) &= \frac{\sqrt{1/u \sum_{i=t-u+1}^{t} \left|v^l_{1,i} - v^l_{2,j}\right|^2}}{2\left(\sigma^2_{1,\mathrm{v}} + \sigma^2_{2,\mathrm{v}}\right)}, \\
d_{\mathrm{c}}(i,j) &= \frac{\sqrt{1/u \sum_{i=t-u+1}^{t}} \left|c^l_{1,i} - c^l_{2,j}\right|^2}{2\left(\sigma^2_{1,\mathrm{c}} + \sigma^2_{2,\mathrm{c}}\right)}.
\end{aligned} \tag{4}$$

Based on the related scene input data $\widetilde{\mathbf{C}}_{e,t}$, the related feature input data $\mathbf{D}_{t,i,j}$, the related decision output data $y_{t,i,j}$, and the loss function L obtained from the human-computer interaction problem representation of the hotel, the deep learning technology is adopted to design the human-computer interaction algorithm of the deep learning hotel. The steps are as follows:

(i) Step 1: first, set the maximum number of hotel human-computer interactions as N, then preprocess the input data $\widetilde{\mathbf{C}}_{e,t}$ of the three associated scenes at time t with zero value peripheral filling so that they are the same size, all $N \times N$, and finally merge them into $N \times \mathrm{N} \times 3$ tensor $\widetilde{\mathbf{C}}_{e,t}$.

(ii) Step 2: the deep convolution neural network is used to embed $\widetilde{\mathbf{C}}_{e,t}$ to obtain the vector representation V_C of the associated scene.

(iii) Step 3: the multi-layer neural network is used to upgrade the dimension of the associated feature input data $\mathbf{D}_{t,i,j}$ to obtain the high-dimensional representation V_D of the associated feature.

(iv) Step 4: combine the hotel-associated scene vector representation V_C and the associated feature high-dimensional representation V_D and use the multilayer neural network to process. The network output is $y_{t,i,j}$, and the excitation function of the last layer of the neural network is the sigmoid function.

(v) Step 5: using typical datasets, according to the cross-entropy loss function L, train the neural network according to steps 1–4 to obtain the weight of the neural network.

Among them, for steps 2–4, the typical network structure is shown in Figure 2, including the hotel scene embedded network, feature dimension upgrading network, and associated decision network. According to the complexity of the correlation problem and the training effect of the neural network, the network structure can be further adjusted.

3.2. Design of Hardware and Software. The mainstream speech recognition chips in the market include icroute ld3320, iFLYTEK xfs5152ce, and Shanghai Xinfeng micro hbr740. Because the command word list of iFLYTEK xfs5152ce cannot be dynamically edited, the manufacturer only accepts the customization of customer command words, so fs5152ce is not selected as the speech recognition module. Compared with hbr740, ld3320 has the same recognizable length each time, but hbr740 recognizes more candidate recognition sentences each time, so hbr740 is selected as the speech recognition chip [22].

The whole system takes android as the platform and provides the android5.0.2 system on the friendly arm tiny4412. It mainly uses an SD card to burn the bootloader, Linux kernel, Android root partition image, Android system partition image, and Android data partition image. Since tiny4412 has insufficient resources to develop software, a cross-development mode is required when adding a dynamic link library to tiny4412's Android system. The so-called cross-development mode is to edit and compile the software on the host (PC) and then run and verify the

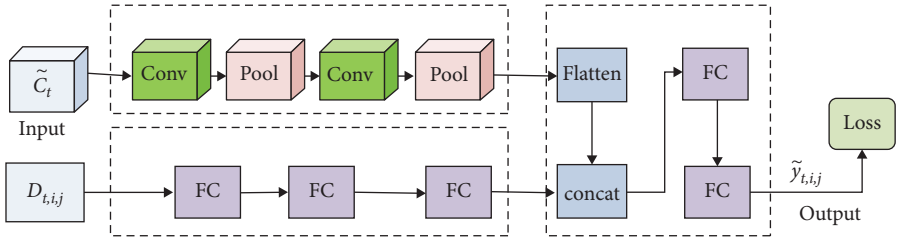

Figure 2: The hotel human-computer interaction deep learning network.

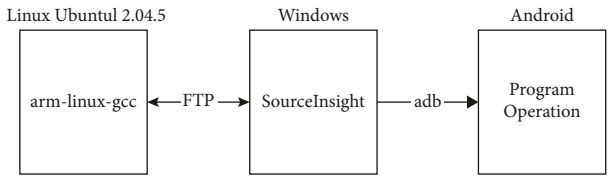

Figure 3: The cross-compilation mode.

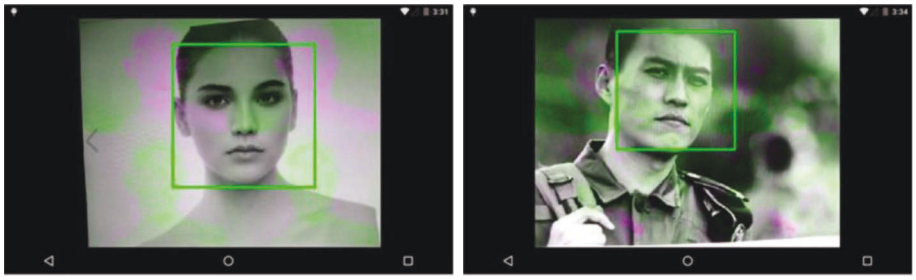

Figure 4: Static image face detection results.

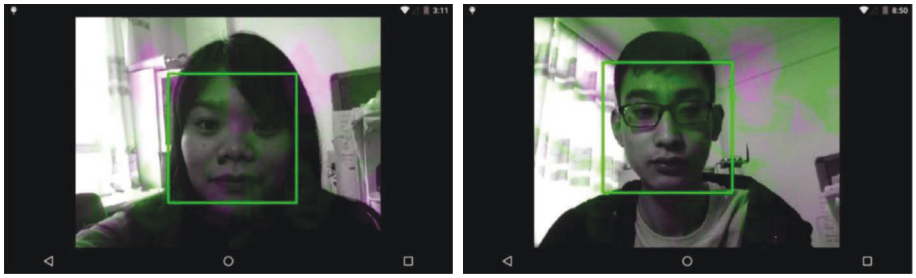

Figure 5: Dynamic image face detection results.

program on the target board (embedded device). The target development board of this article is tiny4412 [23]. The host of this article uses the Linux system installed on the virtual machine. Figure 3 shows the cross-development mode established in this paper.

On the PC operating system windows, first, edit the program on SourceInsight, and then use FTP (File Transfer Protocol) to transfer it to the virtual machine Linux system. On the Linux system, arm Linux GCC is used to compile the program and then FTP protocol is used to transfer the program to Windows system. On the windows system, use the ADB (Android debug bridge) tool to transfer the program to tiny4412 and run it.

4. Hotel Human-Computer Interaction System Test

4.1. Face Detection Test. Open the face detection activity to test the face detection function module. The expected phenomenon is that when the camera detects a face, it will draw a green box. As shown in Figure 4, face detection is carried out on static images, and the test results of face detection of the system meet the expectations. As shown in Figure 5, face detection is performed on the dynamic image. When the people in the lens move continuously, successful face detection can also be achieved, and the detection results meet the expectations [24].

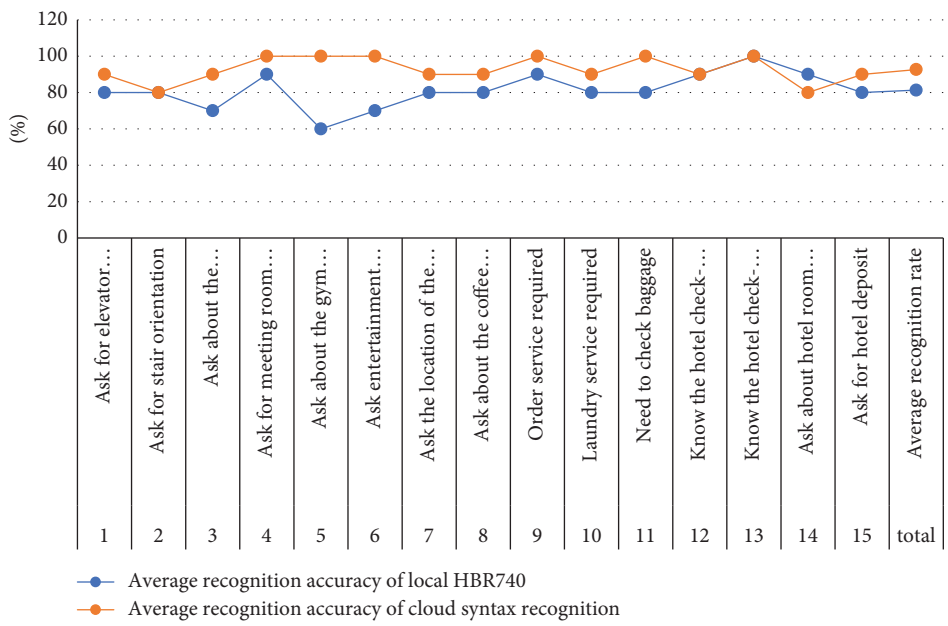

Figure 6: Average recognition accuracy of 15 test commands in the hotel human-computer interaction.

4.2. Voice Interaction Test. The voice interaction system designed in this paper is used in hotel service, facing a variety of hotel guests. When hotel guests interact with the service robot, they must speak naturally as usual. In order that the system can meet the needs of different guests' speaking characteristics, that is, as long as the meaning of voice commands is the same and the expression is different, the system can still grasp the keywords to recognize voice commands. This paper considers the input of speech recognition entries with different expressions in the same sentence when editing the entry project of the local speech recognition module hbr740. During the cloud grammar recognition, the common statements of people are simulated when constructing the grammar file. Both the keywords of command recognition and the irrelevant words are written. Therefore, the speech recognition range of the system has been expanded, but whether it has an impact on the speech recognition effect is unknown. Whether this paper can still ensure a certain recognition accuracy under the premise of maintaining natural interaction, this paper has carried out relevant experiments.

A total of 10 participants were selected [25]. Each participant said 15 relevant voice commands at a time to test the local voice recognition system based on the hbr740 voice recognition chip and the cloud voice recognition system based on cloud grammar recognition. The test environment was in an office environment. All participants' instructions have the same meaning, but the expression is based on the participants' personal speaking characteristics. The average recognition rate of each instruction is counted to see whether it can meet the requirements of recognition accuracy. The test results are shown in Figure 6.

According to the content in Figure 6, we can see that the average recognition accuracy of local hbr740 is 81.33%, the average recognition accuracy of cloud syntax recognition is 92.67%, and the recognition rate of cloud syntax recognition is higher. Because various nonkeywords are added during the construction of cloud grammar, which can be freely combined, covering people's ordinary living methods. However, local speech recognition is limited by the number of words. Many statements are not fully included, and the recognition rate is relatively low. The advantages of local speech recognition hbr740 over cloud speech recognition are not limited by network conditions. The cloud speech recognition rate of the whole system is relatively good, and the local speech recognition rate is also within an acceptable range.

5. Conclusions and Future Work

This paper mainly introduces the hotel human-computer interaction system based on deep learning and tests and applies the interaction system. First, test each module of the system face detection for static images and dynamic images. Select 15 typical voice problems that are often needed by hotels, and test the voice recognition based on the hbr740 voice recognition chip and cloud grammar recognition, respectively. It is found that the grammar recognition effect constructed by Xunfei cloud grammar recognition is better; select the answers to 15 typical voice questions often needed by the hotel and test them based on the voice synthesis module syn6288 and the voice synthesis system based on cloud voice synthesis. It is found that the local and cloud voice synthesis effects are very good, but the voice synthesis composed of iFLYTEK and voice synthesis plays better and tests the semantic understanding of iFLYTEK in the system and those within the selected development skills can correctly answer questions. Secondly, according to the test results, a hybrid speech interaction system is built, and the hybrid speech recognition with a network and the local speech recognition without a network are tested. It is found that the speech recognition rate has been improved.

In the future, it can be considered to develop more robust and effective techniques using more sophisticated deep learning techniques including deep neural network (DNN), convolutional neural network (CNN), and graph convolutional network (GCN). Further integration of the attention mechanism to improve the algorithm performance in terms of training and prediction duration using emerging edge and cloud computing technologies is recommended. To increase predction accuracy, appropriate aggregation techniques are suggested to reduce the amount of collected data by removing redundant data.

Data Availability

The corresponding author can provide the datasets used and analyzed during the current study upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interests.

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Research Article

Machine Learning Based Preschool Education Quality Assessment System

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Preschool education (PE) is the initial stage of life education, and early childhood is an unrepeatable process. PE has the same importance as other education stages because of the significant impact it can have on later childhood development. Furthermore, from the perspective of educational equity theory, every child has the right to receive PE, the right to obtain the same high-quality educational resources, and the right to fair final results. Therefore, the research on the quality of PE has theoretical value and practical significance. In order to strengthen the quality of PE, this paper designs a PE quality assessment system to evaluate teachers' teaching achievements. In this regard, the performance of each functional module in the system is tested, and the test results show that the module access is successful at more than 97%, indicating that the system meets the operating requirements. This paper uses the characteristics of the KNN algorithm classification in the machine learning algorithm to classify the teaching quality (TQ) of 7 pre-school teachers, and obtains the membership degrees of teachers in the four categories of grades, indicating that the KNN algorithm is more suitable for the classification of TQ assessment results than the general classification algorithm.

1. Introduction

With the increasing demand for high-quality talents in the market, the importance of talents is constantly being valued, and education is one of the important ways to cultivate talents, so it is very important to develop the potential of young talents. The most important function of education is to promote individual development, including individual socialization and individuation. The social function of education is to train talents for the development of the country and serve the political and economic development of the country. Preschool education provides the future workforce with a solid foundation of knowledge and skills and can develop the skills they need in an increasingly competitive market. The economic functions of emphasizing education in modern society mainly include providing a good background for the sustainable and stable development of the economy; improving the potential labor ability of the educated; and forming concepts, attitudes, and ways of behavior that adapt to modern economic life.

With the increasing importance of PE, it is hoped that more and more scholars will devote themselves to the theoretical and practical research of the PE quality assessment system. A large number of studies at home and abroad have shown that the quality of PE has an important impact on the learning and development of children throughout their lives. The essential characteristic of sports is to develop the body, strengthen the physique, promote the all-round development of people, and serve social development by means of physical exercises. The process of social development is subject to certain political and economic constraints and serves certain political and economic purposes. Developed countries are at the forefront of the world in terms of society and economy, but their education quality has always been a concern for people from all walks of life [1]. Some foreign PE institutions usually publish education quality assessment reports on their websites, and some states have specially designed relevant logos for PE institutions to use. The transformation of human nature through sports is not only the unity of physical structure and physiological

function but also the unity of body and mind. Physical education teaching should pay attention to students' invisible psychological development while pursuing students' physical transformation. On the one hand, more institutions are encouraged to participate in the evaluation system, and on the other hand, it expands the influence of the quality rating system so that parents are more fully aware of the importance of high-quality PE to their children's physical and mental development, and meet families' needs for high-quality PE institutions. After the evaluation is officially completed, all data will be notified to the participating institutions in the form of emails and letters. The public can download PE evaluation reports and other materials from their websites and can also obtain free TQ information and institutions of different PE institutions and to understand the degree of normalization of the relevant institutions[2, 3]. The characteristics of the sports industry include high spatial dependence, obvious time consumption, high consumption level, and high service quality. However, the research on the construction of the PE quality evaluation index system in my country is in the development stage. Most scholars in the field of PE focus their research perspective on the education price system itself, and there are few theories on the setting and selection of various factors in the PE evaluation system [4, 5]. From this point of view, both foreign and domestic attention is paid to the TQ of PE, which has laid a good foundation for the future training of talents. In a broad sense, sports culture refers to a culture with independent significance and value recognized by society by processing, organizing, and ordering physical activities that meet human needs through the body in order to enrich human life and meet the needs of survival. It includes spiritual culture and behavioral culture.

This paper first analyzes the evaluation goal of the evaluation system, which is also the main purpose of evaluation that is to promote child development, early childhood professional development, and family education development; then proposes the KNN algorithm, which can be used to classify teachers' TQ; and then designs PE. The functional modules of the quality evaluation system and the evaluation standard guarantee system; finally, the system functions are tested, the implementation method of the system login module is analyzed, and the evaluation and classification results of the KNN algorithm on the quality of PE are analyzed.

2. Evaluation Purpose and Introduction to KNN Algorithm

2.1. Evaluation Objectives of the PE Quality Evaluation System

2.1.1. Child Development Goals. PE has a certain influence on children's emotional cognition and other aspects, and these factors have a relatively obvious effect on children after entering school for three years. Children's academic achievement is also one of the children's goals, and many preschools hope to give every child the same opportunity to achieve academic success. Its long-term goal is to hope that young children can give full play to their potential, achieve success in life, and become useful social citizens [6, 7]. The system has the functions of statistics, analysis, retrieval according to various requirements, and regular announcements to society. The system provides online inquiry and online evaluation services for students and their parents provides personalized physical health diagnoses for students and enables students to exercise on the basis of accurately understanding their physical health.

2.1.2. Professional Development Goals of Kindergarten Teachers. The quality standards of PE include the professional development of teachers, the most common ones are teacher training, continuing education, professional development plans, career planning, etc. Early childhood education schools should improve the professional development of preschool teachers by providing scholarships, career development consultants, etc. [8]. The theory of continuing education comes from practice, and its ultimate purpose is to guide practice. It is in this process of two-way interaction that continuing education workers, on the basis of constantly summing up practical experience, constantly absorb excellent research results of relevant disciplines, and strive to build a scientific theoretical system serving practice.

2.1.3. Guiding Goals of Family Education. As an important place for children to grow, the family plays an important role in PE. The PE quality assessment system also puts forward corresponding goals [9]. First and foremost, we hope to enhance parents' understanding and demand for high-quality PE, improve their ability to identify high-quality kindergartens and provide families with a simple tool to choose the best kindergarten for their children. Secondly, parents hope to balance family and work through the TQ evaluation system, which not only emphasizes the importance of family participation in PE but also hopes that PE can reduce the burden on parents in real life [10, 11]. As parents, through their children's every move, word, and deed, they can timely grasp their psychological state at this moment, find problems in their children, timely educate them, correct them in time, and do not let them stay overnight so that bad behavior habits can be nipped in the bud.

Family education and kindergarten education cooperation are part of the content of PE quality assessment. In the assessment, it is necessary to understand the family background, family cultural traditions and customs, family structure, and other aspects of family life and parental needs related to children. Maintain frequent communication and exchanges (e.g., provide opportunities to communicate with parents, and listen to parents' needs). This can not only improve the parenting skills of parents, make parents more involved in PE but also increase parents' trust and respect for PE institutions and also help parents balance family and work [12, 13]. Through the PE quality evaluation and improvement system and its released data, families understand the education that children receive in PE institutions and choose the most suitable educational institution for their own development. At the same time, this also indirectly promotes the continuous improvement of PE institutions. The quality of its education will also be sustainable

development [14]. Educational principles include the principles of equality, respect, exchange, freedom, unity, example, trust, and tolerance.

2.2. Machine Learning Related Algorithms—KNN. The K-nearest neighbors algorithm (KNN) classifies the dataset samples according to the vector space model. The principle is that the dataset samples of the same category will have a high degree of similarity [15]. Therefore, the possible classification of the dataset samples can be predicted according to the similarity between the dataset samples that need to be classified and the dataset samples whose categories are already known [16]. In view of the classification function of the KNN algorithm, this paper uses the KNN algorithm to classify teachers' TQ results in the PE quality assessment system. The construction and implementation of the classifier generally include selecting samples and dividing all samples into two parts: training samples and test samples; executing a classifier algorithm on a training sample to generate a classification model; executing a classification model on a test sample to generate a prediction result; and evaluate the performance of the classification model.

The K-nearest neighbors algorithm is a machine learning algorithm that can be used for both classification and regression and both forms require increasing neighbor weights [17]. KNN method only determines the category of the samples to be classified according to the category of the nearest one or several samples in the classification decision-making. A common way to increase weights is to give each neighbor a weight of 1/n, where n is the distance between neighbors. The classifier does not need to use the training set for training, and the training time complexity is 0. The computational complexity of KNN classification is proportional to the number of documents in the training set, that is, if the total number of documents in the training set is n, the classification time complexity of KNN is O (n). When calculating the distance between objects in KNN, in order to avoid the matching problem between objects, Euclidean distance or Manhattan distance are generally used [18].

Euclidean distance is as follows:

$$d(x, y) = \sqrt{\sum_{k=1}^{n} (x_k - y_k)^2}. \quad (1)$$

Manhattan distance is as follows:

$$d(x, y) = \sum_{k=1}^{n} |x_k - y_k|. \quad (2)$$

Among them, x and y represent the object. The mathematical properties of Manhattan distance include non-negativity, identity, symmetry, and trigonometric inequality.

3. Design of PE Quality Assessment System

3.1. System Function Module Design. Figure 1 shows the four modules of the evaluation system, and their functions are described as follows:

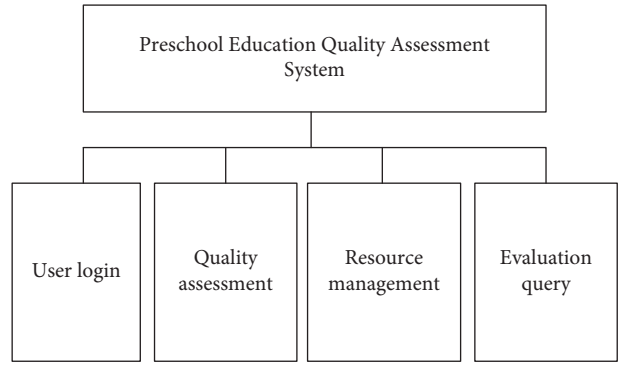

Figure 1: Modules of PE quality assessment system.

3.1.1. User Login Module. User login is the channel for the user to enter the evaluation system. Only by registering the user information can the user obtain the password and account number to log in to the system and then use the functions of the evaluation system. It can effectively distinguish whether the operator is a user or a nonuser of the program, which is conducive to protecting the rights and interests of both parties.

3.1.2. Quality Assessment Module. The quality evaluation module is an evaluation paper that the administrator inputs into the system according to the evaluation indicators and corresponding weights formulated by experts and generates corresponding evaluation indicators and imports information such as the teaching situation and teaching evaluation situation of PE.

3.1.3. Resource Management Module. The main purpose of this module is to manage the basic information of students, teachers, and classes. Perform basic operations such as deleting, adding, and updating the basic information of each object.

3.1.4. Evaluation Query Module. According to different situations of each semester, users with different roles will evaluate the corresponding teachers, and the evaluation result query function includes querying the teaching evaluation results of the corresponding course teachers by course. Teachers not only need to conduct self-assessment on their own TQ but also objectively assess the TQ of other teachers and conduct statistical inquiries on the assessment results so that the teaching assessment results can be fed back to the entire teaching process in a timely manner. Teachers can also check students' opinions and suggestions on teaching so as to change teaching methods in time and use different teaching methods for different teaching objects to improve TQ and improve teaching effect.

3.2. Establishment of a Guarantee System for the Implementation of PE Quality Standards. As an important means of TQ monitoring, TQ assessment has also received more and more attention. Moreover, the Ministry of Education

has also made it clear that it should seize the time to improve the TQ assessment system as soon as possible and strive to revise the assessment indicators to improve the TQ. Moreover, there must be plans and objectives to check the TQ evaluation work and increase the guidance on the TQ evaluation. Learning from the historical experience of PE in developed countries is carried out in order to improve the level of PE. So, the prerequisite must first be to establish a sound education quality assurance system to ensure the sustainable and stable development of PE and the teaching staff and other aspects to strengthen the protection. The factors affecting the quality of education include the rationality of the education system, teaching plan, teaching content, teaching method, teaching organization form, and teaching process; the quality of teachers, the foundation of students, and the enthusiasm of teachers and students to participate in educational activities.

(1) Institutional construction: clarify the important status of PE, lower the entry threshold and encourage social forces to actively participate in the field of PE; coordinate financial institutions to provide corresponding preferential conditions for the establishment of private colleges and universities to solve the problem of financial difficulties in running schools; in view of the improvement of national strength, consider whether PE can be included in the scope of compulsory education to implement full or periodic free tuition.

(2) Financial investment: the government's investment in the field of education has not reached the expected target. In terms of investment direction, most of the education funds flow to the higher education stage, and the amount obtained from preschool education at the lowest level of education is relatively small. Institutions should find an optimal balance in the funding of public colleges and nonprofit private PE institutions and bring private kindergartens and public kindergartens into a unified management system. According to the different nature of the investment object, the financial investment includes free financial allocation that neither collects interest nor recovers the principal; financial loans that both receive interest (generally low interest) and recover the principal; financial investment is an investment that forms national capital and receives capital gains.

(3) Guarantee the quality of teachers: the entry-level of kindergarten teachers is relatively low, the requirements for teacher quality are not high, and there are not too many restrictions on the academic qualifications of teachers. Most teachers do not have professional teaching qualifications. If the level of teachers' qualifications cannot be guaranteed, it is simply empty talk to improve the quality of PE. For this reason, teachers who do not have the qualifications must be sacked or on-the-job training wait for them to meet the requirements for re-employment; substitute teachers are required to participate in teaching skills training on a regular and irregular basis, and teachers and staff are encouraged to actively participate in industry competitions. Improve teachers' teaching ability; in economically poor areas, teachers' salaries and social security benefits should be improved to avoid excessively high job turnover and turnover rates in the teaching team. Teachers can be rotated between different economic development areas to improve the teaching ability of teachers in backward areas.

(4) Establish a scientific PE supervision system: in order to prevent the occurrence of the phenomenon of teaching supervision being a mere formality, it is first necessary to strengthen the sense of responsibility of government staff, clarify the responsibility and authority of teaching evaluation staff, and strictly implement the accountability of asking questions at the end. The second is to formulate a set of work standard procedures that conform to the laws of teaching supervision and standardize the behaviors of executors.

4. Evaluation System Application Analysis

4.1. System Test

4.1.1. Module Test. In the process of accessing the success rate test of the PE TQ evaluation system, this paper conducts key tests on the system management, resource management, quality evaluation, and evaluation query modules in the system. A total of 180 test cases are designed, of which 176 are tested. The results meet the requirements of the system, 4 results do not meet the requirements, and the success rate reaches more than 97%. The test results show that the system has no major defects, operates normally, and has stable performance, which meets the system requirements for PE TQ evaluation. The test results are listed in Table 1.

4.1.2. Performance Test. As shown in Table 2 and Figure 2, the response time test results of the system web page under the condition that the number of users online at the same time are different through the telephone dial-up network, broadband, and optical network test system, and the system load test results under different user numbers. According to the experimental results, it can be seen that with the increase in the number of users online, the response time of the web page will increase under the three network usage conditions. When using the telephone dial-up network test, the response time of the web page is relatively long. When using the broadband and optical fiber network, the connection speed is not bad, indicating that the system is suitable for the application in broadband Internet access or the optical fiber network environment. When using the fiber optic network, the response speed of the web page is the fastest, and the increase in users has little effect on the response time. Under different numbers of users, the load test of the system in this paper is normal. The concurrent performance test and load

Table 1: System module test results.

Module	Testing frequency	Number of successes	Number of failures	Success rate (%)
User login	20	20	0	100
Quality assessment	65	63	2	96.92
Resource management	45	44	1	97.78
Evaluation query	50	49	1	98

Table 2: System response time (s) when users are concurrent.

Number of simultaneous online users	Phone dial	Broadband	Optical fiber	Is the system normal
50	9.6	1.8	1.4	Normal
100	11.3	2.2	1.5	Normal
200	17.8	2.9	1.9	Normal
400	28.2	3.7	2.4	Normal
550	31.5	3.9	2.8	Normal

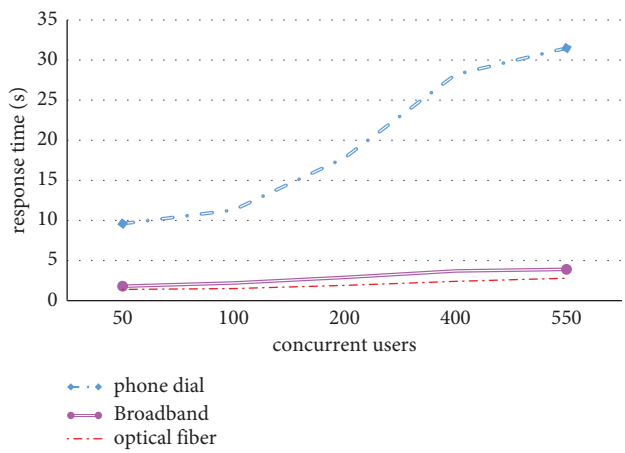

Figure 2: Concurrency test results.

test show that the system has good performance and can meet the evaluation requirements of the system for PE TQ.

4.2. User Login Function and its Security Implementation. In this system because the user login and logout functions are considered at the same time, the user login function is more complicated. It is implemented by the page UserLoginPage.aspx, the user control UserLogin.ascx and the user control UserLoginInfo.ascx. UserLoginPage.aspx.cs, UserLogin.ascx.cs, and UserLoginInfo.ascx.cs are their code-behind files, respectively. These pages and user controls are saved in the folder "UserControl".

Unauthorized users do not have access qualifications during the operation cycle of the system, which is the first security that the system must have. This security can be achieved by using Session detection. The specific implementation method is to first set the Session in the user login module and then detect the Session in the subsequent pages. Due to another security requirement, authorized users cannot operate beyond their authority and also need to use the Session detection function. Therefore, restricting the access of unauthorized users can be implemented in the process of preventing authorized users from the unauthorized operation. Authorized users cannot perform unauthorized operations. This requires different treatments in the Session detection of the page. The specific implementation is as follows:

First, add the setting part of the Session to the user identification function module. As long as the currently logged-in user has passed the user identification, a data segment of user type is added to the Session, and the user type of the currently logged-in user is assigned to this data segment. The next step is to test each function page. Since each ASP.NET page has a response function page_load() when it is loaded, the Session content can be detected in this function. If the detection fails, the page that is about to be opened will be closed immediately. As for preventing unauthorized users from unauthorized operations, since each functional page is for one type of user when the currently logged-in user tries to access a functional page that does not match his user type, the session detection of the functional page will also show failed and end, which also satisfies the security need to prevent authorized users from operating beyond their authority.

4.3. Statistics of Teaching Evaluation Results. It is an opportunity for kindergartens to make progress when the district/county PE administrative and business management departments go to preschool institutions for guidance. Figure 3 shows the results of the kindergarten teaching supervision survey. It can be seen from the table that about 15% of the kindergartens have not been supervised by the higher-level leading department once a year, and about 37% of the kindergartens have received guidance 2–3 times a year, about 22% of kindergartens get 4–5 times of guidance, and about 13% of kindergartens get supervised more than 6 times a year, and there is not much difference in administrative areas.

Educational evaluation is the main way to improve the quality of kindergarten education and for teachers to improve their educational work. The evaluation times and evaluation methods accepted by kindergartens are directly or indirectly related to the accuracy of evaluation results. As shown in Table 3, it is the proportion of each evaluation subject for preschool TQ evaluation. It can be seen from the

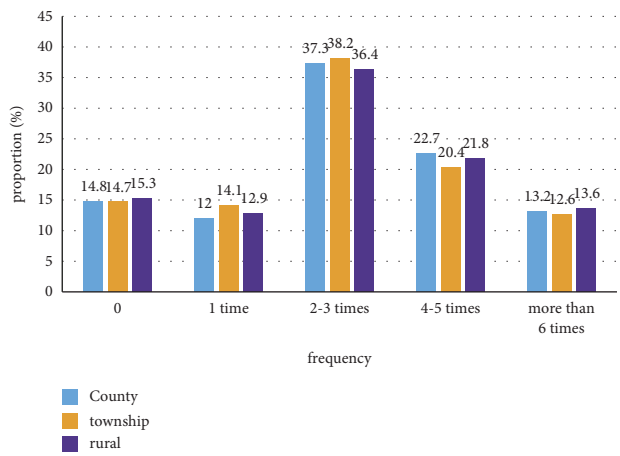

Figure 3: Survey results of kindergarten teaching supervision.

Table 3: Evaluation subjects and evaluation methods of kindergarten teachers.

Evaluation subject	Kindergarten principal	Teacher	Parents	Other
Proportion (%)	38.6	35.4	21.3	4.7
Evaluation method	Other people's evaluation	Mutual evaluation	Self-evaluation	Other
Proportion (%)	10.9	43.2	37.5	8.4

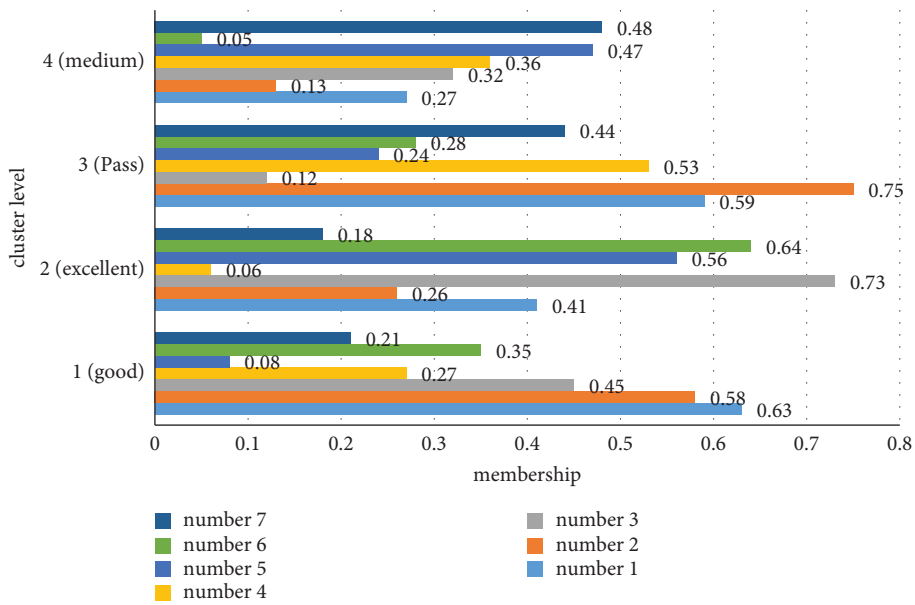

Figure 4: KNN classification result.

table that in terms of PE quality teaching evaluation, it is mainly based on external teaching supervision. Teachers' evaluations accounted for 38.6%, which is still the dominant position and parents' evaluations of teachers accounted for 21.3%. When interviewing parents about the number of times teachers actively contacted themselves each semester, many parents said that kindergarten teachers contacted them almost every semester 3–4 times, it can be clearly seen from this that teachers lack communication with parents, and parents' lack of teaching supervision is also one of the reasons that affect the quality of PE. In terms of evaluation methods, teachers' mutual evaluation and self-evaluation dominate, accounting for 43.2% and 37.5%, respectively. There are many objective factors in mutual evaluation and self-evaluation between teachers, which will affect the evaluation results. The final evaluation results of preschool TQ also have a great impact.

4.4. Evaluation Results Based on KNN. Using KNN classification, the TQ of 7 preschool teachers (numbered 1–7) was scored, and the calculation results shown in Figure 4 are

obtained. Combined with the analysis of the scores of the fuzzy comprehensive evaluation method, the scores can be divided into four categories, which are considered to be good, excellent, pass, and medium and correspond to category 1, category 2, category 3, and category 4, respectively. Taking the class with the largest membership degree of each object as its final classification, the same classification result as the system classification method can be obtained. However, the KNN classification provides more information than the system classification. For example, the maximum value of teachers No. 3, 5, and 6 is in the second category, but the membership degree of teacher No. 3 is 0.73, while that of teacher No. 4 is 0.73. The degree of membership is only 0.56. This shows that KNN classification is more scientific and reasonable than the general classification algorithm in the classification of TQ evaluation results.

5. Conclusion

With the dissemination and development of the thought of lifelong education worldwide, early childhood education is becoming more and more important. In the context of the expansion of the democratization of PE, more and more children are entering early childhood education institutions for education, which has promoted the development of education to a certain extent, but at the same time, all sectors of society have begun to pay attention to the quality of education. Because of this, the TQ evaluation system has become a new way to ensure and improve the quality of PE. Teachers, principals, and parents can log in to the system to evaluate the TQ of teachers, and the system will generate an evaluation report. From the rating, you can know how good the TQ of teachers is. Aiming at the system designed in this paper, the module access test and concurrent performance test verify that the system function has a high success rate of access, and it can better meet the concurrent use of users in the broadband network or optical fiber network environment.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Authors' Contributions

The author read and approved the manuscript for submission.

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Research Article

Using Green IoT as a Development Path of Green Trade Economy for Ecological Sustainable Development

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The advancement of the Internet of Things (IoT) technology and its incorporation into the trade economy has altered and improved our way of life and work. However, IoT technologies pose various issues in the green economy, including increased energy consumption, hazardous pollutants, and electronic waste. Therefore, green IoT contributes to a more environmentally friendly atmosphere that is more affordable for the green economy. As a result, it is critical to address tactics and strategies for decreasing pollution threats, traffic waste, resource utilization, energy usage, public safety, living standard, environmental sustainability, and cost management. Apart from these, the continual deepening of the trade economy has accelerated Shandong Province's rapid economic development, and the province's broad economic development mode had major negative consequences on the ecological environment. Based on the evolution of international commerce in Shandong Province and the present status of the ecological environment, this study first calculates the province's carbon emissions using the Kaya identity and derives the regression findings using the Eviews software. It examines the data link between the province's carbon emissions, energy consumption, and trade by determining the province's export carbon emissions from various industrial sectors. According to the statistics, the export carbon emissions of Shandong Province's ferrous metal rolling industry, chemical raw material production sector, and textile industry are relatively high, at 6.764 million tons, 5.502 million tons, and 3.918 million tons, respectively. The carbon emissions from the three industrial sectors mentioned above account for approximately 49% of total carbon emissions, which is a considerable reduction and in line with the concept of green IoT.

1. Introduction

The fast development and use of Information and Communication Technology are having a direct and significant influence on many parts of life, converting it from an "industrialized" civilization to a global "knowledge" society. New ICT technologies, notably the Internet of Things (IoT), are altering how individuals manage their lives, engage with one another, and participate in numerous societal domains. The Internet of Things, as a global network, involves four basic physical objects. In all, it drastically reshapes and alters the lives of individuals, companies, and society by linking individuals and things whenever, with anything and anyone, anyhow, and everywhere. As a result of the internet, mobile computing, and the Internet of Things, people, places, organizations, and infrastructure are now interconnected in unparalleled ways. Despite the enormous benefits of technological advancement and the "smartness" provided by IoT to various parts of society, their fast rise promotes greater waste, emissions of greenhouse gases, and the use of nonrenewable and natural raw materials. The resource-intensive production and distribution of ICT items and systems enhanced energy requirements throughout their use, and increasing volumes of diversified waste has the potential to hurt human health and the surroundings [1]. Thus, it poses major challenges to sustainable growth and a sustainable way of life.

As we know, several elements impact a building's energy usage, including climatic region differences, proposed methodology, construction techniques, construction material, property, and power management. The computation of carbon emissions is quite complicated. At the moment, a study on carbon emissions from structures has yielded some results based on life cycle analysis [2]. The LCA approach is

primarily used to calculate a product's carbon emissions across its entire life cycle, encompassing raw materials, manufacture, usage, and destruction. We first define the boundaries of the research model, then quantify the resource consumption and carbon emissions, and lastly assess the environmental implications. The measuring method, process analysis technique [3], input-output analysis techniques [4], and hybrid approach [5] are the primary extant fundamental methodologies for quantifying carbon emissions. The hybrid approach is classified into three types depending on its composing constructions: tiered hybrid evaluation, input output-based hybrid assessment, and comprehensive hybrid assessment [6]. The hybrid analysis includes the advantages of both approaches and has recently become popular in carbon emission measurement [7]. Some researchers use basic data from the international panel on climate change to calculate total carbon dioxide emissions, however, the outcomes can only represent the entire carbon dioxide emissions of building projects, which cannot be divided into direct and indirect emissions. Carbon emissions vary throughout a building's life cycle, particularly during the embodied phase, when a high quantity of materials, construction equipment, and equipment are utilized, and diesel, petrol, electricity, as well as other sources of energy are consumed. According to research, construction materials have large carbon emissions, with indirect carbon emissions accounting for more than 92 percent [8]. The author of [9] created a hierarchical LCA system to quantify the energy consumption and environmental effect of the building sector in the United States. The IO-LCA calculates the environmental effect of the materials, and the process analysis approach is utilized to assess the environmental impact of the building phase. Nevertheless, because of the complexity of calculating carbon dioxide emissions during the integrated phase of construction, it has not been the focus of the current building carbon emissions research [10]. Carbon dioxide emissions from the building life cycle are significant in the embodied phase, accounting for about 20% [11], and some studies indicate that they can reach 40% to 45% [12]. As a result, during the embodied phase, carbon emissions have a significant influence on building carbon trading. In addition, IoT plays an important part in the growth of the green trade economy, affecting several ways through its different applications in improving community transformation. It reduces congestion, develops cost-effective municipal services, preserves people's safety and health, lowers energy usage, improves monitoring systems, and lowers pollution. However, academics have focused on IoT ecological challenges, including energy utilization, carbon emissions, energy savings, trade, carbon classification, and footprint. As a result, IoT-based carbon emission reduction and energy-saving solutions are summarized. The paper examines IoT technologies that enable real-time intelligent awareness of the environment and produce and gather energy usage throughout the production life cycle.

There are many kinds of international trade protectionism, among which green trade barriers are one. The low-carbon economy has become a basic direction of economic development in all countries and regions in the world, especially in China. It requires China to build an intensive environmental protection low-carbon foreign trade growth mode at present to replace the traditional extensive foreign trade growth mode and improve the sustainability of China's economic development [13, 14]. In the process of discussing environmental issues, the blueprint for the green economy (1989) first proposed the concept of "green economy," which is an innovative new concept. In essence, it is an economic model corresponding to the black economy [15]. The limit of growth was born in the early 1970s. This analysis report comprehensively expounds on the negative effects of environmental pollution, resource poverty, population explosion, and other negative effects caused by the one-sided pursuit of economic development. It has started and gradually triggered thinking on the direction of human development, directly impacting the traditional ideas that economic growth is equal to economic development and human conquest of nature [16, 17]. The focus of the analysis of the relationship between economic growth and resources and the environment includes two aspects. Firstly, taking the scarcity of nonrenewable resources as the starting point to analyze how resource depletion restricts the long-term economic growth rate. Secondly, focusing on the negative external effects of pollution, this paper analyzes the basic way that pollution emissions indirectly affect human long-term economic growth rate and consumption decision-making mode on the premise of the utility function and production function interference [18, 19].

The innovations of this paper are as follows: (1) this study performs an empirical analysis of the impact of green barriers on the sustainable development of China's trade in terms of green IoT. Based on the collected materials and data, this paper will explain the impact of green barriers on the sustainable development of trade from the positive and negative effects of green barriers on the quantity, amount, international competitiveness, and structure of export commodities. (2) This study explores the data relationship between the province's carbon emissions, energy consumption, and trade by utilizing Kaya identity to compute the province's carbon emissions and then obtaining the regression results with Eviews software. (3) Finally, it computes the province's export carbon emissions from various industrial sectors.

The structure of the remaining sections in the paper is organized as follows: Section 2 of the paper highlights the contributions of other researchers, scholars, and experts. Section 3 is based on the selected material and suggested methodology of ecologically sustainable development. The design of the carbon emission measurement method for ecological green trade is presented in Section 4. The analysis of the calculation results of total carbon emissions in Shandong Province can be presented in Section 5, and the work of this paper is concluded in the last section, i.e., Section 6 of the paper.

2. Related Work

The concept of green development has been formed and continuously spread. The exploration of the green

development path, evaluation of green economic growth, and related theories are the focus of theoretical exploration in this field [20]. Because of the difference between the main body of green trade barriers and the degree of change, according to the gradient of its change, green trade barriers have three basic structures that are gradually progressive and change according to the gradient. To protect the ecological environment and safeguard the common interests of mankind, the international community has formulated a series of conventions, agreements, and management standards for the protection of the ecological environment since the late nineteenth century, which can be specifically divided into two categories. The first one includes some international multilateral agreements, conventions, and technical standards for the protection of the ecological environment. The purpose of formulating these public multilateral agreements and conventions is to protect the ecological environment together, there is no intention to set up technical trade barriers. The first one includes the international standards of environmental management and relevant international rules, which are aimed at the sustainable development of human beings or the protection of the life and health of human beings, animals, and plants from infringement. The formulation of these agreements, conventions, standards, and rules is dominated by developed countries, and there is often a certain range of flexible changes. Chinese scholars also analyzed the concept of green development from various angles. The path and connotation of green development are the focus of Chinese academia [21]. Research shows that the bottleneck of China's economic development has become increasingly prominent. To break this situation and ensure the sustainable development of China's economy, we must adhere to the road of green development (high efficiency, low pollution, and low-energy consumption) and pay attention to the coordinated development of environmental protection and economy [22]. Based on the perspective of "five constructions," this paper analyzes and expounds on the concept of green development and points out that the essence of green development lies in harmonious development, upward development, inclusive development, sustainable development, high-level development, and innovation-driven development [23]. In the subject of exploring the path of green development, the analysis sample selected by scholars is Anji, Zhejiang Province. They believe that it is necessary to develop a green economy with ecological civilization as the goal under the premise of combining guidance and mobilization (value level), collaborative governance of an innovative environment, and an economic operation system [24]. The green trade barrier is the product of the conflict between the environment, trade, and ecological environment. Low energy consumption efficiency, fast growth, and large total amount are the basic forms of foreign trade growth in Shandong Province [25]. From the perspective of environmental protection, the road of foreign trade with high pollution and high energy consumption in the province must be terminated, and the development mode of foreign trade must be changed, which is the basic requirement of sustainable and healthy development. Inspired from the work of above scholars, this paper first calculates the province's carbon emissions using the Kaya identity, and then, it derives the regression findings using the Eviews software. In addition, it examines the data link between the province's carbon emissions, energy consumption, and trade by determining the province's export carbon emissions from various industrial sectors.

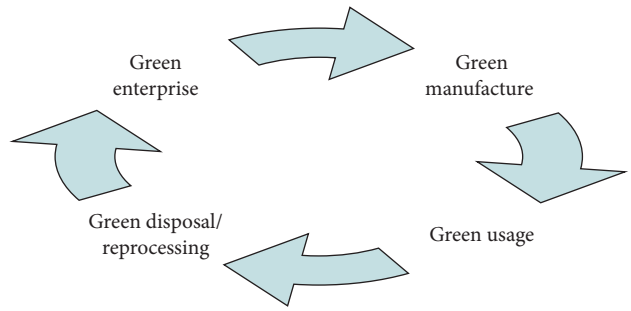

Figure 1: Life cycle of green Internet of Things.

3. Material and Methods

3.1. Material

3.1.1. Green ICT for Ecological Sustainable Development. Consumers can obtain, access, store, and manage information using green information and communications technologies (ICT) [13]. They perform an important part in greening IoT and bringing several advantages to the public, such as reducing the amount of energy consumed in developing, producing, and delivering ICT facilities and gadgets. They are fascinating, however, they have only been used in a few cases and are restricted manners. Furthermore, ICT technologies have an important role in lowering CO_2 and the consumption of energy in green IoT systems in green infrastructures, such as intelligent transportation, intelligent buildings, and parking management [26]. In this regard, the authors of [27] discussed green ICT and green IoT, which rely on a green power grid, and presented and discussed green calculating skills.

Greening IoT entails discovering novel resources, utilizing ecological maintenance, reducing the utilization of existing resources and expenses, and reducing the negative effects of IoT on the environment and human health, such as CO_2 emissions, NO_2, and other pollutants [28]. The writers of [29] presented information on how industrial emissions affect the environment through time. To make the environment healthier, Internet of Things' energy usage must be reduced [30]. Likewise, greening ICT technologies aid in ecological protection and financial development [31], and as a result, new IoT technologies have made the world greener and smarter.

3.1.2. Introduction of the Green Internet of Things. Green IoT is a low-energy method, which includes connecting devices in an energy-efficient procedure to decrease energy usage, greenhouse effects, and emissions of carbon dioxide. Green computes units, interoperability, and network-based designs with optimum bandwidth utilization and relatively

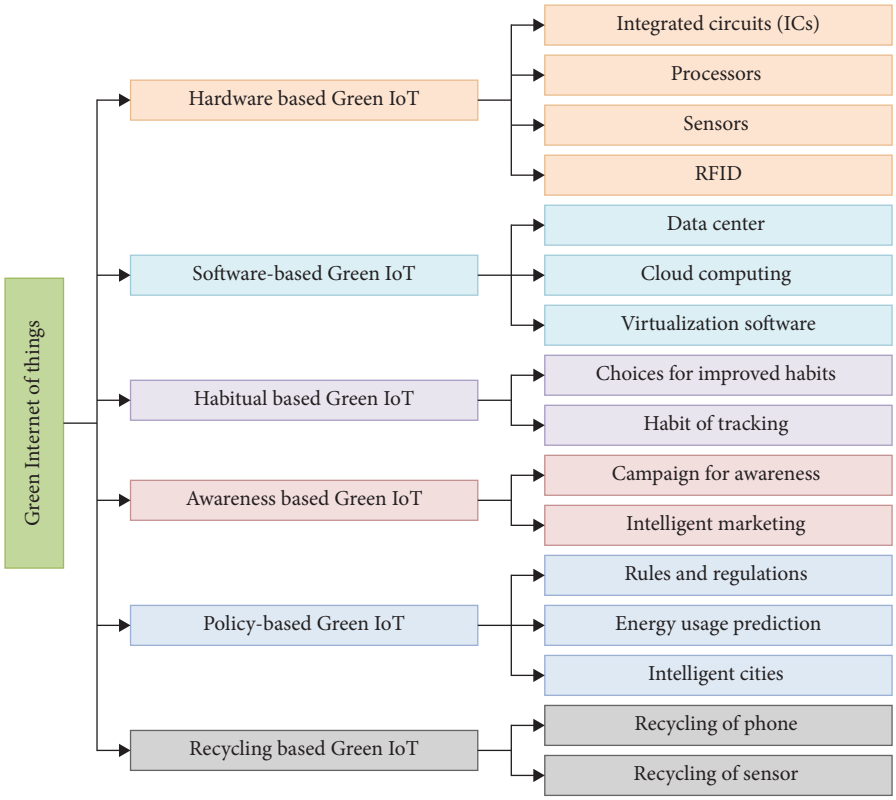

Figure 2: Organization of Green IoT skill.

minimal energy consumption. Ecological development and energy efficiency are the critical components of Green IoT. Green IoT products must pass through a closed loop that includes green design, green manufacturing, green use, and green disposal/reprocessing. Figure 1 explains the life cycle of green IoT.

(i) Green enterprise: green enterprise is the creation of energy-efficient cooling equipment, servers, computers, and components.

(ii) Green manufacturing involves the production of computers, electronic components, and other related subsystems.

(iii) Green usage: using computers and other information systems with as little electricity as possible.

(iv) Green disposal/reprocessing: it involves recycling computers and other electronic devices that are no longer in use.

The organization of Green IoT skill is shown in Figure 2.

(i) Hardware-based green IoT: the architecture of integrated circuits (ICs) is crucial for conserving energy in IoT infrastructure. Green IoT improves the IoT network design by combining sensors and computing power on a single chip to reduce infrastructure investment energy usage, carbon emissions, traffic, and e-waste. CPU-based low-energy processor that may be divided into two cores. One core is dedicated to low-computing operations, while the other is dedicated to high-computing duties. To decrease energy use, use the scheduling system to allocate jobs. The incorporation of detecting and wireless transmission has led to the creation of sensor networks. WSN is composed of a large variety of static sensor nodes that interact over short-range wireless connections and have limited processing, energy, and storage capability. Numerous inbuilt sensors on the sensor nodes may gather information from the surroundings. WSN applications help the environment by increasing resource effectiveness and lowering emissions of greenhouse gases. RFID is one of the potential green IoT wireless solutions, composed of a collection of RFID tags and a limited number of RFID tag receivers. An RFID tag is a small microchip that is linked to a radio. RFID tags have a distinct identity and may retain data about the objects to that they are connected. RFID readers initiate the information flow by sending a request signal, and the neighboring RFID tags respond. RFID tags can be passive or active, with passive tags lacking built-in batteries and relying on the notion of induction to receive energy from the prior authorization. Active tags, on the other hand, feature a battery that powers the transmitted signal and enhances the range. RFID is widely employed in applications that help to promote a better environment among many other things, increasing waste disposal, decreasing energy usage in buildings, and cutting automobile emissions.

(ii) Software-based green IoT: data centers can be key components of a power IoT network, but they need to be made highly energy-efficient for IoT to be practical. The green data center (GDC) serves as a central location for data distribution, administration, and storage. This data is created by objects, systems, users, and so on. The smartly chosen servers then send the processed information back to the client devices. Unfortunately, this approach needs the deployment of OA on every client device, in addition to the use of backup servers to provide reliability, which may lead to significant energy usage. As a consequence, to increase energy efficiency, it must feature a context-aware sensing platform that leverages choice sensing. Cloud computing is a virtualization approach that uses the internet. It offers limitless storage, processing power, and service delivery across the internet. IoT is widely used, and CC technology is widely used to link them. The primary purpose of GCC is to encourage the use of ecologically friendly materials that can be readily recycled and reused. It is possible to do this with paperless virtualization, proper power management, and allocation of resources for product lifespan. Centrally regulated data replication is essential in cloud computing to provide users with a high degree of service and reliability, however, it uses a significant amount of energy and bandwidth. A solution to reduce transmission delay is required, which might be accomplished by replicating data nearer to the consumers on cloud services. Virtualization can reduce the amount of hardware resources utilized in design, thus minimizing energy consumption.

(iii) Habitual-based green IoT: it is a small-scale metric, however, if the entire world changes to this way, it would produce a massive scale. It is accomplished by changing basic habits in our everyday life to minimize CO_2 emissions. It might be at home, office, or somewhere else.

(iv) Awareness-based green IoT: raising awareness programs are an important aspect of reducing energy use. Smart metering technology may be used to deliver real-time feedback to consumers on their power use from different sources in their buildings, workplaces, and residences. Using real-time data, green IoT may then advise clients on how to manage and reduce their energy consumption.

(v) Policy-based green IoT: policies based on available data from IoT devices have the potential to save energy on a huge scale. The process of defining rules for energy conservation includes numerous stages, involving mechanization, user feedback, information management, and tracking.

(vi) Recycling-based green IoT: the utilization of recyclable materials in the manufacturing of equipment in an IoT network can help the network to be more environmentally friendly. Mobile phones are made from valuable natural resources, such as nonbiodegradable materials, plastics, and metal, and if not disposed properly after use, they can cause the greenhouse effect.

3.2. Regional Overview of Ecological Sustainable Development

3.2.1. Geographical Location Overview. Shandong Province is located in eastern China and is one of the top ten coastline provinces in China. Figure 3 depicts the region. The province has more than 20 natural coastline outer ports with excellent geographical settings. In recent years, the Shandong provincial party committee and administration have chosen a long-term approach, increasing support for overseas commerce. Essentially, it established a multilevel, all-around, highly export competitive, and reasonably structured economy. In addition, it established a trade pattern that laid the groundwork for the steady and rapid development of province's economy and increased the province's economic development driving force, which effectively promoted the province's economic and trade development.

3.3. Overview of Shandong Trade and Economic Development Research

3.3.1. Overview of Import and Export Trade in Shandong Province. After China's reform and opening up in the 1980s, the province quickly established its own economic development goal, i.e., to develop foreign trade in an all-round way [32]. Because of the clear goal and powerful measures, the comprehensive foreign trade development achieved remarkable results. In the first decade of reform and opening up, the total foreign trade volume of the province was only US $3.417 billion (equivalent to RMB), but by 2019, the total foreign trade volume of the province had increased to US 171.06 $billion, an increase of around 50 times. The specific development of import and export trade in Shandong Province in recent ten years is shown in Figure 4.

3.3.2. Analysis on the Current Situation of the Regional Pattern of Foreign Trade in Shandong Province. Shandong Province has taken the initiative to carry out comprehensive trade exchanges with all countries and regions around the world. Up to now, the intercontinental pattern of foreign trade (mainly the European Union, North America, and Asia, supplemented by Oceania, South America, Europe, and Africa) has taken shape [33]. Table 1 shows the foreign trade data of the province and all over the world. It can be seen that the key regions of the province's foreign trade are North America, Europe, and Asia. From the overall development of the province's foreign trade market, the trade volume of North America, Europe, and Asia account for about 75%. From the perspective of geographical and economic advantages, the Asian market is the first target of the province's foreign trade, with about

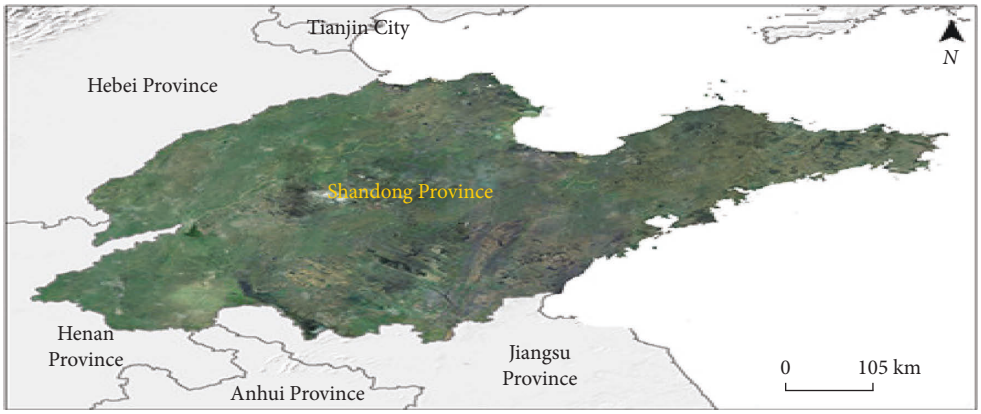

Figure 3: Schematic diagram of study area.

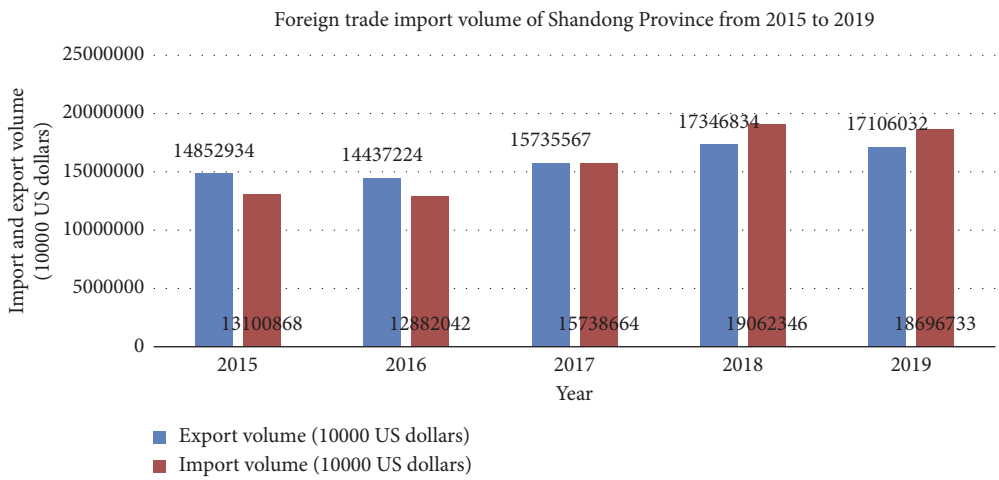

Figure 4: Change trend of import and export trade volume of Shandong Province from 2015 to 2019.

Table 1: Analysis on the regional development pattern of foreign trade in Shandong Province (proportion: %).

Region	2015	2016	2017	2018	2019
Asia	53.46	51.34	53.29	51.98	65.42
Africa	3.24	3.42	3.56	4.34	1.78
Europe	17.46	18.55	16.94	17.08	5.21
South America	4.52	5.79	7.06	6.25	19.9
North America	17.74	17.66	15.95	17.13	4.16
Oceania	3.58	3.24	3.2	3.22	5.53

51.34~65.42% of the foreign trade volume occurring in the Asian market. However, other regions outside Asia are also the key areas of long-term trade in the province, and the trade development ideas are conducive to the construction of multilevel and all-around trade relations.

3.4. Analysis of Ecological Environment in Shandong Province. The data of industrial waste gas emissions in Figure 1 below shows that the industrial waste gas emissions in Shandong Province have also increased from 3628.6 billion cubic meters in 2015 to 401.2 billion cubic meters in 2019. Industrial waste gas emissions are large. The data are shown in Figure 5. On the one hand, it significantly reduces the air quality of the province, and on the other hand, it leads to frequent haze weather in the province.

Like the development of industrial waste gas emission, industrial wastewater emission also shows an increasing trend year by year. Figure 6 shows the changes in industrial wastewater discharge in Shandong Province from 2015 to 2019. A large amount of industrial wastewater also significantly affects the natural environment, especially the water environment, and the water environment quality of nearby sea areas is significantly affected.

By analyzing the statistical data of the province (from the statistical information network), we can also see from Figure 7 that from 2015 to 2019, the province formed a discharge scale of 231.108 million tons of industrial solid

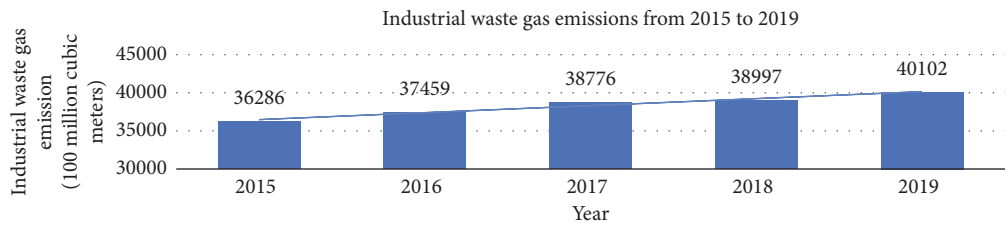

Figure 5: Industrial waste gas emissions in Shandong Province from 2015 to 2019.

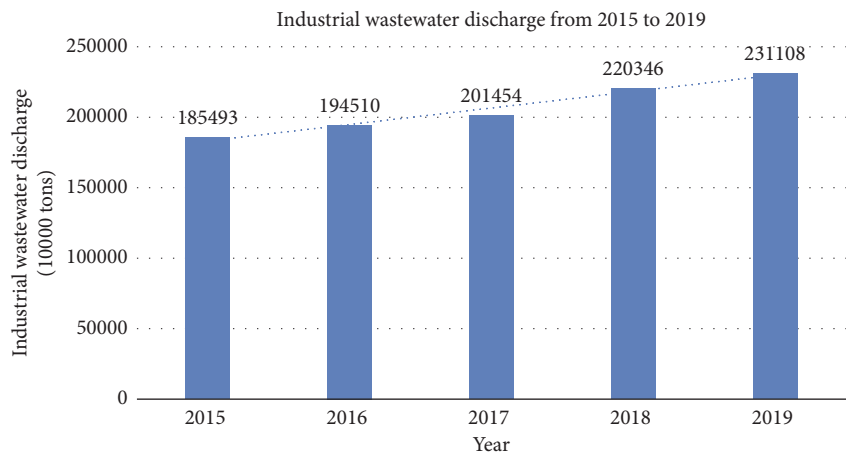

Figure 6: Changes in industrial wastewater discharge in Shandong Province from 2015 to 2019.

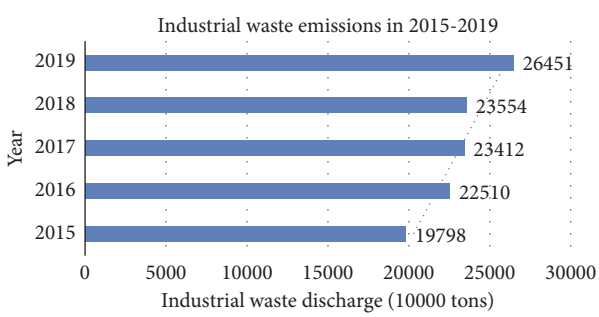

Figure 7: Change trend of industrial solid waste emissions in Shandong Province from 2015 to 2019.

waste, an increase of 456.15 million tons compared with 2015, with an average annual increase of 91.23 million tons. A large amount of solid waste discharged not only leads to the rapid expansion of land occupation but also significantly pollutes the surface and underground water bodies in the garbage storage area.

4. Design of Carbon Emission Measurement Method for Ecological Green Trade

4.1. Carbon Emission Estimation Method. At the moment, the developing world's economy is quickly expanding, and the formerly moderate growth rate of greenhouse gas emissions is accelerating, further deteriorating the worldwide ecological situation. Carbon tariffs' primary purpose is to "reduce carbon emissions," but the core of green trade barriers also exists. Developed countries or regions have completed the carbon tariff setting based on the current situation in which environmental protection issues have increasingly attracted global attention and their technology, particularly the cutting edge of emission reduction technology, which means that the economic interests of their own countries or regions are protected while the economic development competitiveness of developing countries or developing regions is significantly limited. Carbon taxes have had a substantial impact on Shandong Province's international trade [34]. Based on the reaction of green trade barriers in developed nations or regions and the resolution of economic growth obstacles, it is required to thoroughly examine the province's carbon emission status, and (1) is the carbon emission estimating equation.

$$C_t = \sum_{i}^{m} m_i \alpha_i \beta_i. \tag{1}$$

In the above equation, E_t represents the carbon emission in period t, m_i represents the consumption of the ith energy, α_i refers to the conversion coefficient of the ith energy into standard coal, and β_i refers to the carbon emission coefficient of the ith energy.

The primary definition of energy in the study is three types of fossil energy (natural gas, oil, and coal). The energy conversion coefficient is based on data from the 2019 China Energy Statistics Yearbook, while the energy consumption data is based on the regional energy balance table (China Energy Statistical Yearbook) and the Shandong statistical yearbook. Table 2 shows the estimated energy emission coefficient based on China's Energy Research Report.

Table 2: Statistics of carbon emission coefficient of various energy sources.

Data sources	Coal	Petroleum	Natural gas	Hydropower
National development and reform commission energy research institute	0.746	0.582	0.443	0.000

4.2. Design of Ecological Green Trade and Carbon Emission Measurement Method

4.2.1. Calculation of Total Energy Carbon Emissions. Energy is a core element of product production [35]. Shandong Province is a major energy-consuming Province, and its basic energy is natural gas, oil, and coal, which are three kinds of fossil energy [36]. Carbon emission is one of the by-products of energy consumption and economic development. Foreign trade export sectors like the textile and electromechanical industries consume a lot of energy and are important foreign trade industries in Shandong Province. Such industries have a high energy consumption, which directly increases carbon emissions. Economic growth, energy consumption, and international commerce are the explanatory variables employed in this work. The model calculates the link between economic growth, energy consumption, and foreign commerce, particularly the association between carbon emissions and international trade. The (2) formula is designed to make it easier to understand the dynamic link between economic growth, energy consumption, international trade, and carbon emissions.

$$C = f(E, Y, F). \tag{2}$$

Its linear model can be specifically expressed as follows:

$$C_t = \alpha + \beta_1 E_t + \beta_2 Y_t + \beta_3 F_t + \mu_i. \tag{3}$$

In the above equation, the random coefficient term is represented by μ_i, and the total amount of import and export trade (period t) is represented by F_t. Similarly, the regional GDP (period t) is represented by Y_t with unit: 100 million yuan. Besides, primary energy consumption (period t) is represented by E_t with unit: 10000 tons of standard coal. The total carbon emission (period t) is represented by C_t with unit: 10000 tons of standard coal.

The core problem of this model is the calculation of carbon emissions, which is based on Di's decomposition equation and derived by using the Kaya identity, which can be described as follows:

$$C = \sum_i \left(\frac{E_i}{E}\right) * \left(\frac{C_i}{E_i}\right) * E = \sum_i S_i * F_i * E. \tag{4}$$

In the above equation, the carbon emission coefficient of all energy is represented by F_i, i.e., the carbon emission per unit consumed by this energy. In energy consumption, I energy accounts for S_i. The consumption of energy is represented by E_i. The total primary energy consumption (each year) is represented by E. The carbon emission of i energy is represented by C_i, and the total carbon emission is represented by C.

4.2.2. Calculation of Export Carbon Emissions of Various Industrial Sectors in Shandong Province. The calculation of CO_2 emissions from various industrial sectors in Shandong Province is the premise of the calculation of CO_2 emissions from its export trade. The energy consumption of each industrial sector in the province can be obtained from the statistical yearbook of the province. The CO_2 emission of each industrial sector is equal to the product of the CO_2 emission coefficient of each industrial sector and its energy consumption. Since the export volume of each industrial sector is known, the greenhouse gas emissions caused by the foreign trade of each industrial sector are equal to the ratio of the total export volume. Meanwhile, the entire production of each industrial sector is multiplied by the product of each industrial sector's total CO_2 emissions, as shown in equation (5).

$$C = C' * \frac{q}{Q}. \tag{5}$$

In the above equation, C is the amount of carbon dioxide produced by an industrial sector because of export trade II, C' is the carbon dioxide produced by the industrial sector, and q/Q is the proportion of the export volume of the industrial sector in the GDP.

5. Results and Analysis

5.1. Analysis on the Calculation Results of Total Carbon Emissions in Shandong Province. The total carbon emissions of the province can be obtained by calculating the carbon emissions caused by various energy consumption, which is essentially the sum of the product of the carbon emission coefficient and the total energy consumption of each kind. From the perspective of the IPCC assumption, we can assume that the carbon emission coefficient of a certain type of energy is in a stable state [37]. Based on the data released by relevant institutions of the national development and reform commission, the author determines the carbon emission coefficient of three types of fossil fuels: natural gas, oil, and coal, namely, natural gas carbon emission coefficient of 0.443, oil carbon emission coefficient 0.582, and coal carbon emission coefficient 0.747. The total carbon emissions of the province are estimated based on the statistical yearbook data of the province over the years. Change trends in carbon emissions in Shandong Province from 2015 to 2019 can be shown in Figure 8.

The regression equation between foreign trade, regional GDP, energy consumption, and carbon emissions is based on the Eviews regression analysis, which is calculated in equation (6).

$$\begin{aligned} C_t &= 18.291 + 0.732E_t - 0.049Y \\ &\quad + 0.281F\,(0.0070)\,(0.0088)\,(0.0365). \end{aligned} \tag{6}$$

In regression mode, the coefficient value in brackets represent the standard error, and −53.01 is the likelihood

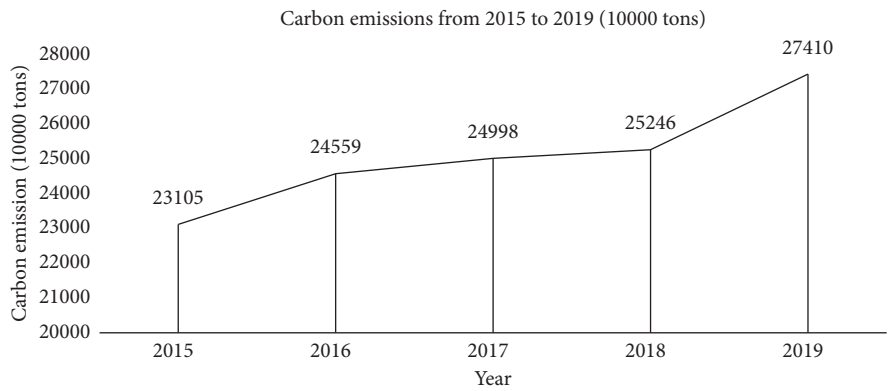

Figure 8: Change trends of carbon emissions in Shandong Province from 2015 to 2019.

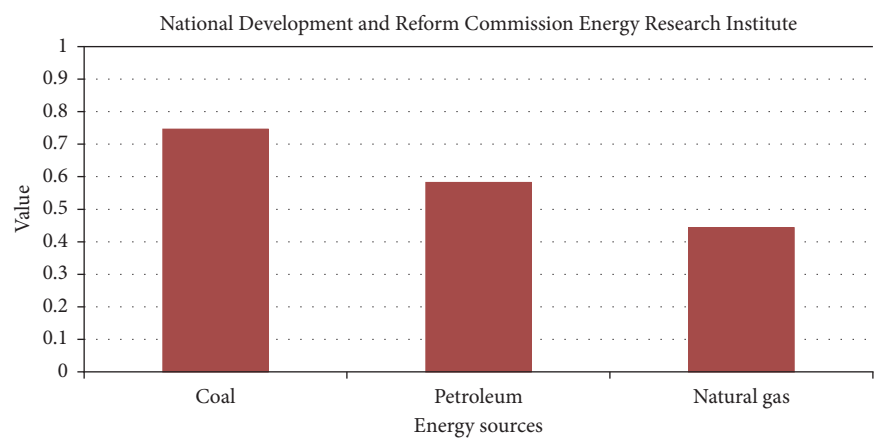

Figure 9: Comparison of data resources for the estimated energy emission coefficient based on China's Energy Research Report.

ratio of the equation. R2 is about 1, which proves to have relatively ideal goodness of fit. The analysis of the regression coefficient of explanatory variables shows that the regional GDP, namely economic growth, is inversely proportional to the total carbon emissions, and the foreign trade, energy consumption, and total carbon emissions are positively proportional.

Figure 9 compares data resources for the estimated energy emission coefficient based on China's Energy Research Report. This graph contrasts three types of fossil energy, namely natural gas, oil, and coal, which are the paper's core definitions of energy. The energy conversion coefficient in this study is based on data from the 2019 China Energy Statistical Yearbook, and the energy consumption data are from the China Energy Statistical Yearbook and the Shandong statistical yearbook.

5.2. Calculation and Analysis of Export Carbon Emissions of Various Industrial Sectors in Shandong Province. The statistics in Tables 3 and 4 of CO_2 emissions (induced by international commerce) of various industrial departments in the province show that ferrous metal smelting and calendaring ranked first, followed by the production of chemical raw materials and chemicals, and the textile sector ranked third. The top three accounted for 47.26% of the province's total CO_2 emissions from overseas trade of major industrial sectors. It demonstrates that the top three industrial sectors in Shandong Province account for a majority of CO_2 emissions from overseas trade. In essence, it is still impossible to adequately describe the structural flaws of the province's international commerce based on such data.

From the above analysis, it is clear that about 50% of the total CO_2 emissions of foreign trade in the province come from the top three departments, however, from the perspective of the total export volume of the province, the total export volume of the top three CO_2 emissions only accounts for 15.71%. For example, the food manufacturing industry, which ranks seventh in CO_2 emissions, ranks 13th in foreign trade volume. The nonmetallic mineral products business ranks sixth in terms of CO_2 emissions (2.584 million tons) but only fourteenth in terms of international trade volume. The ferrous metal smelting and rolling processing business rank first in terms of CO_2 emissions from overseas commerce (6.764 million tons) but only sixteenth in terms of export volume. The papermaking and paper products business ranks ninth in terms of CO_2 emissions but twenty-first in terms of international trade volume. Some industrial sectors with low CO_2 emissions have relatively high foreign trade volume rankings. Hence, it is the focus of the province's future development, i.e., to achieve the goal of optimizing and upgrading the province's foreign trade structure

Table 3: Carbon emission statistics of various industrial sectors in Shandong Province in 2019.

Industry	Carbon emission (10000 tons)	Industry	Carbon emission (10000 tons)	Industry	Carbon emission (10000 tons)
Ferrous metal rolling industry	3854.1	Oil and gas exploitation	295.7	Chemical fiber	76.6
Chemical raw materials and chemical products industry	3501.2	Electrical and mechanical equipment manufacturing industry	289.5	Nonferrous metal mining and beneficiation industry	46.2
Nonmetallic mineral manufacturing	2016.5	Rubber products industry	274.1	Nonmetallic mining and beneficiation industry	44.2
Petroleum refineries	1984.6	Pharmaceutical industry	169.5	Leather products industry	43.6
Nonferrous metal rolling industry	1110.8	Special equipment manufacturing	174.3	Handicraft and other manufacturing industries	42.9
Coal mining industry	1004.9	Metal products industry	168.6	Furniture manufacturing industry	38.4
Textile industry	967.3	Ferrous metal mining and beneficiation industry	155.4	Culture, education, and sports manufacturing industry	29.6
Paper industry	801.4	Wood processing and grass products industry	133.8	Printing and recording media	23.1
Agricultural and sideline food processing industry	705.5	Plastic products industry	120.1	Instrument and meter office manufacturing industry	19.5
General equipment manufacturing	581.2	Communication equipment manufacturing	108.1	Tobacco industry	7.0
Food manufacturing	327.9	Beverage manufacturing	89.4	Waste resource processing industry	4.1
Transportation equipment occupation	301.7	Textile, clothing, shoes and hats profession	78.6	Other mining industries	0

Table 4: Statistics of export carbon emissions of various industrial sectors in Shandong Province in 2019.

Industry	Carbon emission (10000 tons)	Industry	Carbon emission (10000 tons)
Ferrous metal rolling industry	676.4	Rubber and plastic products industry	311.5
Chemical raw materials and chemical products industry	550.2	Pharmaceutical industry	60.3
Nonmetallic mineral manufacturing	258.4	Special equipment manufacturing	23.1
Petroleum refineries	21.3	Metal products industry	58.2
Coal mining industry	2.9	Wood processing and grass products industry	28.4
Textile industry	391.8	Beverage manufacturing	13.1
Paper industry	90.2	Textile, clothing, shoes, and hats profession	70.0
Agricultural and sideline food processing industry	301.2	Chemical fiber manufacturing	48.4
General equipment manufacturing	71.8	Nonmetallic mining and beneficiation industry	0.5
Food manufacturing	136.5	Leather products industry	27.0
Transportation equipment manufacturing	115.2	Handicraft and other manufacturing industries	2.3
Electrical and mechanical equipment manufacturing industry	69.1	Furniture manufacturing industry	21.6
Culture, education, and sports manufacturing industry	1.8	Instrument and meter office manufacturing industry	3.6
Printing and recording media	2.5	Tobacco industry	0.2
Waste resource processing industry	0.06		

and promoting the reduction of carbon emissions from exports.

6. Conclusions

Currently, the IoT technology has reported higher benefits in improving our life quality in the green economy. Unfortunately, the growth of technology demands a large amount of energy, which is associated with unintended electrical waste and carbon emissions. This research looked at methods and ways for improving our quality of life by creating a green economy more ecological and safer. According to the computation of Shandong Province's carbon emission statistics, the province's carbon emission data from 2015 to 2019 are computed and retrieved using Excel. According to the data, the province's overall carbon emissions are growing year after year, which is divided into two stages: the first of which is 2015–2017, and this index indicates a stable development trend in this stage, while the second stage is 2018–2019 with a clear upward tendency. According to the regression coefficient, the elasticity of energy consumption in the growth process of carbon emissions is 0.732, which means that if the province's energy consumption is decreased or raised by one unit, its total carbon emissions will be lowered or increased by 0.732 units. The regression coefficient of its regional GDP is 0.049. This data shows that the province's economic development will not increase its total carbon emissions, however, its economic development has formed and promoted the emission reduction effect. The analysis shows that the proportion of some departments in the total export volume of foreign trade of the province is too heavy, and the proportion of carbon emissions of the corresponding departments in the total emissions is too large, which indicates that there are structural defects in its foreign trade. Only in this way can the goal of emission reduction and consumption reduction be achieved, the green trade economy can be made realistic, and the sustainability of the province's economic and social development be implemented.

Data Availability

The data used to support the findings of the study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Operation Mode and Creation of Film Media Based on the Internet Logic under the Field Theory

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With the development of information technology and new media technology, the Internet has had a profound impact on the development of the film and television industry. Mainstream media, new media, Internet companies, cultural media companies, etc. are all eager to try, and the forces from the state, capital, media, and users are intertwined. The film and television field is the behavioral practice field of various stakeholders. Capital stimulates the industrial functions of the film and television industry from the perspective of commercial interests. The interests of users are being redefined in the context of the Internet, and the film and television industry actively promotes the creative process from its own interests. In order to analyze the influence and motivation of the Internet on the operation mode and creation research of the film and television media industry, this paper relied on Bourdieu's field theory to explore the forces and interests that promote the development of the film and television media industry from different aspects. This provided development suggestions for the construction of a new pattern combining the Internet and film media. The integration of film and television and the Internet has become the new normal in the film and television industry. At present, people's online entertainment time at home has increased significantly, which has led to a rapid increase in the number of movie viewers. The introduction of Internet technology into the film industry media operation model can improve the operation efficiency of enterprises by 6.5%.

1. Introduction

The Internet is a new type of economy, which uses the distribution of the Internet in various fields to successfully create and transform various industries and improve their productivity. In addition, data is the development of modernity, which emphasizes efficiency, regularity, and growth, this concept quickly linked to the development of the Internet. Under this trend, the traditional model has been greatly impacted and influenced and has gradually changed. Therefore, film and television works must also keep pace with the times. The creation of online creation and the dissemination of data make the creative process more convenient, faster, more peaceful, and more popular. It is of great significance to introduce the Internet into the film industry media operation model and creative research.

Field theory is defined as a network of related relationships that exist in different spaces. The field has a relatively independent space. Due to the increasing influence of the field on real life, there are more and more research on the field. Malek defined the relevant generalized structures and found integrable conditions that give twisted semipoles and vacuum [1]. Liao and Ma studied two aspects of high-dimensional operators in the Standard Model effective field theory and introduced a perturbation power counting rule for entries in anomalous dimensionality matrices of equal-quality dimensional operators [2]. Stasyuk and Hera attempted to seek an explicit realization of quantum gauge conversion from Coulomb gauge to a class of static gauges in free electromagnetism [3]. Bond E recognized that the electromagnetic information theory was a promising framework for explaining intentionality and the spectrum of arousal as an effect of electromagnetic fields, and proposed that relatively low-frequency electromagnetic radiation is emitted by accelerating currents in neurons [4]. Lizana and Perez-Victoria investigated the exact connection between

exact renormalization groups with local coupling and renormalization of composite operator correlation functions in a scale-invariant theory [5]. Ramadan and Altamimi found after research on imprint lithography that this technique would directly etch into high cavities with large mode confinement while improving emission characteristics [6]. With digitalization in full swing, many are wondering how the adoption of new technologies affects job creation and destruction. Tai et al. found through research that this largely depends on the specific tasks that the machine undertakes, and how many new tasks are created through the adoption of new digital technologies [7]. These studies have more specific interpretations of field theory, but they are not related to the operation mode of the film industry and media, nor do they talk about creative research.

Film industry media operation refers to being familiar with the video industry such as film and television and the Internet operation mode. It refers to the process of understanding the problem channels of operating means, then planning related activities, as well as optimizing the plan through data effect analysis. With the advent of the Internet era, the development of the film and television industry is getting faster and faster, and there are more and more studies on the film and television industry. Llorian et al. found that the continuous innovation of Internet finance and the increasing complexity of business have exacerbated the uncertainty of industry risks. And it was found that in order to establish and improve a long-term supervision mechanism that adapts to the development characteristics of Internet finance, regulators also put forward a "penetrating" supervision plan for Internet finance [8]. Thirukkumaran and Muthukannan introduced a trust-aware access control system using fuzzy logic for IoT. This access control is an important mechanism to ensure that only trusted users/devices can access data from sensor devices or command actuators to perform certain tasks in an IoT environment [9]. Garg et al. proposed an electrothermally actuated Micro-Electro-Mechanical System (MEMS, Micro-Electro-Mechanical System) Pirani meter with an integrated polymer film. Experimental results showed that the integrated polymer film was very effective in providing mechanical strength to metal resistors and reducing solid conduction losses to the substrate [10]. Li et al. believed that due to the development of smart devices, embedded and ubiquitous communication technologies, and the combination with the online world, film media operations had become more important to the real world. It can provide many intelligent services, but these services also bring new challenges to security and privacy issues [11]. Delavari et al. believed that with the rapid development of the Internet era, the way people obtain information is also changing, so the effective use of mobile digital terminals can spread information more widely and faster [12]. Animation as a medium to express cultural information through the Internet has become an important means of regional cultural exchanges. Harun et al. believed that the creators and producers of animation determined the quality of animation, and how to cultivate such talents had become a problem worth thinking about in the process of animation education [13]. Schneider et al. found through research that information is an online service. It offers an extensive database and full-content publication offering the vast majority of national academic research for the education, research, and business sectors [14]. These studies on the Internet and the film and television industry are relatively comprehensive, but they do not include the knowledge of field theory.

Now in the era of diversification, future development is even more unpredictable. The randomness, uncertainty, and suddenness of the complex environment have caused a series of complex and intractable problems, including aesthetic consciousness, cultural model, tradition and innovation, and ecological environment. These problems are not only in the film and television and creative industries but also in today's multidisciplinary era, which brings challenges to people and the development of various disciplines. Just like this, those in different fields need to explore and reflect from a deeper and newer perspective. With the development of the social economy and the advancement of Internet technology, all walks of life are bound to be affected and impacted by it. In order to better adapt to the development of the times, the film and television operation model must be reformed and innovated, thus ushering in new development opportunities.

2. Field Theory Elements

2.1. Definition of Field Idea. The idea of a field is defined as some kind of relationship between networks or places and things, and these places are defined accordingly. In other words, the idea of a field is not a place surrounded by some boundaries, but an inner dynamic life [15]. Figure 1 shows that the study of contemporary French society by the field concept using anthropological methods involves two different levels: whether to use anthropological methods and how to use anthropological methods.

2.2. Elemental Analysis of Field Theory. The Field theory integrates elements of different elements into a whole and respects individual individuality, constructing a dynamic, and inclusive network. Therefore, the integrated concept of "field" is introduced into the development process of things [16], this is important because the introduction of the field into the development process can shift the focus of things from the local to the whole. It looks at the changes in things from the perspective of "global view" and "integrity", and uses a dynamic, related, ordered, and even self-organized structural system as the basis for the development of parametric space design. This provides a new direction for interdisciplinary design research, as shown in Figure 2.

2.3. Analysis of Field Diversification. Sectoral diversity is the result of social differentiation, and field theory regards this differentiation process as a process of sectoral autonomy. Independence essentially means that a field gets rid of the constraints and influences of other fields and reflects its natural essence in its development [17]. Every field has a ruler and a rule, and every rule in the field means conflict. The boundary that defines the field and the field is also full of

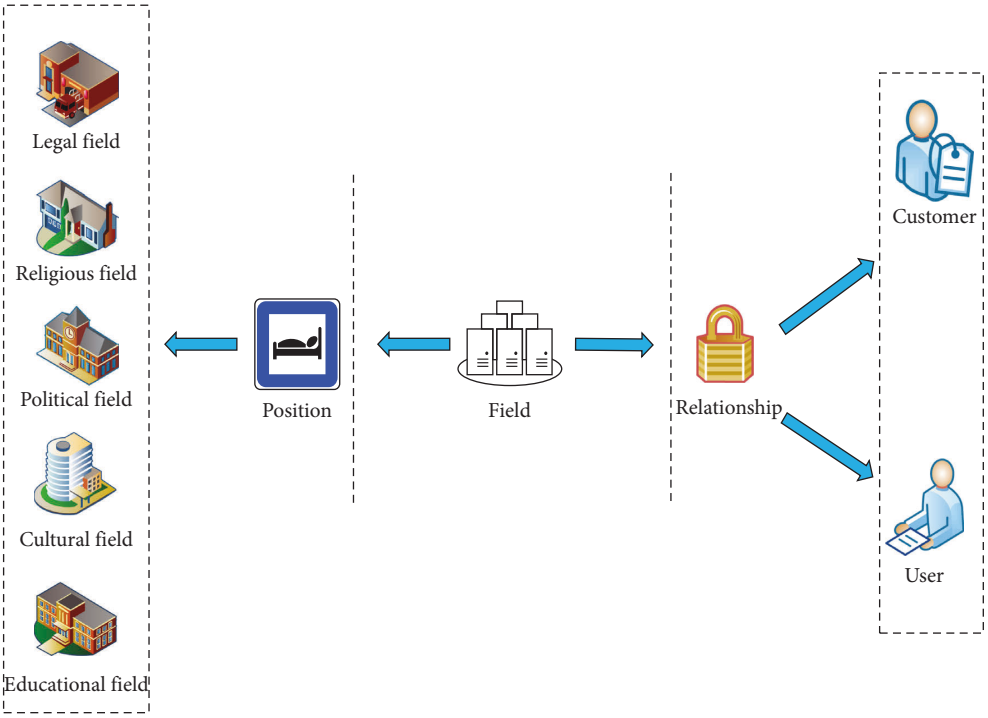

Figure 1: Field concept proposed by Bourdie.

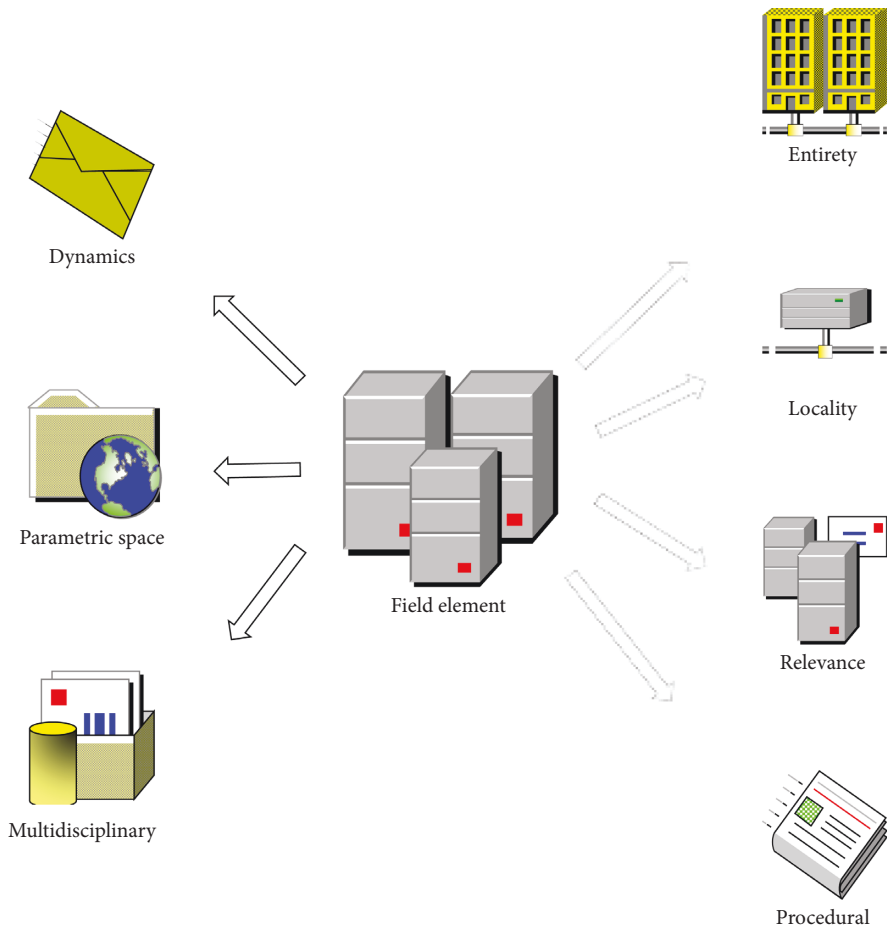

Figure 2: Element analysis of field theory.

conflicts between different power relations. The logic of competition is the logic of money, and money cannot exist and function if it is not connected to the field [18, 19], as shown in Figure 3.

3. Operation Mode of the Film Industry under the Logic of the Internet

3.1. Strategies for Building an Internet Film Media Operation System. The construction of the Internet film industry operating system can obtain more customer resources and reduce operating costs. The establishment of a public platform can increase communication with customers and allow customers to understand better relevant information [20, 21]. There are two logics in the current film and television industry, one is Hollywood, and the other one is the Internet. With the continuous improvement of the innovation power of the network economy, the film and television industry is also trying to get rid of the imitation of Hollywood logic and create a development path that not only conforms to the laws of the cultural market but also fully reflects the economic and social benefits. The logical advantages of the Internet are prominent, indicating the future changes in the film and television industry. The film and television industry has also pushed the logic of the Internet to a new level, and changes and upgrades have taken place within it, as shown in Figure 4.

3.2. Strengthening the Construction of Internet Film Media Operation Team. According to the operation characteristics and actual situation, the team is involved in the film and television operation, so as to improve the work efficiency and work quality of the team. The operation and film and television production sides should strengthen communication and exchanges. It is necessary to cooperate according to the needs of customers and exercise the ability of teamwork, so as to improve the operation and management efficiency of the platform [22]. Improvements in various methods, such as messaging and service delivery planning activities, have made the platform more attractive. Improved trade and communication with potential clients make public forums more attractive. Clients can collaborate and promote the use of media product content through public forums. It is also needed to understand the general needs of the client to prepare the information for the team. It is also necessary to communicate with customers on specific issues and collaboration needs, which is an important prerequisite for strengthening the construction of the Internet Films media operation team.

3.3. Comparison of the Traditional Film Industry Operation Model and the Internet Film Industry Operation Model. The disadvantages of traditional film and television production are as follows: first, the operation mode is backward; second, the cost problem; third, the information flow is not smooth. The Internet business operation model has many advantages: first, the information resources are abundant, the company can obtain more information resources

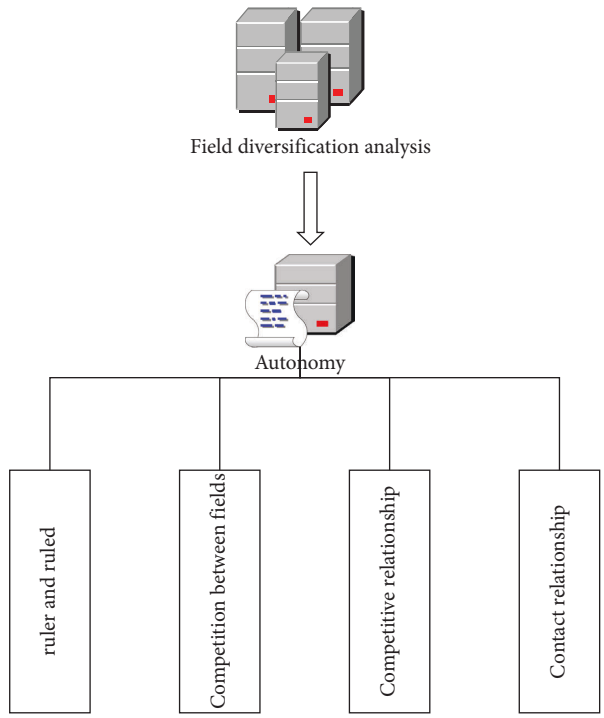

Figure 3: Field diversity analysis.

through the Internet channel, the communication between the same industry becomes convenient, and the experience and market conditions can be accessed. The second is the reduction of production costs, by using Internet technology to reduce production costs and increase corporate income.

The third is the improvement of adaptability. With the use of Internet technology, it is no longer dependent on face-to-face communication. The specific operation mode of the Internet film industry is shown in Figure 5.

4. Creation under the Logic of the Internet

4.1. The Influence of the Internet on the Creative Space. The term "creation" as a subject cover more than writing, also includes images, music, architecture, and video. In the networked space, the network pays attention to the content of the guidance, so that the space where the creation takes place is being transferred to the online on a large scale. If in the past, work had to go through a series of links in the physical world before it was handed over to consumers, now it may take place in the screen world, perhaps in two-dimensional interactive interfaces such as documents and official accounts. Even if older or more traditional creators still use paper and pen to create their work, the Internet remains a key channel for promotion. It can be said that the Internet space is gradually becoming an important and even major place for "creation" and "publishing", as shown in Figure 6.

4.2. The Influence of the Internet on Personal Creation. The network supports connections, uploads, and exchanges anytime, anywhere, so everything needs to be kept in check.

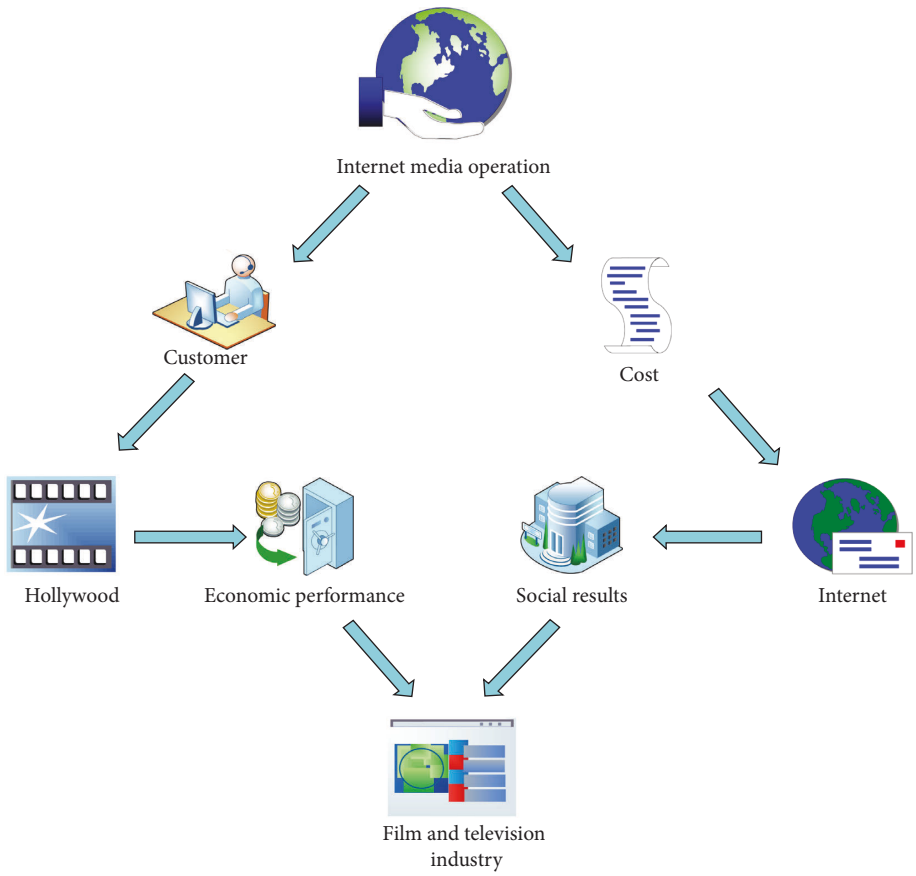

Figure 4: Strategies for building the media operation system of the Internet film industry.

Due to the popularity of the Internet, personal space is constantly being shortened [23]. In this Internet environment, creators no longer need to be isolated from the world, let alone find a quiet place for inspiration and creative thinking. The creator only needs to put the smartphone on the desk, and the screen would immediately transport the creator to the big world of the Internet. Currently, creators need a social network as an intermediary so that they can easily communicate with other creators.

5. Application of Field Similarity Algorithm to Film Media Operation Mode and Creation

The development direction of the film and television industry in the system is mainly based on the interests and hobbies of users. In order to calculate the potential relevance of users, the cosine algorithm, Pearson coefficient, and Pearson similarity need to be used to calculate the liking of certain things. It is assumed that $\partial(\alpha,\beta)$ represents the similarity between interests α,β, the similarity of user interests is calculated as

$$\partial(\alpha,\beta)=\frac{\sum_{i=1}^{n} t_n t_m}{\sum_{i=1}^{n}\left(t_i-t_{i-1}\right)^2\sum_{i=1}^{n}\left(t_i-t_{i-1}\right)}. \quad (1)$$

Among them, the smaller the correlation coefficient values of random variables α,β, the weaker the correlation between the changing faces. Conversely, if the variable content of α,β is larger, it can indicate that the correlation between variables is stronger.

The calculation of cosine similarity mainly relies on the correlation of two vectors in the space, so the correlation between user T and α,β is

$$A(\alpha,\beta)=\frac{\sum_{i\in 1}^{n}\left(t_m-t_n\right)\left(t_m-t\right)}{\sum_{i\in 1(\alpha)}\left(t_i-t_{i-1}\right)^2\sum_{i=1(\beta)}\left(t_i-t_{i-1}\right)^2}. \quad (2)$$

The Pearson coefficient represents the association between two vectors and is used in the calculation of the correlation between attributes. In the recommendation system, the Pearson coefficient mainly solves the related problem of the difference in the likeness. In order to improve the accuracy of user preference calculation, taking into account the difference of users' preference for film and television works, the user preference is calculated using the Pearson coefficient. The related likeness of user T is expressed by the Pearson coefficient as

$$P(\alpha,\beta)=\frac{\sum_{i\in 1(\alpha,\beta)}^{n}\left(t_m-t_n\right)\left(t_m-t_n\right)^2}{\sum_{i\in 1(\alpha,\beta)}\left(t_i-t_{i-1}\right)^2\sum_{i=1(\alpha,\beta)}\left(t_i-t_{i-1}\right)^2}. \quad (3)$$

As time changes, user T's favorite value $PT(r)$ for movie r is expressed as

$$PT(r)=M\times Y_i+(1-m). \quad (4)$$

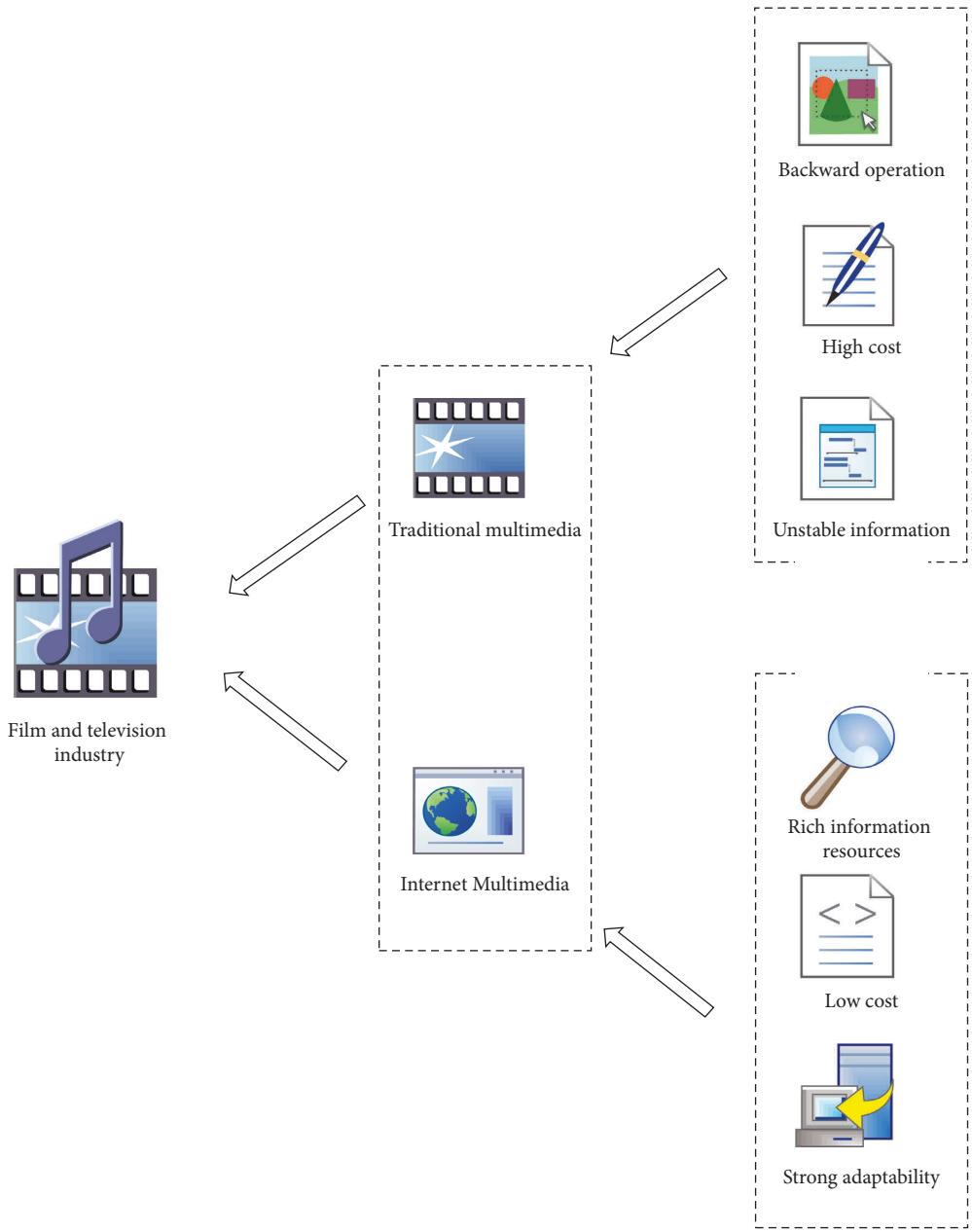

Figure 5: Comparison between traditional film industry operation mode and Internet film industry operation mode.

For formula, Y indicates the rating value of user T for movie r, and M indicates the time value, then the calculation of M is

$$M = \frac{T(\alpha, \beta)}{T_{sim}(r)} + U. \tag{5}$$

Among them, U represents the forgetting curve.

It is assumed that the total number of movie watching times of user v is $L_{\text{sim}}(v)$, the user's viewing frequency of a movie is calculated as

$$\text{Rate}(v, i) = p\frac{L(v, i)}{L_{\text{sim}}(v)}. \tag{6}$$

For formula, L represents the attribute dimension of the random variable.

User emotions are comprehensively considered. It is assumed that user p's positive emotions are P and negative emotions are M, then

$$P(L, \alpha, \beta) \in P\left(T, M, \alpha^2\right)P(M\alpha_i). \tag{7}$$

The correlation coefficient between random variables T and P is

$$T_n = \frac{T_i}{\sum_{i=1}^{n} TP}\left|T_i\right|. \tag{8}$$

The degree of liking among users shows the change of personal character of users. To this end, the relationship

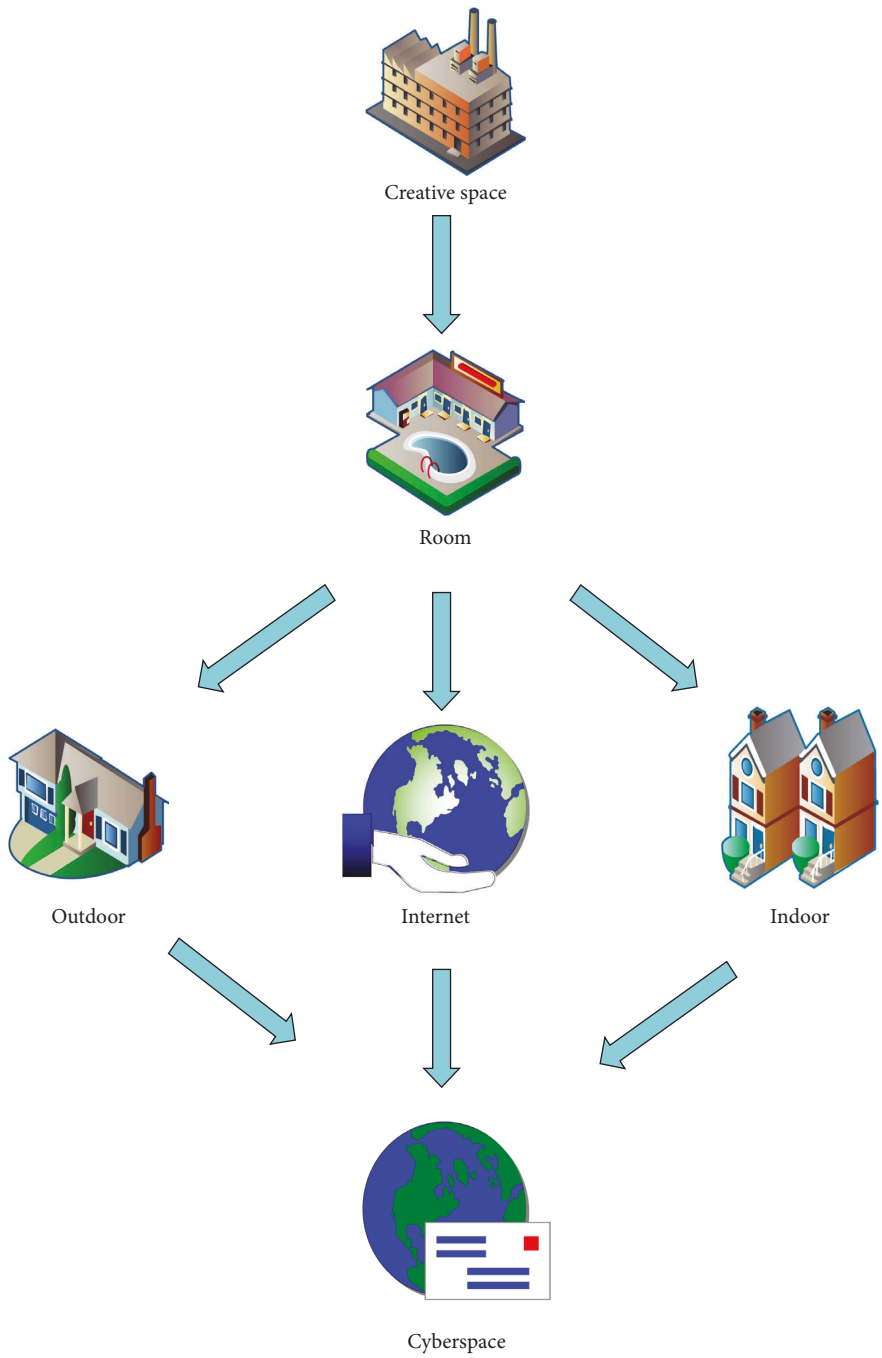

Figure 6: The impact of the Internet on creative space.

between the n-th feature can be calculated according to the degree of preference between users

$$L_n = (1-\alpha)\bar{t}_i + \beta_n,$$
$$L_u = \sum_{i=1}^{n} \operatorname{sim}(\alpha,\beta)^2. \tag{9}$$

If M, T is the similarity of favorites between users, then the related similarity between user's needs to be quantified according to the likes of users to the development of the film and television industry. Then the correlation approximation between user likes is calculated as

$$P(R,T) = \sum_{i=1}^{i}\sum_{n=1}^{n} M\left(r_v p \,\middle|\, (i_2 n)^2\right)^n,$$
$$P\left(T \,\middle|\, M^2\right) \sum_{i=1}^{n} M\left(v_1 \,\middle|\, \alpha_i^2\right),$$
$$P\left(P \,\middle|\, T, \alpha_v^2\right) = P\left(P \,\middle|\, T \sum T\alpha_v \alpha_i^2\right),$$
$$P\left(M, T \,\middle|\, v, \alpha_i^2, \alpha_n^2\right) = P(M \mid v) \sum_{i=1}^{i}\sum_{N=1}^{N} (T_v). \tag{10}$$

The background information of users is extracted, the user's preference information for movies mainly includes

text and facial expressions. The similarity between users is calculated according to the characteristics of users. On this basis, the user's favorite degree is further calculated. At the same time, the accuracy of its calculation is verified by the mean absolute difference verification method. The calculation of the mean absolute difference verification method is as

$$\partial = \frac{1}{2}\sum_{i=1}^{n}\left(r_v - p\left(T_i M_n\right)\right) + \sum_{n=1}^{n} T_2,$$

$$\partial = \sum_{i=1}^{n} L_n^i P\left(TM_{\mathrm{n}}\right) + \alpha\beta_i, \tag{11}$$

$$\partial = \sum_{n=1}^{n} L_n^2 p\left(TM_n\right) + \alpha\beta.$$

If sim represents the test set, T represents the user's preference for movies, and n represents the target user's emotion for a certain movie, then when the error between the recommended movie review emotion and the target user's emotion is small, the recommendation is considered valid. Then the calculation of selecting the best α, β value through the change of *sim* is

$$\mathrm{sim}\sqrt{\frac{1}{2}\sum_{i\in 1}\left(T_{n1} - M_{i2}\right)^2},$$

$$\mathrm{sim}T = \frac{1}{2}\sum_{i\in 1}^{n}\left(T_{n1} - M_{n2}\right)^2, \tag{12}$$

$$T = \mathrm{sim}\frac{1}{2}M^2 + v_i\sum_{i,n=1}^{n}(\alpha, \beta).$$

6. Results of the Combination of Field Similarity Algorithm and Practical Application

In order to detect the influence of Internet logic on the operation mode of film and television media, six film and television media companies were investigated for evaluation and testing. The content of the survey was about the results of employees' approval and help for the operation model. The six media companies were A, B, C, D, E, and F, respectively. The evaluation results were embodied in the improvement of Internet logic in the execution and office efficiency of film and television companies, with a sample size of 600 people. The evaluation results were divided into four levels: satisfied, good, commonly, and uninterested. The specific effects are shown in Figure 7.

Figure 7 shows that the employees of the six film and television companies had a relatively high degree of recognition of the logic of the Internet, and most of them were satisfied. Among them, the employees of the two film and television companies D and F had the highest satisfaction with the Internet logic, while the employees with low recognition and disapproval were less. Internet logic is still well recognized and loved by employees, and it has played a great role in improving office capabilities and improving operational levels. With the change of Internet logic to the operation mode of enterprises, the operation efficiency of the company has been gradually strengthened. The concept of work has undergone a great change, and it has begun to effectively control and operate the film and television operation process.

In order to compare and analyze the traditional film media operation mode and the Internet film media operation mode, the efficiency of a film and television company under the two operation modes was investigated. The specific data are shown in Table 1.

As can be seen from Table 1, the two operating modes showed different states. This was because the channels and dissemination methods of the two operating models are different, and the operating efficiency would not remain the same. A comprehensive comparison of the two operation modes showed that the traditional operation mode had low operational efficiency and fluctuates greatly. The new operating model had fluctuations, but the fluctuations were not large, and the operation efficiency was higher. Enterprises conducting film and television publicity through the Internet can increase more exposure and maximize the effect of film and television publicity. According to the research on the status of the two operation modes in Table 1, it can be concluded that the introduction of Internet technology into the operation mode of the film industry can improve the operation efficiency of the enterprise by 6.5%.

In order to examine the impact of Internet logic on creative research, two editorial offices, and two film and television companies were investigated. In order to make the data more intuitive and clearer, they were named respectively: 1, 2, 3, 4. Among them, 1 and 2 are editorial departments, and 3 and 4 are film and television companies. When conducting the survey, it was mainly based on the creative efficiency and evaluation results under the Internet mode. The evaluation results were embodied in the changes and influence of creators on the creation of the Internet model, with a sample size of 400 people. The price results were divided into four levels: satisfied, good, commonly, and uninterested. The specific effects are shown in Figure 8.

According to Figure 8, it can be seen that creators were highly interested in the Internet creation mode, and satisfaction accounted for the majority. There were very few creators with low interest and no interest, and the Internet creation model was very supported by creators. This was because the Internet creation mode had played a great role in improving the creative efficiency of creators. With the change of creative mode, the creative mode and creative mentality of creators have changed greatly. Creators not only no longer put themselves in a small space, but also see more pictures with the help of the Internet. Creators create more excellent film and television works, and begin to change and extend their creative process.

In order to compare the efficiency of traditional creative research and Internet creative research, the creative efficiency of creators under the two creative modes were investigated, and the changes are shown in Figure 9.

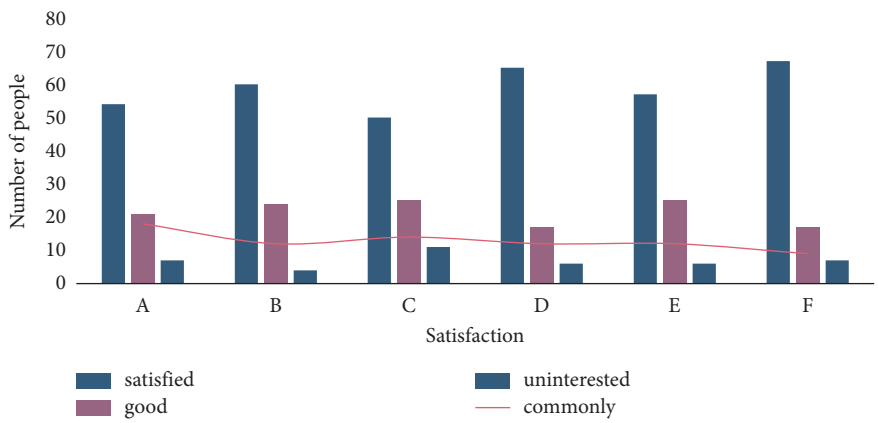

Figure 7: The impact of Internet logic on the operation mode of film media.

Table 1: Comparison between traditional film media operation mode and Internet film media operation mode.

	Traditional mode	New mode
Satisfied	73	47
Good	11	26
Commonly	9	18
Uninterested	7	9

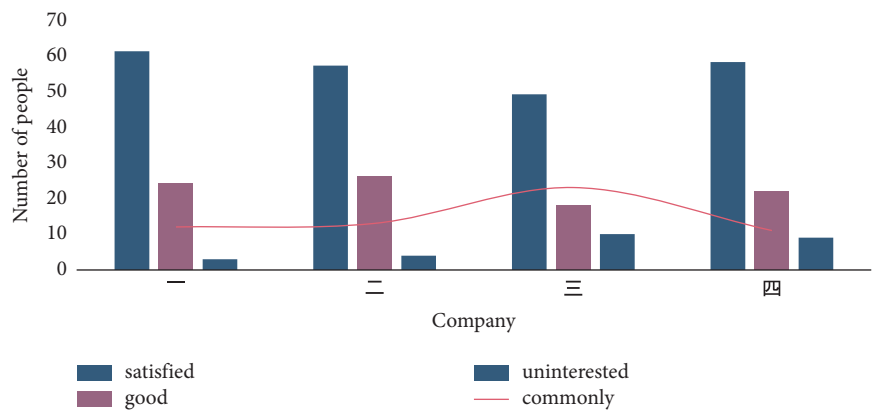

Figure 8: The influence of Internet logic on creative research.

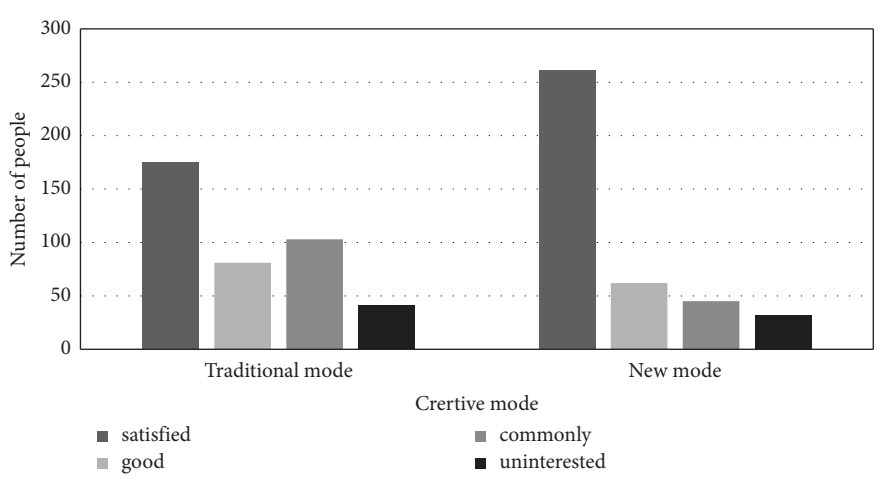

Figure 9: Efficiency comparison between traditional creative research and Internet creative research.

As can be seen from the bar chart in Figure 9, the two authoring modes showed different states. Because the creative methods and course methods of the two creative modes were different, the creative efficiency would not remain the same. A comprehensive comparison of the two creative modes showed that the creative efficiency of the traditional creative mode was relatively low and fluctuated greatly. The new creative mode fluctuated less, and the creative efficiency was higher.

7. Conclusion

The popularity of mobile terminals has broken the traditional barriers and achieved integration in various industries. The selection mechanism has gradually become an important way to guide people's consumption, which is a brand-new thing that has never appeared under the logic of film and television in the past. What determines the quality of film and television works is always the content quality, including the entire process from script, director, production, and operation. At present, policies are driving out bad money in the market, and the production of content has broken through a certain order of magnitude. However, there is still huge uncertainty about whether its quality can prolong the user's love. Whether film and television companies can take this opportunity to transform and rely on algorithms and data to make content production decisions, thereby forming a closed loop of high-quality content production mechanisms, would become the key point for film and television companies to stand firm. In this context, film and television companies can only win more market space by changing themselves and actively contacting the logic of the Internet from all aspects of creation, production, and distribution.

Data Availability

The data of this paper can be obtained through the e-mail to the authors.

Conflicts of Interest

The authors declare that there are no conflict of interest regarding the publication of this work.

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Research Article

An Internet of Things-Based Empirical Study on the Coordination between Rural Economic Development and Ecological Environment Conflict for Luoyang

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At present, key elements of the Internet of Things (IoT) are becoming increasingly affordable, making the technology incredibly attractive to many countries, particularly China. Collecting data from multiple IoT resources and combining them with data from other sources lead to significant rural economic development, ecological environment, and ecological and environmental ramifications in these nations. The most visible effects of the IoT in these nations include advances in rural economic growth, environmental conflict, and the efficiency of critical sectors. Furthermore, the IoT has the potential to revolutionize the industrial and commercial sectors, notably in terms of data confidentiality and information security. It is required to conduct an empirical study on the coordinated interaction between rural economic growth and ecological environmental conflict in Luoyang using an IoT environment. Because the IoT plays a key role in economic growth and the ecological environment, this study examines the coordination of rural economic development and ecological environment conflict in Luoyang's IoT environment. To analyze the original data for the establishment of index weight, it first employs the enhanced entropy approach by building the coordinated assessment index scheme of rural financial development and environmental surroundings conflict in the IoT environment of Luoyang. Second, it calculates the benefits of rural financial growth and the environmental surroundings benefit index of Luoyang. Then, it carried out the Pearson correlation analysis of the abovementioned calculation results using SPSS software that uses the layered architecture of the IoT, and the degree of conflict and coordination among rural financial growth and the ecological environment in Luoyang is judged by referring to relevant standards from 2010 to 2019. The experimental result of this study indicates that the conflict coordination state between rural financial growth and the ecological environment in Luoyang has gradually enhanced. Through this study, local decision makers can give additional consideration to the balance between economic development and the coordination of ecological environmental conflicts, especially those indicators that have a great influence on the coordinated development of the two.

1. Introduction

In the current modern world, the world's ecological environment and economic development are going through considerable change as a result of the adoption of the Internet of Things (IoT). The confluence of multiple developments, including advancements in inexpensive devices and sensors, scalable network connection, and the maturation of mobile, cloud, and big data paradigms, is noteworthy concerning the attractiveness of the IoT in tackling the area's current significant concerns. These supporting technologies have aided users in realizing the advantages of the Internet of Things. Besides, this modern environment economic sector is a service business that combines transportation, warehousing, logistics services, and information technology. It covers a wide range of topics and is crucial in promoting items and driving domestic demand. The environment economic sector is undergoing great expansion as a result of the rapid development of the manufacturing economy and the emergence of the consumer market [1]. The environment economic sector has placed a high value on decision-making departments as a critical component of

economic growth. Internet-based technologies, such as the IoT, add management, mechanization, incorporation of ecological finances, and information technology to the environmental economics sector. Furthermore, procedure control skills bring to the industrial surroundings the capability not only to increase economic effectiveness and cost regulator but also to make stronger economic and environmental advantages and effectively enhance the information standards of businesses and associated regions to drive industrial growth.

Based on the foregoing, information and communication technologies have evolved into a collection of tools current in daily life and the financial division, growing supply, defining the creation of novel facilities, and, finally, encouraging cost savings, all of which have an impact on an organization's management platform. Thus, the corporation is ruled over by advances centered on communication and information technologies, among which is the progress brought about by communication systems. In 2020, the IoT increased rapidly at the corporate level, with Asia experiencing the fastest growth (18%), North America experiencing the fastest growth (15%), and Europe experiencing the lowest percentage (9.8%) [2]. Their communication sensors allow them to communicate information and data only through technology, without the need for human intervention.

In addition to the above, with the constant growth and progress of human society, the relationship between man and nature is also changing, and human cognition of nature is also gradually deepening. Meanwhile, the idea of sustainable growth was put forward at the conference on environment and development in 1992, nations all over the globe have begun to pay consideration to environmental issues, and how to reach an agreement with the association between economic development and ecological defense is the top priority [3, 4]. The traditional mode of economic growth is extensive, mainly by sacrificing the environment to promote economic development, which leads to increasingly serious ecological environment problems in the process of regional economic development and poses a great threat to human survival and development. The conflict and uncoordinated association between financial growth and the ecological environment have become a huge problem faced by regional development, and ecological environmental problems have begun to hinder the healthy and sustainable development of the regional economy [5, 6]. To solve a sequence of environmental and conservational complications brought about by the process of economic growth, China adopted the "China Agenda 21" in 1994. It marked the official implementation of the sustainable development strategy in China and officially launched the pilot project of building ecological demonstration areas in 1995. The development aim of constructing an environmental protection demonstration city was proposed in the tenth five-year plan. At the 17th National Congress held in 2008, the concept of ecological civilization construction was first put forward and included in the party constitution, which demonstrates the importance of coordinated growth between economic development and the ecological situation [7, 8].

The innovations of this study are as follows: (1) This study conducts an empirical investigation in the IoT environment of Luoyang on the coordination of rural economic growth and ecological environment conflict. As per the principles of establishing the indexing scheme and the real condition of Luoyang, this research builds the index scheme of the financial organization and environmental systems. After standardizing the novel data of the index and obtaining the weight, the coupling degree model and coupling coordination degree model are used to calculate the coupling degree result of the economy and environment in Luoyang. In addition, according to the standard of coordinated development, we judge the stage of the coordinated growth level of economic and environmental coupling in the IoT environment of Luoyang. (2) Taking the villages of Luoyang as the investigation object, this research explores the coordinated development process, law of rural financial growth, and ecological environmental conflict by studying the empirical relationship between rural economic development and ecological environmental conflict in Luoyang. Through this study, we hope to provide some references and feasible references for realizing rural revitalization and building beautiful villages in China.

The organization of the rest of this research work is as follows: Section 2 presents the pertinent research of other researchers in the chosen field. Section 3 is based on the materials and methods chosen for coordinating rural economic growth and environmental conflict in Luoyang. Section 4 depicts the evolution of a conflict model between rural economic growth and the natural environment. The study's outcomes and analysis are reported in Section 5, and the conclusion is offered in Section 6, which is the final portion of this work.

2. Related Work

To understand the function of IoT coordination between rural economic growth and ecological environment conflict in the Luoyang Internet of Things environment, it is necessary to first comprehend the many reasons for underdevelopment and development. According to our study of the literature, previous scholars identified basic and proximal reasons for wealth and poverty. Institutions, culture, and geography are all arguably important drivers of wealth. Physical capital disparities, technological differences, human resource differences, and market functioning are all proximal factors. Furthermore, the causes of economic decline are interrelated. For example, in China's Luoyang city, a shortage of human capital has resulted in a poor rate of structural capital formation. Due to diverse economic theories and environmental development at various phases of economic and social development, foreign theoretical study on the relationship between the economy and the ecological environment is necessary. Because of the various degrees of science and technology, as well as the limitations of people's comprehension, economists place varying emphasis on this study and reach different conclusions. Foreign theoretical research on the relationship between the economic environments is mainly reflected in two aspects: the first one is

whether there is a limit to economic growth caused by the environment and the second one is about the circumstances for the coordinated growth of the economy and surroundings. On the one hand, aiming at the problem of the limit of economic growth, the first is the Club of Rome, led by meadows in 1972. Some economists published the report "the limit of growth" and first put forward this concept. The publication of this report triggered an extensive and fierce debate among economists on whether there is a limit to economic growth. The debate is mainly divided into two factions: pessimism and optimism. The pessimism represented by Mishan (1967) believes that while economic growth provides more material enjoyment to mankind, it also brings more pollutants and the continuous decline of environmental quality, which turns welfare into a negative effect. The optimism represented by Cole (1973) believes that as long as the growth rate of resources is faster than that of population and consumption, the economic system cannot collapse, and there is no limit problem. Domestic research on the coordination relationship between regional economic development and ecological environmental conflict began in the 1990s. The more representative ones are the quantitative analysis methods based on the coordinated development model, which is used to quantitatively analyze the coordination relationship between economic development and ecological environmental conflict in the Pearl River Delta region [9]. Based on the coordinated development trend index method, this method is used to compare and analyze the coordinated relationship between tourism economic development and ecological environmental conflicts in Haikou and Sanya in Hainan Province [10]. Based on the method of integrating the coordination degree and obstacle degree models, this model is used to comprehensively evaluate the coordination state of economic development and ecological environment conflict in the process of urbanization in Guiyang City, Guizhou Province, and further analyze the obstacles [11]. The abovementioned methods and models mainly focus on the conflict and coordination between urban economic development and the ecological environment and do not pay attention to the relationship between economic development and the ecological environment in rural areas.

Nowadays, the contradiction between China's ecological environmental problems and economic development has become increasingly prominent and has expanded to become a key topic of common concern all over the world, which is related to how to achieve harmony between man and nature in the future. This is also the development goal pursued by all countries in the world [12, 13]. In particular, the rapid rise of rural tourism in recent years has brought great pressure on the ecological surroundings. It is imperative to study the coordination relationship between rural financial development and environmental environment conflict [14, 15]. Therefore, this study evaluates and empirically analyzes the coordinated growth level of the rural economy and ecological environment conflict in Luoyang from 2010 to 2019 in Henan Province using the IoT. It concludes that, in the future, China should place emphasis on these indicators with greater weight. The coupling degree between rural economic growth and the ecological situation in Luoyang is relatively high, indicating that there is a coordination relationship between the two.

3. Materials and Methodology

3.1. Multidimensional Collaborative Management Framework of Coordination between Rural Economic Development and Ecological Environment Based on the Internet of Things. The environmental economy and the unfavorable environment are two aspects of multidimensional ecological economic cooperation. This economy encompasses not only waste goods recovery but also the categorization, identification, and disassembly of manufacturing and reprocessing reverse ecological economic processes. However, it also comprises new and reprocessing product storage, distribution, and significant environmental financial procedure allocation, and the network model is complicated, with numerous linkages. As a result, full utilization of the IoT, cloud services, big data, and other technologies for communication and information is required. The system in different areas and nodes should be anticipated with information exchange and communication platforms. Intelligent multidimensional ecological financial activity should be executed, with control being especially vital. The cooperative organization unit is both the particular object and objective of the actual implementation of the information synergy outcomes, as well as the source of data and information for improving the manufacturing of the environment economics to achieve information synergy. As a result, the cooperative organization unit is the bedrock and heart of multifunctional ecological financial data synergy. Figure 1 illustrates the design using the three-layer IoT architecture. The data included in the multidimensional ecological financial coordinated organization, match organization, choice organization, and cooperative organization 4 function components may be separated into cooperation and collaboration, sensory acknowledgment, data transmission, data sharing, and request services, depending on the information service level.

According to the figure mentioned above, resource integration focuses mostly on the dimensions of environmental and economic involvement in the firm, and remanufacturing of car parts as well as other material resources are categorized and combined. Simultaneously, the physical qualities of numerous types of resources, as well as the organization features of information coding and classifying, must be provided with perceptual and communication components. It serves as the physical foundation for the IoT to see and identify things as well as gather data and information. Awareness recognition denotes the physical assets used in remanufacturing infrastructures, industrial equipment, and automotive components such as radio frequency identification systems, sensors, GPS, and wireless sensors. Furthermore, the multidimensional environment's physical amount of economic material assets such as chemical compositions and biomass is translated into digital signals, associated processing, and communication tasks. This allows for the dynamic sensing and identification of

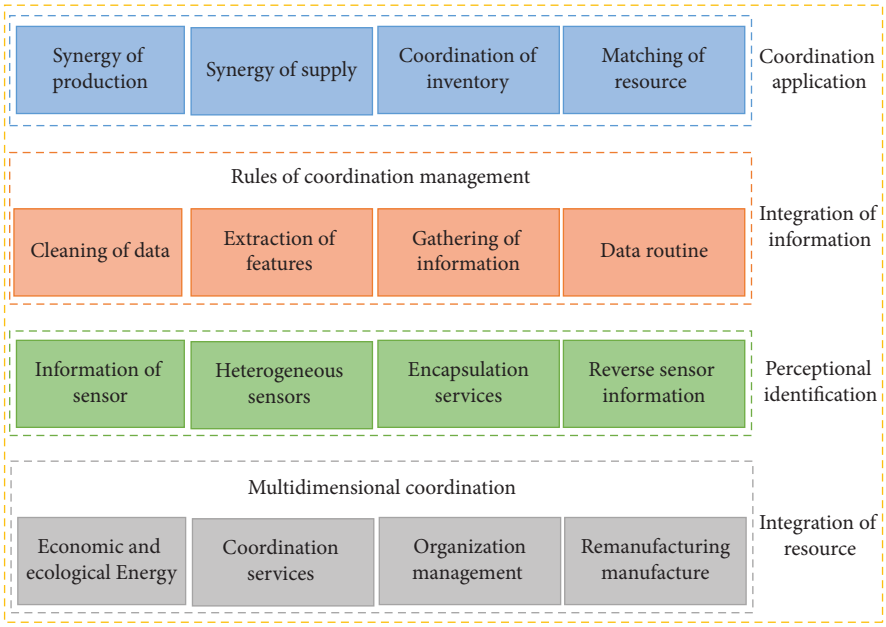

Figure 1: Design based on the three-layer IoT architecture.

physical production resources. Furthermore, real-time and reliable information collection for remanufacturing data coordination may be accomplished.

In addition to the above, control and data information can be exchanged bidirectionally and dynamically. Data incorporation is built on cloud computing, including cloud services, virtual machines, and database information retrieval skills for examining different database provisions via mass information storing, comparable computation and mining, comprehensive smart enormous data computation, and the incorporation of multisensor heterogeneous sensory processing data. It satisfies the need for comprehensive environmental coordination and financial organization data. A request facility is created on a service-oriented design, which is achieved through cloud technology, big data, and fuzzy recognition of intelligent computer technologies, including developing multidimensional ecological financial key connections and varied industry demands of the application program service platform. The use of various modular functions, as well as the coordinated administration of multidimensional ecological economical information, allows for rapid and predictable deployment and development.

3.2. Economical and Ecological Environment Evaluation System

3.2.1. Data Sources. The data required for this study are mainly from the Henan statistical yearbook, China Environmental Statistical Yearbook, China Statistical Yearbook, and Henan statistical bulletin of national financial and social growth from 2010 to 2019 [16, 17].

3.2.2. Building the Index System. This study chooses three functional groups of ecological foundation, ecological pressure, and ecological response to describe the objective *(X)* of the rural ecological environment in Luoyang; Three functional groups, rural economic benefits, farmers' quality of life, and the current situation of agricultural development, are selected to describe the rural economic development goal *(Y)* of Luoyang.

By discussing the current research outcomes, together with the current situation of rural financial growth in Luoyang and the opinions of industry experts [18, 19], this article studies and selects 22 indicators to build an assessment index scheme for the coordinated growth of rural financial growth and environmental situation conflict in Luoyang. The specific index system is shown in Tables 1 and 2. The data in the tables are the standardized data obtained from the original data after the range method is used [20, 21]. Among them, the index weight value is mainly calculated by the improved entropy method, which can effectively reflect the index information entropy utility value [22].

4. Construction of a Conflict Model between Rural Economic Development and the Ecological Environment

Figure 2 illustrates a complete cooperative architecture of multidimensional economy and the environment in the IoT environment. The purpose of this model is to accomplish intensive and lean management of the multidimensional economy and environment.

As per the abovementioned figure, a business procedure is primarily the sequencing from the design and planning stages to the subsequent updated phase in time, and its foundation is the method of the control scheme and execution throughout the project's life cycle. The closed-loop monitoring of the entire process is an important component of lean implementation since it optimizes and improves the

Table 1: Benefit index of rural economic development in Luoyang.

Element layer	Index layer	Code	Information entropy	Weight	Forward
Rural economic benefits (Y_A)	Proportion of agricultural GDP in GDP (%)	y_1	0.981	0.063	Forward
	Labor productivity (Yuan/person)	y_2	0.980	0.089	Forward
	Grain per capita (kg/person)	y_3	0.978	0.055	Forward
	Per capita share of livestock products (kg)	y_4	0.978	0.032	Forward
Farmers' living standards (Y_B)	Per capita net income of farmers (Yuan)	y_5	0.985	0.077	Forward
	Engel coefficient of farmers (%)	y_6	0.979	0.121	Negative direction
	Number of health centers owned by farmers per 1000 people	y_7	0.990	0.156	Forward
Current situation of agricultural development (Y_C)	Cultivated land area per capita (hm^2/person)	y_8	0.983	0.122	Forward
	Total momentum of agricultural machinery (kw)	y_9	0.976	0.112	Forward
	Agricultural land productivity (Yuan/hm^2)	y_{10}	.0984	0.047	Forward
	Proportion of effective irrigation area (%)	y_{11}	0.985	0.127	Forward

Table 2: Benefit index of the rural ecological environment in Luoyang.

Element layer	Index layer	Code	Information entropy	Weight	Forward
Ecological basis (X_A)	Forest coverage (%)	x_1	0.989	0.093	Forward
	Water resources per capita (m^3)	x_2	0.984	0.099	Forward
	Annual average concentration of SO_2 in the atmosphere (%)	x_3	0.990	0.108	Negative direction
	Proportion of sections meeting the specified water quality category in the total monitoring (%)	x_4	0.994	0.109	Forward
Ecological pressure (X_b)	Use of agricultural chemical fertilizer (T)	x_5	0.986	0.078	Negative direction
	Pesticide usage (T)	x_6	0.979	0.103	Negative direction
	Usage of mulching film (T)	x_7	0.973	0.050	Negative direction
Ecological response (X_C)	Population growth rate (%)	x_8	0.979	0.084	Forward
	Environmental protection investment (Yuan)	x_9	0.980	0.119	Forward
	Investment in water and soil loss control (Yuan)	x_{10}	0.992	0.082	Forward
	Afforestation area in that year hm^2	x_{11x}	0.978	0.075	Forward

existing business process. As a core component of asset cooperative management, business process cooperation must be thoroughly investigated and refined to enhance the existing business procedure and achieve fundamental cost, quality, and improved efficiency. The cooperative procedure system continues to optimize company processes collaboratively from the viewpoint of multidimensional environment economics, which uses this core activity as the principal line of operation. This work standardizes and coordinates substance organization from the supplier of the multidimensional ecological scheme to guarantee a seamless linking of business operations till the termination of the multidimensional environmental economic system, and we enhance the backward multidimensional ecological coordination planning and claim development top organization commercial relationships and transmission of information.

4.1. Luoyang Rural Economic Development Benefit and Ecological Environment Benefit Index. Suppose $x_1, x_2, \ldots, x_{11}$ and $y_1, y_2, \ldots, y_{11}$ are used to describe Luoyang rural economic development benefit index and Luoyang rural ecological environment benefit index, respectively, and the functional relationship between the two can be expressed as

$$\left\{ f(x) = \sum_{i=1}^{n} w_i x_i', f(y) = \sum_{j=1}^{n} w_j y_i'. \right. \quad (1)$$

In the abovementioned equation, $f(x)$ and $f(y)$ represent the Luoyang rural economic development benefit index and ecological environment benefit index, respectively. On the other hand, w_i and w_j, respectively, represent the weight of rural economic development benefit indicators and ecological environment benefit indicators in Luoyang. In addition, x_i' and y_i', respectively, represent the index values after standardization; n refers to the number of indicators. i and j correspond to various indicators of rural financial development benefits and ecological situation benefits in Luoyang correspondingly.

4.2. Index Correlation Analysis. The correlation investigation is a statistical device used to regulate whether or not there is a connection between two different factors and the

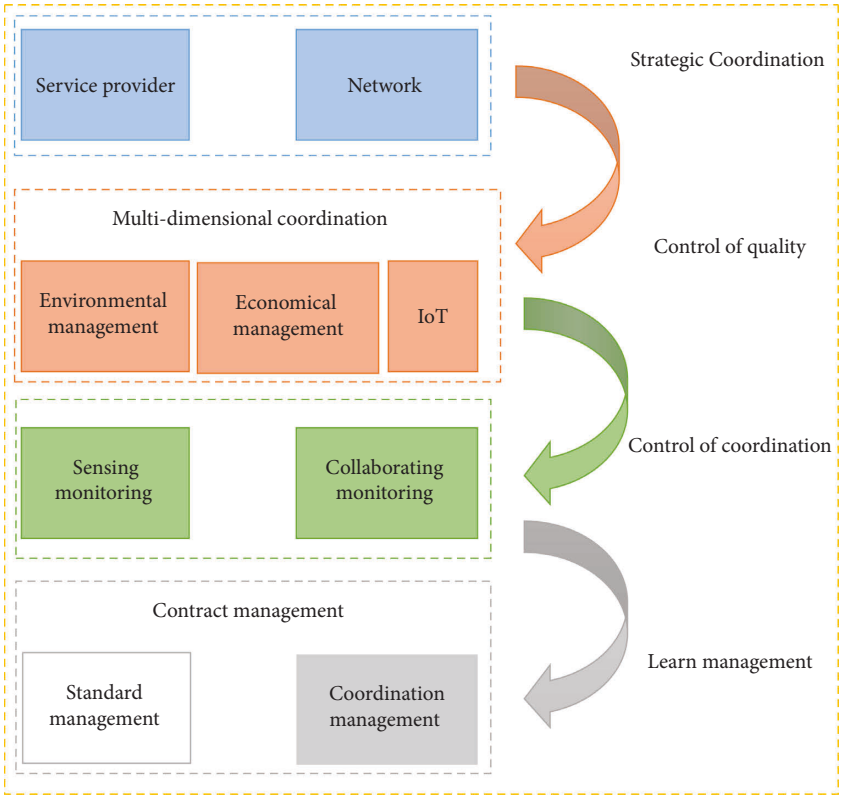

Figure 2: Multidimensional coordination model of rural economic development and the ecological environment.

strength of that association. A Pearson correlation analysis of the previously computed Luoyang rural economic development benefit index $f(x)$ and ecological environment benefit index $f(y)$ is essential to regulate if the evaluation of the coordinated development degree of the conflict between the two is worthwhile [23]. If the Pearson correlation number between the two is larger than 0.6, it suggests that assessing the coordinated growth degree of Luoyang rural financial growth and environmental conflict is worthwhile. The specific calculation formula is given as

$$r = \frac{\sum_{i=1}^{n}\left[f(x_u) - f(\overline{x})\right] \times \left[f(y_u) - f(\overline{y})\right]}{\sqrt{\sum_{i=1}^{n}\left[f(x_u) - f(\overline{x})\right]^2 \times \left[f(y_u) - f(\overline{y})\right]^2}}. \quad (2)$$

In the abovementioned equation, u represents the specific year and r represents the Pearson correlation coefficient. The closer the absolute value of r is to 1, the stronger is the correlation between $f(x)$ and $f(y)$.

Using spss22.0 software to carry out Pearson correlation analysis on the sequence values of $f(x)$ and $f(y)$ calculated above, $r = 0.872$ can be obtained, which shows that there is a positive correlation between Luoyang rural economic development benefit index $f(x)$ and ecological environment benefit index $f(y)$.

4.3. Coordinated Development Degree Model. SPSS analyses data for qualitative and multivariate analysis statistics, numerical result forecasts, and grouping identification predictions. Data transformation, charting, and direct marketing capabilities are all included in the product. In its overall form, the software system shows open data analogous to a spreadsheet. The degree of coordinated development, also known as the coefficient of coordinated development, is used to quantitatively describe the degree of coordinated development between two or more systems. As shown in Figure 3, the coupling mechanism between rural financial growth and the ecological environment in Luoyang is given. This study uses this model to judge the degree of coordination between rural economic development and the

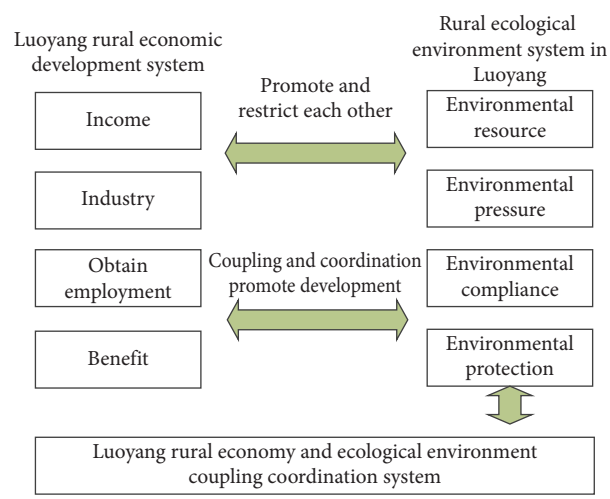

Figure 3: Coupling mechanism between rural economic development and the ecological environment in Luoyang.

Table 3: Criteria for judging the degree of coordination between rural economic development and ecological environmental conflict in Luoyang.

Numerical value	Degree of coordinated growth	Numerical value	Degree of synchronized growth
0 to.09	Risky illness	0.50 to 0.59	Unwillingly manage
0.10 to 0.19	Severe illness	0.60 to 0.69	Key organization
0.20 to 0.29	Moderate illness	0.70 to 0.79	Middle organization
0.30 to 0.39	Mild illness	0.80 to 0.89	Decent organization
0.40 to 0.49	Edge of disorder	0.90 to 1.00	High-excellence organization

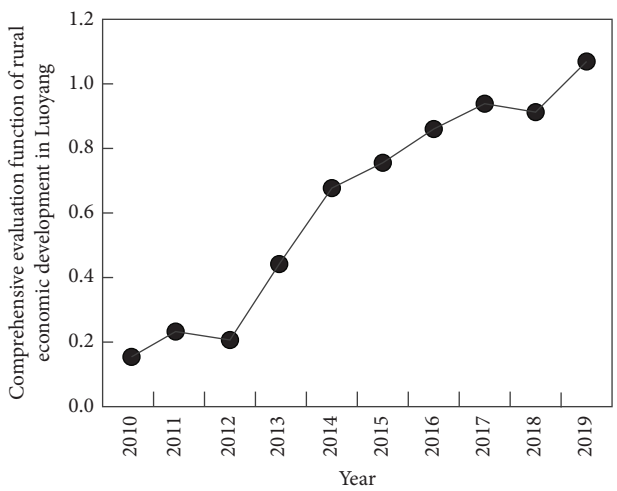

Figure 4: Comprehensive evaluation results of rural financial development in Luoyang.

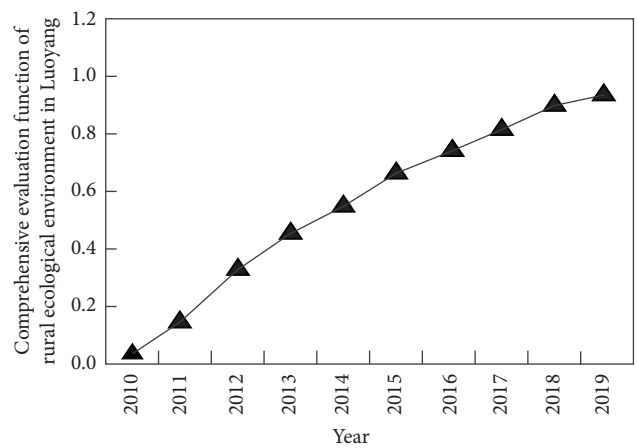

Figure 5: Comprehensive evaluation results of the rural environmental situation in Luoyang.

ecological environment in Luoyang. The specific calculation formula is given as

$$D = T^{(1/2)} \left\{ \frac{4f(x)f(y)}{f(x) + f(y)} \right\}^{(k/2)}. \quad (3)$$

In the abovementioned equation, k represents the adjustment coefficient, assuming $k = 2$, and T refers to the comprehensive assessment index of rural financial growth benefits and ecological environmental benefits in Luoyang. Similarly, $D \in [0, 1]$, and the closer the value of D is to 1, the better the coordination degree is. On the contrary, the closer the value of D is to 0, the worse the coordination degree is.

According to the abovementioned calculation, based on the existing research results, the judgment criteria for the coordination degree of rural economic development and ecological environmental conflict in Luoyang are set as shown in Table 3 [24].

5. Results and Analysis

5.1. Investigation on the Development Trend of Rural Economy and Environmental Situation in Luoyang. We choose the year as the abscissa based on the empirical analysis results. The comprehensive evaluation functions of Luoyang rural financial growth and Luoyang rural ecological environment are chosen as the ordinates. We draw the line chart as shown in Figures 4 and 5 to analyze the development and change trend of Luoyang's rural financial growth and ecological environment.

It can be seen from the abovementioned figures that the comprehensive evaluation function of the rural ecological environment in Luoyang has always shown an upward trend from 2010 to 2019, which shows that the development of the rural environmental situation in Luoyang is changing in a good way. In addition to a slight decline in 2012, the overall trend of the complete assessment function value of rural financial development in Luoyang is also gradually improving. Besides, the complete assessment function value of rural economic development in Luoyang is lower than the comprehensive evaluation function value of the environmental situation from 2011 to 2013. In addition, the complete assessment function value of economic development in other years is greater than the complete assessment function value of the ecological environment, which shows that the growth speed of the rural economy in Luoyang is gradually accelerating. Hence, this growth speed is quicker than the defense of the ecological situation. In the ten years from 2010 to 2019, the complete assessment index value of the rural ecological situation and the complete assessment function value of economic development in Luoyang increased from 0.025 to 0.965 and from 0.188 to 1.098, respectively. The growth rates of both were very large, but the comprehensive evaluation function value of rural economic development in Luoyang decreased in 2012 and 2018, respectively. The fluctuation range before beginning the 2012 reduction was significant, whereas the fluctuation

range before and following the 2018 decrease was insignificant. According to the abovementioned study, there are two inflection points in the complete evaluation function value of Luoyang rural economic development from 2010 to 2019, and the growth pattern is slightly complex. Since 2012, the comprehensive evaluation function value of Luoyang rural economic development has always been greater than the comprehensive evaluation function value of ecological development. The development trend of the comprehensive evaluation function value of the rural ecological environment in Luoyang is always rising.

5.2. Investigation of the Indicators That Have the Greatest Impact on the Results of Empirical Analysis. From the perspective of the index weight of Luoyang rural economic development benefit and ecological environment benefit, the principal component analysis method is used to weight each index in the abovementioned Luoyang rural economic development benefit index system and ecological environment benefit index system, and the results shown in Tables 1 and 2 can be obtained. It can be seen from these tables that in the Luoyang rural ecological environment function group, the weight value of environmental protection investment is the largest, which is 0.119. After that, the section meets the specified water quality category, accounting for the total monitoring proportion, and the weight value is 0.109. It shows that the ecological environment benefit index of environmental protection investment has the greatest impact on the empirical analysis results. In addition, the section meets the specified water quality category, accounting for the total monitoring proportion. The index with the smallest weight is the use of plastic film, which is 0.050. The index with a slightly higher weight than the use of plastic film is the proportion of effective irrigation area, which is 0.075. It shows that the use of plastic film, an eco-environmental benefit index, has the least impact on the empirical analysis results, followed by the proportion of effective irrigation area.

In Luoyang's rural economic development functional group, the number of health centers owned by thousands of rural residents is the index with the largest weight, with a weight of 0.990, followed by the proportion of rural residents per capita net income and effective irrigation area, with a weight of 0.985, agricultural land productivity, per capita cultivated land area, and the proportion of agricultural GDP. The weight values are close, with 0.984, 0.983, and 0.981, respectively. This shows that the index of the number of health centers owned by rural residents per thousand has the greatest impact on the results of the empirical analysis. Of course, the two indicators of rural occupiers' per capita net income and the proportion of effective irrigation area also have a great impact on the results of the empirical analysis. The index with the lowest weight value is the total power of agricultural machinery, which is 0.975, indicating that this index has the least impact on the results of empirical analysis. This shows that in the future, China should emphasize environmental protection investment.

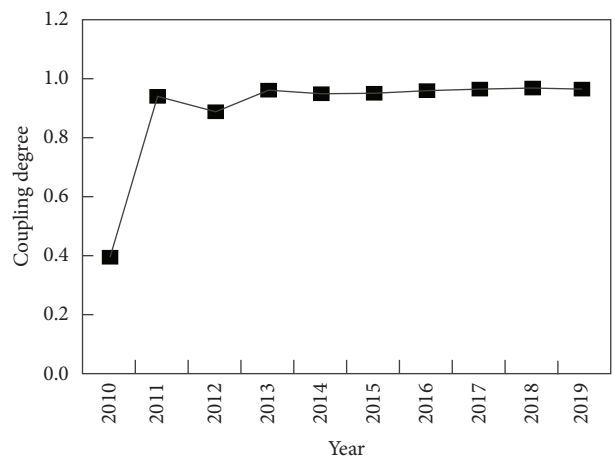

Figure 6: Evaluation of the coupling degree between rural economic development and the ecological environment in Luoyang.

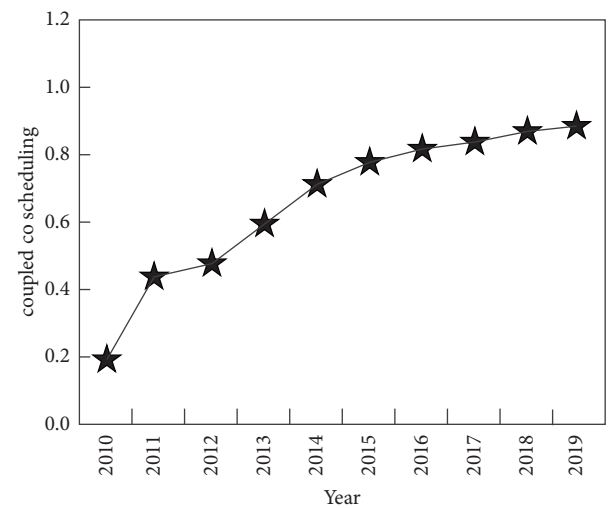

Figure 7: Evaluation of the coupling coordination degree between rural economic development and the ecological environment in Luoyang.

5.3. Evaluation of the Degree of Coordinated Development between Rural Economic Development and the Ecological Environment in Luoyang. Based on the analysis of the coordinated development degree and division standard of rural financial growth and the ecological environment in Luoyang, as shown in Figures 6 and 7, the coupling degree of the two and the broken line diagram of the calculation results of the coupling coordination degree are given, respectively.

As can be seen from Figure 6, the coupling degree between rural economic development and the ecological environment in Luoyang as a whole showed an upward and downward trend, then increased and decreased, and finally, stabilized. From 2010 to 2013, the coupling degree between the two fluctuated between 0.385 and 1.000, and the floating range was relatively large. Between 2013 and 2019, the fluctuation range of the coupling degree of the two was very small, almost a straight line, and the coupling degree value of the two was relatively high in other years, floating around

0.9, except in 2010, when the coupling degree of the two was 0.385. However, the relatively high degree of coupling between rural economic development and the ecological environment in Luoyang can only indicate that there is a coordinated relationship between the two and cannot accurately describe the degree of coordination between the two.

As can be seen from Figure 7, the degree of coupling and coordination between rural economic development and the ecological environment in Luoyang has always been on the rise, and the floating range is relatively large. According to the comparison standard mentioned above, the coupling coordination degree of rural economic development and the ecological environment in Luoyang has experienced four stages in the decade 2010–2019, including a mild imbalance in 2010, primary coordination in 2011–2012, good coordination in 2013–2014, and high-quality coordinated development in 2015–2019. This displays that with the incessant growth of the rural economy in Luoyang, the interaction between the ecological environment and economic development is deepening. The degree of coupling and coordination between the two is also increasing. Among them, the results of the coupling coordination degree from 2011 to 2012 and 2015 to 2019 show the ecological lag type, which shows that the development of the rural economy in Luoyang has caused a certain degree of damage to the ecological environment, which is the rapid economic development at the expense of the ecological environment. The result of the coupling coordination degree from 2012 to 2013 shows that the economy lags, indicating that the rural economy in Luoyang at this stage has a relatively low level of development and a slow development speed, which may be related to the imperfection of relevant laws and regulations and the weak awareness of residents on ecological environmental protection.

6. Conclusion

The Internet of Things (IoT) is emerging to impact every aspect of operation in all major sectors. The use of IoT technology and massive industrial machinery fosters the development of a new economy. The industrial IoT allows machines to connect with humans. It enhances the security, safety, and effectiveness of the system. These days, the IoT has the capacity to considerably improve economic effects such as coordinated economic growth and ecological environmental conflict. However, these have become a key issue of concern all over the world. In addition, it is also the top priority for China to implement the national policy of sustainable development strategy. Many scholars at home and abroad have carried out a lot of research and exploration in this area, and the evaluation methods are becoming more and more diverse and have made some achievements. Based on the previous research results, this study evaluates and empirically analyzes the coordinated development level of rural economy and ecological environment conflict in Luoyang from 2010 to 2019 in Henan Province using the IoT. The empirical analysis results show that the comprehensive evaluation function value of rural ecological environmental benefits in Luoyang shows an upward trend from 2010 to 2019, indicating that the overall development trend of the ecological environment is good. Although there are two fluctuations in the comprehensive evaluation function value of rural economic development in Luoyang, the overall situation is also gradually getting better. In the Luoyang rural economic development functional group, the number of health centers owned by rural residents per thousand is the index with the largest weight, with a weight of 0.990, followed by the proportion of rural residents per capita net income and effective irrigation area, with a weight of 0.985. In the future, China should focus on these indicators with greater weight. The degree of coupling coordination between the two has constantly been increasing, and the floating range is rather vast, ranging from a slight imbalance in 2010 to main coordination in 2011–2012, strong coordination in 2013–2014, and ultimately high-quality coordination in 2015–2019. This completely demonstrates that the coordination of rural economic growth and ecological environmental conflict in Luoyang has increasingly improved, as has the coordination of development between the two.

Data Availability

Data are available on reasonable request from the author.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Research and Analysis on Japanese Teaching Mode of Online Education under Multimedia Network Environment

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Japanese is among the international languages in extreme demand in the modern education system. There is a technological revolution in language learning, with blended learning (BL) in the classroom and online resources offering the possibility of autonomous learning education. The advancement of Information Communication Technology (ICT) and the development of the Internet, predominantly the Web, has transformed the way students get curriculum materials in online environments. Teaching Japanese languages has experienced crucial changes with multimedia technologies aimed at simulating a native-speaking environment in audition and oral communication. Evaluating student readiness for online learning is the beginning point for online course design using the multimedia network. Hence, this paper proposes the Multimedia Network-assisted Online Japanese Language Teaching Method (MN-OJLTM) to enhance student engagement in the online learning environment. This study identifies probabilities for better incorporation of technology and Japanese language learning and learners' interest and desires via tactical education of Japanese online courses. This paper examines the role and influence of an intelligent learning environment of ICT multimedia in Japanese education. Experimental outcomes show that the suggested MN-OJLTM method enhances the accuracy of usage and Japanese language students' fluency and expression in writing and speaking. The simulation outcomes demonstrate that the proposed MN-OJLTM method improves student learning ability ratio by 98.4%, language fluency level by 96.2%, performance ratio by 97.5%, student engagement ratio by 95.6%, and efficiency ratio by 97.9% compared to other popular methods.

1. Introduction to Japanese Language Teaching and Learning through Online and Multimedia Networks

Learning a second language has become more important in today's globalized world, as graduates who are adept at functioning in multicultural or international situations are in high demand [1]. Over a 140 million people in Japan speak Japanese, a natural second language for Chinese and Korean speakers. Although China and India, two of Japan's closest neighbors, have developed faster. Even after China, Japan is the world's second-largest economy [2]. Innovation in Japanese language education is needed to meet the demands of today's Internet generation, in line with the advancement of Information Communication and Technology (ICT) [3]. The Digital generation is a social generation that actively interacts, collaborates, and connects using technology in the virtual world [4]. The trend in higher education institutions is to gradually familiarize more online course modules with courses within all programs [5]. Through the comprehensive application of network technology, computer technology, information technology, big data technology, multimedia technology, virtual reality technology, etc., foreign language professional knowledge will be accurately pushed through the online form to college students based on their curriculum planning and learning needs [6]. This can help realize the rational use of foreign language learning resources, fully mobilize the interest and enthusiasm of foreign language majors in autonomous learning, enhance self-learning ability, and improve the learning effects and quality [7].

Cognitive learning theory impacts students because understanding their thought processes can help them learn. Cognitivism identifies that not all students have a similar level of cognitive abilities. Consequently, not all distance learners will progress at a similar level. Therefore, electronic learning course designers must permit individual students to sequence learning content based on how they feel fits their requirements [8]. In recent years, the Japanese teaching model based on online learning has attracted the attention of many researchers. Japanese college teachers have not fully implemented online learning due to the lack of support from intelligent technology and the poor decision-making of college management [9]. Online learning of minority languages such as Japanese requires comprehensive knowledge transfer in terms of listening, speaking, reading, writing, translating, etc. [10]. It relies only on existing multimedia technology or network applet technology, which can no longer meet the online learning needs of Japanese majors [11]. Thus, it urgently needs support in the existing technical conditions, continuously increasing the introduction and in-depth application of advanced intelligent technology, and improving the technical support means and the ability for Japanese online learning in colleges [12].

Most students' interest and excitement for learning Japanese have been inspired recently by multimedia teaching technology, an Internet-based teaching approach that has improved the theoretical foundation and practical effects of language practice for college students [13–15]. The quick expansion of multimedia technology delivers more systematic, theoretical management channels and material provision basis for college Japanese and can optimize classroom structure's energy efficiency and enhance the overall teaching quality standard [16]. The training techniques for superior Japanese skills are becoming more conservative, and the teaching impact is decreasing [17]. However, multimedia technology is essential in Japanese education [18]. Comprehensive issues with multimedia auxiliary equipment application and overall progress in Japanese applied teaching levels are now a vital tie among educational institutions [19]. Therefore, it has become an essential part of Japanese professional knowledge in teaching how to obtain adequate and reasonable professional knowledge in this massive Japanese knowledge base [20]. It is based on various digital technologies, meets multiple learning needs, and ultimately promotes learning [21]. The features of this learning model include, first, rich and diverse learning content consisting of digits integrated by multimedia technology; second, some scenes in the learning process are entirely virtual, and learners can complete the study in a virtual environment; and third, the participants in the entire learning model include learners, teachers, and experts of related areas, which form the learning community [22].

The main contribution of the research is as follows:

(i) Introducing computer-assisted multimedia teaching technology in Japanese online education.

(ii) Designing the multimedia network-assisted online Japanese language teaching method (MN-OJLTM) to enhance student engagement in the online learning environment.

(iii) The experimental outcomes have been implemented, and the recommended MN-OJLTM method enhances student engagement, student learning ratio accuracy, and student fluency compared to other existing methods.

Section 2 discusses the related study on Japanese teaching, and Section 3 proposes the MN-OJLTM method for Japanese online education. In Section 4, experimental outcomes have been performed. Section 5 concludes the research article.

2. Related Study

Udjaja [23] suggested the gamification-assisted language learning (GALL) technique for the Japanese language utilizing Expert Point Cloud Recognizer. Using this strategy, students (players) can engage their sensory and motor nerve systems, encouraging them to study more. The fact that players' abilities went from 20% to 100% is proof of this. Role-playing learning to write Japanese may be made easier by playing a role-playing game with a combat system that uses both turn-based strategy and active time battle (ATB). Many factors increase a person's ability, and each individual has a unique set of talents. The more a person studies, the more science they can retain. One of the most important qualities of a great game is that its participants enjoy themselves while learning about science.

Asadchykh and Dybska [24] proposed the blended learning methods (BLM) for oral Japanese language teaching. This study selected four basic models of blended learning (BL) for teaching spoken Japanese: face-to-face driver, activities rotation model for second-year students, working space rotation model for third-year students, and flipped classroom model for fourth-year pupils. Students who study on their schedules or are required to catch up on specific material use the flex model, the online lab model, and the self-blend model as auxiliary models in the experiment. The self-blend model was designed to help learners who are already independent users and working to manage their own time and study independently.

Abrahim et al. [25] discussed the online social networking sites (OSNS) for analyzing Japanese learners' perceptions and attitudes toward Facebook. This paper examines whether Japanese learners consider Facebook an efficient online language-learning platform and whether this social learning method can enable learners to willingly learn English and gain experiences that aid them in better connecting with foreigners in English through social interaction. It was conducted with 88 students at the University of Toyama, Japan, to see what they thought of the efficacy of Facebook for online language study and how they felt about it. Students were chosen at random to complete a standardized questionnaire that was used to gather the data. Almost unanimously, the applicants believed that Facebook has tremendous potential for making English learning easier

and increasing their drive and self-confidence when communicating with their peers in the language via Facebook.

Miller et al. [26] recommended the content-based language teaching (CBLT) curriculum for an English for Academic Purposes (EAP) program at a Japanese university. The curriculum is designed to help learners prepare for 2 years of study at an English-speaking university. Backward design curriculum theory was merged with second language acquisition theory in an institutional environment where administrative directives and shifting learner and faculty demographics influenced how the project was implemented. The curriculum team did a requirements analysis using numerous data sources, realized the curriculum, and then showed an assessment based on different data sources. Faculty and curriculum designers were surprised by the needs analysis results, which contradicted their preconceptions. Similarly, students and teachers gave different assessments of the curriculum's efficacy, making it impossible to conclude its effectiveness.

Kew [27] deliberated the computer game-based student response systems (CGSRS) for Japanese learners' English language learning experience. The purpose of this article was to explore how integrating a collaborative learning strategy with Kahoot! The application affects the learning experiences of Japanese learners in an English language classroom. Japanese students' learning outcomes were examined using an experimental research technique using a Kahoot program. The research tools in this study were a student involvement observation form and a feedback form. The population of this study was 20 Japanese learners who enrolled in an English language course and contributed to this experiment.

Based on the survey, there are several challenges to existing methods such as gamification-assisted language learning (GALL), blended learning methods (BLM), online social networking sites (OSNS), content-based language teaching (CBLT), and computer game-based student response systems (CGSRS) in achieving high student engagement, student learning ratio, accuracy, and student fluency level. Hence, in this paper, the MN-OJLTM method has been proposed.

3. Multimedia Network-Assisted Online Japanese Language Teaching Method (MN-OJLTM)

With the advent of globalization, the number of people learning foreign languages is increasing. College Japanese is an integral part of foreign language majors in colleges, and Japanese language learning is conducted in the class by a native or nonnative teacher. One primary purpose of online learning Japanese for college students using the MN-OJLTM method is to obtain more abundant Japanese learning resources. In constructing a Japanese online learning system for college students, the teaching resources for online learning should be ensured in the aspects of different types, forms, levels, perspectives, etc. The rapid development of Internet technology has dramatically changed our learning model. In addition to the ordinary learning models, online learning has become an essential way for people to learn knowledge and is widely used in university education. The emergence of the online and multimedia-based learning model significantly changed the existing teaching model. This learning model is based on Internet technology and fully uses the external environment and changes in real time.

Figure 1 shows the proposed MN-OJLTM method. Based on an open-source platform, the MN-OJLTM method uses the open-source platform for architectural and secondary advancement. Utilizing wireless network communication, the MN-OJLTM method's entire architecture will be standardized and increase the development process efficiency. It is possible to separate the MN-OJLTM method into five distinct modules based on the hierarchical tree structure it utilizes: a module for representation, one for business logic, one for transfer, one for data service, and one for equipment. In computing, platform hardware is the actual hardware that makes up a computer and includes multimedia components like music, video, and photographs. The database serves as the realistic carrier for different logic programs.

The data collector could search and gather user history learning data, such as course data, web browsing data, user retrieval keywords, message information, exchange and interaction data, resource download records, result data, and other information to understand the user inclinations. Administrator administration, teacher management, and student management submodules may be separated into software modules to enhance the MN-OJLTM method's overall functionality. The administrator submodule manages multimedia Japanese online education. The key role is to maintain and administer the platform and the website to guarantee its stability and the growth of instructors' instructional engagement. When login into the multimedia Japanese online teaching using the browser for the first time, new users are required to submit their e-mail and other contact information, as well as role matching and authority division, based on the information supplied by users. Course management is a platform that allows administrators to create and remove platform function categories based on the actual Japanese teaching scenario itself.

In addition, the administrator can relocate, alter, or consequence new courses for every function, as well as the ability to restore and back up courses. One of the key functions of multimedia Japanese online teaching is the teacher management submodule, which instructors access. Providing instructors with different permission and function via the application is a main obligation of the design to facilitate educational activities. Using the multimedia network platform's features, this research may intensively design the Japanese teaching procedure and carry out successful interactive actions to meet the goal of teaching entertainingly. Students are another key user of the student management submodule of the multimedia Japanese online education. The student management submodule has been expanded to include new features that make it easier for students to navigate the network platform, such as the ability to pick course learning, interactive course activities, online

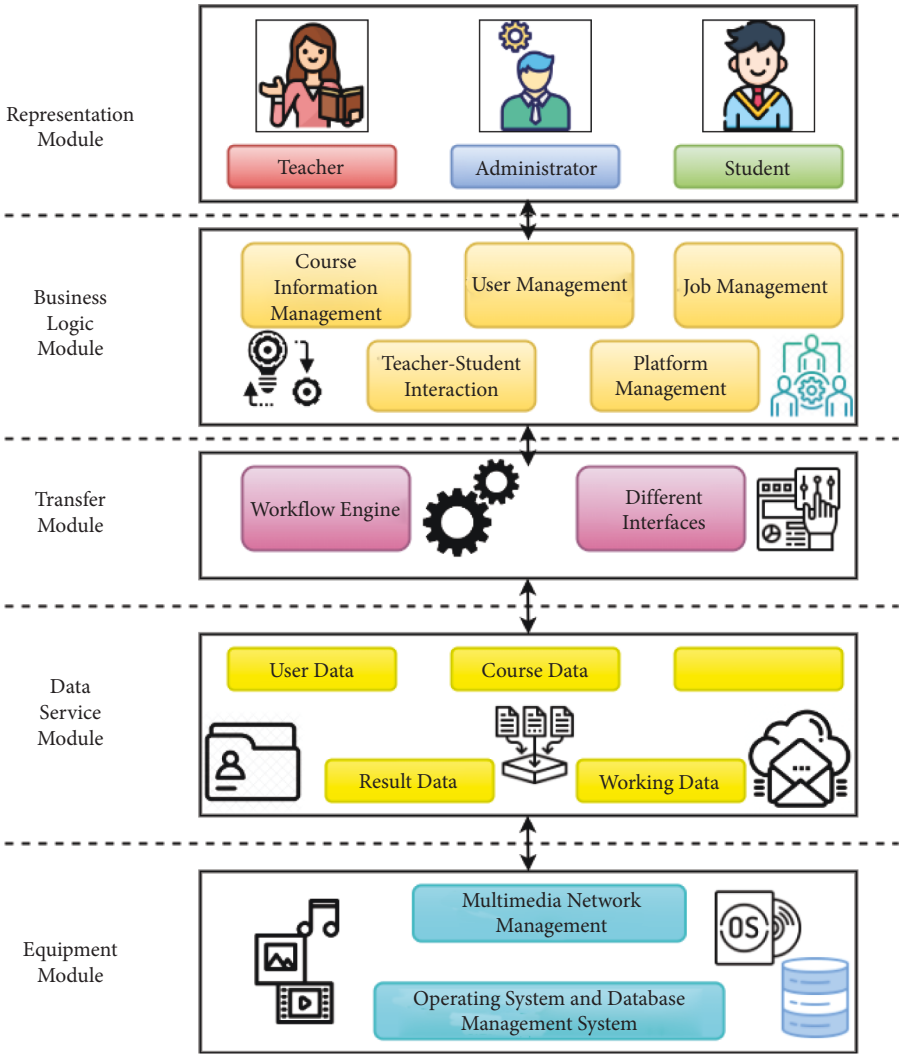

Figure 1: Proposed MN-OJLTM method.

exam responses, and personal data input. By teaching instruction in multimedia using a Japanese online teaching platform, students may debate relevant issues with instructors and other learners to carry out a series of interactive exercises that will help them enhance their learning abilities.

Figure 2 shows the important role of multimedia networks in Japanese teaching. Multimedia technology defines computer-based, interactive applications that permit people to communicate ideas and data with animations, video, audio, images, and digital print components. Students' learning foundation, accepting ability, and cognitive traits may be improved by increasing the overall quality of the students in this research. Students' potential and creativity may be efficiently simulated by multimedia networks, which can completely activate students' attention, passion, and determination. This research can potentially promote the development of students' personalities in a way that any other educational approach cannot match. A contemporary learning environment cannot be realized without a network resource. Students may develop clearer cognitive norms by connecting multilevel knowledge resources, communication, and multibranch organization. Using multimedia networks, students may more readily practice Japanese speaking, listening, reading, translation, writing, and other language abilities. Student learning occurs when they independently explore and discover new information while guided by knowledgeable instructors. Teaching is an intentional, well-thought-out, and well-executed endeavor to foster students' knowledge growth. Students' learning capacities may be cultivated by using multimedia networks.

To sum up, the complete method of multimedia Japanese online teaching is preliminarily intended to utilize wireless network communication. Every functional module is examined and intended in point based on this framework. A preparation decision-making objective is set as N_a, and expressions

$$N_a = X_y + P_w. \tag{1}$$

As shown in equation (1), where X_y denotes the influencing factor and P_w indicates the crucial data of X_y

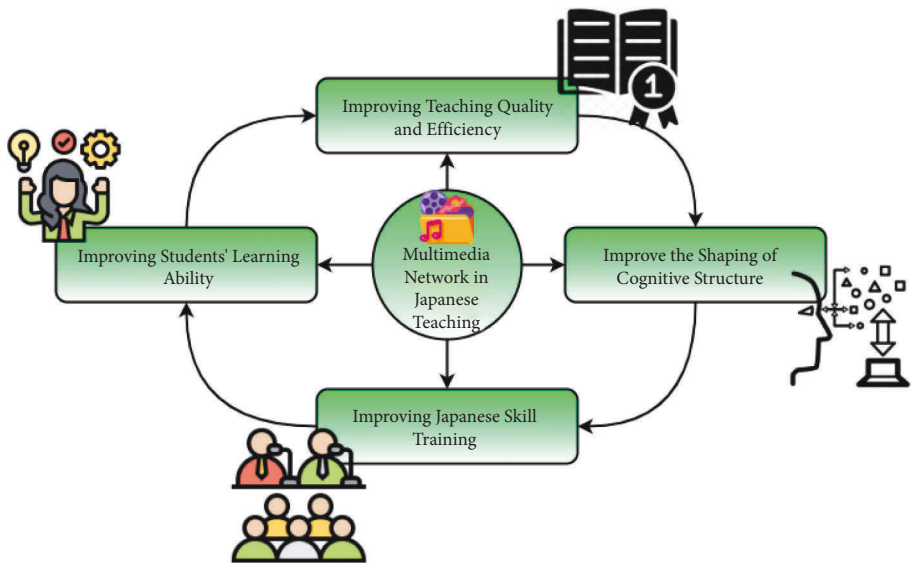

Figure 2: The important role of multimedia networks in Japanese teaching.

respective to the preparation goals. Owing to the variance in influence degree of impact factors on targets N_a, it is essential to associate the influence degree, and the comparison outcomes can be articulated by C matrices:

$$C = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ c_{n1} & c_{n2} & \cdots & c_{nn} \end{bmatrix}. \quad (2)$$

As inferred from equation (2), c_{nn} signifies the influence degree co-efficient in rows n and columns n. Let us assume that matrices C fulfil the consistency state, then the respective solution to the eigenvalue issue:

$$C' = c_{nn} \times R_v. \quad (3)$$

As discussed in equation (3), R_v denotes the fuzzy comprehensive assessment coefficient. The fuzzy comprehensive assessment technique is a statistical assessment technique. It creates a precise, objective, and practical multimedia Japanese online teaching assessment to resolve the issues in the teaching process efficiently. The comprehensive fuzzy assessment gives priority to gathering materials for the precise assessment of multimedia Japanese online teaching and identifying the primary grades and factors of appraisal; then, the weight distributions of the online teaching assessment index are identified by the analytic hierarchy process (AHP), and the fuzzy statistical model is developed. Supposing that the AHP is utilized to identify the weight, the assessment domain-level models:

$$B = (b_1, b_2, \ldots b_m). \quad (4)$$

As found in equation (4), $b_1, b_2, \ldots, b_m$ symbolize the assessment grade coefficient. The teaching quality assessment outcomes of diverse instructors are attained via assessment domain-level models, and the respective advancement measures are provided in time united with the assessment outcomes to guarantee the efficient development of the quality of the multimedia Japanese online teaching to comprehensive the design of the multimedia Japanese online teaching under the ICT.

To reflect the importance of the online learning ability evaluation index for Japanese learners in different colleges, this paper utilizes the analytic hierarchy process (AHP) method to obtain the weights of the Japanese online learning ability evaluation index. Experts in the field have been invited to evaluate and score the significance of the assessment index using the same metrics, thereby obtaining the initial judgment matrix A for the evaluation index:

$$A = \left[a_{ji}\right]_{m \times m}. \quad (5)$$

As shown in the above formula, a_{ji} denotes the importance of the evaluation index j relative to i, which is generally measured in the form of a 1:9 ratio, and satisfies $a_{ji} = 1/a_{ji}$; and m denotes the number of evaluation indexes.

To determine the maximum characteristic root $\lambda(A)$ of initial judgment matrices, the consistency index CI can be computed as in

$$CI = \frac{(\lambda(A) - m)}{m - 1}. \quad (6)$$

According to the number m of evaluation indicators, the relevant tables have been inquired to obtain the value of the consistency index. Then, the consistency ratio CR is computed as:

$$CR = \frac{CI}{CR}. \quad (7)$$

If satisfying $CR < 0.1$, it means that the initial judgment matrix A encounters the consistency requirement, and the weight wi of the evaluation index j for Japanese online

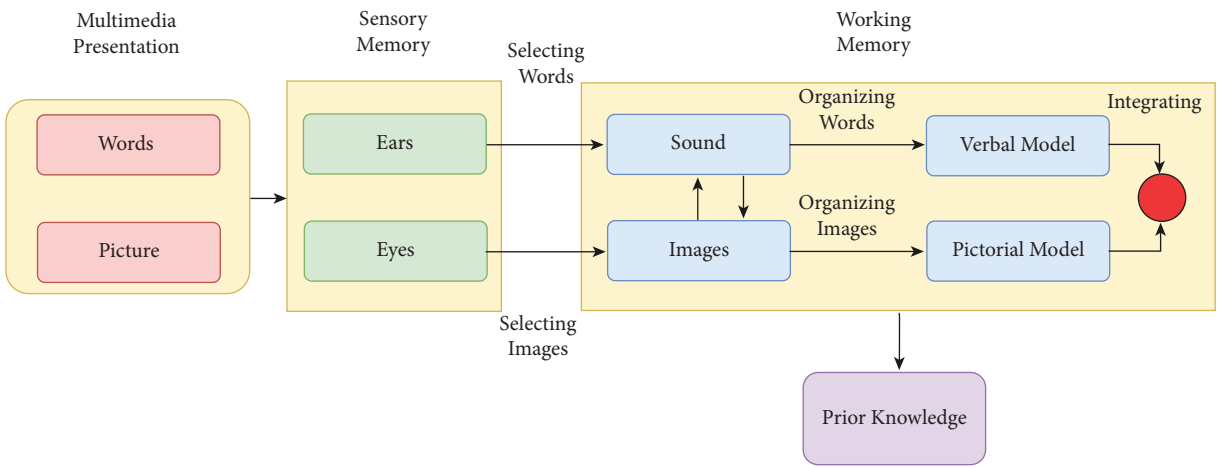

Figure 3: Cognitive theory of multimedia learning in Japanese language teaching.

learning ability among college students can be determined as in equation (8).

$$s_j = \frac{\sum_{i=1}^{m} a_{ji}}{\sum_{j=1}^{m} \sum_{i=1}^{m} a_{ji}}. \quad (8)$$

Thus, the weight sequence S of the evaluation index for all college students is given as:

$$S = \left[s_1, \ldots, s_j \ldots, s_m\right]. \quad (9)$$

As shown in equation (9), s_m denotes evaluation indicators.

Figure 3 shows the cognitive theory of multimedia learning in Japanese language teaching. Applying cognitive theory is the innovative utilization of multimedia technology to establish interaction components that support scenario-based training. These simple multimedia interactions support modern notions and unite with other interactive components to create more difficult integrated practical exercises in Japanese teaching. Japanese instructors utilize slides to aid students in learning and understanding Japanese vocabulary in class. Learners' attitudes and retention suffer due to the instructors' inexperience with modern forms of information and communication technology (ICT). Many instructors in the classroom utilized ICT and projected Japanese language terms. Students' attention will be diverted in one way or another by ICT. A lack of technical expertise among many instructors has prevented them from making the most of the benefits of acquiring the Japanese language. Using these instructional control slides does not add to student learning results since they do not consider multimedia's benefits. The cognitive theory of multimedia learning (CTML) uses temporal contiguity and multimedia principles. This approach aims to emphasize technology and shift away from the negative perception of Japanese as a boring language. Otherwise, it is vital to serve as a guide or valuable data for other Japanese curriculum instructors to review their teaching style while directing Japanese vocabulary sessions to enhance the quality of teaching. Learning in multimedia environments is based on five cognitive theories (CTML).

In the first step, the phonological loops, graphic, and spatial sketch are included in the presentation. When selecting words and images, sensory memory has a limited capacity. Thirdly, significant learning happens when appropriate data are gathered and processed into logical presentation structures. As a fourth step, the visual depiction in working memory and the verbal utterance are linked together. Narration and graphic images develop mental representations in words and pictures, which may be used in conjunction with past information to create new understandings.

Figure 4 shows the listening and speaking exercise model for Japanese teaching. While studying Japanese utilizing an existing computer and mobile application or platform, this study perceived their task performance and noted any problems teachers encountered. During the improvement stage, this study divided the method into a client side for the application on interactive devices and the server side for the backend information engine based on visions collected in the prerequisite analysis stage. According to user stories, this application's critical feature is transforming user speeches into part of learning interaction. Audio (student's speech) has been converted into texts by Text-To-Speech (TTS) that uses application programming interface (API) and vice versa. After gathering information, this research adopted expressive statistics to analyze the assessment outcomes of learning results through the database. Teachers navigate the quiz segment and get the score by responding to the question based on the learning material. Firebase authentication aims to make it simple for developers to create secure authentication systems while enhancing end customers' sign-in and onboarding experience. As a complete identification solution, it works with both e-mail and password accounts and phone verification.

Figure 5 shows the multimedia-enhanced instructional communication process. Teachers may utilize multimedia to convey knowledge in various ways, including voice, text, animation, video, and graphics. Using a variety of media enhances the learning experience and helps students remember what they have been taught longer. When teachers incorporate multimedia into their teaching process, the

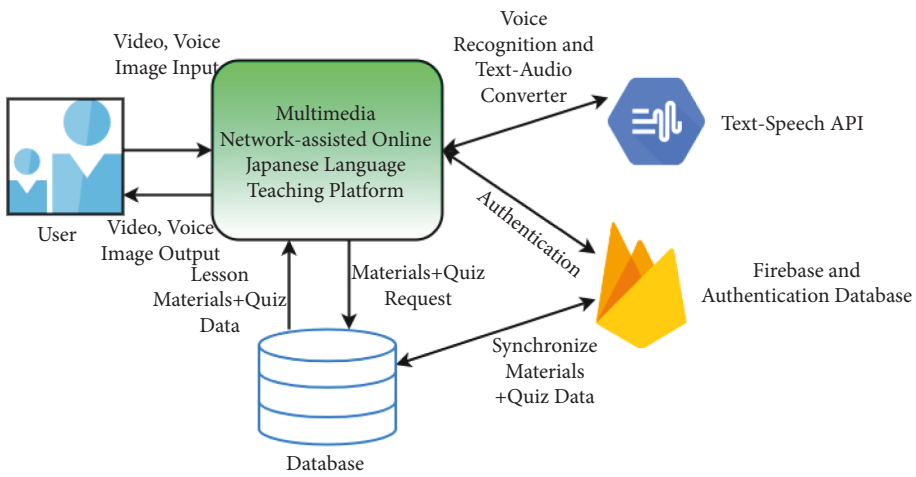

Figure 4: Listening and speaking exercise model for Japanese teaching.

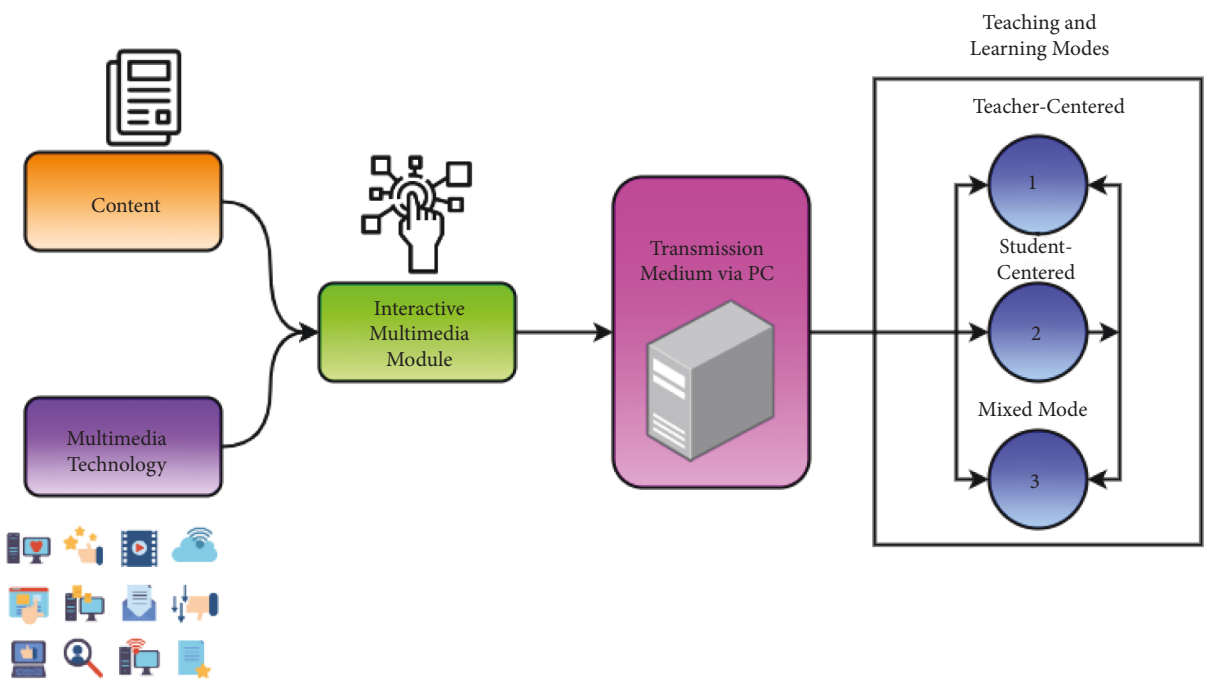

Figure 5: Multimedia-enhanced instructional communication process.

educational material and multimedia technology will be integrated into one. The combination of technology and content will generate multisensory multimedia content applications, visually difficult, and interactive. Many multimedia creation software programs simplify developing these kinds of interactive multimedia content. The conventional instructional communication process (ICP) is a paradigm that transfers data from the resource (or sender) to the receiver through a delivery or transmission medium to provide data. As a result, the final interactive content that is developed may be offered to the learner in different ways and made accessible for various teachings and learning modes, like student centered, teacher centered, and mixed modes. As a result, adding multimedia to the teaching and learning progression and delivery systems will help educational organizations meet the growing demands of the 21st century society. This paper presents the MN-OJLTM method for enhancing student engagement in Japanese online teaching. Computer-assisted multimedia teaching technology in Japanese online education has been introduced. The help of cognitive theory occupies a vital role in a student's overall development, as they include the brain's core functions like learning, thinking, retaining data, reading, and paying attention and are utilized to resolve problems, recollect tasks, and make a decision. Analytic hierarchy process has been employed for evaluating the student score in Japanese online learning using multimedia technology. The proposed MN-OJLTM method enhances the student learning ability, language fluency, performance ratio,

student engagement ratio, and efficiency ratio compared to other existing methods.

4. Experimental Outcome

This paper presents the MN-OJLTM method for enhancing student engagement in Japanese online teaching. This study used the dataset https://www.oecd.org/education/database.htm [28] to analyze the performance metrics of the proposed MN-OJLTM method. Online Education Database (OECD) developed a developing statistics dataset, including the indicators published in Education at a Glance. Values can be searched by year, country, and subject. Complementary to these datasets, trend indicator sequences are available. This online dataset may not always be equivalent because of changes in descriptions and coverage made due to meetings with OECD countries. In this dataset, everyone can access Education at Glance indicators. Furthermore, student learning ability, student language fluency, performance ratio, student engagement ratio, and efficiency ratio have been discussed in this section.

4.1. Student Learning Ability. The subsystem of multimedia learning management and its related functions of this proposed MN-OJLTM method is set for learners, which can achieve many personalized tasks for learners. Learners can choose the learning content and speed according to their needs and ability. Thus, the needs of different learners can be met, providing great convenience for the learners. The online learning resources of the Japanese language for college students are enriched from the professional, practical, theoretical, and other perspectives of college Japanese. For example, set up professional courses based on Japanese grammar and professional knowledge points; open practical courses or academic courses that better trigger students' interest in learning; and cultivate students' language practice ability or theoretical learning ability. The proposed MN-OJLTM method's learning ability can be identified using equation (2). The proposed MN-OJLTM method achieves high student learning ability by 98.4% compared to other existing models. Figure 6 shows the student learning ability ratio.

4.2. Student Language Fluency Level. This research proposes using listening and speaking exercises in the E-learning application of Japanese language learning to give learners a novel experience. The results of a small-scale study on E-learning students employing spoken input are included in this paper. Using speech recognition for speaking activities in an online Japanese language learning application has increased the effectiveness of multimedia interaction as a learning tool. This study aims to present the concept of communicative online learning to give users an intuitive speaking experience. Student language fluency level has been calculated using equation (3). The suggested MN-OJLTM method attains the student language fluency level by 96.2% compared to other existing methods. The student language fluency level is shown in Figure 7.

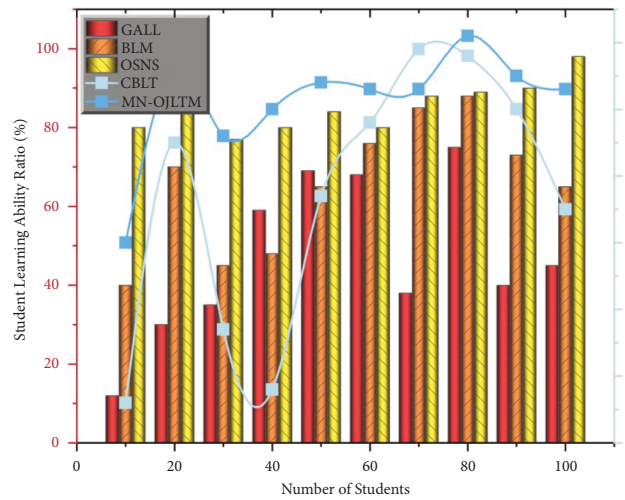

Figure 6: Student learning ability ratio.

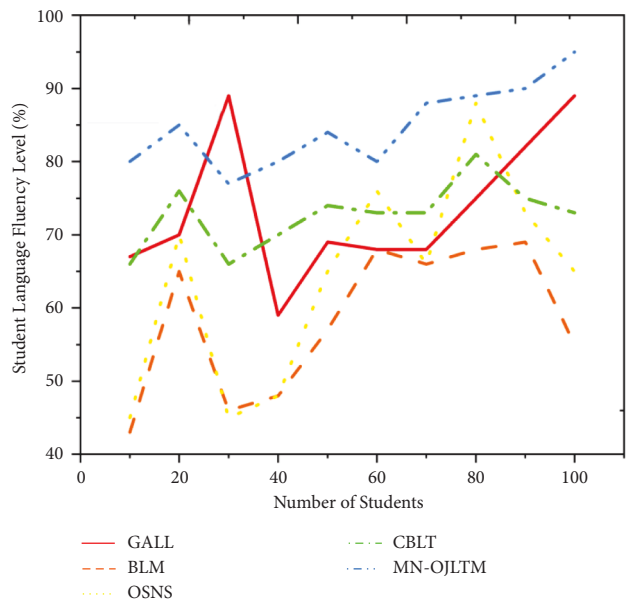

Figure 7: Student language fluency level.

4.3. Performance Ratio of MN-OJLTM Method. The problems existing in the online learning of Japanese among college students were discussed from different aspects, such as platform professionalism and practicality, online learning, resource planning, online learning management, and performance evaluation, and the impacts of these factors on the cultivation of Japanese learning ability were analyzed. New information technology allows offline and online hybrid teaching to be the education and teaching technique of the pandemic age, creating new opportunities for higher education reform in the next generation. The performance ratio has been calculated using equation (4). The suggested MN-OJLTM method achieves a high-performance ratio of 97.5% compared to other existing methods. Tests, quizzes, and graded Japanese course activities measure student performance. Figure 8 illustrates the performance ratio.

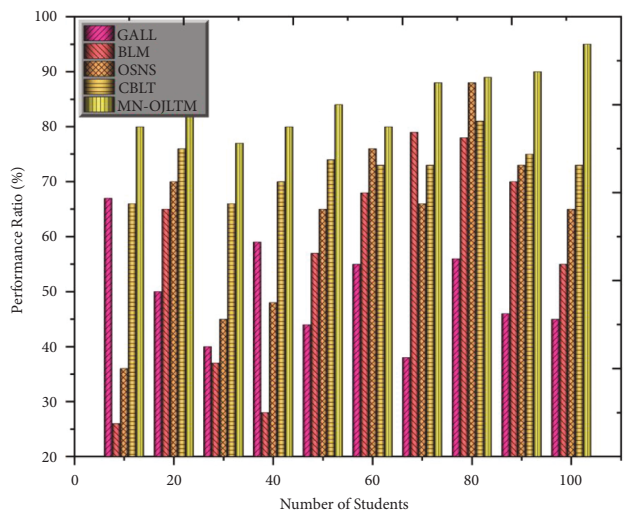

Figure 8: Performance ratio of MN-OJLTM method.

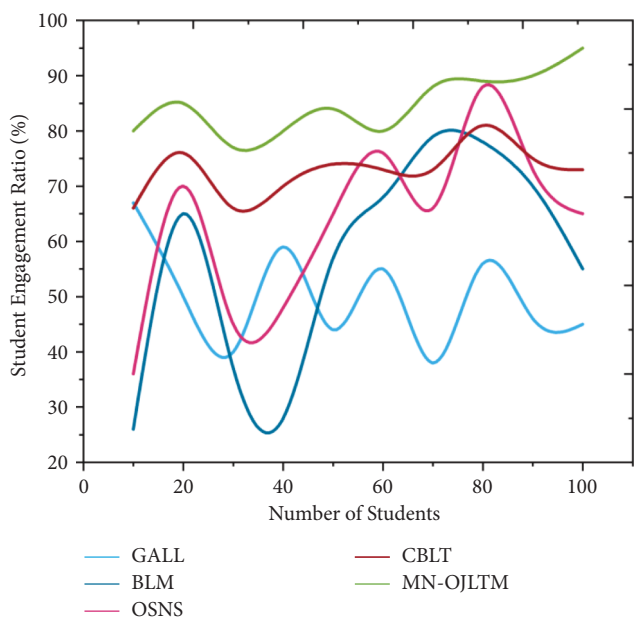

Figure 9: Student engagement ratio.

4.4. Student Engagement Ratio. An important aspect of a good supplemental online course was the development of a scholarly attitude to learning, participation in a learning community, and the online component that helped students proceed through the course. E-learning offers new ways to get students involved and more options than the more traditional teaching methods. It is possible to engage students and processes in E-learning by providing them with features like ease of use and accessibility and a lower overall cost. This research has shown that engaging learners in the online Japanese learning process improve their attention and focus, motivates them to promote meaningful learning experiences, and practice higher-level critical thinking skills. The engagement ratio has been calculated using equation (5). The suggested MN-OJLTM method achieves a high student engagement ratio of 95.6% compared to other existing approaches. Figure 9 signifies the student engagement ratio.

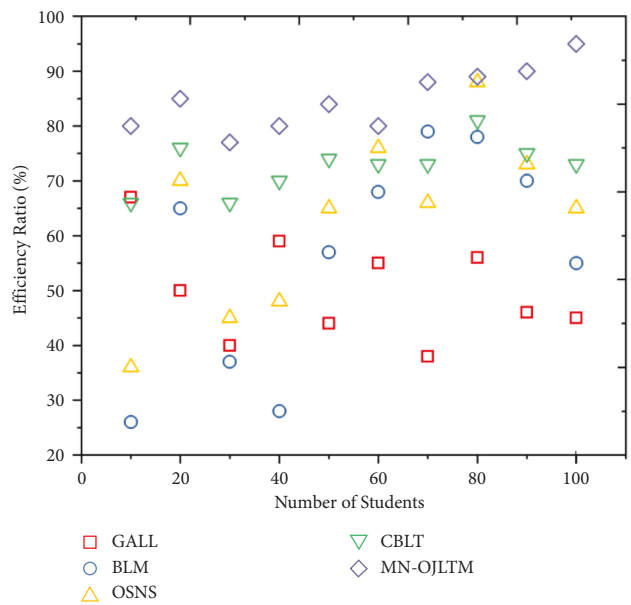

Figure 10: Efficiency ratio.

4.5. Efficiency Ratio of MN-OJLTM Method. Compared to conventional classroom teaching, multimedia technology may ultimately mobilize learners' listening, reading, speaking, and writing all-round senses of classroom experience and the effectiveness of data interaction. The fast advancement of multimedia technology offers a more systematic, theoretical, guiding channels and material aid base for university Japanese and may optimize the energy efficiency of classroom structures and enhance the total standard of teaching. In a classroom utilizing multimedia courseware, pupils can better listen and retain information since they are not distracted by taking notes or trying to copy it from the instructor. It evades other complex links and enhances learners' knowledge-sharing effectiveness. Equations (8) and (9) demonstrate the efficiency ratio of the suggested technique. The suggested MN-OJLTM method attains a high-efficiency ratio of 97.9% compared to other existing models. Figure 10 signifies the efficiency ratio.

The proposed MN-OJLTM method enhances the student learning ability, student language fluency, performance ratio, student engagement ratio, and efficiency ratio compared to other existing methods: gamification-assisted language learning (GALL), blended learning methods (BLM), online social networking sites (OSNS), content-based language teaching (CBLT), computer game-based student response systems (CGSRS).

5. Conclusion

This study presents the MN-OJLTM method to enhance student engagement in the online learning environment. Studying a foreign language has never improved, thanks to

the tremendous benefits of modern information and network technologies. New techniques of instruction may be derived from the material being taught. Teaching Japanese as a professional language requires a combination of technology and information resources that may be used to expand the understanding of Japanese language talents and improve the overall quality of Japanese language professionals. The prompt advancement of multimedia network technology has promoted rapid change in the Japanese language teaching model. Japanese language teaching should conform to the development of the online teaching model and fully use multimedia network technology's advantages, providing diverse, modernized, and personalized teaching services to learners to meet the necessities of the new era. The experimental outcomes demonstrate that the proposed MN-OJLTM method improves student learning ability ratio by 98.4%, language fluency level by 96.2%, performance ratio by 97.5%, student engagement ratio by 95.6%, and efficiency ratio by 97.9% compared to other popular methods. Several multimedia-teaching issues must be addressed immediately. For example, PPT-oriented Japanese class leads to information overlapping and time wastage due to the inappropriate design of courseware that stimulates attention and disruption. The evaluation result indicates that the MN-OJLTM is achievable for future mobile and online learning implementation with good learning result improvement compared to the traditional learning technique. Online open courses will become essential content of future education reforms.

Data Availability

The data of this study can be obtained from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Review Article

A Review of the Research on the Evaluation Metrics for Automatic Grammatical Error Correction System

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The evaluation of an automatic grammatical error correction system is an important content in the field of automatic grammatical error correction. This paper summarizes the technical routes of the four most representative evaluation metrics of the automatic grammatical error correction systems. Firstly, it introduces the characteristics and composition of each metric, then summarizes its defects, and finally puts forward some suggestions for the future development of the metrics. This paper holds that the application of natural language processing technology should be strengthened in the future development of evaluation metrics.

1. Introduction

Machine learning is the study of how to train computers to do tasks like speech recognition, data analysis, computer vision, and natural language processing [1]. Rule-based and machine learning-based methodologies are the two main approaches used in the design of contemporary linguistic experiments and the development of natural language processing systems. The approaches that use supervised learning, or those that are based on manually created training data for learning, get the best results in practical applications of machine learning (ML). A system built on a hybrid method should produce better outcomes, according to what can be termed a general rule for the combining of these two approaches [2].

For the creation of the grammar checking system, we use a new set of matching standards, which aims to identify the preposition usage problems of second language learners. An F-score of 40% and good precision were found in a modest study of this set of rules' performance [3].

Grammatical error correction (GEC) is an important task in the field of natural language processing (NLP) [4]. GEC research has primarily gone through three stages of development: initially, simple string matching and substitution; later, using rules for syntactic error analysis; and currently, using data-driven ways to extract features from the data, and using machine learning algorithms to build a model to detect and correct errors. The ways that based on machine learning have also experienced two stages of development, from the machine translation method based on statistics [5–7] to the most cutting-edge machine translation method based on the neural network [8–10]. The continuous development of GEC in the recent 20 years also drives the progress and improvement of its own evaluation metrics.

As automatic scoring technology for English composition has grown and developed, computer-aided composition marking systems based on this technology have started to appear in colleges and universities to help with the teaching of English writing. The system can translate the probability distribution of certain sentences or word sequences by creating a language model. The BP neural network, which is an adaptive learning model, provides additional advantages when addressing the link between complicated variables [11].

The creation of GEC systems is closely linked to the creation of its evaluation metrics. That's because with the continuous optimization of GEC system research methods, the traditional evaluation metrics cannot meet the needs of multidimensional analysis of GEC system results.

In this context, this paper will introduce and comment on the four most representative automatic grammatical error correction evaluation metrics: Max Match, I-measure, GLEU, and ERRANT.

2. Method

The following section describes method of current work.

2.1. Evaluation Metrics of GEC System. The incorrect and wrong sentence that was originally written is typically referred to as the source sentence in the evaluation index of grammatical error correction systems. The sentence that was manually marked and corrected is known as the reference sentence, and the sentence that was corrected by the grammatical error correction system is known as the hypothetical sentence. The manually marked and corrected sentences are the best template for evaluation, which are used to compare with the hypothetical sentences to evaluate the performance of the system.

2.2. Max Match. Max match, also known as M^2 [12], mainly evaluates the error correction effect of GEC system based on the phrase level edit lattice. The metric first calculates the editing lattice between the source sentence and the hypothetical sentence. The Levenshtein distance [13], which is based on many inserts, deletions, and replacements needed to change one string into another, is used as the basis for the calculation process. For example, to convert *kitten* into *sitting*, the conversion steps are as follows: *kitten (k ⟶ s), sittin (e ⟶ i), sitting (⟶ g)*, and the editing distance is 3. The above example is the calculation method of editing distance at the character level, while M^2 is mainly based on the calculation at the phrase level, that is, the minimum editing operation required to replace one phrase with another. M^2 matches the editing result of the error correction system with the editing between the source sentence and the reference sentence. The higher the coincidence degree, the better the result and the better the system performance.

The method of evaluating edit distance includes three measurement dimensions: P (precision), R (recall), and F. P is used to calculate the precision rate of error correction results, and R is used to calculate the recall rate, as shown in formulas (1) and (2).

$$P = \frac{\sum_{i=1}^{n} \left|\mathbf{e}_i \cap \mathbf{g}i\right|}{\sum_{i=1}^{n} \left|\mathbf{e}_i\right|}, \tag{1}$$

$$R = \frac{\sum_{i=1}^{n} \left|\mathbf{e}_i \cap \mathbf{g}_i\right|}{\sum_{i=1}^{n} \left|\mathbf{g}_i\right|}. \tag{2}$$

In the formula, e_i represents the editing set between the source sentence and the hypothetical sentence I; g_i is the optimal editing set between the source sentence and the reference sentence I; $|e_i \cap g_i|$ is the intersection of edits between e_i and g_i; $|e_i|$ is the number of edits in e_i; and $|g_i|$ is the number of edits in g_i. The value of the intersection of e_i and g_i is shown in formula (3):

$$\mathbf{e}_i \cap \mathbf{g}_i = \left\{e \in \mathbf{e}_i \mid \exists g \in \mathbf{g}_i \left(\text{match}\left(e, g\right)\right)\right\}. \tag{3}$$

Taking the sentence *Our baseline system feed into PB-SMT pipeline* as an example, if the manually modified set $g = \{\text{feed} \longrightarrow \text{feeds, feed} \longrightarrow \text{feed a word}\}$, the modified set $e = \{\text{feed} \longrightarrow \text{feeds}\}$, $|e_i \cap g_i|$ is 1, then the precision of the system is 100% and the recall rate is 50%.

In an ideal evaluation, both P and R values are expected to be as high as possible. But in practice, the precision rate and the recall rate are inconsistent under certain circumstances. Suppose that the optimal editing set $g = 10$, the modified set $e_1 = 5$, $|e_1 \cap g| = 3$ in system 1 and the modified set $e_2 = 8$, $|e_2 \cap g| = 4$ of system 2. Under these conditions, the P value of system 1 is 0.6, R value is 0.3, and system 2 has a P value of 0.5 and an R value of 0.4. The results show that the P value of system 1 is higher than that of system 2, but the R value is lower than that of system 2. Therefore, for the convenience of comparison, the F (F-measure or F-score) [14] is introduced to evaluate the P value and the R value as a whole. The F value is the weighted harmonic average of the P and R values, as shown in formula (4):

$$F_\alpha = \frac{\left(\alpha^2 + 1\right) \times P \times R}{\alpha^2 P + R}. \tag{4}$$

In the M^2 evaluation, the value of α is usually set to 1, and the calculation formula of F_1 is shown in formula (5).

$$F_1 = 2 \times \frac{P \times R}{P + R}. \tag{5}$$

Later, CoNLL-2014 shared mission [15] was introduced and M^2 was used as the official evaluation indicator for the mission evaluation. But because of the nature of the data set, the researchers changed the value of weight α from 1 to 0.5. Because in the shared task evaluation process, the task recognizes that the precision rate weighs more than the recall rate and thus gives it a higher weight, twice as much weight as before, and twice as much precision, $f_{0.5}$ as shown in formula (6).

$$F_{0.5} = \frac{\left(1 + 0.5^2\right) \times P \times R}{0.5^2 \times P + R}. \tag{6}$$

Currently, M^2 is the evaluation index most frequently used in the field of GEC, largely as a result of CoNLL-2014's shared task's promotion. This tool has evolved into the standard for figuring out the GEC system's precision and recall rate. There is a strong association between this evaluation metric and manual error correction [16].

2.3. I-Measure. The construction system of M^2, the official evaluation metric of the CoNLL-2014 shared tasks, has received high recognition but is still limited. Felice and Briscoe [17] believe that (1) relying only on the output results cannot define the difference between the baseline(unmodified system for comparison) system that "does nothing" and other systems that only propose wrong corrections, because their F values are all 0; (2) when multiple correction annotations are used on sentences, the performance of the system is underestimated because the metric automatically selects the maximum F value instead of mixing all the corrections to calculate the

output. As shown in Table 1, the error correction system provides two change schemes, but the system only chooses the combined output with the largest value of F; (3) partial matches are ignored in the evaluation, as shown in Table 2, where the system results are different from the reference sentence results but have an output, but the F value is 0; and (4) editing at the phrase level produces misleading results that often do not reflect effective improvements. As shown in Table 3, the first predicted improvement is significantly better than the second, but the F value is lower;

In light of the above shortcomings, Felice and Briscoe propose a new metric, *I-measure*. First of all, in view of the problem that M^2 underestimates the performance of GEC system under multiple annotations, a new annotation method is proposed, which provides different modification schemes based on the same error type. For example, the source sentence "*This machine is designed for help people.*" Firstly, the error types are defined. There are two kinds of errors in this sentence: SVA (subject-predicate agreement) and V-form (verb form). Then the different modification schemes are annotated under the error types as shown in Table 4. All the alternatives are mutually exclusive. It is because of mutual exclusion that the system can directly combine them to form all kinds of valid and correct sentences, and the problem of multiple annotations can be solved effectively. Secondly, by three-way alignments (source sentence, hypothetical sentence. and reference sentence), the matching of error detection and correction is calculated. After finding the best alignment of source sentence, hypothetical sentence, and reference sentence, the system will be evaluated.

Each word aligned after three-way alignment is classified as TP (true positive), TN (true negative), FP (false positive), and FN (false negative) under the WAS evaluation system [18] which is used in this study. Given that aligned words are represented as w^{src} (word in source sentence),w^{hyp} (word in hypothetical sentence), and w^{ref} (word in reference sentence) under source sentence, hypothesis sentence, and reference sentence, respectively, TP, TN, FP, and FN classifications are defined as follows:

TP:$w^{\text{src}} \neq w^{\text{ref}}$ and $w^{\text{hyp}} = w^{\text{ref}}$

TN:$w^{\text{src}} \neq w^{\text{hyp}} = w^{\text{ref}}$

FP:$w^{\text{src}} \neq w^{\text{hyp}}$ and $w^{\text{hyp}} \neq w^{\text{ref}}$

FN:$w^{\text{src}} \neq w^{\text{ref}}$ and $w^{\text{hyp}} \neq w^{\text{ref}}$

However, due to the particularity of the error correction system, for samples with inconsistent source sentences, hypothetical sentences, and reference sentences, researchers introduce a separate index FPN, which can be classified into FP and FN at the same time. Similarly, in order to solve the problems of (2) and (3) in M^2, the F value is replaced by the accuracy rate, which solves the problem that the system has no valuable output when TP = 0. The calculation formula of accuracy is shown in (7):

$$\text{Acc} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN} - \text{FPN}}. \tag{7}$$

Accuracy gives equal weight to all indicators, but when the sum of different TP and TN is the same, the indicators will not be able to distinguish the advantages and disadvantages of the system. Therefore, the weight is introduced, and the calculation formula is shown in (8):

$$\begin{aligned}\text{WAcc} &= \frac{w \cdot \text{TP} + \text{TN}}{w \cdot \text{TP} + \text{TN} + w \cdot (\text{FP} - \text{FPN}/2) + (\text{FN} - \text{FPN}/2)} \\ &= \frac{w \cdot \text{TP} + \text{TN}}{w \cdot \text{TP} + \text{TN} + w \cdot \text{FP} - w \cdot \text{FPN}/2 + \text{FN} - \text{FPN}/2} \\ &= \frac{w \cdot \text{TP} + \text{TN}}{w \cdot (\text{TP} + \text{FP}) + \text{TN} + \text{FN} - (w + 1) \cdot \text{FPN}/2}.\end{aligned} \tag{8}$$

By comparing the accuracy rate of the assessed system with the accuracy rate obtained through the baseline system, as indicated in formula (9), the I value which is the system's final score is obtained after getting the weighted accuracy rate.

$$I = \begin{cases} \lfloor \text{WAccsys} \rfloor, & \text{if WAccsys} = \text{WAccbase}, \\ \dfrac{\text{WAccsys} - \text{WAccbase}}{1 - \text{WAccbase}}, & \text{if WAccsys} > \text{WAccbase}, \\ \dfrac{\text{WAccsys}}{\text{WAccbase}} - 1, & \text{otherwise}. \end{cases} \tag{9}$$

2.4. GLEU. A variant of the machine translation system measure BLEU (bilateral evaluation understudy) [19], called GLEU (generalized language evaluation understanding), was put forth by IBM researchers in 2001. GLEU is largely used to assess the output of machine translation models, which is typically between 0.0 and 1.0. If the two sentences match perfectly, BLEU = 1.0. Conversely, if the two sentences mismatch perfectly, BLEU = 0.0 [20]. The core of BLEU translation evaluation metric is to detect the number of co-occurrence words between the hypothetical sentences and the reference sentences. The specific implementation method is to calculate the n-grams of the hypothetical sentence and the reference sentence and then count the number of matches to get the score. The more grams the system translation matches with the manual reference translation, the higher the BLEU score. Examples are as follows [21]:

Reference: this is a small test.

Candidate: this is a test.

Table 5 shows that the BLEU score under 1-gram is 0.8 since the hypothetical sentence shares 4 words with the reference sentence. The number of the words in the hypothetical sentence divided by the words in the reference sentence is the final score.

Under 2-gram, as shown in Table 6:

Every two words in the sentence are divided into a 2-gram group. The calculation logic is the same as that of 1-

Table 1: M^2 does not mix and match multiple change scenarios.

Source: This machines is designed for help people.	Annotator 1 (this ⟶ these), (is ⟶ are), (help ⟶ helping)	Annotator 2 (machines ⟶ machine), (for ⟶ to)		
System hypothesis	System edits	P	R	$F_{0.5}$
These machines are designed to help people.	(This ⟶ these), (is ⟶ are),(for ⟶ to)	0.67	0.67	0.67

Table 2: M^2 ignores matching issues.

Source: Machine is design to help people.	Gold edits (Machine ⟶ Machines), (is design ⟶ are designed)			
System hypothesis	System edits	P	R	$F_{0.5}$
Machine is designed to help people.	(Design ⟶ designed)	0.00	0.00	0.00

Table 3: M^2 outputs misleading results.

Source: Machine is design to help people.	Gold edits (machine ⟶ machines), (is ⟶ are), (design ⟶ designed)			
System hypothesis	System edits (machine is⟶The machine is),	P	R	$F_{0.5}$
The machine is designed for helping people.	(Design ⟶ designed), (to help people ⟶ for helping people)	0.33	0.33	0.33
Machines is a design on the helping of the people.	(Machine ⟶ machines), (is design to help ⟶ is a design on the helping of the)	0.50	0.33	0.45

Table 4: Two modification schemes.

Error type	Modification
SVA	Scheme 1:This ⟶ These, is ⟶ are Scheme 2:machines ⟶ machine
V-form	Scheme 1:help ⟶ helping Scheme 2:for ⟶ to

Table 5: Word segmentation of reference and hypothetical sentences under 1-gram.

Reference	Hypothetical
This	This
Is	Is
A	A
Small	
Test	Test
Same gram	4
Gram of reference	5
BLUE	0.8

gram. Under the conditions of the same reference sentence and hypothetical sentence, BLEU score is 0.5.

Napoles et al. [22] contend that because there is still a crucial distinction between translation tasks and error correction tasks, it is inaccurate to consider machine translation as merely a monolingual translation. Direct application of BLEU to GEC tasks could result in less-than-ideal output scores. Because of this, researchers have created a simple BLEU metric variant called GLEU that is suited to the requirements of the error correction task. The accuracy of the GEC system is calculated through the comparison of reference sentence and source sentence, giving more weight to the gram with correct correction, rewarding the correct

Table 6: Word segmentation of reference and hypothetical sentences under 2-gram.

Reference	Candidate
This	This
Is	Is
A	A
Small	
Test	Test
Same gram	2
Gram of reference	4
BLUE	0.5

correction result and the correct source text without correction, and punishing the gram with incorrect correction.

The calculation formula is as follows (10):

$$\mathrm{GLEU} = \mathrm{BP} \cdot \exp\left(\sum_{n=1}^{N} wn \log pn\right), \tag{10}$$

$$pn = \frac{N(H,R) - (N(H,S) - N(H,S,R))}{N(H)}, \tag{11}$$

$$\mathrm{BP} = \left\{\begin{matrix} 1 & \text{if } h > r \\ \exp\left(1 - \frac{r}{h}\right) & \text{if } h \le r \end{matrix}\right\}. \tag{12}$$

In the formulas, p_n is the accuracy after n-gram calculation and BP is the penalty factor. In formula (11), H is the length of the hypothetical sentence and R is the length of the reference sentence. The function of penalty factor is to avoid the bias of system scoring. In the scoring process, the matching degree of n-gram may become better with the

Table 7: 25 main error categories in ERRANT.

Code	Meaning	Description/example
ADJ	Adjectives	*big ? wide*
ADJ:FORM	Adjective form	Comparative or superlative adjective errors. *goodest? best, bigger ? biggest, more easy ? easier*
ADV	Adverb	*speedly ? quickly*
CONJ	Conjunction	*and ? but*
CONTR	Contraction	*n't? not*
DET	Determiner	*the ? a*
MORPH	Morphology	Tokens have the same lemma but nothing else in common *quick (adj) ? quickly(adv)*
NOUN	Noun	*person ? people*
NOUN:INFL	Noun inflection	Count-mass noun errors *informations ? information*
NOUN: NUM	Noun number	*cat ? cats*
NOUN: POSS	Noun possessive	*friends?friend's*
ORTH	Orthography	Case and/or whitespace errors. Bestfriend? Best friend
OTHER	Other	Errors that do not fall into any other category (e.g., paraphrasing) at his best? Well, job? Professional
PART	Particle	*(look) in? (look) at*
PRER	Preposition	*of ? at*
PRON	Pronoun	*!?*
SPELL	Spelling	*genetic? genetic, color? colour*
UNK	Unknown	The annotator detected an error but was unable to correct it
VERB	Verb	*ambulate? walk*
VERB: FORM	Verb form	Infinitives (with or without "to"), gerunds (-ing), and participles *to eat? eating, dancing? danced*
VERB:INFL	Verb inflection	Misapplication of tense morphology *getted ? got, fliped ? flipped*
VERB:SVA	Subjective-verb agreement	*(He) have ?(He) has*

shortening of sentence length. Therefore, in order to control this situation, the length of the sentence will be taken into account in the calculation. When the length of the hypothetical sentence is greater than the source sentence, the penalty factor is 1 and no penalty will be imposed. When the length of the hypothetical sentence is greater than the source sentence, the punishment will be carried out. N is the value of n in n-gram of GLEU formula, and its upper limit is 4. N *(H, R)* is the overlapping n-grams in the hypothetical sentence and the source sentence, and $N(H, S, R)$ is the overlapping n-grams in the hypothetical sentence, the source sentence, and the reference sentence, respectively. w_n is the weighted average adopted by the system, and the value is $1/N$.

2.5. ERRANT. ERRANT (ERRor ANnotation Toolkit) [23] was proposed by ALTA Research Institute of Cambridge University. The evaluation metric is mainly divided into two steps. Firstly, the phrase level editing between hypothetical sentence and source sentence pair is extracted, and then the editing is classified according to the error type based on rules. The extraction of phrase level editing mainly adopts a new method proposed by Felice [24]—edit extraction using a linguistically enhanced alignment algorithm supported by a set of merging rules. In terms of rule classification, ERRANT first applies the part-of-speech (POS) tagging techniques already in use to identify and categorize errors at the part-of-speech level and then adds rules to pinpoint errors like missing, redundant, and replacement. It finally broadens the approach to locate errors outside the part-of-speech, like spelling, word placement, and so forth. The final coding is about 50 rules. The following table lists the main 25 rules and their examples and comments in Table 7.

The calculation method of F value in errant is the same as that in M^2. However, the advantage of ERRANT is that the internal classification of the method is transparent, the category of errors can be clearly identified, and the requirements for data annotation are not high. Users can clearly know the causes of wrong classification, which is more beneficial to the development of GEC system.

3. Discussion

Table 8 summarizes the calculation core, advantages, and disadvantages of the above four evaluation metrics.

From calculation point, the majority of evaluation metrics continue to compare the editing differences between the source sentence and the hypothetical sentence and the source sentence and the reference sentence in order to assess the benefits and drawbacks of the model. The main difference lies in the difference of calculation methods. M^2 and ERRANT evaluate the performance of the model by calculating the accuracy rate and recall rate of the error correction system, and I-measure calculates the quality of the output samples produced by the error correction system based on the accuracy rate. The main advantage of the method based on edits statistics is that the calculation is simple, but there is no way to obtain the information at the semantic level because all its operations are completely

Table 8: Comparison of four evaluation metrics.

Metrics	Calculation core	Strength	Weakness
M^2	Editing	1. The calculation is relatively simple and convenient 2. Help of CoNLL-2014 shared tasks	1. The difference between "no correction" and "error correction" cannot be captured 2. The selective output of correction results may lead to the underestimation of system performance
I-measure	Editing	1. Multiple annotations make the systematic evaluation more objective 2. Consider a wider range of sample extraction	1. Heavy marking workload 2. There is no way to obtain semantic information based on the structure of the text itself
GLEU	Language model	1. No need to make detailed comments on the location and error type of each correction, and the annotation cost is small 2. Adapt to multiple languages	1. Regardless of meaning. 2. Without directly consider sentence structure. 3. Cannot handle language-rich text well. 4. Inconsistent with human judgment [25]
ERRANT	Editing	1. Low requirements for database 2. Be able to conduct specific performance evaluation for different error types	1. Artificial rules have limited coverage of error types high postmaintenance cost

calculated based on the structure of the text itself, the modification validity of the system on the semantic errors of the text cannot be effectively evaluated, and the cost of manual annotation in the early stage is high at beginning. GLEU abandons the traditional editing and extraction mode and uses the translation evaluation method to calculate the difference between the hypothetical sentence and the reference sentence. This translation-evaluation-based algorithm greatly reduces the manual intervention in the early stage of model construction.

From the perspective of individual metrics, although M^2 is the most widely used evaluation metric, problems of the metrics themselves emerge in the process of continuous use.

Firstly, as a result of its calculation method, it is not possible to distinguish the extreme cases at first, and it is impossible to distinguish between the results of zero F value and those of no correction and total error correction for GEC system.

Secondly, the selected output of indicators will underestimate the performance of the system [26]. But overall, M^2 is simple to use, and with the promotion of shared tasks, M^2 is still the first choice for all major GEC system evaluation indicators. I-measurements are mainly based on M^2, with multilevel annotations for editing calculations, more comprehensive sampling than M^2, and richer scenarios to consider. GLEU jumps out of the framework of extracting editing features from the original indicators and introduces the translation evaluation model into the field of error correction, which solves the problem of complex annotations of the above two models [27–29], with less computational cost. Moreover, the evaluation form of language model has no requirement on language type and can be used in a wider range. However, in the process of calculating the result of the metric, gram calculation does not take into account the issue of semantic errors and sentence structural errors, and excessive focus is put on local errors and overall grammatical coherence is ignored. ERRANT classifies errors based on grammar rules and then evaluates them. The overall calculation method is similar to M^2, but the advantage lies in the classification process. By classifying and calculating the index, we can output the performance of different systems in different error types, which is more meaningful for the further development of GEC system. The disadvantage is that even though the number of rules written is broad enough, it still cannot cover all the error types in predicting, new errors are discovered later, and rules need to be manually added to update maintenance system, which is costly.

4. Conclusion

The study presented above leads this paper to the conclusion that future evaluation criteria should be more oriented toward lowering the investment in manual labeling and labor and strengthening the use of natural language processing technologies.

Firstly, the development of the evaluation metrics of grammar error correction system partially reflects the development process of natural language processing technology—from the rule era of manual labeling errors and a large number of manual intervention to the deep learning era of manual work reduction and machine processing of corpus. However, there is still room for considerable progress. From the perspective of individual evaluation indicators, the evaluation results still have limitations. The focus of all indicators is still on the comparative evaluation of the results of local error correction, which does not reflect the evaluation of the correction effect of long difficult sentences and text level, and the scope of evaluation is very limited. In the future, the improvement of indicators should focus more on the syntactic and textual levels.

Secondly, on the whole, although the application of methods in evaluation metrics has been improved, manual labeling is still in a dominant position. It does not fully

reflect the idea of deep learning. The future methods should be more integrated into machine work and reduce the manual intervention in corpus.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Research Article

Research on the Evaluation Method of University Bi-Entrepreneurship Curriculum Based on IoT Integrated with AHP Algorithm

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The Internet of Things (IoT) is essential for the success and adoption of digital entrepreneurship in universities. The Internet of Things (IoT) is the integration of electronic objects, peripherals, cities, and other items and equipment with embedded software, electronics, actuators, network connections, and sensors that allow these things and equipment to share and gather data. The usage of IoT for university bi-entrepreneurship can equalize the playing field in many areas of the economy, creating options like as remote work at any time and from anywhere. Nowadays, universities are playing an essential part in the careers of students. In this regard, government departments provide considerable assistance in recruiting individuals and companies in a variety of ways, including funding and tax policies. However, many factors affect university students' innovation and entrepreneurship education. Therefore, it is necessary to establish a quality evaluation system of innovation and entrepreneurship education, which can guide university students' targeted innovation and entrepreneurship by improving the comprehensive ability and employability of these students. Therefore, this paper constructs an evaluation index system of university students' innovation and entrepreneurship education quality, including several dimensions and several sub-indicators. On this basis, the analytic hierarchy process (AHP) algorithm is used to construct the judgment matrix, and the ranking weight of each comparison element is calculated according to the judgment matrix. The suggested system first constructs a hierarchical model to conceptualize the relationship between different elements and then builds a judgment matrix. After establishing the judgment matrix, the calculation methods of the characteristic root, square root, and idempotent relative weight are systematically checked. The experimental results reveal that the proposed evaluation system has a stronger impact on promoting university students' creativity, entrepreneurship, and employment.

1. Introduction

When facing the challenge of a fast-changing, development education environment, such as what is happening significantly now throughout many universities with the Internet of Things (IoT), most of the universities launch a series of trials without first creating a robust and overarching strategy. The consequences of IoT for developing models must be looked at from the lens of university entrepreneurship, in which a corporation strives to utilize its current education skills in new, adjacent sectors for development. We contend that the Internet of Things, like many other high-impact technological advances, entails greater levels of risk than conventional and gradual upgrades to present university operations. In addition, IoT needs a strong and extensible architecture of the system that include a variety of sensors that are linked to the Cloud using wireless technology, and data are collected and processed to produce and act on data analytics. Furthermore, a Cloud link to a heart monitor combined with background analytics can notify healthcare call centers and patients of impending heart attacks. The necessity for disciplined architectural design is prevalent wherever there is a mix of software and hardware combined into a real-time warning system.

Under the background of increasing employment pressure, strengthening entrepreneurship and innovation

education for university students has certain application value, which is in line with the law of development of university students in China and is also an effective way to solve the employment of university students nowadays [1]. Innovation education solves the employment problem and boosts university students' innovation, independent learning, analysis, and problem-solving abilities, which improves their innovation ability. Innovation ability is fundamental to national development, especially university students' innovation ability. However, the current innovation education in the university still stays a primary stage, and many indicators and systems are not very sound now, which is a problem that we need to improve at present. First, there is a lack of scientific innovation and entrepreneurship education concepts, and schools and students do not know enough about entrepreneurship education. Second, there is a lack of a reasonable entrepreneurship education curriculum system most of our universities and universities offer entrepreneurship education as elective courses. In addition, the curriculum and teaching methods are single, and most replace them with university students' career planning courses. Third, the teachers' strength in entrepreneurship education is weak, and most of them teach entrepreneurship as a hobby [2].

Aside from the foregoing, our country's university students' capacity to adjust to culture, jobs, and entrepreneurship is lacking, whereas innovative and composite talents are in limited supply. Even though various agencies have implemented different preferential measures and policies to promote entrepreneurship and innovation education for university students, all types of universities and colleges have effectively cultured innovation. Additionally, the skilled staff training designs are intended to produce new entrepreneurial talents and abilities. It can be said that China's innovation and entrepreneurship talents are still in their early stages of growth. Numerous issues regarding the growth of creative entrepreneurial talents must be investigated both in practice. How to assess and choose entrepreneurial and innovative skills is perhaps the most important issue in the entrepreneurship and innovation training mode. As a result, it is critical to develop a talent evaluation process for entrepreneurship and innovation.

Because of the aforementioned issues, this paper develops an evaluation index system for the reliability of innovation and entrepreneurship education provided to university students, which includes several dimensions and sub-indicators. The judgment matrix is constructed using the analytical hierarchy process (AHP) algorithm, and the ranking weight of each comparison element is calculated using the judgment matrix. The purpose of this paper is to draw a connection between entrepreneurship education in universities and the need for curriculum reform. It explicitly mentions unemployment levels in China while taking into account the execution of entrepreneurship education in universities to decrease the occurrence of youth unemployment and the significance of teacher education.

The key contribution of this research work consists of the following:

This study divided the quality assessment of innovation and entrepreneurship education into three dimensions universities, students, and social groups to classify the assessment indexes [3]. Universities are the main body of innovation and entrepreneurship education. In this study, the indicators of schools in the quality assessment of innovation and entrepreneurship education are classified into entrepreneurship teachers, venues, and support. Innovation and entrepreneurship education in universities include talent cultivation, curriculum, and teaching methods [4]. On the other hand, entrepreneurship teachers include teaching methods, teachers' innovation, entrepreneurship education teaching ability, assessment and evaluation of innovation, and entrepreneurship education. This study divides student indicators of innovation and entrepreneurship education quality into entrepreneurial practice, innovation and entrepreneurial effect, entrepreneurial status, and entrepreneurial satisfaction. Students' entrepreneurial practice includes internships, competitions, and skills competitions in innovation and entrepreneurship [5]. In this study, social groups in innovation and entrepreneurship education are classified based on entrepreneurial effectiveness and satisfaction.

The organization of the rest of this paper is listed as follows: Section 2 discusses related work by international and national scholars. Section 3 presents the material and proposed methodology for this paper. Section 4 presents experimental work for the proposed model as well as its analysis. Section 5, the final section of this paper, contains the conclusion.

2. Related Work

2.1. Innovation Education Evaluation. Harvard University offered a course on entrepreneurship education in 1947, marking the beginning of innovative entrepreneurship education [6]. In the 1990s, American magazines such as Business Week and Entrepreneur and Success began to evaluate university entrepreneurship education programs once a year, in terms of the number of entrepreneurship courses, the rate of entrepreneurship among university students, and, the amount of financing for entrepreneurial enterprises [7]. Foreign scholars have studied the impact of innovative entrepreneurship education on the economy and society, as well as the time and opportunity costs for investors in educational institutions and educated people [8]. The authors of Ref. [9] argue that the consistency of entrepreneurship education in universities is low. Most evaluation criteria are specific to university entrepreneurship education, and there are no universal evaluation criteria for entrepreneurship education. In this regard, the scholar of [10] conducted a thorough investigation into the effectiveness of implementing entrepreneurship education courses based on the theory of planned behavior. It discovered that the most important outcome of entrepreneurship education is not the promotion of entrepreneurship among students, but the conceptual change of students' attitudes and values, which leads to a

stronger entrepreneurial will and entrepreneurship. The third edition of the Oslo Manual of the Organization for Economic Cooperation and Development (OECD) represents research in the area of innovation measurement [11]. The handbook has made breakthroughs in the collection and interpretation of innovation data, but still has shortcomings, such as the difficulty of reflecting changes in process methods and organizations. In October 2018, the OECD released the fourth edition of the Oslo Manual. Several international research institutions are also conducting ongoing research on innovation assessment projects [12]. They have constructed innovation indicator systems mainly for global or cross-country innovation measures, such as the National Innovation Capacity Index, the Global Composite Innovation Index, and the World Knowledge Competitiveness Index, and have adopted different evaluation indicators or methods according to different evaluation objectives. From the research trend of foreign innovation and entrepreneurship education, the research content of innovation and entrepreneurship education evaluation not only includes the selection of evaluation indicators, the determination of evaluation methods, and the effectiveness of evaluation but also forms a more complete quality evaluation system.

Most of the literature in this field discusses the necessity of entrepreneurship education, realization path, development model, international and regional comparison, practice methods, and other dimensions [13]. There are fewer studies on the evaluation system and quality control of innovation and entrepreneurship education, among which there are fewer empirical studies. Due to the complexity of entrepreneurship education evaluation and other constraints, some research results are limited to exploring the necessity of innovation and entrepreneurship education evaluation, and innovation education evaluation indices and techniques have few quantitative investigations. There is no evaluation system to measure the quality of innovation and entrepreneurship education. First, research on innovation and entrepreneurship education evaluation is weak, and a scientific index system and representative research results are lacking. The assessment index system is naively quantitative, the evaluation material is not comprehensive, and the index weights are not scientific enough, which impacts the evaluation system of innovation and entrepreneurship education in university's and universities [14]. Small sample coverage, lack of convincing research conclusions, mainly qualitative research, lacking of empirical research based on large sample data analysis, failure to build a scientific and reasonable index system, etc. are problems in China's innovation and entrepreneurship education evaluation system research. The research on innovation and entrepreneurship education evaluation systems lacks theoretical depth, and the important issues are not adequate. This research builds a scientific and acceptable evaluation system of innovation and entrepreneurship education quality in China based on big sample data and three dimensions: development state, final results, and implementation method.

2.2. Research on Evaluation of Innovative Entrepreneurship Education

2.2.1. There Is Variability in Evaluation Indexes. There is a lag in innovative entrepreneurship education due to its impact, and some scholars believe that longitudinal evaluation should be conducted on innovative entrepreneurship education. The scholar of Ref. [15] believes that there is little consistency in innovative entrepreneurship education programs among universities and most of the evaluation criteria are for innovative entrepreneurship education in a particular university, and there are no universal evaluation criteria for entrepreneurship education. In this regard, the early work of Ref. [16] took five principles such as subjectivity, practicability, technological advancement, innovation, and team integrity as the principles for the construction of university students' innovation and entrepreneurship evaluation system. Hence, the scholar of Ref. [17] measured innovation education in 8 domains.

2.2.2. Innovation and Entrepreneurship Indexes Are Hard to Validate. The scholars of Ref. [18] determine the innovation and entrepreneurship education assessment method, but hard to ensure it is effective. For this purpose, the work of Ref. [19] proposed that when domestic universities conduct research on innovation and entrepreneurship, they ignore the overall level design and do not effectively analyze the entrepreneurship education goals, which leads to the disconnection between theory and practice. Nowadays, there is no recognized definite assessment subject for the assessment of innovation and entrepreneurship education. Although most universities assess from the perspective of schools and students' associations and society, there is still a problem of ignoring the demands of different assessment subjects in the assessment process.

2.2.3. Innovation and Entrepreneurship Education Evaluation Differs. The early work of Ref. [20] takes three aspects of school, students, and entrepreneurship projects as the main subjects of innovation and entrepreneurship education evaluation thus conducting the systematic evaluation. The author of Ref. [21] on the other hand, systematically evaluated four aspects of the entrepreneurship education environment, entrepreneurship teachers, entrepreneurship education curriculum, and entrepreneurship students according to students' innovation and entrepreneurship reality. Similarly, the work of Ref. [22] evaluated four dimensions the target level, object level, teaching and research level, and resource level.

2.2.4. Factors. The global market economy, the shape, substance, and teaching methods of innovation education in different geographies and universities, and even individuals' psychological states and circumstances affect innovation and entrepreneurship education. The researchers of Ref. [23] believe that as the global economy changes, so must our innovation and entrepreneurship education to produce

innovative individuals who are more flexible. The scholars in Ref. [24] note that the quality of entrepreneurship education and the assessment of innovation and entrepreneurship education is a complex process that is affected by individuals' psychological and social status. Distinct researchers have different study themes, purposes, and opinions. Hence their evaluation indexes, procedures, and evaluation subjects will be different. This study seeks to perform an empirical study on the quality of innovation and entrepreneurship education of self-employed graduates in a city to increase the quality of higher education employment served by innovation and entrepreneurship education in a city.

Inspired by the work aforementioned, this research work draws a connection between entrepreneurship education in universities and the need for curriculum reform. It explicitly mentions unemployment levels in China while taking into account the execution of entrepreneurship education in universities to decrease the occurrence of youth unemployment and the significance of teacher education. This paper uses a hierarchical analysis algorithm to evaluate the quality of university students' innovation and entrepreneurship education. AHP algorithm is a hierarchical, structured, combined qualitative, and quantitative decision-making method. The key steps are to construct the judgment matrix and to calculate the ranking weights of each element being compared from the judgment matrix. For our proposed education quality evaluation system, a hierarchical model is constructed to conceptualize the relationship between different elements, and then a judgment matrix is constructed. After constructing the judgment matrix, this system analyzes methods for calculating element weights, such as characteristic root, square root, and power. By comparing and studying the advantages and disadvantages of the above methods, an innovative improved algorithm combining the least squares method and the iterative power method with each other is proposed. The improved algorithm is verified by example to have better adaptability and also reduce the computational complexity.

3. Materials and Method

3.1. IoT for University Bi-Entrepreneurship Curriculum. This section expands on the idea of IoT use in entrepreneurship training and instruction in Chinese universities. First, this section describes and discusses IoT in the context of the chosen domain. Following that, it provides the Hierarchical Analysis of University Entrepreneurship Education. Finally, the revised AHP algorithm for the university's Bi-Entrepreneurship program is discussed in this section.

The emergence of IoT technology provides an opportunity for universities and staff to solve limits and inadequacies in present entrepreneurship teaching and training programs. In general, IoT describes a network of intelligent devices capable of detecting, recording, and monitoring events or activities and sending the acquired data to another device or apps for analysis or action over the Internet or a network. IoT devices may have built-in processing capacity or may outsource computation to apps and devices in their surrounding environment.

3.1.1. Hierarchical Analysis (AHP Algorithm). The application of hierarchical analysis (AHP) first appeared in the field of operations research. In 1977, the first global conference on mathematical modeling was held in the United States. Professor Satie, a famous operations research scientist, published "Modeling of Unstructured Decision Problems—Hierarchical Analysis" [25], which proposed a new modeling method and introduced the mathematical approach to social problems for the first time. Since then, the vision has shifted from studying qualitative problems to studying quantitative problems. People started to pay attention to the hierarchical analysis method. Due to the advantages of simple operation, practicality, and systematicity [26], hierarchical analysis has been gradually applied to a wide range of fields such as scientific management, multi-objective decision-making [27], economic development evaluation [28], and evaluation system construction [29]. The basic steps of the traditional hierarchical analysis method are shown in Figure 1.

(i) Establishing a Hierarchical Structure Model. Hierarchical analysis (AHP) focuses on the hierarchical relationships between elements. For the problem to be solved, the first step is to gradually hierarchize all elements and build a framework diagram. It is usually divided into three levels, wherein the first level is the highest level of the problem to be solved. The second level is the middle level, which is some criteria to be solved, and the last level the third level is some options or factors of the problem [30]. The general hierarchy diagram of AHP is shown in Figure 2.

(ii) Create a Comparison Matrix [25]. To determine the relative importance of the elements and to quantify the results of the comparison, the elements of each layer are compared in pairs. Typically, numbers 1 through 9 are used to indicate the importance of each of these two elements. While the number 1 indicates that the two elements are of equal importance and the importance will increase in increasing order of the number. Similarly, the number 9 indicates the comparison of two elements, one of which is very important. Finally, the comparison results are used to form a judgment matrix for analysis. Let the upper element and n elements. Based on the results of all comparisons of the relative importance of Bi to BJ, a judgment matrix B of influence elements is formed, which may be seen in the following equation:

$$B = \begin{matrix} b_{11} & b_{12} & \dots & b_{1n}, \\ b_{21} & b_{22} & \dots & b_{2n}, \\ \dots & \dots & \dots & \dots \\ b_{n1} & b_{n2} & \dots & b_{nn}. \end{matrix} \tag{1}$$

(iii) Calculate the Importance Weights between the Elements of Each Layer. Eigenvector is a nonzero vector that varies by a scalar factor whenever that transformation function is performed on it. The eigenvalues, on the other hand, were employed to compute the theoretical limit of the amount of data that could be conveyed through a communication

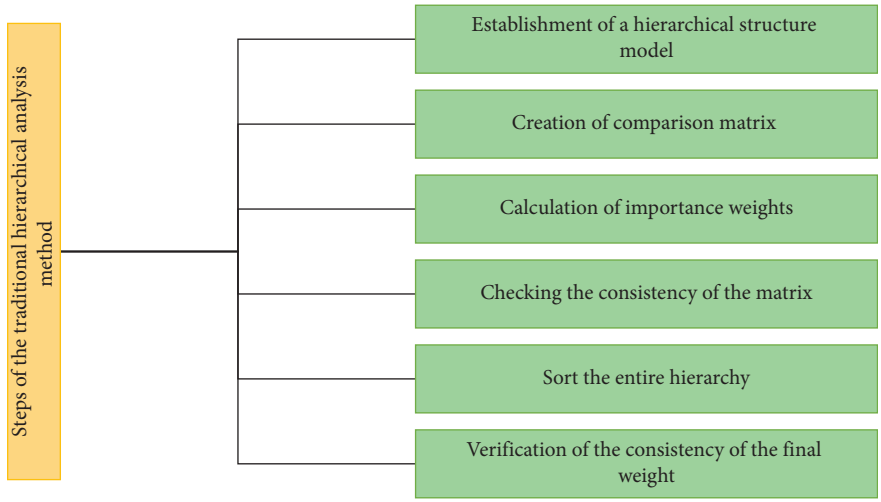

Figure 1: Basic steps of the traditional hierarchical analysis method.

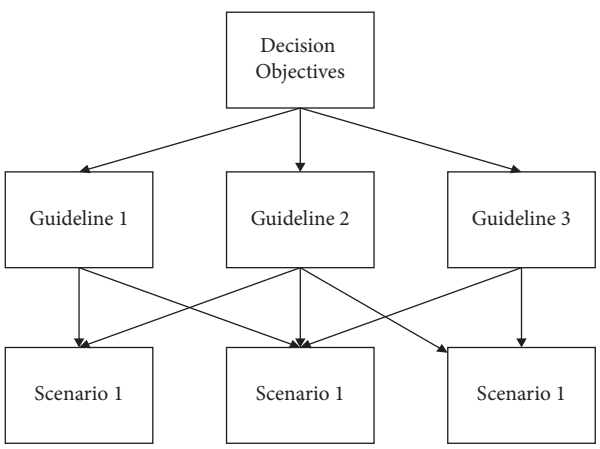

Figure 2: General hierarchy chart.

channel. This is accomplished by computing the communications channel's eigenvectors and eigenvalues and then water filled on the eigenvalues. The eigenvalues are therefore essentially the gains of the channel's basic phases that are recorded by the eigenvectors. If A_k is a linear function from a vector space W to a field F, it may be determined using the following equation:

$$A_K W = \lambda_{\max} W. \tag{2}$$

In the above equation, $\lambda_{\max}$ is a scalar in function (F), recognized as the eigenvalue related with W. Normalizing judgment matrix $A_1, A_2, \ldots, A_n$ arranges the previous level's element weights.

(iv) Check the Consistency of the Matrix. Consistency is the fundamental driver for achievement, which necessitates a huge commitment from the proposed work and entails continued work in repeating behaviors until you attain desired objectives. After calculating the weights of each matrix at each level, its consistency needs to be verified. Import the indicator CI calculated through the following equation:

$$CI = \frac{\lambda_{\max} - n}{n - 1}. \tag{3}$$

When = 0, the judgment matrix is perfectly consistent, but the actual situation is often not so perfect. The calculation result is usually > 0. At this time, the average random consistency index RI is needed. RI is used to check the satisfactory consistency of the judgment matrix, and its calculation formula can be represented as follows:

$$RI = \frac{\lambda_{\max}' - n}{n - 1}, \tag{4}$$

where $\lambda_{\max}'$ is the maximum eigenvalue of the matrix constructed above, and the average value is obtained. The Consistency Ratio (CR) is a statistic that measures the consistency of pairwise comparisons. As a result, consistency is intimately linked to the transitive property. If the value of CR is less than or equivalent to 10%, inconsistency is accepted, while subjective assessment must be revised is if the CR is larger than 10%. After obtaining the CI and RI, the consistency ratio CR is calculated as follows:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}. \tag{5}$$

According to the above equation, when CR < 0.10, it can be concluded that the consistency of the matrix is good. Otherwise, the comparison matrix should be adjusted appropriately until it satisfies CR < 0.10. At this time, the maximum eigenvalue $\lambda_{\max}$ of the comparison matrix is calculated and the corresponding eigenvectors are normalized to obtain the order of the weights of each layer [31].

(v) Sort the Entire Hierarchy. Calculate the weight of each sub-element in the last layer relative to the target problem to be solved. This step is the most important step in the whole hierarchical analysis method, and the calculation result directly affects the final judgment and selection. Assume that the weights of all elements in layer are $a_1, a_2, \ldots, a_m$ and the weight of each element in that layer under that layer assumed

to be b. Then, the total ranking weights of the elements in layer B are derived by referring to the formula in Table 1.

(vi) Verify the Consistency of the Final Weight Ranking Results. To verify the consistency of the final weight ranking results, let CI be the one-time indicator of the total hierarchical ranking, and the formula for its calculation can be represented as follows:

$$CI = \sum_{i=1}^{m} a_i CI_i. \tag{6}$$

In the above equation, CI is the consistency value of each matrix of the intermediate layer obtained from the above step. Let RI be the random consistency index of the total hierarchical ranking and the formula for RI be presented as follows:

$$RI = \sum_{i=1}^{m} a_i RI_i. \tag{7}$$

In the above equation, RI is the random consistency index of each matrix of the intermediate layer obtained from the above step. The overall consistency index is calculated as equation (5).

From all these equations, it is clear that when the calculated CR < 0.10, it can be judged that the consistency of the hierarchical total sorting results meets the requirements. At this point, the computed results can be used to analyze and evaluate the problem to be solved.

3.2. Method

3.2.1. Improved AHP Algorithm. Universities that do not carry out defined curriculum construction will be completely removed by the times, due to the rapid growth of the information community. The selection of rising education is a crucial stage for businesses to take when developing a Bi-Entrepreneurship curriculum. The AHP analytic hierarchy process is used to break down the items relating to the selection decision. The model for multilevel analysis has been defined. After establishing the significance of each factor at each level, a hierarchy ordering and stability test is conducted along with the creation of a judgment matrix. This paper obtains an AHP-based Bi-Entrepreneurship curriculum for the university selection method. The suggested AHP university Bi-Entrepreneurship curriculum is divided into three layers. As shown in Figure 3, these layers are comprised of the target, attribute, and solution layers. The target layer is made up of three different elements: school, student, and social group. When choosing a university curriculum, the attribute layer includes aspects such as form, venue, support, innovative practice, the effect of innovation, satisfaction, benefits, and prospects. Support, places, a type of education, practices, effectiveness, satisfaction, gain, and development are all aspects of the solution layer.

This paper employs an analytic hierarchy process (AHP) algorithm to build an evaluation indicator system of university students' innovation and entrepreneurship education quality. Figure 4 shows a flow chart illustrating the multiple stages involved in conducting the AHP research.

(i) Step 1: the goal of this research is to create an evaluation method for the university Bi-Entrepreneurship curriculum to maximize benefits and prioritize the allocation of resources to individual practice throughout model implementation.

(ii) Step 2: the recommended algorithm's second step is based on analysis. During this step, the problem is analyzed. Once the problem is analyzed, a hierarchical structure model is established, which typically includes the target layer, attributes layer, and solution layer.

(iii) Step 3: the judgment of each layer is very important, so in order to judge each matrix layer, our suggested model uses T.L. Saaty's 1~9 scale to judge each matrix layer [30].

(iv) Step 4: the most crucial instrument for any judgment analyst to master is weighted ranking. The technique is highly efficient: it is the perfect tool available in terms of input effort involved data is expressed advantage received. By far the most powerful measure for one's time and efforts available. Hence, step 4 calculates each layer's ranking weights using square roots.

(v) Step 5: the consistency ratio indicates the consistency of the judgment matrix. A greater number indicates less consistency, while a lower number indicates greater consistency. In general, the decision-maker's answers are relatively consistent if the consistency ratio has been 0.10 or even less. When the consistency ratio exceeds 0.10, the research study must contemplate re-evaluating reactions during the pairwise comparisons that were used to generate the original matrix of pairwise comparisons. In our case, step 5 of the suggested algorithm checks the consistency of the Matrix judgment with formula (8), and if it is consistent, goes to step 5; otherwise, amend the Matrix judgment with formula (3) and go to step 3.

(vi) Step 6: finally, step 6 calculates the total ranking weight of each scheme.

3.2.2. Modifying the Judgment Matrix. The judgment matrix method is a pairwise comparison-based multicriteria decision-aiding technique. Similar to AHP, pairwise comparisons among various criteria and various alternative solutions with respect to the criteria allow the decision-maker to express their desires. If the elements in the judgment matrix satisfy [32]: $a_{ij} > 0, a_{ij} = 1/a_{ji}, a_{ij} = 1\,(i, j = 1, 2, \ldots, n)$ then the matrix A is said to be a positive-inverse inverse matrix.

Definition 1 (see [33]). Let the Matrix judgment$A = (a_{ij})_{n\times n} \forall i, j, k = 1, 2, \ldots, n, a_{ij} = a_{ik}a_{kj}$ then the Matrix judgment A is a consistency matrix.

Table 1: Level combination weighting.

	$\mathbf{A_1}$ $\mathbf{a_1}$	$\mathbf{A_2}$ $\mathbf{a_2}$	...	$\mathbf{A_m}$ $\mathbf{a_m}$	Weight sorting
$\mathbf{B_1}$	b_1^1	b_1^2	...	b_1^3	$b_1 = \sum_{i=1}^{m} a_i b_1^i$
$\mathbf{B_2}$	b_2^1	b_2^2	...	b_2^3	$b_2 = \sum_{i=1}^{m} a_i b_2^i$
...	...	...	...	...	...
$\mathbf{B_n}$	b_n^1	b_n^2	...	b_n^3	$b_n = \sum_{i=1}^{m} a_i b_n^i$

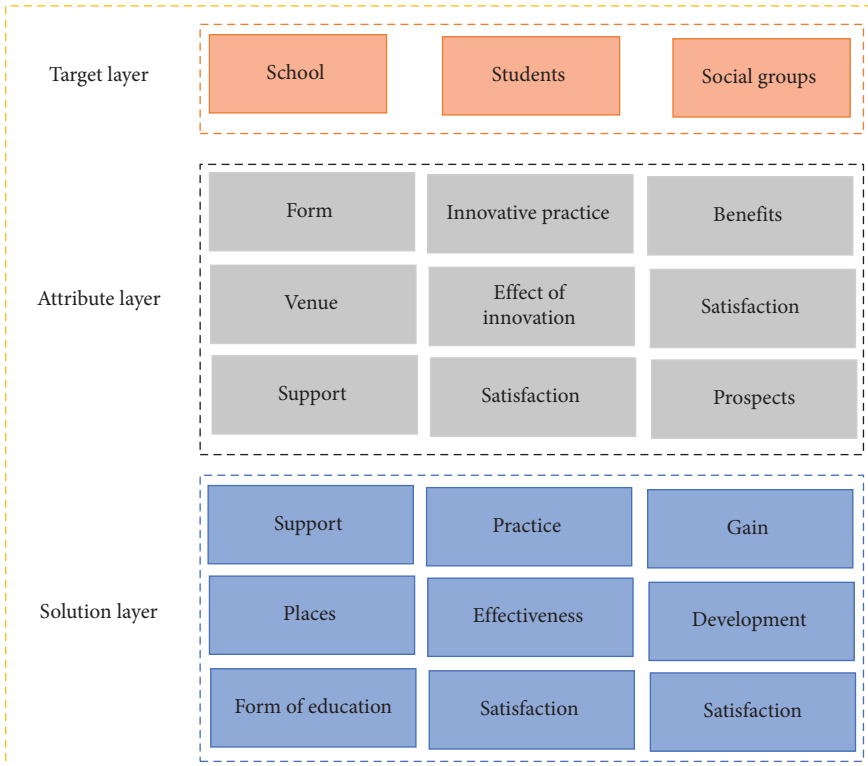

Figure 3: Suggested AHP university Bi-entrepreneurship curriculum.

The consistency matrix has the following properties:

Theorem 1 (see [34]). *A sufficient condition for the Matrix judgment $A = (a_{ij})_{n\times n}$ is that the maximum eigenvalue $\lambda_{\max} = n$ of A with normalized eigenvectors$\tilde{\omega} = (\tilde{\omega}_1, \tilde{\omega}_2, ..., \tilde{\omega}_n)^T$is the weight vector.*

Theorem 2 (see [35]). *A sufficient condition for the matrix $A = (a_{ij})_{n\times n}$ to be completely consistent is that $a_{ij} = a_{ik}a_{kj} \forall i, j, k = 1, 2, ..., n$.*

Positive and negative matrix A is consistent according to Definition 1 and Theorem 2:

$$\forall i, j, k = 1, 2, \cdots, n; a_{ij} = a_{ij}a_{kj}. \tag{8}$$

For (8), the summation of the two sides with respect to k is obtained in [30].

$$a_{ij} = \frac{1}{n}\sum_{k=1}^{n} a_{ik}a_{kj}, \tag{9}$$

where (8) and (9) are necessary for positive and negative matrix A consistency.

If (9) does not hold, then matrix A is not consistent. Equation (10) is a precondition for determining the consistency matrix.

$$b_{ij} = \begin{cases} \frac{1}{n}\sum_{k=1}^{n} a_{ik}a_{kj}, i < j, 1, i = j, \frac{1}{b_{ij}}, i > j. \end{cases} \tag{10}$$

Using $B = (b_{ij})_{n\times n}$ as A's correction matrix can improve its consistency; if $A = (a_{ij})_{n\times n}$ is the consistency matrix, then $B = A$.

3.2.3. Improvement of the Consistency Test. The strength of a consistent test for a repaired factually incorrect hypothesis grows to one as the number of information items tends to increase. Consistency in program evaluation is critical to ensuring that every applicant has the same expertise and is fairly treated. If we let ω be the normalized eigenvector corresponding to the largest eigenvalue $\lambda_{\max}$ of matrix A, we

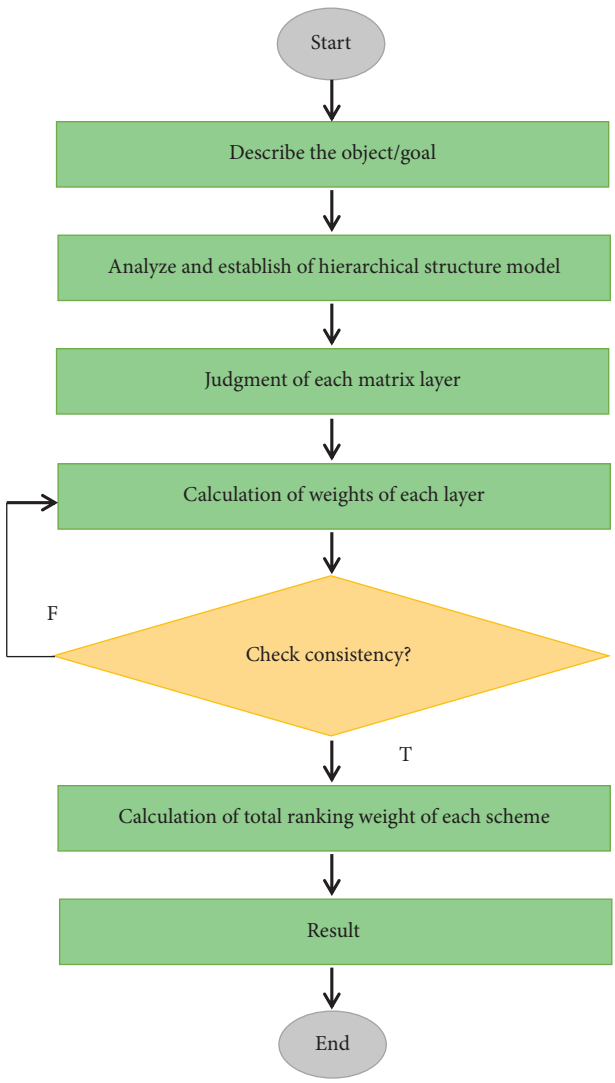

Figure 4: Flowchart to conduct AHP research.

know from Theorem 1 that $\tilde{\omega} = (\tilde{\omega}_1, \tilde{\omega}_2, \ldots, \tilde{\omega}_n)^T$ is the weight vector of the hierarchical single ordering, as calculated in the following equation:

$$A\tilde{\omega} = \lambda_{\max}\tilde{\omega}. \tag{11}$$

If the matrix A $n \times n$ is a perfectly consistent matrix, then its maximum eigenvalue $\lambda_{\max} = n$. If A is not perfectly consistent, then the maximum eigenvalue $\lambda_{\max}$ of A will be slightly larger than n; so, using the following equation:

$$\|A\tilde{\omega} - \lambda\tilde{\omega}\| = \|A\tilde{\omega} - \mathrm{n}\tilde{\omega}\| < \varepsilon. \tag{12}$$

As the criterion to test whether the matrix A satisfies the consistency criterion. According to Professor T.L. Saaty's [29] consistency ratio$CR = CI/RI = \lambda_{\max} - n/(n-1)RI < 0.1$, we can get the following equation:

$$\left|\lambda_{\max} - n\right| < 0.1\,(n-1)RI. \tag{13}$$

And$\|A\tilde{\omega} - \mathrm{n}\tilde{\omega}\| = |\lambda_{\max} - n| \cdot \|\tilde{\omega}\| \le |\lambda_{\max} - n|$, and substituting (6) into the equation, we get the following equation:

$$\varepsilon = 0.1\,(n-1)RI. \tag{14}$$

It is obvious that we use the following equation:

$$\|A\tilde{\omega} - \lambda\tilde{\omega}\| < 0.1\,(n-1)RI. \tag{15}$$

To determine whether the matrix's consistency is satisfactory, the eigenvalues of A can be omitted and only the sorting vector must be calculated which simplifies the operation and increases its running speed.

3.2.4. Matrix Consistency Test. To test the matrix consistency, we know that $A = \begin{vmatrix} 1 & 8 & 9 \\ 1/8 & 1 & 9 \\ 1/9 & 1/9 & 1 \end{vmatrix}$ and its normalized eigenvalue vector $\tilde{\omega} = \begin{vmatrix} 0.829 \\ 0.325 \\ 0.034 \end{vmatrix}$ by the square root method, where $\varepsilon = 0.1\,(n-1)RI = 0.116$, and $\|A\tilde{\omega} - \mathrm{n}\tilde{\omega}\| = \|A\tilde{\omega} - 3\tilde{\omega}\| = 1.161 > 0.116$, which does not satisfy (8), so the consistency of the matrix is not satisfactory.

The matrix A is corrected by (10) to obtain matrix B.

$$B = \begin{vmatrix} 1 & 17/3 & 30 \\ 3/17 & 1 & 51/8 \\ 1/30 & 8/51 & 1 \end{vmatrix}. \tag{16}$$

The normalized eigenvalue vector $\tilde{\omega} = \begin{vmatrix} 0.736 \\ 0.372 \\ 0.041 \end{vmatrix}$, and the test equation $\|B\tilde{\omega} - \mathrm{n}\tilde{\omega}\| = \|B\tilde{\omega} - 3\tilde{\omega}\| = 0.013 < 0.116$, so the corrected matrix has satisfactory consistency, which is given as follows:.

$$\tilde{\omega}_i = \sum_{j=1}^{m} \tilde{\omega}_j^c \tilde{\omega}_i^j. \tag{17}$$

In the above equation, $\tilde{\omega}_i^j$is scheme i's attribute j weight, $\tilde{\omega}_j^c$ denotes j's weight, and m denotes counts characteristics.

Compared with the original AHP algorithm, the new and improved hierarchical analysis (AHP) algorithm created in this paper avoids the process of re-survey, data collection, and Matrix judgment construction. In addition, it shortens the problem-solving time and saves human and financial resources due to the modification of the inconsistent Matrix judgment. Due to the improved consistency discrimination method, we can directly use the normalized eigenvectors and Matrix judgment to maximize the computation process of eigenvalues, thus avoiding the computation. A significant amount of practice demonstrates that the Matrix judgment that does not satisfy the consistency situation requires only one correction. If the consistency is still not satisfied after one correction.

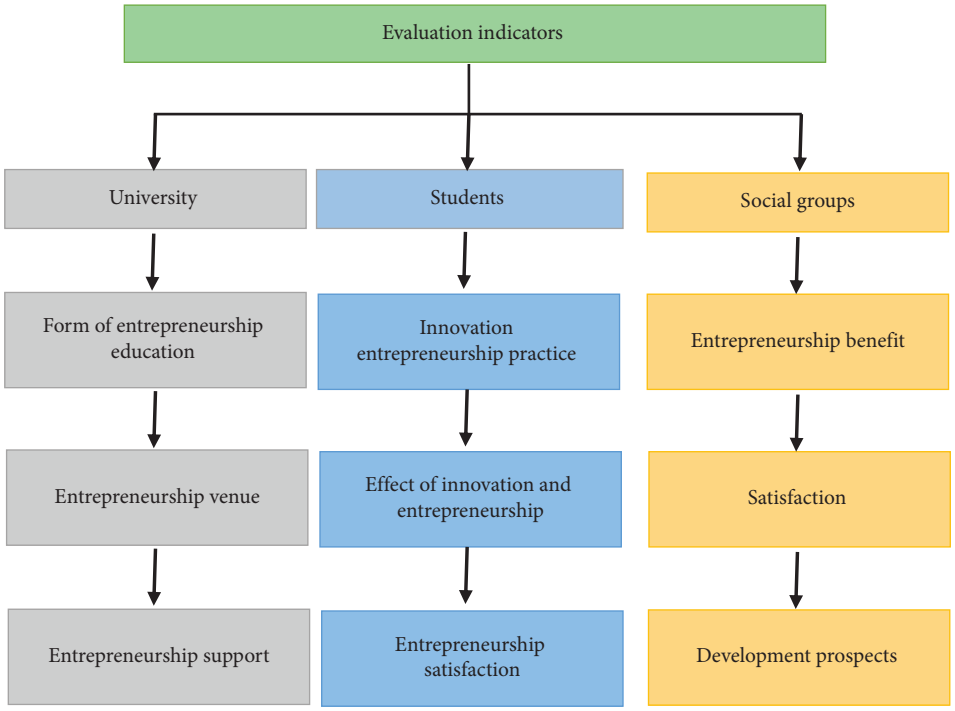

Figure 5: Evaluation index system.

4. Experimental Work and Analysis

4.1. Evaluation Index. A university is used as an example to more thoroughly study how hierarchical analysis algorithms are applied in the system of evaluating educational quality. The evaluation indexes are numerous, generally subject to multiple factors, and have multilevel characteristics. With the best decision scheme as the target layer, the overall structure of evaluation indicators is refined according to the specific situation, as shown in Figure 5.

4.2. Analysis Optimization Function. We use the previous paper to establish the consistency index function CI, solve for the weights, set the variable $p = 5$, set the initial interval to [0, 1], the population size $n = 50$, the interval precision 0.001, the coding length $e = 10$, the maximum number of iterations 500, and record as AHP (1), load the great module in Python, and obtain the 267th generation population in the optimal values. According to the data processing results, the single ranking weights of threat indicators were 0.501, 0.086, 0.229, 0.138, and 0.046, and the optimal CI value was 0.0157. According to Section 3.3, the consistency test was performed with RI (5) = 1.12, and then CR = 0.014 < 0.1, which satisfied the consistency condition.

In order to obtain the optimal consistency ratio, we adjusted the search interval, coding length, interval precision, and other parameters: to adopt two-point hybridization, set the interval precision to 0.000 (1), corresponding to the coding length $e = 14$, and obtain the optimal value in the 466th generation population, which is denoted as AHP (2). We set the interval precision to 0.000 01, corresponding to the coding length $e = 17$, and obtain the optimal value in the 224th generation population, which is denoted as AHP (3). The optimal value is obtained at the 224th generation population and is denoted as AHP (3). Based on $e = 14$, the initial interval is reduced to [0, 0.5] and is denoted as AHP (4). The optimal value is obtained at the 294th generation population. The number of iterations is set to 1,000, 1,500, and 2,000, and the optimal values are obtained at the 325th, 1,396th, and 695th generation populations, which are denoted as AHP (5), AHP (6), and AHP (7), respectively. A single-point the optimal values were obtained at the 1,835th generation of the population, which were recorded as AHP (8), by adopting a single-point hybridization with interval precision of 0.000 1, coding length $e = 14$, and iteration number 2,000. By comparison, it can be concluded that the optimal consistency ratio, AHP (7), can be obtained at an interval precision of 0.000 1, coding length $e = 14$, iteration number of 2,000, and two-point hybridization, as shown in Figure 6.

4.3. The Importance of Evaluation Indicators. Figure 7 shows a comparison of index weights and total weights for C11, C12, and C13, respectively. This figure compares Matrix judgment of indicators corresponding to the university factor. According to this figure, C12 has a higher index weight than the other two, as well as the highest total weight when compared to the others.

Figure 8 shows a comparison of index weights and total weights for C11, C12, and C13, respectively. This figure compares Matrix judgment of indicators

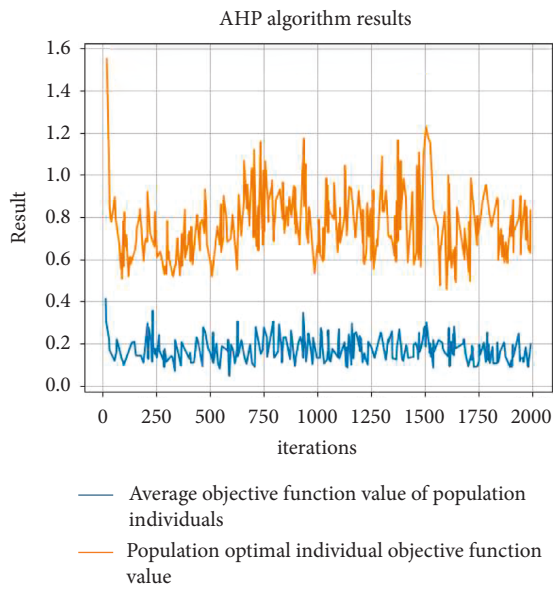

Figure 6: AHP algorithm results.

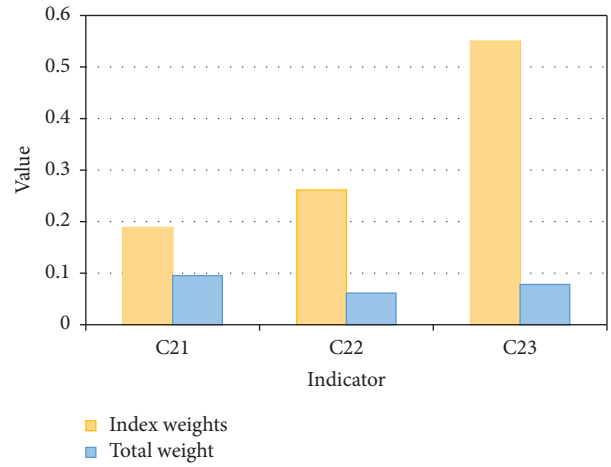

Figure 8: Comparison of matrix judgment of indicators corresponding to the student factor.

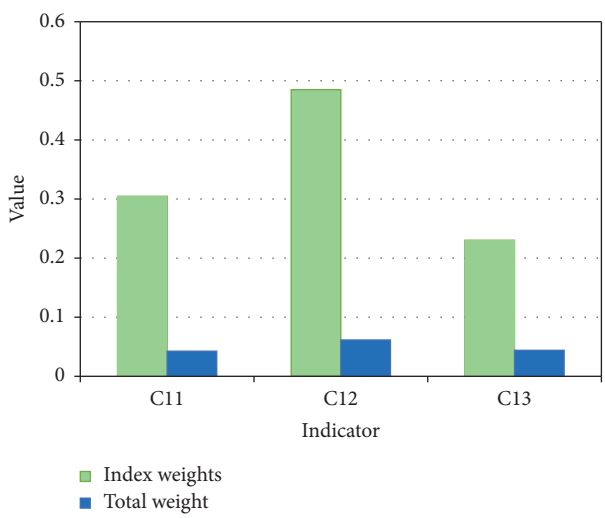

Figure 7: Comparison of matrix judgment of indicators corresponding to the university factor.

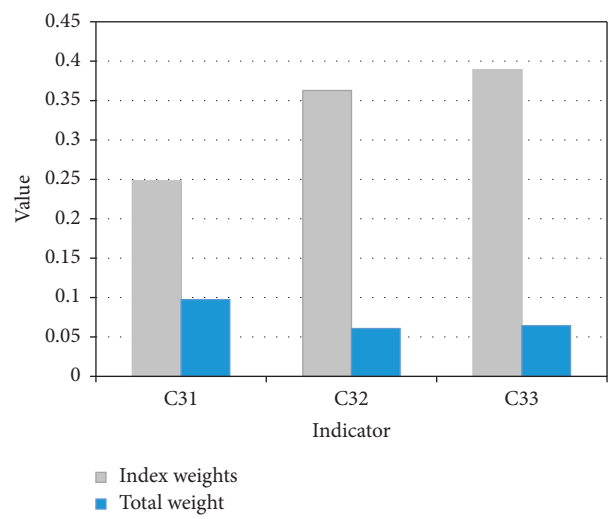

Figure 9: Comparison of matrix judgment of indicators corresponding to the group factor.

corresponding to the student factor. According to this figure, C23 has a higher index weight than the other two, while C21 has the highest total weight when compared to the others.

Figure 9 shows a comparison of index weights and total weights for C11, C12, and C13, respectively. This figure compares Matrix judgment of indicators corresponding to the group factor. According to this figure, C33 has a higher index weight than the other two, while C31 has the highest total weight when compared to the others.

In summary of the above figures, this work compared the importance of secondary indicators in each indicator of schools, students, and associations. From Tables 2 to 4, we can see that the ranking of school indicators: entrepreneurial support > entrepreneurial places > the form of entrepreneurial education, and the ranking of student indicators: innovation Entrepreneurial practice > effect of innovation and entrepreneurship > entrepreneurial satisfaction, ranking according to community indicators: entrepreneurial income > development prospects > satisfaction.

4.4. Comparison with Other Methods. Figure 10 shows the comparison results of multiple methods. According to this figure, it is the result of the comparison between the GA AHP algorithm and other methods. The comparison illustrates the superiority of the AHP algorithm in optimizing the accuracy and consistency ratio of the feature vectors.

Table 2: Matrix judgment of indicators corresponding to the university factor.

C1	Support	Places	Form of education	Index weights	Total weight
C11	(0.5, 0.5, 0.5)	(0.325, 0.439, 0.5)	(0.439, 0.5, 0.6)	0.3046	0.0425
C12	(0.5, 0.561, 0.675)	(0.5, 0.5, 0.5)	(0.561, 0.6, 0.675)	0.4851	0.0615
C13	(0.4, 0.5, 0.561)	(0.325, 0.4, 0.439)	(0.5, 0.5, 0.5)	0.2303	0.0440

Table 3: Matrix judgment of indicators corresponding to the student factor.

C2	Practice	Effectiveness	Satisfaction	Index weights	Total weight
C21	(0.5, 0.5, 0.5)	(0.5, 0.6, 0.675)	(0.5, 0.561, 0.6)	0.1886	0.0953
C22	(0.325, 0.4, 0.5)	(0.5, 0.5, 0.5)	(0.7, 0.4, 0.3)	0.2615	0.0614
C23	(0.3, 0.4, 0.5)	(0.5, 0.561, 0.6)	(0.2, 0.325, 0.4)	0.5499	0.0781

Table 4: Matrix judgment of indicators corresponding to the community factor.

C3	Gain	Development	Satisfaction	Index weights	Total weight
C31	(0.5, 0.5, 0.5)	(0.5, 0.6, 0.675)	(0.5, 0.561, 0.6)	0.2479	0.0974
C32	(0.325, 0.4, 0.5)	(0.5, 0.5, 0.5)	(0.4, 0.5, 0.6)	0.3628	0.0607
C33	(0.4, 0.439, 0.5)	(0.4, 0.5, 0.6)	(0.5, 0.5, 0.5)	0.3893	0.0643

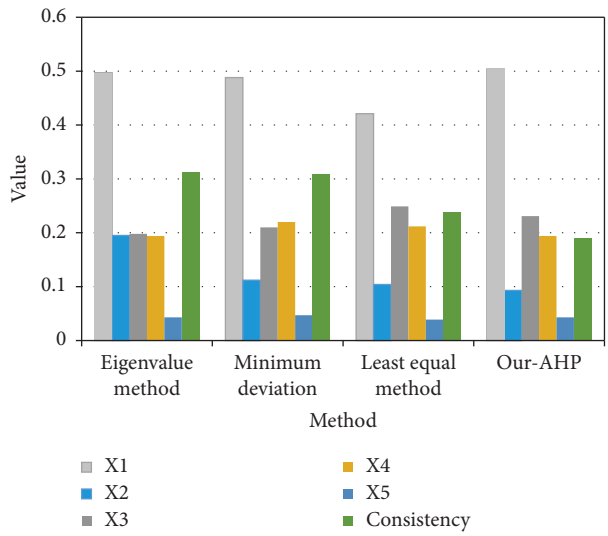

Figure 10: Comparison results of multiple methods.

5. Conclusions

Currently, the utilization of IoT technology and devices has altered several industries, especially healthcare, commerce, and transportation. IoT systems and enabling technologies, like those in other sectors, have the potential to change university entrepreneurship course offerings. IoT technology can enable entrepreneurship professors and institutions to analyze students, adapt entrepreneurship courses, incorporate external resources and entrepreneurship ecosystem players into courses and incorporate learning experiences into courses. Keeping in view of the above, this research provides a quality evaluation system for innovation and entrepreneurship education to support university students in becoming more creative and entrepreneurial. In this research, innovation and entrepreneurship education are accurately evaluated. First, this work optimizes the existing evaluation indexes and builds a multi-dimensional and multi-sub-indicator evaluation index system for university students' innovation and entrepreneurship education. Second, the hierarchical analysis is done after determining evaluation indices. We created a hierarchical model and a Matrix judgment for our suggested education quality evaluation system. Scaling approaches for Matrix judgment were examined, and the optimum scaling option was chosen by weighing its benefits and drawbacks. During the construction of the Matrix judgment, strategies for computing relative weights such as feature root, square root, and power were investigated. Numerical examples demonstrate the new algorithm's flexibility and reduced complexity.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

Acknowledgments

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Research Article

Evaluation of IoT-Enabled Interactive UI Design Effect Based on the Discrete Mathematical Model

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Today, the Internet of Things (IoT), often referred to as smart home technology, is used by many individuals in their daily life. The majority of IoT devices include a companion mobile application that consumers must install on their tablet or smartphone to operate, configure, and interface with the IoT device. Multiple kinds of IoT systems have grown in popularity alongside the growth of information engineering. The accessibility of a user interface (UI) in an IoT system is becoming increasingly crucial. This causes major issues with accuracy and evaluation time. This research suggests a discrete mathematical model for IoT-enabled interactive UI design impact assessment approach to address the concerns of low evaluation accuracy and long evaluation time in existing interactive UI design effect evaluation methods. It creates an IoT-enabled interactive UI design effect assessment index system using interactive UI design vision, hearing, and feeling. It gets IoT-enabled interactive UI design effect evaluation indexes, builds a judgment matrix, derives the weight coefficient of each evaluation index, and employs the hierarchy based on the weight coefficient produced. To complete the assessment of the IoT-enabled interactive UI design effect, the analytical approach evaluates the relative value of the seven evaluation indicators by utilizing the discrete Hopfield neural network to develop the evaluation mathematical model. The simulation results reveal that the suggested method's IoT-enabled interactive UI design effect evaluation accuracy is greater, while the evaluation time is shorter.

1. Introduction

Currently, the adoption of Internet of Things (IoT) technologies, which connect numerous objects to computer networks and offer value, has been widespread. In an IoT system, the user interface is how the system presents the information it generates to the interactive user interface (UI). As a result, it is not an exaggeration to suggest that the quality of the UI has a significant impact on the effectiveness of the IoT system. The IoT system's user interface is realized as a graphical user interface (GUI) employing touch panel screens, for example. Furthermore, gadgets' featuring buttons, switches, LEDs, and so on may be employed in various types of IoT systems. As a result, the IoT system's UI should be developed to combine the usage of GUI with UI devices such as switches and buttons.

As IoT largely depends on the Internet that developed in the West during the second part of the twentieth century. The Internet ushered in a new era of human communication, allowing knowledge to be distributed across traditional political, economic, cultural, and geographic barriers, resulting in a qualitative improvement in the breadth, speed, and efficiency of information transmission. The Internet's platform got increasingly complete in the 1990s, and the web interface became the initial vision of all netizens. With the Internet's continued popularity and proliferation in this explosive period, it has become a crucial conduit for information distribution and the most common mode of information transmission [1]. The Internet is made up of thousands of websites, and each website is made up of several web pages. As a result, the web interface serves as the web page's front end. For information distribution, the visual design of the web interface is especially crucial. In

comparison to the West, the visual design of the web interface in China is relatively behind and has not been generally acknowledged by the public.

At present, there are few Chinese websites with sophisticated interface designs and unique artistic creations. Based on the current development of China's Internet, the visual design of China's web interface is far from reaching. The Western level of art has not caused its due design and cultural influence [2]. Based on the above factors and the increasingly strong aesthetic needs of modern society with increasingly rich material life, it is believed that the research on the visual design of web interfaces has extraordinary theoretical and practical significance. The task of web interface visual design is to use basic elements such as text, graphics, color, animation, and audio to visualize information content to help viewers deepen their understanding of information and achieve the purpose of conveying information [3]. In other words, it must play a variety of diagnostic and interpretation functions for the information disseminated, while at the same time satisfying the aesthetic needs of the viewer group targeted by the website. Users and linked businesses place higher importance on the interactive and aesthetic aspects of the user interface. In addition, mobile games and tablet computers require UI designers to optimize them as a whole. In addition, from the perspective of traditional visual communication, UI design refers to the GUI such as the design of the interactive operation of the screen product and the visual effect of the interface, emphasizing the systematic design of the environment, the machine, and the human, which needs to be combined with ergonomics science, aesthetics, computer science, psychology, and market demand. For example, the well-known Huawei Honor series mobile phones and Apple's smart products, iPad and iPhone, are widely loved by consumers. The reason why the products of these two companies are so popular is reflected in the outstanding software and hardware design. The fast and attractive UI interface design also piques consumers' interest in purchasing. As a result, the impact of interactive UI design is assessed to enhance the quality of interactive UI interface design impacts. Many researchers have contributed to the creation of effective UI in this area. The contributions of these academics are detailed in Section 2.

Based on perceptual engineering, the early work of Zhu et al. [4] presents a technique for measuring the influence of e-commerce website product design and specifies product design goals and product design aspects by employing Internet technology to randomly redirect visiting visitors. The enhanced version collects data on user activity, does data statistics and analysis, and derives the evaluation result. The user takes part in the test without realizing it. The original and upgraded versions of the product are both available online at the same time and are influenced by a variety of external objective variables. The evaluation conclusions are more accurate and credible. The product design scheme combining an e-commerce APP and a hotel reservation APP verifies the validity and feasibility of the evaluation scheme. This method has certain reference significance for the perceptual design and design evaluation of Internet e-commerce websites. However, the design effect evaluation of this method takes a long period, causing low evaluation efficiency. Similarly, Li et al. [5] proposed a product design evaluation method under VR interactive technology. The user feed backs the evaluation requirements to the system main controller through the human-computer interaction module, and the main controller transmits the formulated user requirements to the evaluation index system management subsystem. The subsystem first queries relevant demand information through the information query subsystem and then uses the three-tier classification evaluation model to establish and modify the product evaluation index system. It changes the evaluation index weights under the mandatory judgment method and the expert method. It sorts the evaluation indicators according to the index weights and comprehensively evaluates them. In addition, the analysis subsystem comprehensively evaluates the product design effect according to the sorted evaluation indicators. The viewer can view the evaluation effect in the evaluation result output module. After experimental analysis, it is found that the shortest time of the evaluated product design plan is 4.9 ms, and the minimum energy consumption is 0.498 kJ. The effect of human-computer interaction is good. The work of Li et al. [6] proposed a neural network-based interactive design evaluation method for dairy products. Aiming at the three indicators of interactive evaluation of dairy products, namely, "usability, education, entertainment" and its subindices, the ANP network analysis method is used to determine the weight of each index in the overall evaluation. After that, it establishes an evaluation model for the interactive design of baby products based on the RBF neural network and uses actual cases to verify its feasibility. The evaluation method has been verified in practice and its evaluation effect is objective and reasonable. It has a certain reference value for a more accurate evaluation of the interactive design of baby products. However, the above two methods have low accuracy in evaluating the effect of interactive UI design, resulting in a poor evaluation effect.

Because of the problems of the above methods, this study proposes IoT-enabled interactive UI design effect evaluation method based on discrete mathematical models, verifies the effectiveness of this method through simulation experiments, solves the problems in the traditional methods, and lays the foundation for interactive interface design.

The major contributions of this research work are listed below:

(i) This research suggests a discrete mathematical model for IoT-enabled interactive UI design impact assessment approach to address the concerns of low evaluation accuracy and long evaluation time in existing interactive UI design effect evaluation methods.

(ii) It first explains the structure of the IoT system for interactive design effect and IoT-enabled interactive UI design effect evaluation index system. After that, the evaluation and simulation of the mathematical model based on a discrete Hopfield neural network are thoroughly explained.

(iii) Secondly, it creates an IoT-enabled interactive UI design effect assessment index system using interactive UI design vision, hearing, and feeling.

(iv) Finally, it gets IoT-enabled interactive UI design effect evaluation indexes, builds a judgment matrix, derives the weight coefficient of each evaluation index, and employs the hierarchy based on the weight coefficient produced.

The rest of the sections of this study are organized in an organized manner as given below. The evaluation method of interactive IoT-enabled UI design effect based on the discrete mathematical model is presented in Section 2. Section 3 is based on the simulation and experimental analysis of the suggested method of IoT-enabled interactive UI design effect based on the discrete mathematical model. Finally, Section 3 highlights the conclusion of this study.

2. Evaluation Method of Interactive IoT-Enabled UI Design Effect Based on the Discrete Mathematical Model

2.1. Structure of IoT System for Interactive Design Effect. The Internet of Things system is made up of many functional parts. This study focuses primarily on the interactive IoT-enabled UI design effect of the functional component in charge of information display. Figure 1 depicts the organization of an IoT system, which includes a sensing component, an actuation component, a digital communications component, and an information processing component.

As shown in Figure 1, the sensing device is connected to a thing and is responsible for gathering information from the object. Similarly, the actuating component communicates with and controls the item. The data processing component analyses data from sensing devices to provide more valuable information, which is then transmitted to the actuation component through the data connection component. The sensor component, actuation component, and data transfer component are all implemented as embedded systems in several IoT networks.

On the contrary, the information processing component is also realized as an IT system. In an IoT system with this architecture, the information display function is primarily implemented as one of the embedded system's functions. The information generated by the information processing component can be used by a system user with help of the information presentation function offered by the embedded system. As a result, we will enhance the design process in this research, focusing on the UI element of the embedded system built as the information presentation component of the IoT system for effectively evaluating the effect of interactive IoT-enabled UI design.

2.2. IoT-Enabled Interactive UI Design Effect Evaluation Index System. User interface (UI) design must not only fully reflect the interaction between the interface and the user but also meet the needs of different groups of users and carry out effective R&D and design according to the user's perspective.

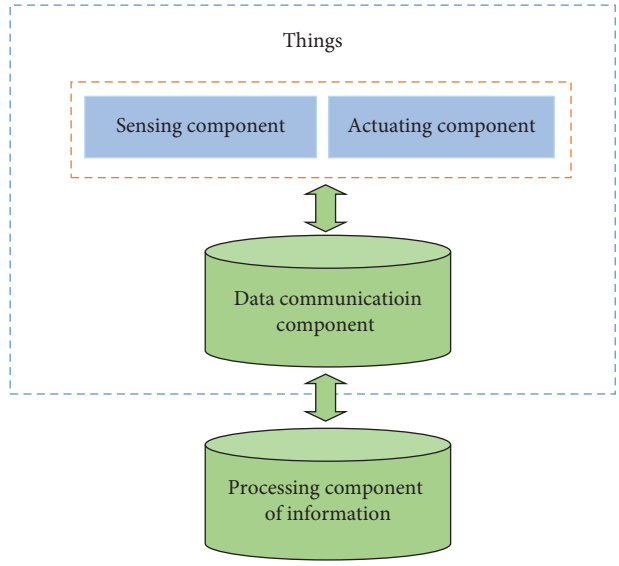

Figure 1: Organization of Internet of Things (IoT)-enabled system.

Based on providing people with more convenient and high-quality services, the interaction and ease of use of UI design are comprehensively improved. The visual elements of interactive UI design include perception, hearing, and vision. Designers need to have an in-depth understanding of software functions and requirements, use information technology to conduct comprehensive analysis and research on related data, and quickly locate usage methods. The user environment and users carry out a series of design activities to fully satisfy the user needs of end users. In addition, it is necessary to fully consider the reading habits, usage rules, interest preferences, and other characteristics of different user groups and carry out in-depth thinking and innovation on the design form. In the concrete practice process, designers should cleverly use contemporary elements and innovative design concepts. Grasp the user's visual thinking rules, scientifically use innovative technological methods to fine-process the preliminary design, and effectively optimize the design details to ensure that the transmission, communication, and exchange of information can be better completed [7].

Designers must thoroughly adhere to the principles of consistency, interactivity, and simplicity of use of interface visual design, grasp the link between interaction, objectives, design, and elements, and consider the user's experience and emotions while creating specific designs. Users can create numerous interface design styles from which to pick or optimize the look of the interface design based on user input. Text is the most direct and effective visual element in interactive user interface design, as well as a significant means of information transfer and interaction in human-computer interaction [8]. In the set interface, avoid using conventional or unusual characters as much as possible, and instead use plain and undecorated text symbols. According to online survey data, interactive UI designers can establish the default font, font size, and format and put appropriate text guides or template instructions in the interface to help users to

customize settings based on their preferences. Panel design must be powerful in both aesthetics and usefulness not only to appeal to people's aesthetics but also to correctly transmit vital information. When creating graphical visual elements such as buttons and icons, it is required to scientifically define the shape, color, composition, characteristics, functions, and names based on the interface theme and overall impact, as well as conduct interactive actions such as touch, click, and slide. [9] Optimization we may also add static pictures in BMP, PSD, PEG, PNG, GIF, and Web formats to the website, display them using compression methods, and account for brightness and color distortion, among other things, to boost the application difference in the post-design makeup procedure. When choosing an interface color, examine the usage impact of the color tone as well as the user's comfort and optimize the color brightness, standard color application, color matching, and major color division. When developing the layout, you may take into account the user's left-to-right, top-down surfing tendencies and concentrate on the commonly used application functionalities in a specific region, so the user can focus and operate it the first time. Hide certain seldom used functionalities so that users can view them based on their requirements, making the interface cleaner and more orderly [10].

As a result, this study builds an IoT-enabled interactive UI design effect evaluation index system using interactive UI design vision, hearing, and feeling to produce the interactive UI design effect evaluation index displayed in Table 1.

2.3. The Weight of Each Indicator Is Determined. We calculated the weight of each evaluation index after building the IoT-enabled interactive UI design effect evaluation index system and collected the interactive UI design effect evaluation index. When calculating the weight of each index, the weight coefficient of each evaluation index is acquired using the built judgment matrix, and the analytic hierarchy procedure is utilized to compute the relative relevance of the seven evaluation indexes based on the obtained weight coefficient [11]. We set the evaluation set's scale from 1 to 9 and then create a judgment matrix based on the meaning provided by the set of assessments. The scale of the assessment set utilized is revealed in Table 2.

By examining the evaluation set in Table 2, we suppose that the same type of interactive UI design effect evaluation index is a criterion level, and compare a level n index $U_{m1}, U_{m2}, \ldots, U_{mn}$. The influence of IoT-enabled interactive UI design effect evaluation index in another criterion layer is assumed to be O. The two evaluation indexes such as U_i, U_j are taken each time, and a_{ij} is utilized to denote the proportion of the effect of U_i and U_j to O, which forms a judgment matrix A given in the following equation:

$$A = \begin{bmatrix} a_{11} & & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}, \tag{1}$$

where $A = (a_{ij})_{n\times n}, a_{ij} > 0, a_{ji} = 1/a_{ij}, i, j = 1, 2, \ldots, n$. At this time, the above equation is a positive and reciprocal matrix.

Table 1: IoT-enabled interactive UI design effect evaluation index system.

First-level indicators	Secondary indicators	Third-level indicators
Interactive UI design effect U	Visual U_1	Color U_{11}
		Brightness U_{12}
		Image U_{13}
	Hearing U_2	Sound U_{21}
		Noise U_{22}
	Feel U_3	Form U_{31}
		Overall effect U_{32}

Table 2: Proportional scale evaluation set.

Serial no.	Scale	Description
(a)	One	This expression signifies that two elements are equally essential
(b)	Three	This indicates that one aspect is somewhat more essential than the other
(c)	Five	One aspect is more critical than the other
(d)	Seven	It indicates that when two things are compared, one is manifestly more essential than the other
(e)	Nine	It indicates that when two things are compared, one is more essential than the other
(f)	2, 4, 6, 8	The median value of the two adjacent judgments mentioned above
(g)	1, 1/2, . . ., 1/9	The comparative judgment ratio

In a weighing technique, the coefficient related to observation is its weight. The decision makers assign a priority ranking to the multiobjectives by selecting weighting coefficients. This results in a more general understanding of the utility function that represents the decision maker's choice (s). According to the above equation, the weight coefficient is obtained in the following equation:

$$A\omega = \lambda\omega, \tag{2}$$

where λ represents the largest eigenvalue of A and ω represents the eigenvector of λ.

Combining (1) and (2), we get the index weight value [12]. According to the weight values obtained, the analytic hierarchy process is used to calculate the relative importance of the 7 evaluation indicators including color, brightness, image, sound, noise, shape, and overall effect. Hence, (3) represents the calculation formula:

$$wi = \frac{c}{A\omega\left(U_{m1}, U_{m2}, U_{mn}\right)}, \tag{3}$$

where c represents the degree of influence on the effect of IoT-enabled interactive UI design.

2.4. Evaluation and Simulation of the Mathematical Model Based on Discrete Hopfield Neural Network. A Hopfield network is a sort of spin glass network popularised by John

Hopfield in 1982, as described previously by Little in 1974, relying on Ernst Ising's work with Wilhelm Lenz on the Ising model. Hopfield has made significant contributions to the artificial neural revolution, demonstrating that a modeled neural network shows crucial computational features. Hopfield networks may be utilized as associative memory to store and retrieve information, as well as to solve combinatorial optimization issues. Hopfield neural system is a fully associated feedback network, comprising continuous and discrete types. A Discrete Hopfield Neural Network (DHNN) is a single-layer neural network with binary input and output. Therefore, according to the relative importance of evaluation indicators, this study uses a discrete Hopfield neural network to construct IoT-enabled interactive UI design effects. Evaluation of mathematical models [13].

The input of the network is represented by $I_1, I_2, ..., I_n$ and can be used as a threshold; on the contrary, the output is represented by $V_1, V_2, ..., V_n$, and the relationship between input and output can be obtained as per equations (4) and (5):

$$xj(t) = \sum_{wij} V_j + I_j, \tag{4}$$

$$V_i(t+1) = \operatorname{sgn}(xj(t)), \tag{5}$$

where $\operatorname{sgn}(\cdot)$ is a symmetrical step function, and the output is +1 and −1. While, W represents the connection weight matrix of the network, and its element wij represents the connection weight of the ith neuron to the jth neuron [14].

The development of the Hopfield neural network state is a complicated nonlinear dynamic system. An "energy function" can be used to assess the system's stability. When specific criteria are satisfied, the network's energy gradually lowers until it reaches the system's stable point. If the system's stable point is thought of as a remembrance, the process of moving from the starting state to this steady point is the procedure of looking for the memory. Associative memory is the primary use of DHNN. Once the input vector I is used as a preliminary value, the system changes through feedback, and a vector V is obtained from the production of the system. Similarly, V is a steady memory associated with the development from the preliminary value I. If we utilize it to resolve the supplier evaluation issue, we must first design W and I so that the sample of the memory pattern corresponds to the steady point of the system, which is equal to the training of the neural network procedure. The skilled memory model resembles the normal supplier evaluation rating, and the data to be assessed (i.e., the supplier to be rated) are then used as the new initial state. The network considers the starting state to be a novel rapid mode (i.e., the occurrence of certain distorted and noisy memory patterns) and recalls the memory pattern that is "closest" to it. This is the procedure of interlink memory [15].

The Hopfield network evaluation method is broken into two stages: memory and association. Because each assessment index has a varied weight, weight must be considered when assessing. A tougher task is expressing the weights of numerous indicators in discrete neural systems. In this research, a strategy of logically grouping neurons is employed to address this problem based on the weight of each evaluation indicator. Neurons in a similar group correspond to the same evaluation index. The superior the weight of the index, the number of neurons in the matching group, the more and the greater the effect on the evaluation outcome of the neural system. The specific method is as follows.

Supposing the overall amount of evaluation indicators is represented by m, and the weights of each indicator are, respectively, $wi, 1 < i < m$ after adjustment; then, there are $0 < wi < 1$ and $\sum_{i=1}^{m} wi = 1$. Suppose the group corresponding to the weight wi is G_i; then, the number of neurons n_i contained in G_i is calculated in the following equation:

$$n_i = RND(100 * wi) \tag{6}$$

where $RND(\cdot)$ represents a rounding function that is calculated as per the standard of rounding, and the principle of maximum carry at the end is used for specific processing of n_i, and the total is guaranteed to be 100. In the mode of memory, the neurons in the similar group take the same value; in the rapid mode (data to be evaluated), the neurons in the similar group also take the similar value, which is equal to the input data of the matching index of the group. Since these neurons in the same group have the same value in the procedure of memory and relationship, they have the "same" effect on the evaluation result. The bigger the weight of the index, the greater the number of neurons in its associated group, the stronger the force of "identity," and the greater the influence on the neural network's assessment outcomes. In this way, the role of weight is included in the evaluation outcome.

The total number of neurons in each level of the neural network is represented by N, and the memory capacity of Hopfield is (0.13~0.15) N. When N is about 100, the corresponding memory capacity is 13–15. If the amount of samples in the memory mode is less than 13, then the Hopfield network designed according to this is reasonable and feasible, and the expression of the mathematical model for constructing an interactive UI design effect evaluation is given in the following equation:

$$S = \frac{n_i N}{V_i(t+1)}. \tag{7}$$

3. Simulation and Experimental Analysis of the Suggested Method of IoT-Enabled Interactive UI Design Effect Based on the Discrete Mathematical Model

The user interface is the extent to which an interface assists a user in completing the activity for which it was designed. This usually refers to the extent to which errors are prevented and tasks are completed successfully, which is measured by the "rate of success" or "task completion percentage." In this research, a simulation experiment analysis was done under the MatLab simulation platform to validate the efficiency of the IoT-enabled interactive UI

design effect evaluation method based on the discrete mathematical model in the actual usage of the apps. As the experimental material, we use IoT-enabled interactive UI design effect assessment indicators such as color, brightness, picture, sound, noise, shape, and overall effect. In addition, we perform an interactive UI design effect evaluation and randomly choose experimental samples from 7 indications to assess the usefulness of sample data. The sample size statistics of each indicator in the experiment are shown in Figure 2.

Figure 3 indicates that the correctness of the training samples and the correctness of the testing samples are quite comparable in all 30 classifiers (packet sensitivity type, packet content type, and interaction type). The accuracy rate is the classifier's accuracy on the samples of training, whereas the accuracy testing is the classifier's accuracy on the testing samples. Whereas if the correctness of the training samples is nearly identical to the correctness of the testing samples, there is no overfitting, otherwise, there is overfitting.

The IoT-enabled interactive UI design effect assessment approach is based on the discrete mathematical model proposed in this research, with the above effective experimental sample number as the experimental object. The product design assessment approach presented in [5] under VR interactive technology and in [6] proposed based on the evaluation method of interactive design of infant items based on neural network compares and evaluated the evaluation accuracy of interactive UI design. The comparison result is shown in Figure 4.

According to Figure 4, it can be seen that the interactive UI design effect evaluation accuracy of the interactive UI design effect evaluation method based on the discrete mathematical model proposed in this study can reach up to 100%, which is higher than the product design evaluation method under the VR interactive technology proposed in [5]. Li et al. [6] proposed the interactive UI design effect evaluation accuracy of the interactive design evaluation method based on the neural network of the baby products with high accuracy.

The discrete mathematical model put forward in this research serves as the foundation for the IoT-enabled interactive UI design effect evaluation approach, which is used to further validate the efficacy of the method. The product design evaluation approach under VR interactive technology suggested in [5, 6] is based on the neural network. The interactive design assessment approach for infant items is a comparative examination of the interactive UI design evaluation time. Figure 5 depicts the comparative result.

Analysis of Figure 5 shows that the evaluation time of IoT-enabled interactive UI design effect using the discrete mathematical model-based interactive UI design effect evaluation method proposed in this study is within 2 s. This is better than the product design evaluation method and product design evaluation method under VR interactive technology proposed in [5]. Li et al. [6] proposed a short evaluation time of interactive UI design effect based on neural network-based interactive design evaluation method for baby products.

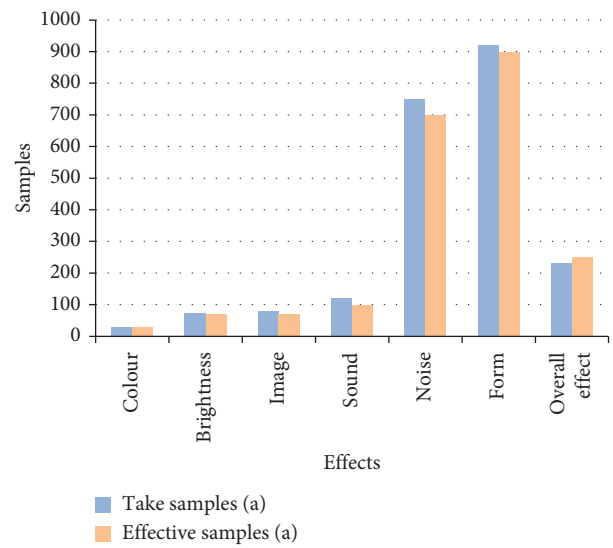

Figure 2: Number of experimental samples.

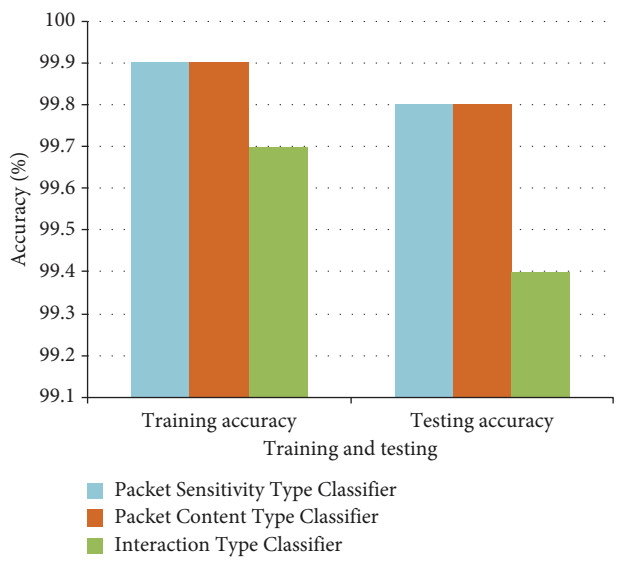

Figure 3: Comparison of the accuracy of the training samples and the accuracy of the testing samples.

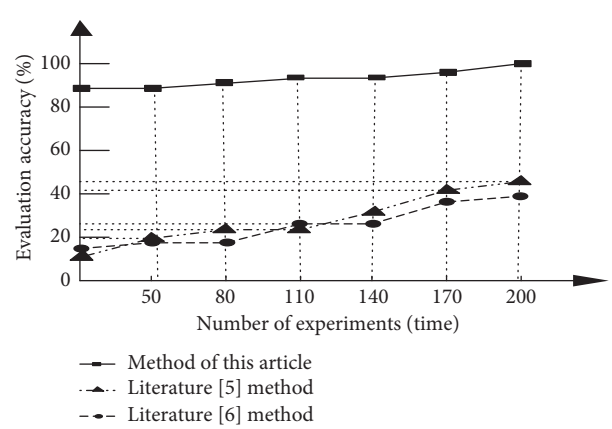

Figure 4: Comparison results of the evaluation accuracy of the three methods.

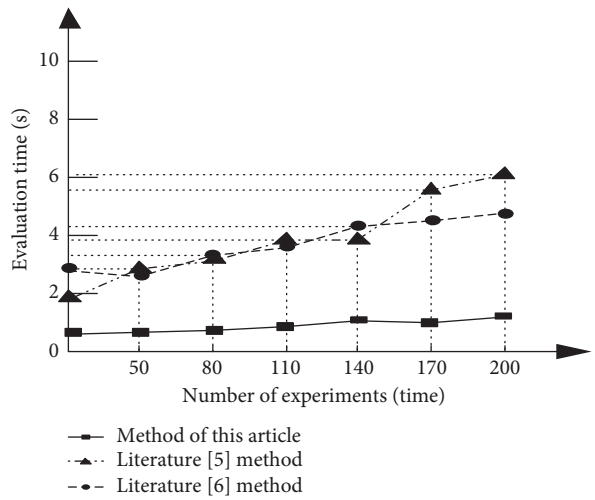

Figure 5: Comparison results of the evaluation time of the three methods.

4. Conclusions

Currently, the Internet, with the assistance of IoT, is rapidly changing the world. With the rapid development of network information, more and more people use this technology to facilitate themselves. It has contributed to the formation of the embryonic form of the network economy, especially since e-commerce has also entered people's daily lives. Nowadays, shopping through e-commerce is a very common thing. With the emergence of a hundred schools of thought on e-commerce websites, under the premise of fierce competition, e-commerce, there are more and more website interface designs. At the same time, the extension of e-commerce continues to expand. As a result, assessing the impact of interactive UI design is critical. Based on these findings, this study suggested an IoT-enabled interactive UI design effect evaluation approach based on discrete mathematical models, validated its efficacy through simulation tests, overcame difficulties in existing methods, and provided the groundwork for interactive interface design. According to the simulation findings, the proposed method's IoT-enabled interactive UI design effect evaluation accuracy is higher, while the evaluation time is lower.

Data Availability

The data used to support the findings of the study can be obtained from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest in the publication of this paper.

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Research Article

Evaluation of College Students' Classroom Learning Effect Based on the Neural Network Algorithm

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With the advent of the digital society, the amount of information we face will increase exponentially, which will challenge our level of educational knowledge, so we begin to pay attention to the effect of education and teaching in the context of digitalization. The purpose of this paper is to study the evaluation of students' classroom learning effect based on the neural network algorithm and scientific objectivity. Assessment and other principles are to create an assessment system for students' learning outcomes in the classroom. The system includes three first-level indicators, including first-level indicators and their weights. By selecting a university to test the system, the results show that the system can quantitatively evaluate the learning outcomes, and the corresponding scores and grades can be obtained through the formula. After adjusting the parameters of the hidden layer nodes, the BP elastic gradient algorithm is used to complete the evaluation model generation. The training error results show that the target curve and the output curve almost coincide, and the error curve is also between −0.2 and 0.5. Therefore, the learning outcome score obtained by the BP neural network based on the principal component factor data is basically consistent with the given learning outcome score.

1. Introduction

With the rapid rise of MOOCs in the world, the reform of online learning in the field of higher education has also become a hot topic of educational research at home and abroad. Although online learning has entered the campus with the characteristics of openness and flexibility and emerged, the traditional offline teaching is still more in line with the thinking inertia and ideological expectations of teachers and students. At the same time, there are still many problems in online learning, such as lack of teacher-student interaction, limited learning support, and academic integrity, especially the discussion about its learning quality and effect, which has always existed [1]. Therefore, it is necessary to find out the learning effects of the two learning styles [2].

At home and abroad, there are in-depth studies on the theory of classroom learning outcome evaluation, the improvement of related technologies, practical application, and evaluation. Omare employed a mixed method design, combining Solomon's four-group experimental design with in-depth interviews. The study used a random sampling procedure of 3 students from 23 public high schools and 1,397 students from 49 English teachers, and 283 of the 3

students participated in the study. Four groups of participants were randomly divided into experimental and control groups. Twelve (12) English teachers were recruited using purposeful sampling techniques. Data were collected by triangulation, using pre/post-test scores, focus group discussions, in-depth interviews, and a metacognitive learning strategies' questionnaire. The results of multiple regression analysis showed that self-efficacy explained 6.4% of the difference in English academic performance [3]. Dhamodharavadhani and Rathipriya developed a COVID-19 mortality prediction (MRP) model for India using statistical neural networks and generalized recurrent networks and Gaussian process regression (GPR). Hyperparameter optimization or tuning is used in these regression models, which is the process of determining the best set of hyperparameters with minimal error [4]. Therefore, further research and innovation are needed on the evaluation of college students' classroom learning effect.

For the first time, this paper focuses on the comparative study of the learning effects of online learning and blended learning on noncommon language learning, hoping to help course learners improve their learning effects through strategies and suggestions and provide references for later resource construction and platform function development. Through the review and analysis of existing research and related literature, understand the interpretation of online learning and blended learning at home and abroad, clarify the main trends of the current online learning effect and blended learning effect research, and evaluate the effect of the two learning methods. This paper sorts out the research status of learning effects at home and abroad, excavates the evaluation framework suitable for this research, and clarifies the value and significance of learning effect evaluation to improve teaching quality. Summarize the current learners' problems in course learning and lay a theoretical foundation for putting forward strategies to improve the learning effect. After studying the relevant literature, it is found that there is very little research on the learning effect of nonlingua franca at home and abroad, and the research will make up for the shortcomings of the current research to a considerable extent.

2. Research on the Evaluation of the Classroom Learning Effect Based on the Neural Network Algorithm

2.1. BP Neural Network Algorithm. The BP neural network is used as a neural network for error correction algorithms. The mean is less than the specified error, saving the weights and margins of the network. The structure of the BP neural network is similar to RBF, which is a multilayer network structure. The same layer is not connected. Similar to RBF, the BP neural network has a good mapping ability, so it has been widely recognized in various fields and has achieved satisfactory results [5, 6].

2.2. Learning Evaluation. This paper believes that the so-called learning evaluation is under the guidance of the national education policy, under the guidance of the education policy, based on the implementation requirements of specific teaching objectives, applying the theories and methods of systematic science and responding to the realization of the teaching objectives in various teaching and learning processes. To establish an objective evaluation standard system, measure the relevant data and data collection, display, and inspection and make a relatively objective value judgment [7, 8]. Learning evaluation is a systematic investigation of teaching effects or all aspects of student development according to certain standards and value analysis and judgment based on the acquisition of sufficient data. The learning evaluation index system is a series of variables that reflect the quantitative characteristics of the entire learning process. In blended learning, learning evaluation is more important to monitor the entire learning process, and students and teachers are both the object of evaluation and the evaluator [9, 10].

2.3. Principles of Learning Effect Evaluation

(1) *Feasibility*. The way and content of evaluation can be different, but there is a condition here, that is, no matter how the form and method of evaluation change, it must be ensured that all evaluation work can be carried out smoothly and can play a role [11, 12].

(2) *Subjectivity*. As an important participant in learning activities, students are both the object of evaluation and the object to be evaluated. Therefore, it is necessary to improve students' participation in the evaluation process so that students can fully understand their own learning situation and adjust their learning strategies in time [13, 14].

(3) *Differences*. It is well known that there are individual differences among students. This difference complicates the subject of education and brings great difficulties to teaching activities. However, in the evaluation process, especially when evaluating students' learning, more attention should be paid to this difference to ensure the accuracy of the evaluation results [15, 16].

(4) *Guiding*. The purpose of assessment is not just to check the number of educational activities but to give people an idea of how well students are learning so that they can see the deficiencies and develop better. Therefore, evaluation activities must play a guiding role in the progress of students and teaching activities, in order to play a role in guiding and promoting education [17, 18].

3. Model and Research on the Evaluation of College Students' Classroom Learning Effect Based on the Neural Network Algorithm

3.1. Determination of the Evaluation System. By summarizing and sorting out relevant literature, the learning effect of the blended physical education course in higher

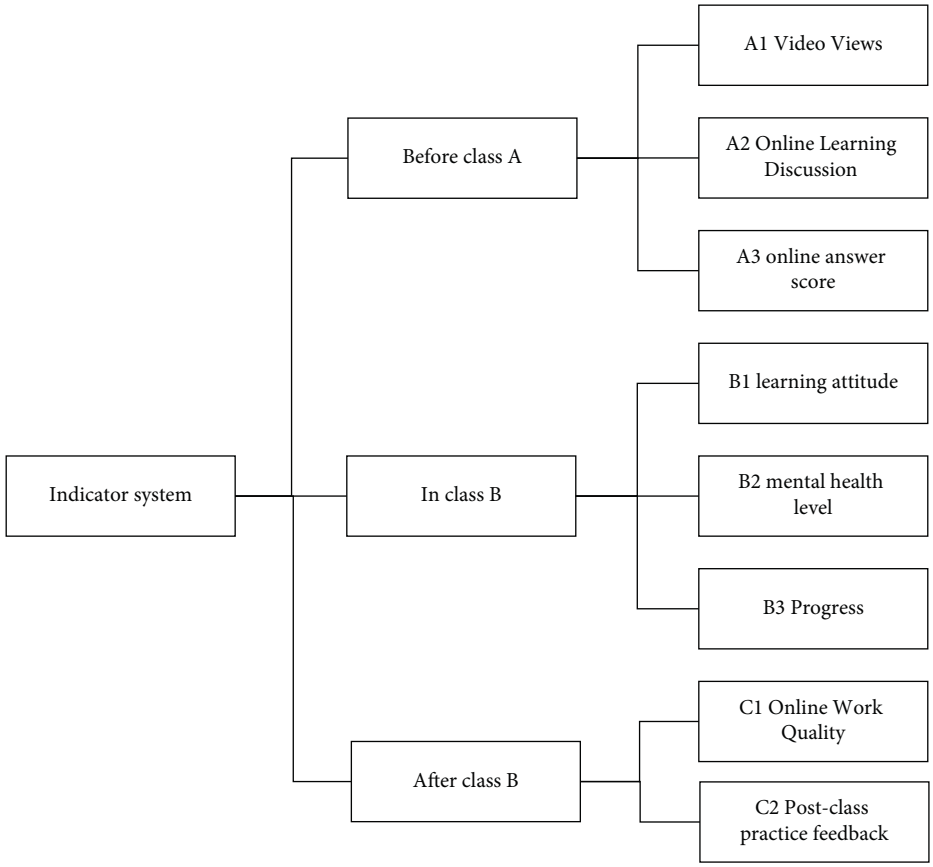

Figure 1: Learning effect evaluation index system.

vocational colleges is defined as the three time nodes (i.e., before class, during class, and after class) of students in higher vocational colleges on the knowledge and the learning effect of emotional attitude values. In order to further define the structure and content of blended learning and learning effect evaluation more clearly and accurately, the researchers conducted interviews with experts in physical education and blended teaching, obtained valuable suggestions and information, and referring to the existing theories based on blended learning and learning effect evaluation, combined with the characteristics of students in higher vocational colleges and related literature; the evaluation indicators of blended physical education courses in higher vocational colleges have been preliminarily established.

As shown in Figure 1, the three time nodes in the mixed physical education course, namely before class, during class, and after class, are the first-level indicators, and the preclass includes three second-level indicators: watching video time, online learning, and discussion. There are participation times, online answering scores, and three secondary indicators in the class as follows: learning attitude, mental health level, and progress; after class, there are two secondary indicators which are as follows: the quality of online homework and after-class practice feedback. Among them, the three-level indicators included in the active learning situation include three indicators: the number of questions asked, the number of questions answered, and the independent preview video; the three-level indicators included in the learning attitude include three indicators: physical education class attendance, classroom performance, and love of sports; psychological: the three-level indicators included in the health level include cooperative communication ability, environmental adaptability, and self-regulation ability; the three-level indicators included in sports healthcare knowledge are the prevention and treatment of common sports injuries and the prevention and rehabilitation of professional-related occupational diseases. There are two indicators; the three-level indicators included in the progress range are the progress of health knowledge, the progress of motor skills, and the improvement of physical fitness; the three-level indicators included in the ideological and moral quality are enterprising consciousness and rule awareness. Indicators: the three-level indicators included in the quality of online homework are the time of submitting homework and the quality of the homework; the three-level indicators included in the after-school practice feedback are after-class practice time and after-class practice quality.

3.2. Neural Network Model. Under normal circumstances, the number of input nodes and input vectors are in one-to-one correspondence, so we simplify the model structure

proposed in and obtain the mathematical model of the neural network that we commonly use as follows:

$$\begin{cases} o_k = f_2(\text{net}_k), \\ \text{net}_k = \sum_{i=0}^{p} w_{jk}^2 y_j. \end{cases} \quad (1)$$

Among them, k is the number of nodes of the evaluation model of college students' classroom learning effect, and w is the input vector of the evaluation model of college students' classroom learning effect.

For the hidden layer, we have

$$\begin{cases} y_j = f_1(\text{net}_j), \\ \text{net}_j = \sum_{i=0}^{m} w_{ij}^1 x_i. \end{cases} \quad (2)$$

The above equation constitutes the mathematical model of the three-layer neural network. Among them, k is the number of nodes in the evaluation model of college students' classroom learning effect, and w is the input vector of the evaluation model of college students' classroom learning effect. Among them, i is the number of nodes of the evaluation model of college students' classroom learning effect, and j is the input vector of the evaluation model of college students' classroom learning effect.

3.3. Determination of the Number of Hidden Layers and the Number of Nodes. For the learning effect evaluation of mobile situational learning, the evaluation factor has only 4 inputs after optimization, and the relationship between the information represented by the principal component factor and the learning effect score is relatively simple to map. The hidden layer is enough, and there is no need to select too many hidden layers to provide the computational efficiency of the model. Considering that the principal component factors of the evaluation model are few, there is also a hidden layer parameter in the mobile scene learning effect evaluation model that must be determined in advance, that is, the number of hidden layer nodes.

In the BP neural network model, the number of nodes in the hidden layer generally does not have a fixed reference and needs to be adjusted according to the data in practical applications. From the overview of BP neural network technology, it can be seen that for a single hidden layer, the number of nodes between the number of input nodes and the number of output nodes is optimal. In order to determine the approximate size of the number of nodes, the result of the optimal number of nodes N in the range of [2, 4] is calculated by the formula.

After the input and output nodes are determined and the relevant parameters of the hidden layer are selected, the network topology of the entire evaluation model is basically determined. The model structure diagram is shown in Figure 2. The entire network model consists of three layers of neurons, the input neuron is the evaluation factor, and the output neuron is the learning effect score.

3.4. AHP. The method is generally divided into the target layer, distribution layer, and index layer according to the factors related to decision-making, and then qualitative analysis and quantitative analysis are carried out to provide more rational analysis and decision-making. According to the evaluation indicators obtained from the questionnaire, we determine the target level, hierarchical level, and index level of AHP and calculate the weight of the first-level indicators according to the expert scores on the judgment table. We calculate the three-level indicators and check the consistency of each matrix and finally use the normalization function to set the sum of the weights of all the level indicators to 1.

CI can be derived from the following formula:

$$\text{CI} = \lambda_{\max} - \frac{n}{n-1}. \quad (3)$$

Among them, λ is the characteristic root, and n is the number of variables in the evaluation system of college students' classroom learning effect.

Calculate the maximum eigenroot λmax of the matrix according to the following formula:

$$\lambda_{\max} = \frac{\left(\sum (BW)_i / W_i\right)}{n}. \quad (4)$$

Among them, λ is the characteristic root, and n is the number of variables in the evaluation system of college students' classroom learning effect.

3.5. Evaluation of the Learning Effect. Learning effect evaluation is a diversified system. In evaluation, various aspects of information are collected, analyzed, and then fed back to teachers and school-related personnel. The overall structure of teaching evaluation is shown in the following figure. According to the analysis of the evaluation stage and the overall structure diagram above, it can be obtained that the evaluation system mainly has three function points: data preparation, evaluation information collection, and evaluation result analysis and feedback.

Data preparation: it mainly prepares the basic data for evaluation, such as departments, majors, semesters, and other basic information.

Evaluation information collection: the content of the collection is determined according to the index system, and the information is collected by the system.

Analysis and feedback of evaluation results: relevant personnel of the school, let teachers find deficiencies and adjust them in time; let managers grasp the overall situation of teaching in a timely manner and formulate policies accordingly.

4. Analysis and Research on the Evaluation of College Students' Classroom Learning Effect Based on the Neural Network Algorithm

4.1. Determination of Indicator Weights. Consistency checks are performed on the expert's comparison matrix according to the formula. As shown in Table 1, finally, the average is

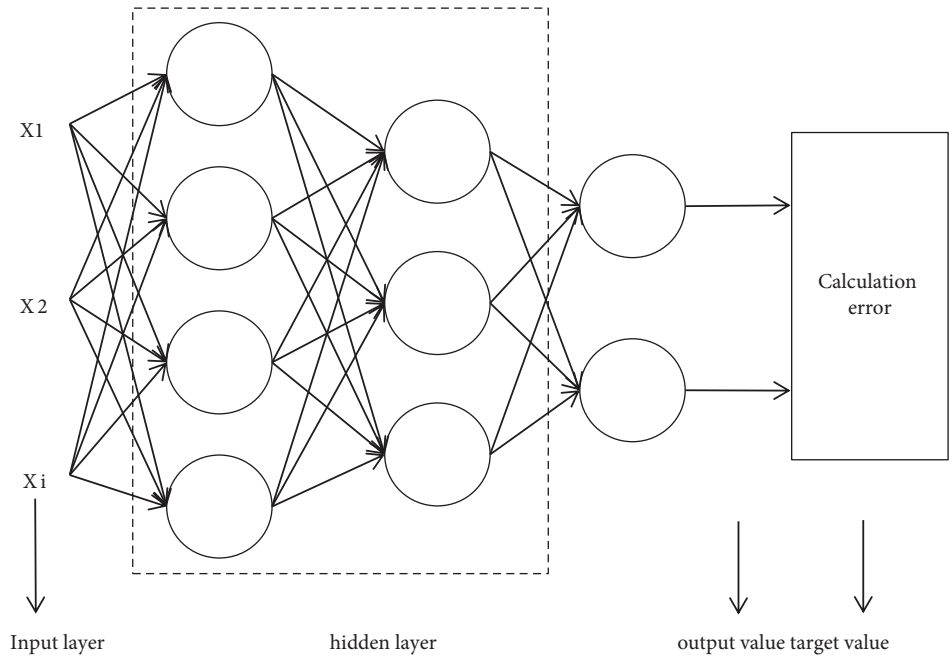

Figure 2: BP neural network model.

Table 1: Index weight coefficient and consistency test result table.

Expert serial number	Online self-study before class A	Learning inquiry in class B	C review and consolidate after the class	CI	RI	CR
1	0.22	0.45	0.26	0.00	0.54	0.00
2	0.18	0.56	0.28	0.04	0.54	0.02
3	0.25	0.63	0.15	0.03	0.54	0.04
4	0.34	0.58	0.26	0.05	0.54	0.05
5	0.28	0.56	0.17	0.04	0.54	0.01
6	0.31	0.48	0.29	0.02	0.54	0.06
7	0.28	0.36	0.34	0.03	0.54	0.04
8	0.15	0.64	0.24	0.02	0.54	0.02
9	0.24	0.55	0.16	0.01	0.54	0.03

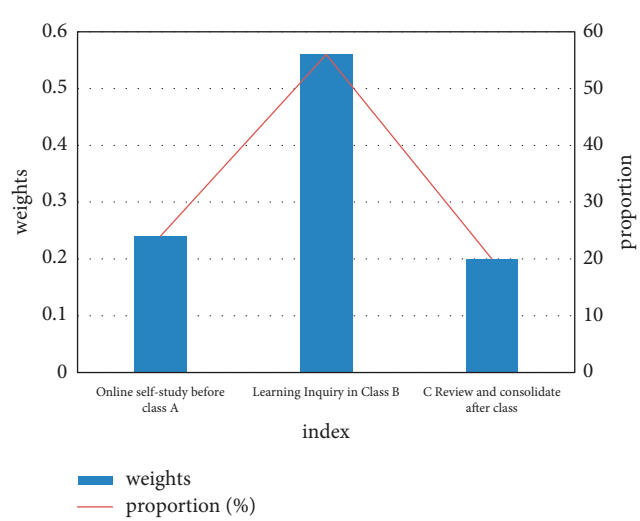

Figure 3: Comparison of indicator weight results.

Table 2: Evaluation results are given by experts and model output results.

Experiment number	Expert rating results	Model output
1	3	2.6
2	2	1.5
3	5	4.6
4	4	4.1
5	3	2.9
6	4	3.9
7	3	3.1
8	3	2.8
9	2	1.6
10	4	4.3

calculated as the weight coefficient of the indicator through the scores of 9 experts.

According to Figure 3, the first-level indicators and their weights are 0.24 for online self-study before class, 0.56 for in-

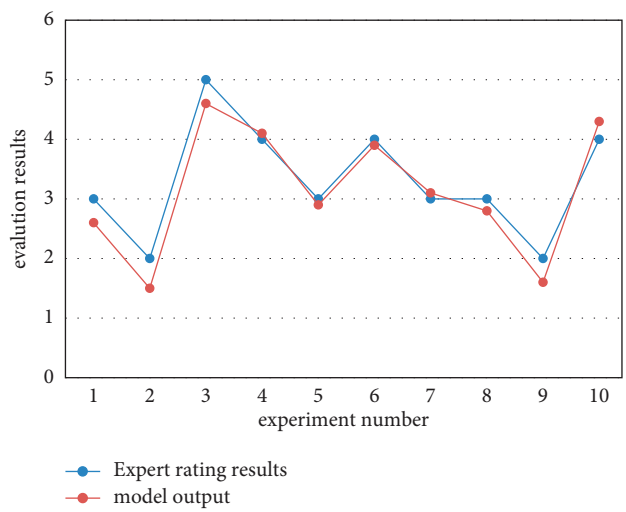

Figure 4: Comparison of evaluation results given by experts and model output results.

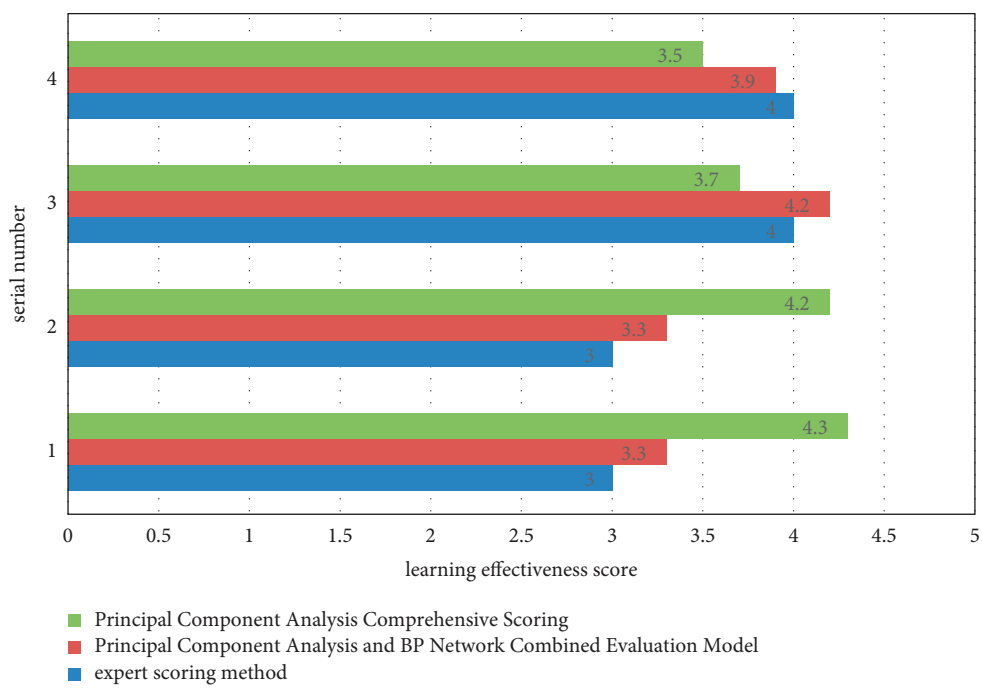

Figure 5: Comparison of the results of the three evaluation methods.

class learning and exploration, and 0.2 for after-class review and consolidation.

4.2. Simulation of the Evaluation Model. After adjusting the hidden layer node parameters, the elastic gradient BP algorithm is used in this paper to complete the establishment of the evaluation model. The training error diagram is shown in Table 2.

It can be found from Figure 4 that the target curve and the output curve almost coincide, and the error curve also fluctuates between −0.2 and 0.5.

4.3. Comparison of Model Calculation Results. In order to compare the evaluation model established in this paper with the comprehensive scoring model of principal component analysis, the scoring results of three evaluation methods can be obtained according to the experiment, as shown in Figure 5.

From the scoring results in Figure 5, the evaluation results of the combination of the principal component analysis and the BP neural network model are closer to the expert opinion than the results calculated by the comprehensive scoring model of the principal component analysis.

Table 3: Descriptive statistics comparison of two types of learners' test unit assessment scores.

Variables	Blended learners	Online learners
N	60	205
Minimum	70	0
Maximum	98	95
Mean	90.32	87.56
SD	5.04	6.35

The evaluation model is more accurate in terms of calculation results.

From the perspective of evaluation time, the evaluation model of the combination of PCA and BP neural network established in this paper takes the same time as the comprehensive scoring model of PCA, and it takes less than 10 seconds from data import to data operation. The scoring method is given after monitoring the entire learning process, and the average time spent on each evaluation is about 10 minutes.

From the comparison of the above two points, the evaluation model established in this paper can not only ensure the accuracy of evaluation results but also reduce the cost of evaluation work.

4.4. Comparison of Learning Effects. In order to ensure the fair evaluation of online learning results and hybrid learning results, the BP neural network evaluates these two learning methods.

Table 3 is a descriptive statistical comparison of the test unit assessment scores of blended learners and online learners that are compared longitudinally. The maximum test scores of the two test units are 98 and 95, respectively, with little difference. The average score of blended learners ($M = 90.32$) is higher than that of online learners ($M = 87.56$), which is about 3 points higher, which means that the average level of blended learners exceeds that of online learners to a certain extent. The standard deviations of the test unit assessment scores for blended learners and online learners are 5.04 and 6.35, respectively. The standard deviation of the blended learners' test scores is lower than that of online learners, indicating that the individual differences among blended learners are small.

5. Conclusions

Through preliminary empirical research, this paper understands the current situation of noncommon language teaching in the College of International Chinese Education and the overall situation of students' learning effects, finds problems in language teaching and analyzes the reasons, and explores the advantages of online learning and blended learning. The practice path for reference is used to solve the related problems and offline classroom teaching. According to the survey results, the research intends to compare and analyze the learning effects of learners in different dimensions through the questionnaire survey method and interview method, combined with the learning data provided by the platform, and explores the current learning effects from the differences and correlations between the two learning methods. The problems in learning are expected to guide teaching practice through strategies and suggestions for problems, so the practical significance of the research is to provide reference suggestions for online learning resources and curriculum construction, as well as online learning and blended learning-teaching activities.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Tracking and Analysing Error in Feedback Linearized Motion Trajectory of Hydraulic Actuator Based on the Internet of Things

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In the current era of technology, the Internet of Things (IoT) is gaining more importance as compared to the rest of the technologies because of its tremendous improvement and application in various areas including tracking and error controlling of physical devices. Controlling physical equipment from afar has become necessary in today's practice. This type of operation needs a robust infrastructure that connects various types of equipment, such as sensors, actuators, plants, and so on, with controllers located in remote locations, either centralized or decentralized, via a communication channel. The variety of platforms makes it difficult to integrate all of these components; nevertheless, the usage of the IoT effectively offers communication across several devices and platforms. However, the drive joints of the traditional hydraulic actuator arm mostly take the form of a combination of a motor and a reducer, resulting in a very small load-to-weight ratio and the power-to-volume ratio of the traditional hydraulic actuator arm. In addition, the load-bearing ratio is one of the important indicators to measure the performance of industrial robots. In response to this problem, this paper studies the combined advantages of hydraulic transmission, a six-degree-of-freedom hydraulic actuator based on a vane-type hydraulic swing cylinder as a joint. According to the performance requirements of the butterfly valve, the hydraulic actuator components, such as hydraulic cylinders, AC servo motors, and hydraulic pumps, have been selected and designed. Furthermore, the calculation and construction of hydraulic pipelines and integrated valve blocks have been accomplished, as has the selection summary of various actuator components. Considering joint flexibility, this research work carries out trajectory planning in joint space, during which it resolves the optimal value of each joint angle under the condition of joint flexibility and obtains a smoother joint motion parameter curve by relying on the layered structure of the IoT framework. The simulation results show that this method can ensure that the acceleration at the start and end time is 0, and it can avoid the vibration of the hydraulic actuator arm at the start and stop.

1. Introduction

These days, the usage of physical devices in many areas is increasing at an extraordinary speed. Even a single system is made up of several subsystems that each contains several interconnected components. These devices are linked to a medium of communication based on the IoT idea, for which cyber-physical technologies and networked control mechanisms are two more preferred terminology. Currently, the IoT play a significant role in several fields that improve the lives we lead. Transportation, industrial automation, universal healthcare, and emergency management in disaster management circumstances are among the domains. It offers a means for physical things to communicate data and coordinate choices. The fundamental technologies like ubiquitous and pervasive computers, embedded systems, communications technology, Internet protocols, and programs are used to achieve the IoT. In the Internet of Things (IoT) paradigm, items are network-connected to transmit and receive information. Hardware resources, computational platforms, and communications equipment are all integrated into the architecture. These three crucial components are vastly different from one another. The integration of multiple devices with that computer system and communication channel is the most difficult due to heterogeneity in system-level features and local attributes of elements [1]. Interactions between various systems have an impact on their performance, such as tracking and mistake

analysis. The coupled physical's dynamics, calculation, and disciplines of communication must be adequately understood before putting out the whole framework to track and evaluate the feedback linearized motion trajectory of the hydraulic actuator.

The trajectory planning of the hydraulic actuator manipulator refers to the motion trajectory of the hydraulic actuator manipulator arm in the joint space and Cartesian space and its generation based on the kinematics and dynamics of the hydraulic actuator manipulator [2]. The trajectory planning of the hydraulic actuator manipulator is divided into joint space planning and Cartesian space trajectory planning [3]. The former refers to the change law of the motion parameters of every joint of the hydraulic actuator controller during the movement process, and the latter refers to the movement of the termination effector of the hydraulic actuator controller. In the case of certain known conditions, the running time is different, and the corresponding motion parameters are also different, but it is necessary to ensure that the obtained change curve of the motion parameter must be continuously smooth [4]. Proper trajectory planning may assure the steady functioning of the hydraulically performed manipulator, decreasing impact and wear on components and extending service life [5]. Compared with the motor transmission, hydraulic transmission has outstanding advantages such as large load, compact structure, and stable transmission under the same power, and its load-weight ratio has significant advantages [6–8]. At the same time, the output power can be controlled by adjusting its system pressure.

In addition to the above, the trajectory planning of the hydraulic actuator manipulator is based on the kinematics of the hydraulic actuator manipulator to generate the motion trajectory of the hydraulic actuator manipulator [9, 10]. For different optimization goals, domestic and foreign scholars have done a lot of research on the trajectory planning of the hydraulic actuator manipulator [11–13]. Relevant scholars have studied the vibration suppression and joint torque minimization of redundant flexible hydraulic execution manipulator trajectory planning. Most of them are proposed using its redundant characteristics for self-motion planning, which not only guarantees the minimization of joint torque but also achieves a good vibration suppression effect [14, 15]. For the research of the rigid-flexible two-link hydraulic actuator manipulator, the researchers proposed to use cubic spline function as the motion trajectory of the hydraulic actuator manipulator joint and use particle swarm optimization (PSO) to optimize the maximum amplitude of the residual vibration at the end [16–18]. Experiments, using simulation, demonstrate the reasonableness of the suggested technique. A two-link flexible hydraulic actuator manipulator has been presented by other researchers [19–21]. An evolutionary method is used to reduce the energy usage of the hydraulic actuator manipulation under the two predetermined joint trajectories [22]. The Hamilton concept is employed to create a model, and the optimizing of joint torque along a trajectory is modeled and judged on the least energy usage, demonstrating the efficacy of the suggested technique [23]. Researchers established a model of the optimal problem with dual boundary value constraints through the Pontryagin principle, obtained the optimal vibration suppression trajectory of the flexible arm system in PTP control, and solved its maximum load [24].

However, due to the small amount of internal leakage of the pendulum cylinder itself and the movement inertia of the pendulum cylinder rotor, the pendulum cylinder produces a rotation angle error [25]. At the same time, the hydraulic control system also has problems such as response lag. Under the combined action of these factors, the joint rotation angle of the hydraulic actuator arm exists. Errors cause the hydraulic actuator arm to have joint flexibility. The joint flexibility eventually leads to a definite error in the end effector of the hydraulic actuator, which determines that the hydraulic actuator lack accuracy compared with the traditional hydraulic actuator [26]. Therefore, the use of the hydraulic actuator is biased. It is suitable for occasions that do not require too high precision, such as handling and palletizing. At the same time, some methods are used to reduce the influence of the joint flexibility of the hydraulic actuator arm on the overall hydraulic actuator arm and decrease the error of the end effector of the hydraulic actuator arm. Therefore, it is necessary to study the influence of joint flexibility on the kinematics characteristics of hydraulic actuators. At the same time, considering the influence of joint flexibility factors, it is particularly important to carry out trajectory planning and kinematic error research on hydraulic actuators.

The key innovations of this research work are listed as follows:

(1) This paper derived the error distribution of the hydraulic actuator arm's end effector with the flexibility of the joints examined in this work. The cubic triangular Bezier spline is used to design the trajectory in joint space to assure the smooth mark and link of the joint motion parameter curve. Simultaneously, the issue of rapid joint angular speeding up is handled by raising the degree of the cubic triangular curve of Bezier spline, and its logic is validated by simulation.

(2) This paper establishes the kinematics design of elastic joint hydraulic actuator manipulators considering the influence of joint flexibility based on rigid kinematics. We perform our experimental work using MATLAB and obtain the motion error dispersal of the end effector of the hydraulic actuator arm under the given joint motion law.

(3) Our findings demonstrate that the kinematics design of the flexible hydraulic actuator arm is accurate. The kinematics simulation is carried out using MATLAB, and the curve of each joint angle is generally smooth, confirming the reasonableness of the hydraulic actuator arm's structural design.

The remainder of this study effort is structured in the following order: Section 2 provides information and techniques for the Internet of Things-based feedback linearized motion trajectory of the hydraulic actuator tracking and

error analysis. We conducted various simulations and experimental experiments on our proposed tracking and error analysis model, which may be discussed in Section 3 of the study. Section 4 is our paper's last section, and it is based on the conclusion of our proposed work and analysis.

2. Materials and Methods

2.1. Tracking of the Feedback Linearized Motion Trajectory of the Hydraulic Actuator Based on the Internet of Things. The network sends packets of data from sensors to remote controllers and from those controllers to actuators. These packets are susceptible to timing latencies and packet loss rates. Figure 1 depicts a schematic of a wirelessly communicated closed network comprising sensors, controllers, and actuators. The fundamental idea of the communication system from [27] has been used in this study, with a few alterations.

2.1.1. Sensors. In the first phase of each sampling interval, the sensors submit measuring packets and other needed packets to the controller. The sensors then fall into a sleep state for the remainder of the sampling moment. The packets from the sensors are received by the controller, which calculates the necessary actions based on the state data. The optimization problem value is calculated using the data and control actions from all projected states. It then awaits the next sample interval. For a certain interval, the actuator actions stay constant. During the most recent sample interval, the actuators acquire instruction packets. When the appropriate packets are properly received, the actuator returns the acknowledgments to the controller. If the packets are corrupted or lost owing to communication inconsistency, the actuator remains operating under the prior instruction packets.

2.1.2. Controllers. Based on the minimal goal function values obtained at each sampling instant of the relevant control intervals, the controller determines the needed control actions for the previous period of analysis. It transmits them towards the actuators and waits for confirmation.

2.1.3. Actuators. The actuators are time-driven because they depend on information supplied from the controller at frequent sampling instants. The most recent time-stamped control packet is utilized to control the plant. Failed packets include corrupted packets and packets that arrive at the actuators in the wrong order and are in the wrong state. The duration of each sample period is set, while the durations of the control intervals vary. The framework competes for the shortest possible length of every control interval. The longer the duration of every control interval, the improved the controller's judgment for actuator operations. The operations of the actuators are determined by the proportional value of an objective function. Because the sensors, controllers, and actuators are well synced, each of them executes its functions as expected during the sample intervals. The duties are assigned to each device on a network.

2.2. Analysis of Hydraulic System Control Scheme. The hydraulic system principle of the hydraulic actuator refers to the direct-drive volume control hydraulic circuit, and on this basis, an optimized design is made for the working conditions of the hydraulic butterfly valve. The hydraulic system of the actuator consists of an AC servo motor, a two-way quantitative hydraulic pump, a rack, a pinion hydraulic cylinder, a hydraulic integrated valve block, a displacement sensor, a controller, and other hydraulic components. All components in the hydraulic system adopt a modular, miniaturized, and integrated design, and oil is closed and independent from the outside.

The entire hydraulic system adopts a fully enclosed internal circulating hydraulic circuit, which can avoid dust and impurities in the working environment from being mixed into the contaminated hydraulic oil. The hydraulic oil in the actuator can be kept clean for a long time and requires almost no maintenance. The hydraulic pump adopts the same amount of oil to be pumped in and pumped out. There is no servo control valve in the hydraulic circuit and no additional heat loss is generated, so it can ensure high mechanical efficiency. The hydraulic system of the hydraulic actuator consists of 4 main pump units, namely, the main valve block unit, the actuator, the hand pump unit, and the butterfly valve load unit. The main pump units, the main valve block unit, the actuator, and the hand pump unit, are all connected by hydraulic pipelines to realize the transmission of oil. The actuator and the butterfly valve load unit transmit torque through a mechanical connection. The main pump unit consists of 4 parts, namely, AC servo motor 1 (hereinafter referred to as motor 1), two-way quantitative hydraulic pump 2, one-way valve 3, and pressure oil tank 4. The coupling is connected with the power output shaft of motor 1 and the power input shaft of pump 2, so that motor 1 can drive pump 2 to work. The pressure oil tank 4 is connected in parallel with pump 2 and connects the first check valve 3.1 and the second check valve 3.2 to provide hydraulic oil for the oil circuit. The main valve block unit is composed of 4 parts, which are the first dual hydraulic control check valve 5.1, the second dual hydraulic control check valve 5.2, the first relief valve 6.1, and the second relief valve 6.2. The main valve block unit plays a role in controlling oil flow and safe unloading in the hydraulic circuit. The actuator is a hydraulic cylinder 7. The high-pressure oil in the circuit enters the hydraulic cylinder to drive the piston. The piston in hydraulic cylinder 7 drives the butterfly valve 8 to open and close through a series of mechanical transmissions. The hand pump unit consists of a manual reversing valve 9 and a manual emergency pump 10. When an emergency occurs during operation, if there is a power failure or hydraulic circuit leakage, the manual emergency pump 10 can be operated to pump oil into the hydraulic cylinder 7 to realize the butterfly valve 8 work. The manual reversing valve 9 can control the flow direction of the oil circuit to control the opening and closing of the butterfly valve 8.

The traditional hydraulic servo valve-controlled actuator adopts an open-loop control system. The control method of the hydraulic actuator studied in this paper is a closed-loop

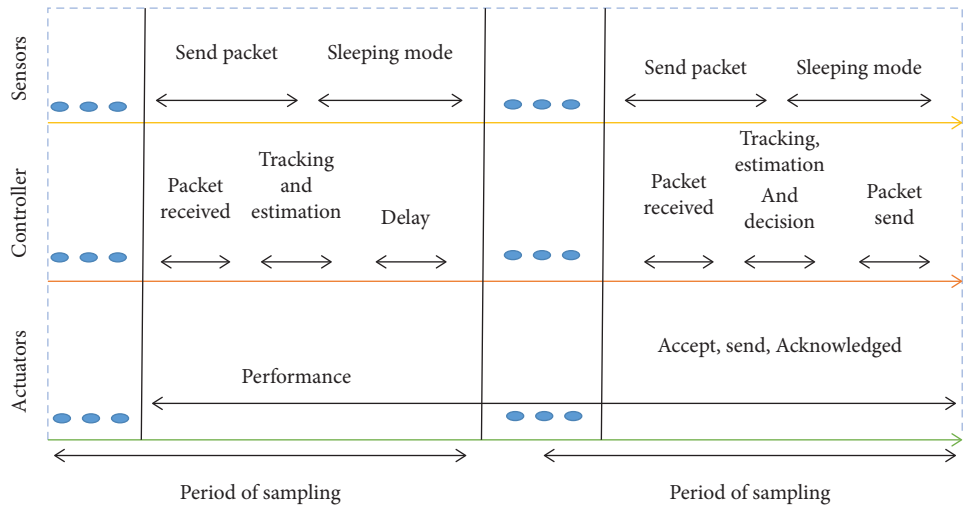

Figure 1: Representation of a wirelessly communicated closed network comprising sensors, controllers, and actuators of the IoT.

control system. The open-loop control no longer affects the input signal after the signal is output, and the closed-loop control will affect the input signal all the time until the target displacement position is reached. The control block diagram of the hydraulic actuator is shown in Figure 2.

Figure 2 shows the closed-loop control process of the hydraulic actuator. The command signal outputs the target displacement. After the controller receives the displacement signal, it drives the AC servo motor to work. The AC servo motor controls the two-way quantitative hydraulic pump by changing the speed and steering, outputting the pressure and direction of the oil, and indirectly controlling the movement speed and direction of the piston of the hydraulic cylinder. The displacement of the piston of the hydraulic cylinder is measured by an angle (or displacement) sensor installed at the connection between the hydraulic cylinder and the butterfly valve. The angle (or displacement) sensor can continuously measure the feedback signal of the hydraulic cylinder displacement and transmit the signal to the controller. The target displacement signal and the position feedback signal are compared and amplified in the controller to obtain the displacement deviation. When the deviation exceeds the set value, the controller sends a signal, and the AC servo motor continues to work until the butterfly valve reaches the predetermined position. The closed-loop control system of hydraulic actuators still needs to develop specific intelligent control methods.

2.3. Structural Design of the Actuator. The AC servo motor 9 and the bidirectional quantitative hydraulic pump 1 are connected by a coupling, and the two parts are externally installed with a metal shell. For the complex working environment, the installed metal shell can protect against collision, dust, and water. The bidirectional quantitative hydraulic pump 1 is equipped with a charge oil tank, which is installed in the metal shell of the hydraulic pump. The metal shell, servo motor, and hydraulic pump are connected and fixed with shell 2 by bolts. Housing 2 is hollow on the interior and has an integrated hydraulic valve block. The hydraulic system oil circuit is included in the hydraulic valve block's integrated board. This design can minimize noise generated by pipeline vibration induced by changes in oil pressure. At one end of housing 2, a hydraulic cylinder 7 is placed. The hydraulic oil port of hydraulic cylinder 7 corresponds to the oil port of the integrated plate of the hydraulic valve block in housing 2, which can realize the communication of oil. The upper part of the hydraulic cylinder 7 is equipped with an angle sensor 6 and the lower part is connected with a butterfly valve 10. We install a hand pump 8 on the other end of the hydraulic cylinder 7 for emergency use. The above constitutes the external structure of the hydraulic actuator.

The structural design of the hydraulic butterfly valve actuator also includes the control structure design. The control structure consists of 4 parts, which are the controller 5, the display 4, the control switch 3, and the angle sensor 6. Control switch 3, the angle sensor 6, and controller 5 are connected by a circuit, and the function of control switch 3 is to open and close the circuit of controller 5. Both display 4 and control switch 3 are fixed on the outer surface of one side of housing 2. Controller 5 is fixed inside housing 2, and its function is to receive and process the displacement signal and control the operation of the AC servo motor to achieve precise control of the rotation angle of the butterfly valve. Controller 5 is equipped with a communication interface based on the field CAN bus, which can communicate with the upper and lower computers. In short, the control structure of the hydraulic actuator can not only achieve precise control of the butterfly valve but also receive and send displacement signals to achieve remote monitoring and control.

2.4. Selection and Analysis of Main Components. This section explains and analyses the main components of our selected model for tracking and error analysis of the feedback linearized motion trajectory of the hydraulic actuator based on

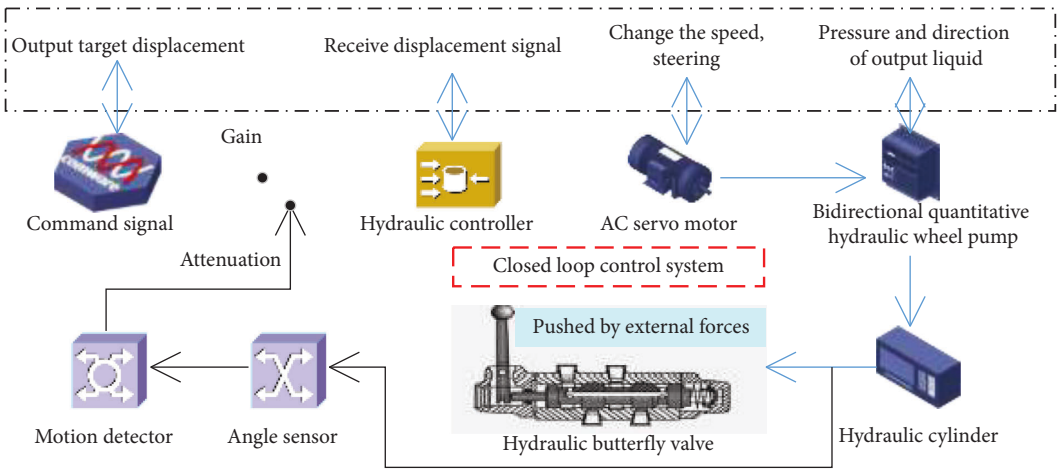

Figure 2: Control process of the hydraulic actuator.

the Internet of Things. This section first explains the selected hydraulic cylinder that has been chosen for our proposed model, and then, it calculates the efficiency of the AC servo motor.

2.4.1. Hydraulic Cylinder. The hydraulic cylinder is the power output device of the hydraulic actuator and is one of the key components. The hydraulic cylinder can convert hydraulic energy into mechanical energy through a series of mechanical transmissions to realize the butterfly valve drive. Piston hydraulic cylinders can be divided into single rod hydraulic cylinders and double rod hydraulic cylinders according to the extension of the piston rod at the end cover. In this paper, the double-barrel hydraulic cylinder is selected, and the double-barrel hydraulic cylinder has a better stable performance of power output under the working environment.

The maximum output torque T required by the butterfly valve is 3000 Nm. Considering that the output voltage is unstable under the working environment, the oil pressure of the hydraulic pump may also be unstable. To ensure that the hydraulic cylinder can withstand higher oil pressure, the maximum pressure of the initially selected hydraulic cylinder is 16 MPa (rated oil pressure is 10–13 MPa). Referring to the hydraulic manual, the force balance equation of the hydraulic cylinder is calculated as follows:.

$$P_1 - P_2 = \frac{2(T-1)}{AD_0}. \tag{1}$$

In the above equation, P_1 represents the pressure of the oil inlet cavity and P_2 is the pressure of the oil return cavity. Similarly, A represents the diameter of the piston and cylinder and D_0 is the index circle diameter of the gear. The area of the piston is calculated as follows:.

$$A = \pi(0.25D)^2. \tag{2}$$

In the above equation, D represents the outer diameter of the piston (inner diameter of the cylinder).

The main technical parameters of the hydraulic cylinder are shown in Table 1. After the high-pressure hydraulic oil enters the cylinder barrel of the hydraulic cylinder, the oil drives the piston in the cylinder barrel to move linearly. The piston drives the rack shaft to mesh with the gear to rotate, and the torque generated by the gear rotation drives the butterfly valve to work. The rotation angle of the gear is proportional to the stroke length of the rack. If the rack is long enough, the gear can theoretically rotate 360°. However, to ensure the compact structure of the hydraulic cylinder, the designed gear rotation angle is generally 0–90°. The meshing distance between the gear and the rack is the stroke of the piston. Considering that the gear requires 10% more rotation, the rotation angle of the gear is calculated as 100°. Therefore, the piston stroke, which is represented by S, is calculated as follows.

$$S = 0.28 \bullet \pi \bullet D_0. \tag{3}$$

2.4.2. AC Servo Motor. An AC servo motor is a type of servomotor that employs alternating current electrical input to create physical output in the shape of accurate angular velocity. AC servomotors are 2 different electric motors with several design differences. The output power of an AC servomotor can range from one watt to several hundred watts. The operational frequency band is between 50 and 400 Hz. It gives the feedback system closed-loop control since it uses a sort of encoder to offer feedback on speed and location.

Given the piston diameter D_1 of the hydraulic cylinder, the piston stroke S, the piston full stroke flow V, and the rated pressure Ps of the hydraulic pump. The time required for the hydraulic cylinder to drive the butterfly valve to open and close once is 7 s. The flow rate q of the hydraulic cylinder per unit of time can be calculated as follows:.

$$q = \pi \bullet D_1 \bullet S/7. \tag{4}$$

Therefore, the required power of the AC servo motor can be calculated using the following equation:

Table 1: Technical parameters of hydraulic cylinders.

Serial no.	Parameter	Parameter value
1	Maximum output torque	2000 Nm
2	Fastest running time	7 s
3	Maximum output angle	90°
4	Transmission form	Gear rack drive
5	Control precision	0.2°
6	Center distance of rack and pinion	80 mm
7	Rated output torque	200 Nm
8	Number of gears	20
9	Piston diameter (inner diameter of the cylinder)	60 mm
10	Rated working pressure of hydraulic pump	12 MPa
11	Modulus	4
12	Maximum working pressure	17 MPa

$$P = P_s \bullet q/20\eta \bullet D_1. \tag{5}$$

In the equation, η represents the overall efficiency of the pump (such as $\eta = 0.82$).

The AC servo motor selects the model 110ST-M04030. The motor can be a small inertia permanent magnet synchronous motor to meet the performance requirements of hydraulic actuators with high positioning accuracy and fast response speed.

2.5. Design of Piping and Hydraulic Valve Block

2.5.1. Piping Design. The hydraulic actuator has servo valve blocks and hydraulic lines built in. This design solution not only eliminates tube vibration and pressure loss but also significantly increases the hydraulic actuator's operating efficiency and operational stability. The following equation can be used to find the pipe diameter.

$$d = 2\,(q/\pi\theta)^{1/2}. \tag{6}$$

In the above equation, q is the oil flow rate in the pipeline, and θ is the allowable flow rate in the pipeline.

2.5.2. Summary of Selection of Hydraulic Valve Block Components. Other components can be selected using the above selection and design of hydraulic cylinders, AC servo motors, and hydraulic pumps. Table 2 provides a summary of the actuator component selection process.

2.6. Feedback Linearization Algorithm. The input-state linearization structure cancels the nonlinear phase in the state equation through the state feedback of the system and converts the nonlinear state equation into a linearly controlled state equation. At this time, it is required that the nonlinear state equation can be written as the following structure:

$$\dot{x} = Ax - B\gamma(x-1) + u\alpha(x). \tag{7}$$

In the above equation, A represents a square matrix of order n, B is an $n \times m$ matrix, (A, B) is controllable for all x, and the matrix $\gamma\ (x)$ is not singular. The term "state feedback" describes the requirement that the feedback control rule is a linear combination of just the state vector (velocity and position). There are various alternative control rules after state feedback is selected as the nature of the control force. One option is to employ pole positioning. In structural control, pole positioning entails finding appropriate modal damping proportions and vibration frequency. The state feedback of the suggested model can be calculated using the following equation:

$$u = \alpha(x-1) - v\beta(x+1). \tag{8}$$

Among them,

$$\beta(x) = \gamma^{-1}(x-1) \bullet \alpha(x). \tag{9}$$

We get the linear equation of state as per above equation.

$$\dot{x} = Ax - B(v+1). \tag{10}$$

We design the virtual input quantity v (if $v = -Kx$); then, the total nonlinear state feedback control law can be calculated as follows:

$$u = Kx\alpha(x) - \beta(x-1). \tag{11}$$

From the above equations, it is clear that input-state linearization has higher requirements on the structure of the system state equation. Even if the state equation is not directly satisfied, it should be able to meet the structural requirements through variable substitution. In addition, this method achieves linearization between the input and the system state. When the output is nonlinear, the closed-loop system is still nonlinear, and the linear system theory cannot be used to design the system controller. Figure 3 shows the structure diagram of input-output linearization.

The input-output linearization structure diagram of the system is shown in Figure 3. That is, the linearization of a system as a whole is realized between the input quantity and the output quantity, allowing the state of the internal system to have a nonlinear phase. This method is mainly realized by selecting appropriate coordinate transformation and state feedback.

It can be seen from the figure that input-state linearization refers to linearization between external input and system state, while input-output linearization is linearization

Table 2: Summary table of the actuator component selection.

Serial no.	Name	Manufacturer	Technical parameters	Model
1	Hydraulic cylinder	Self-made	12 MPa	CBF-B3
2	Hydraulic pump	Fuxin Hydraulic Parts Factory	1.3 ml/r	CBF-E10
3	AC servo motor	Ningbo Hyde	1.2 kw, 3000 r/min	110ST-M04030
4	Pressure tank	HYDAC Company	25 L, 31.5 MPa	SB330-25A1/112A9-330A
5	Relief valve	Beijing Huade Hydraulic	32.6 MPa	DBW10A-2-30/315YG2425 L
6	Check valve	Beijing Huade Hydraulic	31.3 MPa	RVP-10
7	Hydraulic lock	Ningbo Haihong Hydraulic	240 bar, 18 L/min	YYS08-00/0.N.05

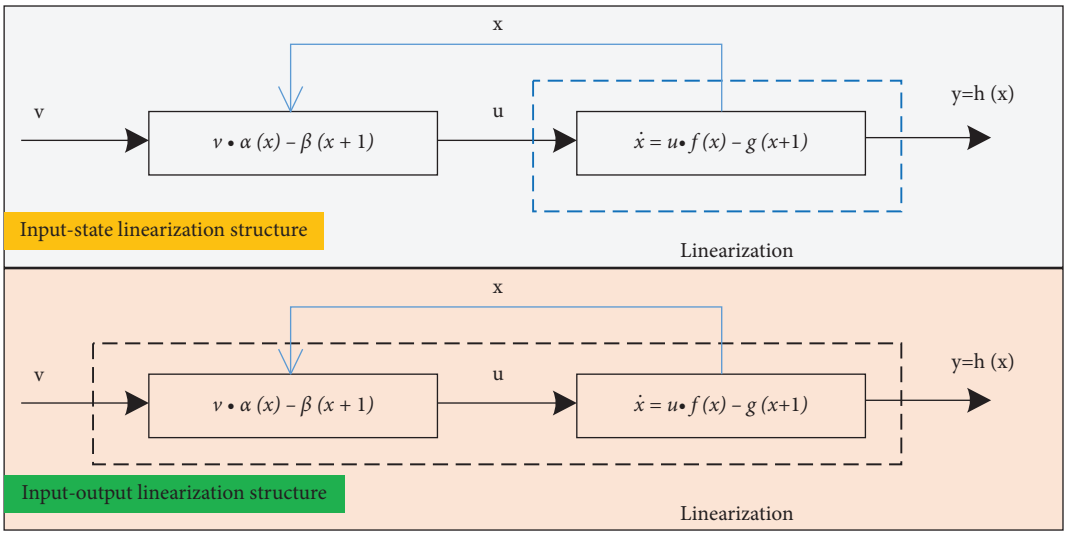

Figure 3: Input-output linearization structure diagram.

between input and output. The two are not the same, but there is also a close connection between the two. For an n-order system, only part of the state is linearized when the relative order of the system is $r < n$. However, when the relative order is $r = n$, then it proves that all states are also linearized. Therefore, if an n-order system is input-output linearizable and the relative order is n, then it must be input-state linearizable, that is, input-state linearization is input-output linearization when the relative order of the function is n.

We can see from the preceding analysis that the specific methods of feedback linearization are similarly classified into two categories. For analysis, we use a single-input single-output nonlinear system as an example. When $r = n$, we select the following coordinate transformation:

$$z(x) = \left[h(x) \;\; L_f h(x) \;\; \cdots \;\; L_f^n h(x) \right]. \tag{12}$$

Then, the original nonlinear system is transformed into the following equation:

$$\dot{z}_n = L_f^r h(x-1) - u L_f h(x+1). \tag{13}$$

We introduce a new input variable v, as calculated in the following equation:

$$v = L_f^r h(x-1) + u L_f^{r-1} h(x+1). \tag{14}$$

At this stage, the closed-loop system is linear and controllable, and the system's state feedback control law may be derived from the following equation:

$$u = -v L_f^r h(x) \bullet L_f^{r-1} h(x+1). \tag{15}$$

In the above equations, when $r < n$, first we carry out the coordinate transformation to obtain r new state quantities. For the other $n - r$ states, we construct a new coordinate transformation for them, so that there is no input quantity in the state equation.

3. Simulation, Experiment, and Analysis

3.1. Kinematics Simulation of the Hydraulic Actuator Manipulator. Kinematic analysis is used to characterize the time course of alterations in the orientation and position of body segments, as well as the geometries of motion in measures of displacements, speeds, and accelerations, despite considering the kinetics of motion production. Thermal imaging systems that capture the 3D location of markers put on the body surface can be used to collect kinematics information. Data are collected at regular periods. Calibration is required for kinematic devices to offer consistency throughout recording sessions. We use the jtraj statement in MATLAB to simulate the kinematics of the hydraulically executed manipulator as given in the following equation:

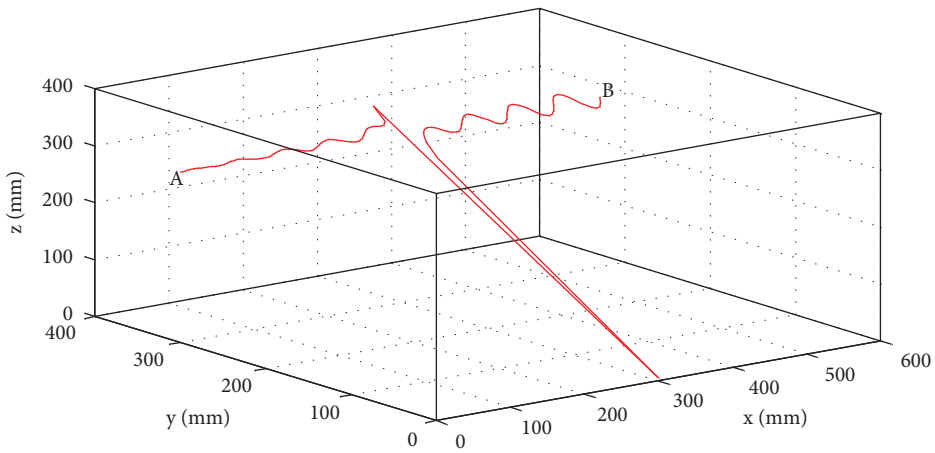

Figure 4: The trajectory of the hydraulic end effector.

$$[qdd\ \ qd\ \ q] = jtraj[t\ \ qA\ \ qB]. \tag{16}$$

In the equation, q represents the joint trajectory from the initial state qA to the final state qB, qd and qdd, respectively, represent the speed and acceleration of the joint angle, and t represents the movement time.

The end effector of the hydraulic actuator manipulator built in this work is defined to move from point A to point B as an example for simulation. Figures 4 and 5, respectively, show the motion trajectory and displacement curve of the end effector of the hydraulic actuator arm. It can be seen that the coordinate curve changes smoothly, that is, it can reach the predetermined position smoothly.

3.2. Joint Angle Error Compensation. In the process of trajectory planning, the starting point, ending point, and running time of the end effector of the hydraulic actuator arm are known, and the joint variables corresponding to the starting point and ending point are solved by inverse kinematics, and interpolation is performed on them. The joint angle time interpolation function $\theta\ (t)$ is used to describe the motion law of each joint of the hydraulic actuator. The value of $\theta\ (t)$ at $t0$ and tf corresponds to the rotation angle of the joint at the starting and ending positions, respectively. There are countless smooth curves between the start and end points, so $\theta\ (t)$ can be selected according to specific constraints.

The hydraulic actuator manipulator designed in this paper has joint flexibility, so the trajectory planning of the hydraulic actuator manipulator considering joint flexibility is carried out. There is a rotation angle fault in the joint of the hydraulic actuator controller that will cause an error among the end effector and the desired point at the termination of the process of the hydraulic actuator manipulator. Therefore, this joint angle error needs to be compensated. First, we use inverse kinematics to find the theoretical value of each joint angle when the end effector reaches the desired position. The joint error is a known range, and the value is randomly selected within a given interval of the joint error and the theoretical angle of rotation is added to the joint. The actual joint angle is obtained from the error, and then, the actual joint angle is substituted into the positive kinematics equation to solve the actual position of the end effector and compared it with the expected position point. The optimum joint error is the joint error that corresponds to the smallest position error. Subtracting the optimum joint fault from the joint angle yields the ideal real joint angle. Finally, the best joint angle is interpolated to calculate the change law curve of the signal parameters of each joint of the hydraulic actuator controller. The theoretical joint variable values in the joint space matching to the route points in the workstation are solved by inverse kinematics, as shown in Figure 6.

Knowing that the maximum rotation angle error of each joint is 0.5°, we randomly selected the error. The theoretical joint rotation angle plus the joint rotation angle error can get the actual joint angle, and then, the actual joint angle is substituted into the positive kinematics equation to find the corresponding end execution. In addition, we compare it with the desired point to find out the joint angle error equivalent to the minimum position error to obtain the best actual joint angle. Combining Figure 6, we write the corresponding program in MATLAB for calculation. Since the angle error of the sixth joint does not affect the location error, only the first 5 joints are studied. We take 500 position points and obtain the error dispersal illustration between the real arrival location and the expected location of the hydraulic actuator arm end effector considering the error of each joint, as shown in Figure 7. The step length of the joint error is fixed to 0.01° to decrease the quantity of calculation. Table 3 displays the optimum joint rotation angle determined.

We take the actual optimal joint path point for each joint angle of the hydraulic actuator arm and then repeat the above steps. The error distribution of the hydraulic actuator's end effector after incorporating joint flexibility correction may be determined by programming and calculating in MATLAB, as illustrated in Figure 8.

When the findings of the figures are compared, it is clear that after joint error benefit, the extreme location error of the hydraulic actuator arm's end effector is greatly decreased, and the range of location error is extra focused. The

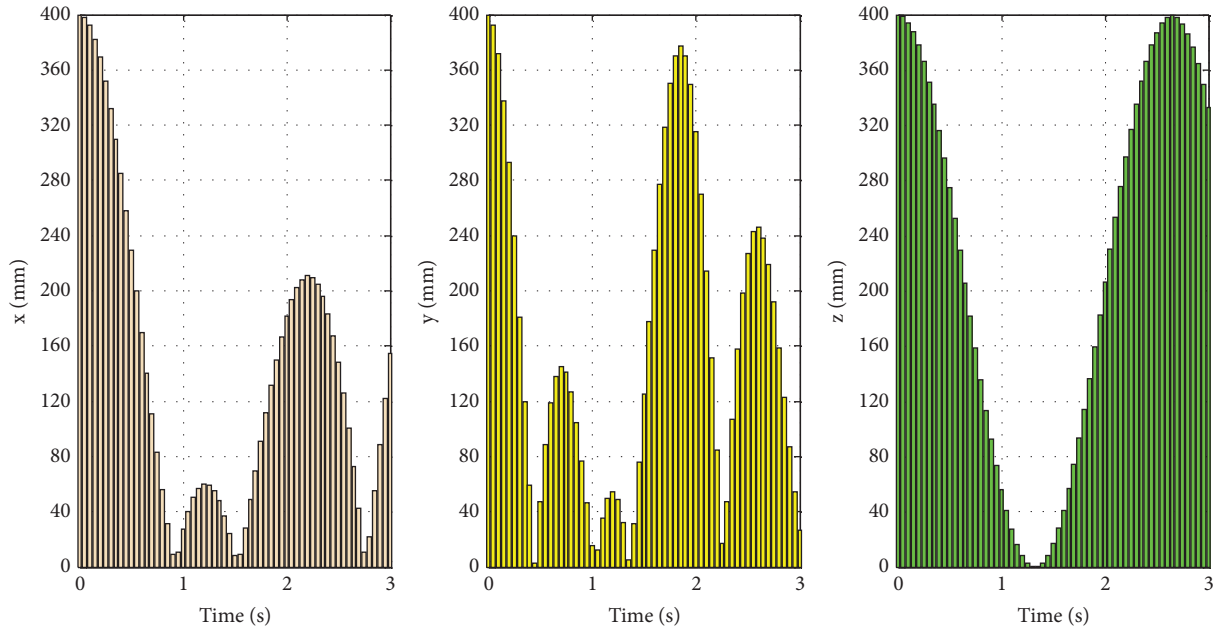

Figure 5: Coordinate projection of end effector of the hydraulic actuator arm.

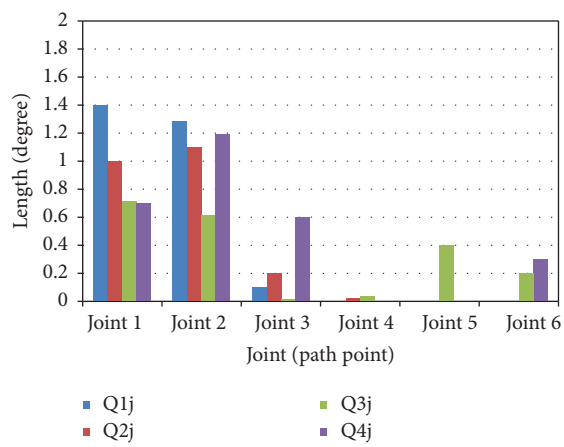

Figure 6: Theoretical path points of each joint (unit: rad).

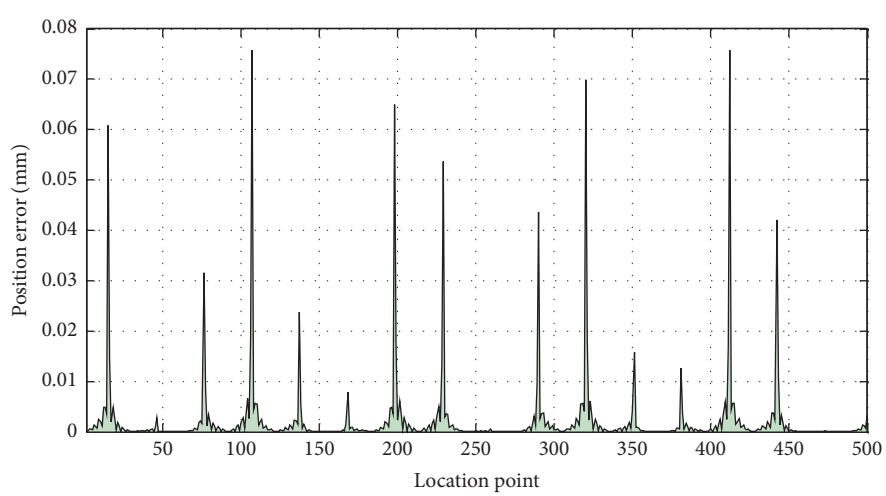

Figure 7: Distribution of position error.

Table 3: Optimal actual joint path points (rad).

Joint\path point	Q1j	Q2j	Q3j	Q4j
Joint 1	1.3	0.1	0.12	0.5
Joint 2	1.2	1.1	0.21	1.0
Joint 3	0.12	0.1	0.03	0.5
Joint 4	0	0.01	0.02	0
Joint 5	0.1	0	0	0
Joint 6	0	0	0.1	0.1

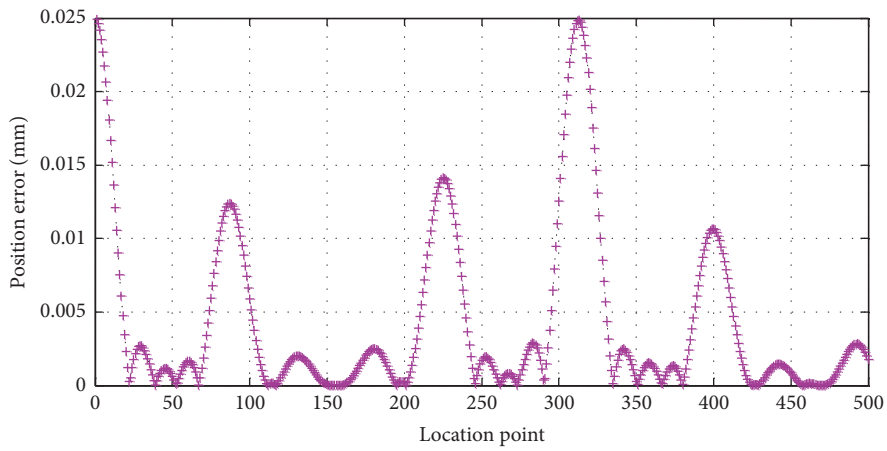

Figure 8: New position error distribution map.

measurement of the complete location interval of error is decreased by around 46.5%, demonstrating the method's viability.

4. Conclusions

The Internet of Things (IoT) infrastructure connects items to the network so that they may transmit and receive data. Physical equipment like hydraulic actuators, computing systems, and communication infrastructure are all integrated into the architecture. These three crucial components are vastly different from one another. The tracking and integration of multiple devices with that computer environment and communication channel is the most difficult problem because of variability in system-level features and the local characteristics of hydraulic actuator parts. The tracking and interactions that take place between various platforms have an impact on their performance. The interplay of physical, computer simulation, and communication disciplines must be fully defined before setting out the entire framework. Based on these issues, this study explores the realization approaches of input-output linearization and input-state linearization of nonlinear systems by evaluating the underlying differences and internal relationships between these two methods. For the hydraulic actuator, the input-output linearization approach is used, the mathematical model of the system is transformed into two linear subsystems, and controllers are created for the two linear subsystems using the pole configuration concept. The simulation findings reveal that feedback linearization control outperforms classical vector control in terms of the hydraulic actuator control effect.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

An Empirical Analysis of the Impact of Environmental Protection Tax on Corporate Earnings Management

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The environmental protection tax (EPT) is an important environmental regulation measure in China and an important guarantee for high-quality economic development. An important measure for the construction of ecological civilization is that local governments promote the construction and improvement of EPT in the way of "Fee-to-Tax." The EPT regulates pollution control, protects and improves the environment through taxation, and forms an effective mechanism for polluters to promote ecological civilization. This study made use of the data collected from different listed companies in Shanghai and Shenzhen provinces from 2010 to 2019, discussing the impacts of EPT on enterprise earnings management. An enterprise analysis model based on IoT-edge computing is suggested to decrease the processing time. The results of the empirical analysis completed in this study showed a significant positive correlation between EPT and enterprise earnings management. In other words, EPT increases the motivation of enterprise earnings management. Moreover, there is heterogeneity in the driving force of EPT on enterprise earnings management. For example, we observed that state-owned enterprises are significantly higher than non-state-owned enterprises. Moreover, pollution-intensive enterprises are significantly higher than non-pollution-intensive enterprises, and economically developed areas are significantly better than economically underdeveloped areas. In order to give better play to the effectiveness of EPT in modern environmental governance, the government should continue to improve the construction of EPT and speed up the construction process of ecological civilization in the republic of China.

1. Introduction

The EPT regulates pollution control, protects and improves the environment through taxation, and forms an effective mechanism for polluters to promote ecological civilization. The EPT is an important environmental regulation measure in China and an important guarantee for high-quality economic development. Since the 18th anniversary of the Communist Party of China, the thought of ecological and environmental protection has been recognized more deeply. However, the intensity of pollution control has never been greater, and the frequency of system introduction has not been higher. Similarly, the scale of supervision and law enforcement has never been higher, as well as the speed of environmental improvement [1]. Ecological and environmental protection has undergone a historic turning point and overall changes from the recognition to the practice. The 5th plenary meeting of the 19th principal group of China's communist party deliberated and implemented the suggestion of the principal committee on articulating the 14th 5-year plan for Social Development and National Economics along with the long-term goals for 2035. The proposal clarifies the goals and tasks for ecological progress and environmental protection in the 14th 5-year plan period and even in 2035. As an important measure of ecological civilization construction and environmental protection, EPT regulates pollution control, protects and improves the environment through taxation rules and regulations, and forms an effective constraint and incentive mechanism for polluters to promote ecological civilization construction. China's EPT system can be divided into two stages: (i) the EPT system based on pollutant discharge fees before 2018

and (ii) the EPT system after the implementation of the Environmental Protection Law of the People's Republic of China on 1 January 2018. In the process of "Changing Fees to Taxes," local governments follow the principle of "Shifting Tax Burden," this study takes sewage fees and EPT as the research object.

This study takes the earnings management of different listed companies as the research perspective and uses the data model to discuss the impact of EPT on the earnings management of enterprises. First, this study analyzes the effect of EPT and earnings management. Then, we study and develop a significant positive correlation between EPT and earnings management. In other words, the collection of EPT promotes the motivation of earnings management of enterprises, but this effect will gradually weaken as time goes by. Secondly, considering the strong heterogeneity of EPT, this study discusses the heterogeneity of the impact of EPT on corporate earnings management from the nature of property rights, industry nature, and regional differences. The study finds that the impact of EPT on earnings management is somehow interesting and could be summarized into three statements: (i) state-owned initiatives are more momentous than non-state-owned initiatives, (ii) pollution-intensive enterprises are more significant than non-pollution-intensive enterprises, and (iii) economically developed areas are more significant than economically underdeveloped areas. Finally, we provide a reference for EPT to stimulate high-quality financial development and initiatives to optimize management strategies to accomplish ecological growth.

The possible research contributions of this manuscript are as follows. First, the micro effect of EPT is investigated from the perspective of corporate earnings management. The EPT is an important environmental regulation measure in China and an important guarantee for high-quality economic development. There are relatively few studies on the EPT and earnings management of enterprises. We further believe that this research area is relatively ignored in the previous literature. In order to comprehensively investigate the effect of EPT collection, this study takes earnings management of listed companies as the starting point to enrich the micro effect of EPT collection from the perspective of EPT development and enterprise surplus management research perspectives. In fact, enterprises are important participants in the market, and their development quality is related to the development quality of the whole economy (especially listed companies). Earnings management is an important measure of corporate profit management, whereas the investigation of the relationship between EPT and earnings management can expand the influencing factors of corporate earnings management. From the results of this study, we observed a substantial positive correlation between corporate earnings management and EPT, and the impact of EPT on corporate earnings management is refined from the dimensions of property rights, industry heterogeneity, and external environmental conditions. The major contributions of this study are as follows:

First, the micro effect of EPT is investigated from the perspective of corporate earnings management.

This study takes earnings management of listed companies as the starting point to enrich the micro effect of EPT collection.

An enterprise analysis model based on IoT-edge computing is suggested.

The study finds a significant positive correlation between corporate earnings management and EPT.

The rest of this study is structured as follows. In section 2, we discuss the literature review. The theoretical analysis of the research hypothesis is described in section 3. In section 4, sample selection and study design are discussed in more detail. In section 5, empirical results and analysis are demonstrated in terms of regression and heterogeneity. Based on the obtained results and conclusions, the policy implications essential to protecting and improving the environment through taxation are summarized in section 6. Finally, conclusions and future research directions are discussed in section 7.

2. Literature Review

Earnings management is an accounting treatment method for managers to transmit future cash flow information of enterprises [2]. Within the scope of laws, regulations, and accounting standards, management selects accounting policies based on their own interests or corporate profits to ensure the realization of goals and objectives [3]. From the perspective of accounting report information transparency, earnings management can be divided into three categories: valuable, neutral, and harmful [4]. According to the manipulation methods of earnings management, it can be divided into three classes: (i) accrued earnings management, (ii) real earnings management, and (iii) classified earnings management [5]. At present, studies on earnings management mainly focus on external and internal governance factors. External governance factors include business environment [6], accounting standards orientation [7], institutional investor research [8, 9], network media attention [10], and intelligent supervision [11]. Internal governance factors include corporate governance [12, 13], enterprise informatization [14], and assessment and incentive [15].

Before the EPT is levied, it includes consumption tax, resource tax, urban construction and maintenance tax, vehicle and vessel tax, vehicle purchase tax, and pollution discharge fee [16]. After levy, the main ring bonded. The research on EPT can be divided into two dimensions: (i) theoretical level and (ii) practical level. The theoretical level includes basic theory [17, 18], tax rate [19–21], implementation dilemma [22], tax collection and management [23, 24], and tax incentives [25]. The practical level can be further divided into macro and micro levels. At the macro level, the emission reduction and pollution control effect of EPT is analyzed mainly from the regional perspective [26–29]. At the micro level, the impact of EPT on enterprise

performance is studied from the perspective of enterprises [30, 31], enterprise technology innovation [32, 33], and the transformation of heavily polluting enterprises [34].

There are a few studies on EPT and corporate earnings management. However, there are studies on corporate earnings management from the perspective of environmental regulation policies with similar effects on EPT. For example, Rongbing and Huifen [35], under the political cost hypothesis, adopted the differential-difference model to test the earnings management of heavily polluting enterprises in the Environmental Protection Law and believed that heavily polluting enterprises were more inclined to choose earnings management to convey the signal of good enterprise development than nonpolluting enterprises. Furthermore, Yiguang and Siyuan [36] studied the impact of environmental regulations on corporate earnings management and concluded that environmental regulations have a significant inhibitory effect on corporate earnings management. Similarly, Kuang and Long [37] used the fixed effect model to analyze the effects of environmental regulation on earnings management and financial performance. They believed that environmental regulation enhanced the effects of earnings management on financial performance.

The literature review found that enterprise surplus management and EPT research has achieved fairly good results, but there is almost no effect of the relationship between studies. This article will be a reference for the environmental regulation effect on the enterprise surplus management research results, combined with the effect of tax revenue and earnings management. Moreover, this will put forward the theoretical hypothesis and test and then get the potential effects of the EPT and earnings management. Finally, this will also help enrich the research perspective of EPT and expand the influencing factors of earnings management.

3. Theoretical Analysis and Research Hypothesis

3.1. EPT and Corporate Earnings Management. Due to the lack of literature on the relationship between EPT and corporate earnings management, this study presents a theoretical analysis and puts forward scientific hypotheses from the perspectives of tax on earnings management and environmental regulation on earnings management. It should be noted that the work presented in this study will also help enrich the research perspective of EPT and expand the influencing factors of earnings management.

3.1.1. From the Perspective of Earnings Management of Taxation. Through literature review, it is found that scholars' research on the relationship between tax and earnings management can be divided into tax cost [38], tax rate [39], tax burden [40], tax collection and administration [41, 42], and tax avoidance [43, 44]. Therefore, this study attempts to analyze the impact of EPT on corporate earnings management from the above perspective.

The first is the cost of taxation. The tax cost in this study is defined from the perspective of enterprises, including the tax cost and indirect cost in the process of paying EPT. As an in-price tax, EPT is bound to increase the cost of tax payments in the short term and reduce the profits of enterprises in the current period. In order to achieve the profit goal, enterprises may choose earnings management to reduce the tax burden. For example, in order to achieve an upward surplus, enterprises will first increase income tax items and avoid the earnings management of VALUE-ADDED tax items [38]. After "Replacing Business Tax with VAT," enterprises operate surplus for tax avoidance to reduce the turnover tax burden [39]. Therefore, the existence of EPT will definitely increase the tax cost of enterprises and then increase the earnings management tendency of enterprises.

The second is the tax burden and tax rate level. Reducing the tax burden is the direct motivation for earnings management, and the change in the tax rate directly affects the tax burden level [39, 45]. This study selects discharge as environmental taxes and environmental taxes as an investigation object. The environmental tax, in the process of following the principle of "tax and fee burden of translation," namely, the tax changes little, is not simply from the perspective of tax analysis enterprise tax burden level. However, the discharge system enforcement rigid deficiencies and lack of administrative intervention are mandatory and more normative [34]. The environmental tax has a more rigid impact on the tax burden level of enterprises than sewage charges. From the perspective of time series, the impact of EPT on the corporate tax burden is gradually increased. Therefore, it can be inferred from the previous statement that the impact of EPT on corporate earnings management is also gradually rigid.

The third is tax collection. Previous studies on the impact of tax collection and management on earnings management show that the conclusions are basically the same. Strong tax collection and management can reduce the level of earnings management of enterprises [41, 42]. Particularly, in the downward earnings management behavior of enterprises, the intensity of high collection and management is significantly positively correlated with earnings management [41]. The EPT also can promote the downward surplus of enterprises, so it is inferred that the strong tax collection of EPT has a significant positive correlation with the earnings management of enterprises.

In addition, EPT belongs to relevant information that enterprises need to disclose. In order to maintain corporate reputation or meet the needs of social responsibility [46], enterprises may be inclined to choose earnings management to reduce the transmission of adverse information. For example, from the perspective of political cost, oil companies choose earnings management to reduce profits and avoid possible government intervention when oil prices soar [47]. In other words, this means that the promotion effect of EPT on earnings management can still be determined from the perspective of relevant information transmission after the collection of EPT.

3.1.2. From the Perspective of Earnings Management by Environmental Regulation. Environmental regulation can be divided into three types: (i) "command-and-control," (ii) market incentive, and (iii) voluntary agreement [46]. EPT is an environmental regulation policy with strong mandatory characteristics. As the intensity of environmental regulation increases, earnings management becomes one of the important ways to reduce the tax burden of enterprises [48]. In order to achieve the goal of compulsory environmental regulation, enterprises will increase their investment in green technology, improve the production process, and/or replace production equipment. Subsequently, this might result in a substantial increase in operating costs. In order to maintain the fundamentals of stable profit growth, enterprises will adopt earnings management to adjust profits [36]. Therefore, from the perspective of the relationship between environmental regulation and corporate earnings management, we can assume the "mandatory" character of EPT, which may potentially increase the operation of corporate earnings management.

From the perspective of the impact of EPT on corporate earnings management and the role of environmental regulation on earnings management, this study puts forward the following hypotheses.

Hypothesis 1. There is a significant positive correlation between EPT and earnings management, and EPT promotes earnings management to regulate corporate profits.

3.2. Heterogeneity of EPT and Corporate Earnings Management

3.2.1. The Nature of Property Rights. Enterprises with different property rights are subject to different levels of government intervention. For example, state-owned enterprises have natural advantages in obtaining government information, and their policy prediction and adaptation are stronger than non-state-owned enterprises [49]. Furthermore, the political relevance of state-owned enterprises reduces their tax inspection risks [50]. According to the results of existing research literature, environmental regulation reduces the tax burden of state-owned enterprises significantly less than that of non-state-owned enterprises [46]. Therefore, it has a higher inhibitory effect on the earnings management of state-owned enterprises than that of non-state-owned enterprises [36]. On the contrary, non-state-owned enterprises are less sensitive to mandated environmental regulations, and state-owned enterprises undertake more national policy-oriented tasks [51]. They have more considerations on EPT, and the effect between state-owned enterprises and EPT is more significant than that of other enterprises. Based on this observation, the following hypotheses are proposed.

Hypothesis 2. Compared with non-state-owned enterprises, EPT plays a more significant role in promoting the earnings management of state-owned enterprises.

3.2.2. The Nature of the Industry. Traditional welfare economics believes that environmental tax can internalize external costs of enterprises and reduce corporate profits to some extent from the perspective of costs. In the traditional economic development model, heavily polluting enterprises are pillar industries of the local economy for a long period of time [52]. The introduction of EPT may directly affect the level of economic development of local governments. Heavy pollution enterprise possibility and total emissions exceed a bid larger [52], making the enterprise tax burden of heavy pollution industry EPT ratio significantly heavier than nonpollution enterprises. Moreover, heavily polluting enterprises, in response to public pressure, tend to choose earnings management behavior to reduce the public attention to the enterprise [46]. In addition, heavily polluting enterprises bear higher political costs than nonpolluting enterprises and are more motivated to carry out earnings management [35]. In order to convey positive stock price information to the public for social image, heavily polluting enterprises tend to choose earnings management to improve their corporate image [35]. EPT has different impacts on enterprises from pollutant emission density and degree. Therefore, the following hypothesis is proposed.

Hypothesis 3. The effect of EPT on the earnings management of enterprises is more significant in pollution-intensive industries than in other industries.

3.2.3. Degree of Economic Development. The purpose of EPT is to force enterprises to make green transformations by means of environmental regulation. However, the transformation requires large-scale investment and has high risk [53]. Due to the differences between tax collection standards and regional tax constraint mechanisms, enterprises may choose to follow the "Pollution Shelter" effect to carry out the spatial transfer. The EPT policy follows the path of "Central Decision-Making–Local Implementation," and policy implementation mainly depends on local governments [53]. It should be noted that the regional economic development level and development goals promote local governments to make policy choices. In addition, economically developed regions have higher awareness of green technology innovation [54]. From the perspective of long-term economic development, regional economic development goals will become an important factor affecting the implementation of EPT. There is heterogeneity in the level of regional economic development in the intensity of EPT collection and enforcement. Therefore, the following hypothesis is proposed.

Hypothesis 4. The promotion effect of EPT on the earnings management of enterprises is more significant in economically developed regions than in economically underdeveloped regions.

3.2.4. Edge Computing for Earning Management. Data processing, profitability analysis, and analysis of the asset structure are the three categories into which the model can

be separated. The study of the assert structure and its analysis is separated into many enterprise management indicators. Similarly, the profitability analysis is also distributed into two different subsections: (a) financial indicator and (b) nonfinancial indicator. Data processing is based on cloud and edge computing models. Based on the input data, an appropriate analysis model is built, and the findings of the enterprise analysis can then be generated [55]. This model can decrease the processing time by implementing the earnings management system over the edge while the data are collected at the client level through sensors and other IoT devices. When needed, data can be moved to the cloud for long-term storage and prediction. In fact, we account for large-scale companies and use machine learning methods, such as convolutional neural networks (CNN), to improve and generalize the finding. In such scenarios, the training may happen on the cloud servers, while the prediction tasks could be accomplished over the edge servers.

4. Sample Selection and Study Design

4.1. Sample Selection and Data Sources. In order to study the impact of EPT on corporate surplus management, this study selects two different datasets: (i) from 2010 to 2017, data on sewage charges, and (ii) from 2018 to 2019, data on environmental taxes [56, 57]. Moreover, these datasets offer various EPT data variables for the following reasons:

The official implementation date of China's environmental protection fee to tax change was 1 January 2018.

The institutional framework and content of sewage charges were still retained.

The local tax amount was determined in general following the overall determination of local tax amounts, which follows the principle of "tax burden shifting."

The tax amounts around the country basically do not change too drastically (Research Group of "New-Era Public Finance and Tax Policy Reform Promoting Green Development," 2021) [58].

Moreover, A-share listed companies in China's Shanghai and Shenzhen markets, from 2010 to 2019, were selected as the initial sample. Before data analysis, in the preprocessing phase, the "ST and ST*" samples in the sample period were excluded. Similarly, the samples with missing data on relevant variables were also excluded due to insufficient details. Finally, 23,014 observations were obtained and considered for evaluation.

4.1.1. Data Sources. The datasets belong to three different sources: (i) EPT data from the China Statistical Yearbook, China Environment Reports, and Annual Reports of some enterprises; (ii) industry breakdown data (classification of pollution-intensive industries and non-pollution-intensive industries) from the Guide to Environmental Information Disclosure for Listed Companies, with reference to the National Economic Classification of Industries (GB/T4754-2011) and the Guidelines on Industry Classification for Listed Companies (2012); and (iii) all other data from the CSMAR database [59].

In order to reduce the effect of extreme values on the results, the article applies tailoring at the 1% and 99% quartiles to all continuous variables. Note that the p-value is kept as 0.05, denoting the 95% confidence interval. Data processing and analysis were done using Stata15 and Excel application software.

4.2. Model Design and Variable definition. In order to test the positive relationship between the EPT and surplus management, we construct the following econometric model that essentially focuses on the impact of EPT on corporate surplus management, which is illustrated as follows:

$$DA_{it} = \alpha_0 + \alpha_1 ET_{it} + \sum_{j=1}^{n} \alpha_{i+j} x_{it} + \varepsilon_{it}. \quad (1)$$

In the above model, DA denotes corporate surplus management, and ET represents the difference between the company's earnings profit and net cash flow from management activities. This study draws on relevant research on surplus management and uses the industry subannual modified Jones model, given by equation (2). The Jones model is used to estimate manipulative accrued profits as a measure of surplus management, modeled as follows:

$$\frac{TA_{it}}{A_{i,t-1}} + \beta_1 \frac{(\Delta REV_{it} - \Delta REC_{it})}{A_{i,t-1}} + \frac{\beta_2 PPE_{it}}{A_{i,t-1}}. \quad (2)$$

In the above equation, TA represents the difference between the company's earnings profit and net cash flow from operating activities. Similarly, ΔREV is the difference between the operating income in the current period and that in the previous period, and ΔREC is the difference between accounts receivable at the end of the current period and accounts receivable at the end of the previous period. Moreover, PPE is the value of the company's fixed assets, $A_{i,t-1}$ is the company's total assets in period t-1, and ε is the residual of the model. Regressions of the root modified Jones model by industry and year yield residuals as a proxy variable for surplus management (i.e., DA), where we take its absolute value. The main variables in the article are defined and described as follows:

EPT (ET): the existing literature on the definition of EPT is divided into two categories: (i) the insurance-related taxes and fees, including consumption tax, resource tax, urban maintenance and construction tax, vehicle tax, vehicle purchase tax, and sewage charge (Xia Yangfan, 2020) [16], and (ii) the EPT after 1 January 2018. Considering the relatively short period of time since the introduction of EPTes, the article defines sewage charges and EPTes as EPTes (ET) because they are basically the same in terms of institutional design and taxation content, and the principle of "tax and fee equalization" is followed in the local EPT collection practice (ET).

Earnings management (DA): earnings management is mainly divided into three types: (i) accrued earnings management, (ii) real earnings management, and (iii) classified transfer earnings management [7]. Accrued earnings management uses specific accounting methods to change corporate earnings, whereas real earnings management is based on the manipulation of corporate earnings in real business activities [60]. The classified transfer earnings management is based on profit classification manipulation of the income statement [5]. This paper considers the existing studies on the impact of tax on corporate earnings management, mainly reflected in accrued earnings management [36, 38, 39]. We select accrued earnings management as the research variable for the results because they have no significant impact on real earnings management.

Control variable (): on the basis of existing research, the following variables were selected as control variables: enterprise size (Sizew), asset-liability ratio (Levw), net cash flow from operations (Cfow), return on assets (Roaw), growth rate of revenue (Growthw), enterprise year (Agew), shareholding ratio of the largest shareholder (Shrcrlw), proportion of independent directors (Indepw), board size (Lnboa), dual, and state property rights (State). The main variables and brief descriptions are defined in Table 1.

4.3. Descriptive Statistics. The descriptive statistical results, as shown in Table 2, show that, among the 23,014 samples, the mean value and standard deviation of accrued earnings management of enterprises are 0.0603 and 0.066, respectively. The values indicate that many listed companies do not use accrued earnings management to manipulate profits, and only a few listed companies have low financial quality reports. The maximum and minimum values of accrued earnings management are 0.0007 and 0.356, respectively. The values illustrate that the degree of accrued earnings management varies greatly in the samples. Other variables are basically consistent with the results of existing research literature, ensuring the stability of sample selection.

5. Empirical Results and Analysis

5.1. Analysis of Regression Results. Table 3 outlines the regression analysis results of EPT and corporate earnings management. The results in column (1) show that, without any control variables, the regression coefficient of EPT (ET) on earnings management (DAW) is approximately 0.001 and is significant at the level of 10%. Similarly, the results in column (2) show that, with the addition of existing control variables, the regression coefficient of EPT (ET) on earnings management (DAW) is approximately 0.001, which is significant at the level of 5%. The latter situation indicates a significant positive correlation between EPT and earnings management. The empirical results show that the EPT encourages listed companies for choosing earnings management to achieve the operation and management purposes of cost reduction, reputation maintenance, and social responsibility. These results are consistent with the expectation of hypothesis 1.

5.2. Heterogeneity Analysis of EPT and Earnings Management. In order to test the heterogeneity of the impact of EPT on earnings management, based on model (2), group regression was conducted. In fact, group regression was conducted on the samples according to the nature of enterprise property rights, industry nature, and economic development degree. Moreover, the difference analysis of the impact of EPT on enterprises with different property rights, industry nature, and different regions was tested. The property rights grouping divides listed companies into state-owned enterprises and non-state-owned enterprises.

The classification of industry nature draws on the research of [61] and [62] to construct the pollution density evaluation index (EPI) from the emission intensity and emission scale of taxable air pollutants, taxable water pollutants, taxable solid waste, and taxable noise:

$$EPIi, t = \sqrt{Ei, t \times Pi, t},$$
$$EPIi = \frac{\sum_{t=0}^{t\max} EPIi, t}{t\max}. \tag{3}$$

In the above equation, $EPI_{i,t}$ is the evaluation index of pollution intensity of industry i in the t year and $\omega_{i,t}$ is the pollution emission intensity of industry i in the t year, that is, pollutant emission per unit industrial output value. Furthermore, $\varpi_{i,t}$ is the pollution emission scale, that is, the proportion of pollutants discharged by industry in the total emission of such pollutants in China. In the other part of (3), EPI_i is the average pollution intensity index of industry i during the study period. In order to make the data have comparability, the normalization method was adopted. Approximately, thirteen pollution-intensive enterprises with an EPI index over 15 were selected, including paper and paper making, textile industry, chemical raw material and chemical products manufacturing industry, and agricultural and sideline food processing industry. For these industries, the value was 1; however, the value of other enterprises was 0.

The degree of economic development was divided into different regions. The main classification refers to regional GDP, per capita GDP, main industrial output value, ecological infrastructure construction, and other aspects. The area was divided into the developed area (Beijing, Shanghai, Tianjin, Jiangsu, Zhejiang, Fujian, Guangdong, Hebei, Jilin, Heilongjiang, Anhui, Chongqing, Sichuan, Jiangxi, Shanxi, Liaoning, Shaanxi) and developed regions (Hainan, Inner Mongolia, Xinjiang, Tibet, Gansu, Guangxi, Guizhou, Yunnan, Qinghai, Ningxia). Note that the developed regional assignment was 1, whereas undeveloped regions were assigned a value of 0.

According to the grouped regression analysis results, as shown in Table 4, the significance of EPT on earnings management is greater for state-owned enterprises than for non-state-owned enterprises. This can be inferred that under

Table 1: Variable definition table.

Symbol	Name	Description
Explained variables		
DA	Enterprise accrual earnings management	Can control the absolute value of accrual earnings management
Explanatory variables		
ET	EPT	Data of pollutant discharge fees shall be collected before 2018, and data of EPT after 2018
Control variables		
Sizew	The enterprise scale	The natural log of the total assets of the firm
Levw	Asset-liability ratio	Total liabilities/total assets
Roaw	Return on assets	Net profit/total assets
Growthw	Growth rate of revenue	(Current period operating income-previous period operating income)/previous period operating income
Cfow	Net cash flow from operations	Net cash flow/total assets from operating activities
Agew	Enterprise year	Take the natural log of the difference between the current year and the founding year
Shrcrlw	Shareholding ratio of the largest shareholder	Shareholding ratio of the largest shareholder
Independ	Proportion of independent directors	Number of independent directors/number of directors
Boardw	Board size	Take the natural log of the number of board members
Dual	Dual	Chairman of the board and general manager of the two posts, take 1; otherwise, take 0
State	State property rights	If the actual controller is a state-owned enterprise, the value is 1; otherwise, the value is 0

Table 2: Descriptive statistics (the size of the sample is 23,014).

Variable	Mean	Standard deviation	Minimum value	Maximum
DA	0.06292	0.0660006	0.0006814	0.355877
ET	3.682749	6.497835	0	19.19368
Sizew	22.13836	1.304221	19.27126	26.03795
Levw	0.4401246	0.2157707	0.0494682	0.9787084
Roaw	0.0345205	0.0654933	−0.3407795	0.2021874
Growthw	0.2041242	0.5346741	−0.6235116	3.946809
Cfow	0.0427779	0.720274	−1.990094	0.2424951
Agew	2.885056	0.2973631	1.94591	3.555348
Shrcrlw	35.25692	14.71769	8.7716	74.9648
Independ	0.3742606	0.0548996	0.125	0.8
Boardw	2.139697	0.199147	1.609438	2.70805
Dual	1.746155	0.4352197	1	2
State	0.4467281	0.4971648	0	1

the same conditions, the tendency of EPT to motivate enterprises to generate earnings management motivation is greater for state-owned enterprises than for non-state-owned enterprises. The EPT on earnings management of significant pollution-intensive industries was noted to be larger than the pollution-intensive industries in the same conditions. Similarly, the EPT to promote the enterprise earnings management motivation orientation of pollution-intensive industries is larger than the pollution-intensive industry. We observed that including non-pollution-intensive industries is 0, the influence of the EPT impact on nonpolluting industries is very small, and that can approximate to 0. The significance of the EPT on earnings management is greater in economically developed areas than in less developed areas. Under the same conditions, EPT is more likely to motivate enterprises in economically developed areas to generate earnings management motivation than in economically less developed areas.

5.3. Robustness Test. In order to verify the robustness of the empirical results, this study reduces the sample period from 2010–2019 to 2016–2019 by shortening the sample period. Moreover, we adopt the method of differential difference analysis. Similarly, to reduce noise interference, we use the technique offered by Yu Lian Chao et al. (2021) to build a differential difference model. The specific model is as given as

$$DA\text{it} = \alpha 0 + \alpha 1 ETi, t + \sum \beta jCVsi, t + \varepsilon i, t. \quad (4)$$

In the above equation, CVs represent the control variable, whereas all other variables are predefined. The regression results show (Table 5) that EPT has a significant positive correlation with the corporate earnings management; therefore, hypothesis 1 is still valid. Note that the p-value is kept as 0.05, which denotes the 95% confidence interval, as described in an earlier section.

Table 3: EPT and earnings management.

Variable	Earnings management (DA)	
	1	2
ET	**0.0001***	**0.0001****
	−0.0001	**−0.0001**
Sizew		−0.0067*** −0.0005
Levw		0.0332*** −0.0034
Roaw		−0.2145*** −0.0153
Growthw		0.0313*** −0.0016
Cfow		−0.0662*** −0.0125
Agew		0.0037** −0.0016
Shrcr1w		0.0001*** 0
Independ		−0.0101 −0.0084
Boardw		−0.0075*** −0.0025
Dual		−0.0007 −0.001
State		−0.0058*** −0.001
_cons	0.0752*** −0.0039	0.2136*** −0.0118
adj. R2	0.03	0.171
F	19.8591	50.1754
N	23014	23014

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.4. Policy Mechanisms. Based on the above results and conclusions, the policy implications essential to protect and improve the environment through taxation are as follows:

Increasing the disclosure degree of taxable pollutant information of corporate EPT: although earnings management is not good or bad, its operation increases the information asymmetry of market participants and may lead to misleading information users. Increasing the disclosure of taxable pollutant information can reduce the possibility of earnings management to a certain extent, enhance the liquidity of market information, and reduce the risk of misjudgment of market participants [56, 63].

The establishment of the EPT rate shall fully consider the nature of the industry and the level of regional economic development. The tax rate is the direct withdrawal of tax burden level, and the scientific and reasonable tax rate can ensure the realization of the tax collection purpose. The purpose of EPT is to reduce the emission of pollutants by market participants and promote the high-quality development of the regional economy while protecting the ecological environment. The current EPT mainly considers the shift of tax burden without fully considering emission reduction, energy saving, and governance efficiency. China's regional natural endowment and economic development level differ greatly. As a local tax, how can EPT give full play to its efficiency and define effective tax rate level become the key. This will also be the focus of our research group's next step: optimizing the EPT system.

Optimizing tax collection and management to reduce the cost of EPT collection: another important indicator associated with tax effectiveness is the efficiency of tax collection and management. The collection of EPT relies on the discharge data of taxable pollutants provided by environmental protection departments, and the monitoring and collection of taxable pollutant data require a large amount of manpower and material resources. EPT can use the rapid development of the Internet and big data to actively build an information sharing platform, reduce information asymmetry, and reduce the cost consumption in the circulation process.

Table 4: Heterogeneity analysis.

Variable	Earnings management (DA)					
	State-owned enterprises	State-owned enterprises	Pollution-intensive industry	Non-pollution-intensive industries	Economically developed area	Economically underdeveloped areas
ET	**0.0002** **	**0.0001**	**0.0003** ***	**0**	**0.0002** **	**0.0001**
	−0.0001	**−0.0001**	**−0.0001**	**−0.0001**	**−0.0001**	**−0.0002**
Sizew	−0.0071***	−0.0063***	−0.0071***	−0.0069***	−0.0064***	−0.0109***
	−0.0006	−0.0008	−0.0008	−0.0006	−0.0005	−0.0017
Levw	0.0299***	0.0385***	0.0243***	0.0371***	0.0327***	0.0393***
	−0.0048	−0.0047	−0.0054	−0.0043	−0.0037	−0.0105
Roaw	−0.1408***	−0.2457***	−0.2477***	−0.2022***	−0.2078***	−0.2392***
	−0.0255	−0.0189	−0.0265	−0.0188	−0.0169	−0.0432
Growthw	0.0327***	0.0298***	0.0397***	0.0281***	0.0313***	0.0301***
	−0.0023	−0.0021	−0.003	−0.0018	−0.0017	−0.0044
Cfow	−0.0375**	−0.0904***	−0.0323	−0.0837***	−0.0701***	−0.0038
	−0.0187	−0.0168	−0.0212	−0.0155	−0.0137	−0.0363
Age	0.0088***	−0.0009	0.0042	0.0033*	0.0042**	−0.0008
	−0.0023	−0.0022	−0.0028	−0.0019	−0.0017	−0.0063
Shrcr1w	0.0001***	0.0001**	0.0002***	0	0.0001**	0.0002*
	0	0	0	0	0	−0.0001
Independ	0.001	−0.0135	0.0059	−0.0155	−0.0143	0.0257
	−0.0113	−0.0131	−0.0134	−0.0106	−0.0092	−0.0245
Boardw	−0.0049	−0.0083**	−0.0062	−0.0081**	−0.0098***	0.0178**
	−0.0032	−0.004	−0.004	−0.0032	−0.0027	−0.0083
Dual	−0.0036*	0.0001	0	−0.0012	−0.0003	0.0013
	−0.002	−0.0012	−0.0017	−0.0012	−0.0011	−0.0039
State	0	0	−0.0062***	−0.0055***	−0.0068***	−0.0012
	(.)	(.)	−0.0016	−0.0012	−0.0011	−0.0033
_cons	0.1964***	0.2203***	0.1975***	0.2298***	0.2128***	0.2270***
	−0.0157	−0.0195	−0.019	−0.015	−0.0127	−0.0378
Adj.R^2	0.161	0.187	0.181	0.172	0.17	0.197
F	26.4662	31.0235	.	36.77	43.1705	.
N	10281	12733	7856	15158	19804	2271

Note: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5: EPT and earnings management.

Variable	Earnings management (DA)	
	1	2
ET	0.076**	0.081**
	2.01	2.43
_cons	0.0401***	−0.4136***
	5.25	−8.41
CVs	No	Yes
adj. R^2	0.1302	0.2247
N	9210	9210

Note: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

6. Conclusions and Future Work

From the perspective of corporate earnings management, in this study, we selected the data of listed companies from 2010 to 2019 as the research sample to analyze the impacts of EPT on corporate earnings management. Through empirical evaluation, our obtained results demonstrated that the EPT has a significant positive correlation with earnings management; that is, EPT promotes earnings management. Furthermore, the EPT drives earnings management of state-owned enterprises more than that of non-state-owned enterprises. Similarly, the EPT-pollution-intensive). We also observed that the level of economic development is one of the influencing factors of the earnings management of enterprises in different regions.

In the future, we will account for large-scale companies and use machine learning methods to improve and generalize the finding of this study. As a local tax, how can EPT give full play to its efficiency and define effective tax rate level become the key. This will also be the focus of our research group's next step: optimizing the EPT system. EPT can use the rapid development of the Internet and big data to actively build an information sharing platform, reduce information asymmetry, and reduce the cost consumption in the circulation process.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest regarding this paper.

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Research Article

Study on Diversified Evaluation of Residential-Type Historical and Cultural Blocks in Guangzhou

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Historical and cultural blocks contribute to urban cultural construction in a very significant way. Regardless of their specific types, historical and cultural blocks not only add brilliance to the cultural heritage of cities but also take on more urban responsibilities through actively expanding their use values. This perfectly embodies the diversified protection and development of traditional blocks. In discussing the diversified development achievements of a block, its users usually have the most since their behaviors are closely related and mutually interactive with block environments. In this sense, collecting user evaluations helps to identify the diversified development status of a block from the inside and explore more values. Considering that the residential-type historical and cultural blocks in Guangzhou have realized diversified development in terms of location values, function expansion, and user integration, this paper takes two typical blocks in the city for a case study and performs user evaluation analysis. Evaluation data are collected through traditional questionnaire surveys and text mining to expand the scale of access to information and enhance data flexibility. An evaluation index set is established for residential-type blocks by discussing the achievements of the diversified block developments and extracting the key factors of block environments based on data analysis. The research results of this paper provide a basic framework for the in-depth analysis of blocks and evaluation models building and offer suggestions of protection and design for other blocks.

1. Introduction

In 1962, France promulgated the *Malraux law*, which was the first national law to stipulate the conservation of historical blocks. Following the example of France, countries such as the UK, Japan, and the USA also introduced their own conservation laws to extend the existing conservation of individual historical architecture. In 1972, the UN adopted the *World Heritage Convention*, which reached a worldwide consensus on the conservation of heritage (including historical blocks). The promulgation of laws in this field, including the subsequent *Recommendation concerning the Safeguarding and Contemporary Role of Historic Areas* (or the *Nairobi Recommendation*) *and The Washington Charter: Charter on the Conservation of Historic Towns and Urban Areas*, fully testifies to the importance attached by countries across the world to the conservation of historical areas. China promulgated its *Cultural Relics Protection Law of the People's Republic of China (2017 Amendment)* in 1982 and later incorporated historical and cultural blocks into the legal protection system in subsequent amendments. Supporting the spirit of this law, various provinces and cities in China have also introduced policies suitable to local realities, including policies that adopt the conservation and utilization of historical and cultural blocks as a vital part of urban development [1].

No discussion can be held about the values of historical and cultural blocks without considering urban development. China's urbanization process started later than in developed countries. It began gradually in the second half of the 19th century and did not enter a stage of rapid development until the 21st century. By the end of 2021, China's urbanization rate also referred to as the "urbanization ratio"had reached 64.72% (Data source: The fourth session of the

Interministerial Joint Conference for Promoting Urbanization and Integrated Urban-Rural Development, held by China's National Development and Reform Commission (NDRC)). Driven by such rapid development, large-scale urban construction has never stopped. However, problems arise from time-to-time during urban development, including the unreasonableness of overall planning; the weakening of urban characteristics; the dispelling of cultural connotations; the collapsing of historical architecture; the rupturing of street texture; and the change of community relations. What is more troubling is how meaningful talks are to be held about cultural confidence when all that is left in the minds and eyes of urban dwellers are identical skyscrapers, uniform gated communities, and rigorously designed parks. What is comforting, however, is that the presence of historical and cultural blocks plays a crucial role in defining individuality, describing the appearance, and forming the context of the city in the course of urban development [2].

2. Diversity and Subjective Evaluation

When we emphasize the differences between cities and individualized construction of cities, the logical starting point must be rooted in the history and culture of cities themselves. Historical architecture, historical figures, historical events, and lifestyles handed down from generation to generation are directions in which we can explore the connotations and individuality of the city. As carriers of all kinds of tangible and intangible cultural heritages, historical and cultural blocks have never separated themselves from urban development since they have always carried important urban functions.

There are more than 1,200 historical and cultural blocks in China (Data source: Press Conference of the State Council Information Office on February 24, 2022). Guided by the national recognition framework, different provinces and cities have established their own recognition principles based on local characteristics. In this regard, the regional diversity of historical and cultural blocks reflects differences in urban scenes under the influence of geography and climate. Different historical and cultural blocks have different characteristics and functional diversity, even when located in the same region. This diversity may have come from differences between blocks in historical origin, functional type, street texture, architectural form, community culture, and industrial structure. The same block usually has a unified scene and temperament, and historical and cultural elements can largely be traced to the same origin. The diversity of a block is often embodied in the styles of individual buildings and the functions of the streets.

The diversity discussed above is direct and tangible and refers to the attributes of blocks themselves. However, the most notable charm of traditional blocks in relation to scattered historical architecture lies in their sociality [3]. Indeed, these blocks have always accommodated the lives, work, and entertainment of numerous people. These people are referred to as "block users." Ultimately, architectures and artificial environments are constructed to meet human needs. Even religious architectures with spiritual and symbolic significance, such as temples and churches, aims to satisfy the secular need for belief. In this sense, any discussion of the built-up environment must consider the users of the environment. In fact, the subjective evaluation of the block by its users can serve as a good indicator of the human-environment relationships in the block.

The situation is even more complex when it comes to the users of historical and cultural blocks, because historical and cultural blocks have multiple urban functions. In the final analysis, the diversity of blocks can be traced to the different needs of different users [4]. In this case, the users' subjective evaluation can be collected to see whether a block's diversity can balance its users' greatly different needs and whether such needs can be satisfied. This way is indirect, but more social and people-oriented to discuss the continuation and optimization of blocks.

3. Basic Information about the Historical and Cultural Blocks

Guangzhou is a historical city with a rich historical and cultural heritage. A total of 26 blocks in Guangzhou, distributed in the downtown and along the Pearl River, have been selected as a priority protection block (Figure 1). Many individual historical buildings have unique historical origins and cultural connotations in these blocks. Many elements can lead to the emergence of historical and cultural blocks, such as the gathering of business people in developed commerce (Baoyuan Road, Duobao Road, Baohua Road, Beijing Road, and Shangxiajiu); dwellings combining Chinese and Western styles (Xinhepu and Overseas Chinese New Village); residential and commercial areas formed around religious architectures (Hualin Temple, Wuxian Temple–Huaisheng Temple–Six Banyan Temple, and HongDe Lane); military and customs architecture (Changzhou Island); education (Southern Wende); and embassies and consulates in concession areas (Shamian) [5]. The 26 blocks were basically formed in the early 20th century. They are very similar to each other in regional and historical conditions, including geography, climate, and historical background. In particular, blocks #1–#20 are geographically adjacent to each other. In addition, they still present a great variety of scenes and characteristics, which fully testify to the diversity of historical and cultural blocks.

Most blocks have combined multiple urban functions, especially residential and commercial. As far as the residential function alone is concerned, there are still many architectural forms, such as Western-style architecture, tube-shaped apartments, and arcades. Even if the same block is distributed among several types of businesses. This fact reflects the visual diversity within the blocks. On the other hand, block users differ from each other in physiological characteristics (such as age and gender); social backgrounds (such as education, work, and experiences); spiritual levels (such as aesthetics and insight); and human-block relationships (such as types and durations of activities). The differences in these aspects interact with the diversity of the blocks themselves.

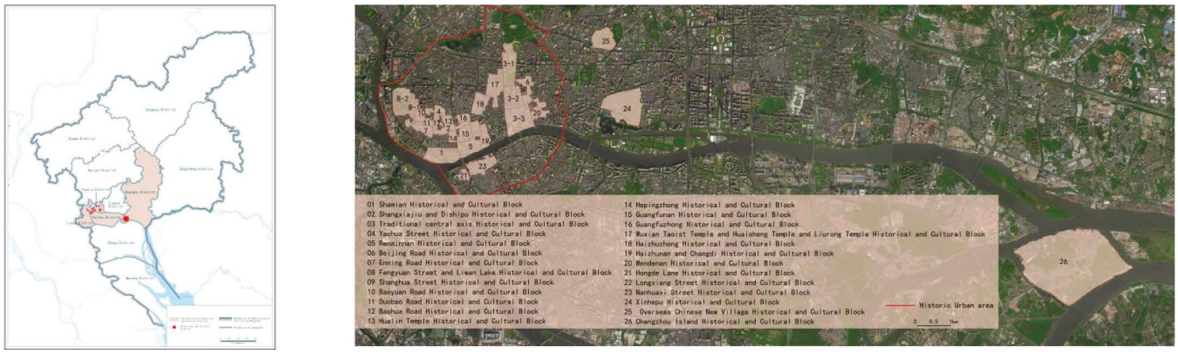

Figure 1: Distribution map of key protected blocks.

4. Diversified Changes of Residential-Type Historical and Cultural Blocks

In 26 priority protected blocks, block #24 and #25 are far away from other blocks, outside the scope of historical districts (Figure 1) and are relatively independent. In terms of block functions, blocks #24 and #25 have similar origins; that is, both emerged as residential areas. Block 24# retains numerous luxury villas, which were built around the 1920s. Block #25 was built as a residential area for overseas Chinese returnees around the 1950s (Figure 2). As can be seen from architectural forms, buildings in Block #24 are mostly red brick villas, with some Western architectural elements. Buildings in Block #25 are mainly garden villas and multistory apartments with modern architecture style, with strong regional characteristics. People who once lived in the two blocks were mainly officials, tycoons, artists, writers, and so on. The two blocks have similar main architectural functions and users in history, but they show different faces in the subsequent development [6, 7].

As a result of historical changes and urban development, these two blocks no longer exclusively serve any specific group but are gradually bearing more urban functions. According to the national and local strategies for the conservation of historical and cultural blocks and the needs of the urban planning development of Guangzhou (planning for the conservation and utilization of Xinhepu historical and cultural block (a collection of texts and images), issued by the Guangzhou Municipal Planning and Natural Resources Bureau), the main orientations of the conservation and utilization of these two blocks are set as partially retaining the residential function; developing culture, tourism, education, and commerce, enriching existing types of business; and elevating cultural and artistic atmosphere. It is clear that, as far as Blocks #24 and #25 are concerned, the intention is to take them towards a more diversified and open direction.

By the end of 2021, these two blocks will have completed most of the conservation and renovation measures. These conservation and renovation measures included repairing historical architectures, building exhibition and memorial halls, adding and renewing public service facilities and equipment, improving landscape quality, creating a cultural and artistic atmosphere, and injecting new types of business.

Traditional architecture in Block #24 Traditional architecture in Block #25

Figure 2: Block scenes.

The current status of these two blocks can be examined hierarchically. The first level refers to the diversification of location values brought about by urban development. Before the founding of the new China, these two blocks were located in the peripheral part of the city, and their geographical values were largely embodied in the echo of the downtown in the west. Nowadays, they are already included in downtown Guangzhou, with two metro lines passing by and arterial roads running through on each side. Within three kilometers to the east of these two blocks is the new urban axis, which is the urban core of business, science, and technology, highlighting the international and modern development of the city. Also, the old urban axis is located three kilometers to the west, which is a political and cultural core area with profound historical and cultural accumulation. In other words, these two blocks are located in the corridor that connects the old and new downtowns.

The second level involves the urban functions borne, which characterize diversity in the most significant way. In addition to the original residential function, many other functions, such as leisure tourism, business, education, and historical and cultural inheritance, have been added to both the blocks. Block #24 is home to the site of the Third National Congress of the Communist Party of China. The site was converted into memorial and exhibition halls to undertake important patriotic propaganda and education functions. Block #25 introduced many creative and cultural entrepreneurship, scientific and technological companies, and many business office functions. Besides, the former residences of celebrities, street names, and landscape trees in Block #25, which contain the imprints and spirit of overseas Chinese celebrities in the early days of the founding of the new China, carry important memory functions.

The third level concerns functional expansion. As their numbers increased, the identities of block users have changed as well, from predominantly residents and service workers to a variety of groups, including residents, business people, artists, office workers, block managers, and visitors. Different identities further lead to diversified activities on the part of block users, as well as different needs and human-block relationships. In particular, when it comes to the spiritual expression of the block, users with different experiences have various degrees of empathy.

5. Development Achievements of These Two Blocks under Subjective Evaluation

Sampling was conducted according to the differences in user identities in order to ensure that at least 15 users of each identity category participated in the interviews. A total of 112 evaluation subjects were selected from five groups (i.e., residents, visitors, commercial tenants, teachers/students, and street management and service workers) for Block #24. A total of 95 evaluation subjects were selected from six groups (i.e., residents, visitors, company staff, shop attendants, service workers, and students) for Block #25. The opinions of these block users about the conservation and development of these two blocks were collected through interviews and questionnaire surveys. As seen from the evaluation results, most of the evaluation subjects recognized the status quo of these two blocks, were full of expectations for their future development, and understood the importance of the conservation and revitalization of historical and cultural blocks for the construction of urban context. Their concerns could be described on two levels, i.e., the material level and the spiritual level. On the material level, they expected further optimization and upgrading of old houses and narrow streets; optimization of traffic and parking facilities; increase of activity spaces and supporting commercial facilities; optimization of road navigation and guidance; and improvement of environmental and facility safety. On the spiritual level, they worried that the renovation and utilization of architecture might ruin original block scenes and that the mixing of different groups would impact block safety and management. The evaluation subjects also pointed out the problems of insufficient propaganda, small pedestrian volume, and economic plight. Based on summarizing the key points mentioned by the evaluation subjects, we calculated the occurrence frequency of similar information and drew the information graphs (Figures 3 and 4).

As can be seen from the results of interviews, different evaluation subjects have very different understandings of these blocks. Such a difference is, first of all, attributable to their different focus points and ultimately to their various identities, which further correspond to the diverse physical environments of these blocks. Material element indices available for establishing an evaluation system can be extracted in this regard. Notably, the differences in different users' striking of history and culture are also very striking. Residents whose families have lived here for generations (elderly people who have lived here for 40 or even 60 years) know very well the history and original appearance of these blocks. Every plant and tree here has integrated into their lives and intertwined with their memories. They often miss the old block scenes and talk about architecture and roads with great familiarity. They feel sorry about the past, but they also rejoice in the present. A careful reading of their opinions reveals that the nostalgia is about their lost youth; the regret is in the powerlessness they feel in keeping up with the times; and that they rejoice in the present because they know that their descendants will have a happier life. These elderly people, like historical architecture, are witnesses to history and the embodiments of culture. Considering that their numbers are declining with each passing day, we should take care of them while conserving the physical environments of historical and cultural blocks. To preserve their memories, lifestyles, and emotional needs means saving these blocks' traditional culture and historical context.

Users who have lived in the block for a long time (people who have lived here for 5–40 years) are familiar with it but may not have a profound feeling of its history due to a lack of personal experiences. Relatively speaking, most users are more concerned with the improvement of their current living environment so that the development of the block can keep pace with the modernization of the city. Most people are not that obsessed with history and culture and are willing to accept the renovation of their blocks. They are stable block users who are the backbone that supports the normal running of their blocks. As for the conservation and revitalization of blocks, these stable users are the main objects to be won over. By improving their understanding of history and enhancing their appreciation of the importance of cultural inheritance, we can deeply involve them in block management and development.

Short-term users (people who have lived here for less than five years, as well as corporate employees, shop workers, and visitors), on the other hand, are polarized. Some of them know little about the block's history and care less about block conservation and utilization. They care more about whether there are sound public and traffic facilities. According to the interviews, they chose to stay here because of the convenience of work or their children's education. Others, who are mostly visitors or entrepreneurs, live here because they appreciate the blocks' historical inheritance and cultural expression. In brief, some are attracted to Lingnan culture, while others intend to transform Lingnan culture into productivity. These users are essential to the construction and development of the urban context, as they are the supervisors of block conservation and the practitioners of block revitalization and utilization.

One advantage of the on-site sampling survey lies in the fact that different users can be classified for the convenience of the interviews, so they can offer more detailed descriptions and evaluations of these blocks with the help of researchers. However, limited by manpower, time, and sample size, the richness of the evaluation is slightly insufficient. Moreover, guided by the researchers, the evaluation subjects showed limited opinions and the information provided by them, which was only intended to answer the questions raised by the researchers, was not sufficiently expandable. In

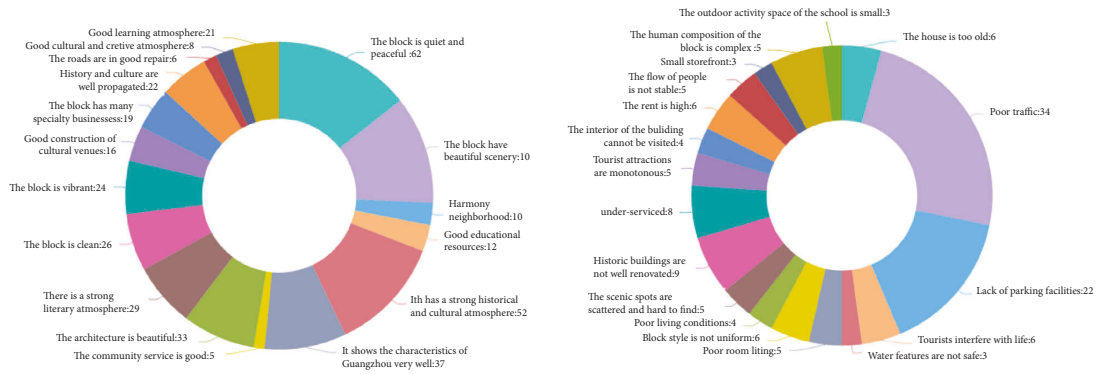

Figure 3: Information graph of user evaluation of Block #24.

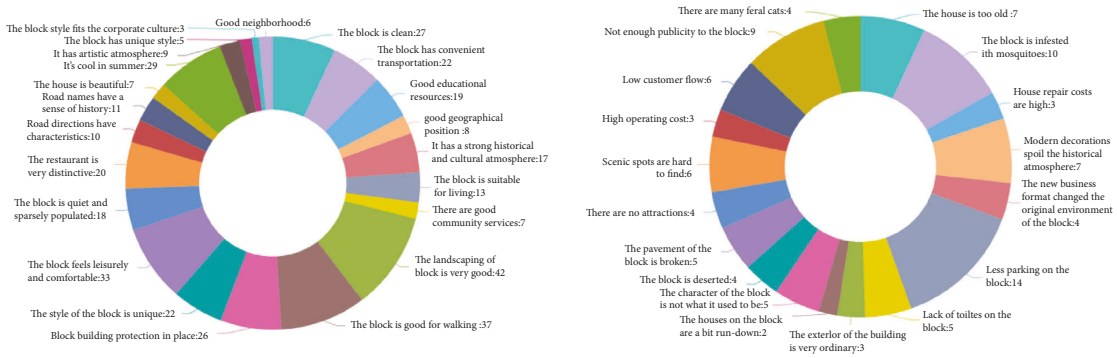

Figure 4: Information graph of user evaluation of Block #25.

this context, the text mining technique can quickly collect rich evaluation information from network platforms on a large scale, thus greatly facilitating evaluation analysis [8].

The Chinese network evaluation information for these two blocks is collected in the R language. In general, the network evaluation of a block spans over a long period in which the block may have been renovated and upgraded. For the purposes of contrast with the on-site sampling survey and the evaluation analysis of present block status, the Chinese evaluation information from January 2020 to December 2021 is excerpted as data support. Data sources include social networking platforms, review websites, and real estate websites. 1,017 and 701 entries of Chinese evaluation information were collected for blocks #24 and #25, respectively. In view of the disorderliness of the information, the R language is used for Chinese word segmentation and cleaning. That is, one sentence is divided into meaningful Chinese words and conjunctions, function words, and special symbols are eliminated. The evaluation information after cleaning generally consists of content words. The frequency of each word is calculated. Words with high frequency are usually common, words expressing block elements of concern or words shared by users. Common words, such as "I," "go," and "here," make up the vast majority. They play only minor roles in studies on block evaluation. To obtain valuable evaluation words, the TF-IDF weighting (TF means term frequency and IDF means inverse document frequency. The TF-IDF weighting method is used to reduce the interference of common words and increase the importance of words that have more research value) method is adopted in word frequency calculation, and the importance of words is considered in screening [9]. In this way, the most common words can be removed. The words screened out through weighting have a high word frequency and recognition degree and can reflect evaluation characteristics.

The high-frequency words screened out are mainly emotional or words that express block elements. Among them, words expressing block elements can show aspects of concern for block users and offer substantial support for establishing an evaluation index set. Therefore, high-frequency words expressing block elements (i.e., words ranked among the top 500 by TF-IDF, with a word frequency of above 10) are selected for Block #24 (307 words) and Block #25 (226 words). Based on this, words with low relevance to the architectural environment and historical and cultural research of these blocks, such as shop and commodity names, are deleted. Ultimately, 127 and 81 words expressing environmental elements are obtained for Blocks #24 and #25, respectively. These words have rich connotations and represent block elements on many levels. Depending on their meaning and directivity, they can be classified as follows in Tables 1 and 2.

As can be seen from the keywords sorted out, many words are shared by these two blocks, which suggests that the focus points of the users of these two blocks are largely similar. As seen from the number of keywords in each category, block resources, and protection design are

Table 1: Classification of words expressing environmental elements for Block #24.

Category	Keyword	Number
Environmental atmosphere	History, atmosphere, artistic atmosphere, literature and art, scene, tradition, lingering charm, feelings, memory, customs, reminiscence, quality, impression, style, characteristics, mood, style, artistic conception, popularity, humanity, environment, walk, night, marketplace	24
Block resources	Spring garden, delicacies, villas, gardens, dwellings, western-style houses, green paths, Xuguyuan road, architectures, site of the third national congress of the communist party of China, online celebrities, tick-off, the Republic of China, Dongshan, wealth, banyan trees, legends, Xiguan, "young master of Dongshan," overseas Chinese, teahouses, trees, heritages, memorial halls, small western-style houses, Kui garden, Miss Xiguan, official residences, shops, primary schools, tourism, revitalization, exhibition, Peizheng, academic degree, green mountains and rivers, mansions, homestay, Western-style, commerce, old Guangzhou, modern, literary youth, coffee, former site, cultural relics, old houses	47
Protection design	Location, spot, traffic, red bricks, position, streets, lanes, ruins, riverway, landscape, ecology, parks, river branches, slab stones, granitic plasters, avenues, balconies, signboards, enclosures, paths, water environment, red bricks and green tiles, design, repair, yard, water quality, scenery, waterborne platforms, walkway, morphology, roads, streetscape, routes, appearance, walk, height, architectural complexes	37
Facility service	Metro, parent-child, activities, drainage, construction, construction site, stations, community, health, motor vehicles, street lamps, bathrooms, parking	13
Others	Xinhepu, Dongshankou, Guangzhou, blocks, Pandemic, Photo taking	6

Table 2: Classification of words expressing environmental elements for Block #25.

Category	Keyword	Number
Environmental atmosphere	Fictitious land of peace, breath, sense of time, environment, history, scene, culture, downtown, art, Chinese and Western culture, customs, walk, style, shady trees	14
Block resources	Memorial archway, "red-thread girl," villas, overseas Chinese, Western-style houses, dwellings, the Republic of China, enterprises, vegetation, gardens, small storied houses, mansions, neighborhood, academic degree, bars, former residences, yard, Western-style buildings, propaganda, gathering places, old homes, schools, cafes, Cantonese opera, Youai road, operas, masters, exhibition, activities, detached houses, house number, restaurants	32
Protective design	Shade, murals, roads, SOHO, wall paintings, locations, decorations, greening, interior, exterior, pavement, trees, staircase, landscape, walkway, entrance, conservation, architectures	19
Facility service	Parking, mutual aid associations, vehicles, street lamps, street signs, supporting facilities, buses, garbage, accidents, community	10
Others	Overseas Chinese new village, COVID-19, Guangzhou, seasons, photo taking	5

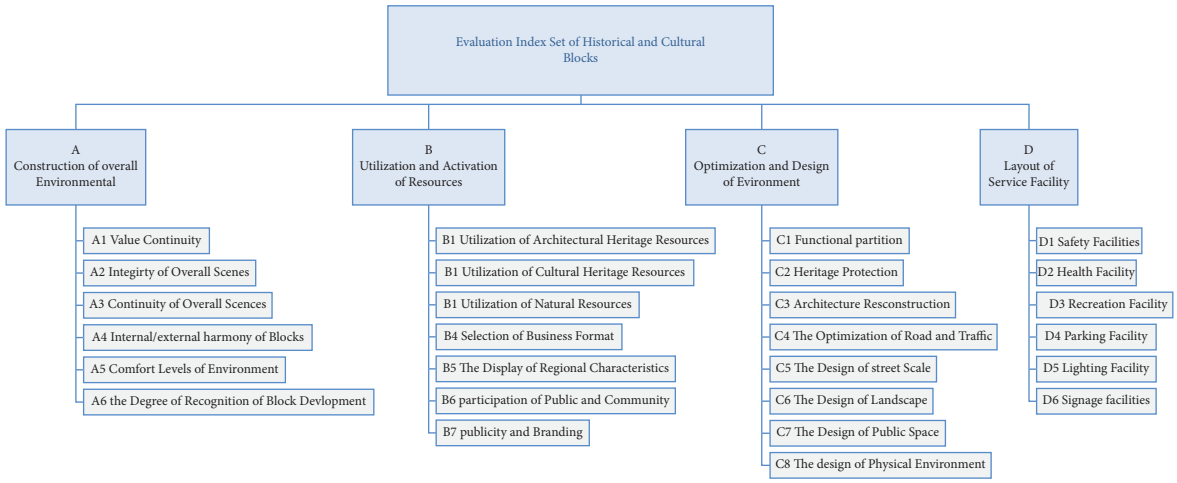

Figure 5: Subjective evaluation index set for Blocks #24 and #25.

frequently discussed, similar to the finding in the case of traditional evaluation. By summarizing and refining the evaluation information obtained by these two methods from a professional point of view, we can establish a block evaluation index set for in-depth, systematic evaluation, as shown in Figure 5. The index set must not only cover specific

block elements of concern for ordinary users but also have a macroscopic perspective of block development. Both material and spiritual elements must be examined. Only a scientific and reasonable index set can be expected to guide the subsequent in-depth evaluation analysis of the blocks, and to be applied in other studies on residential-type historical blocks.

6. Conclusion

Historical and cultural blocks have always been an important cultural heritage. Moreover, blocks are key fields for the inheritance and elevation of the urban context. The importance of blocks is shown in the fact that their use functions have never been annihilated by history. Furthermore, they have long witnessed the history of urban development through close integration with cities. Meanwhile, historical and cultural blocks, especially residential-type blocks, have a lot of users. In the process of regular and long-term activities, users have infiltrated all aspects of blocks with their behavioral patterns, spiritual activities, aesthetic interests, experiences, and backgrounds. Thus, the blocks' users give birth to block environments with profound humanistic connotations. In some cases, residential-type historical and cultural blocks may need to be changed in order to adapt to current urban development. Still, they have always been a product of interactions between users and environments [10]. In this sense, the study of historical and cultural blocks cannot be separated from the involvement of their users.

To explore the diversity of historical and cultural blocks means excavating their modern values, which constitute an essential link in the revitalization of cultural heritage. The urban construction of Guangzhou also starts in the old urban districts and then gradually expands to peripheral areas. Most of its major historical and cultural blocks are distributed in the old urban districts. This means that to support the city's modern development, historical and cultural blocks must transform their aged appearance, and deeply explore their values beyond culture, especially in regard to economic values. Fortunately, as artificial environments, historical and cultural blocks have sufficient inclusiveness and flexibility. In particular, residential-type historical and cultural blocks, with their large scale and complete supporting service facilities, can undertake all kinds of new urban functions and meet a variety of functional needs such as residence, employment, trade and commerce, education, culture, tourism, science and technology, and healthcare. As a result, the diversity of development of historical and cultural blocks is stimulated by these new functions.

Diversified development attracts more diversified users, further adding to the complexity of historical and cultural blocks. Evaluating blocks from users' points of view is a reflection of diversified development. It helps to identify problems and advantages in a more specific and targeted way. By extracting the environmental elements of the block based on the evaluation content, we can better understand the needs of its users, analyze the details of its diversified development from the inside out, and build a systematic evaluation model in order to further examine its development achievements. The evaluation of Blocks #24 and #25 and the extraction of their elements represents a concrete application of this strategy. Methodologically, text mining is used to supplement the shortcomings of traditional evaluation, and a large sample size is used to summarize the characteristics of environmental elements. The index set established in this way can deepen our evaluation of these two blocks and help us find the direction of block optimization. The adopted evaluation model can be extended to evaluate other residential-type blocks. The research path can also be used to study other types of historical and cultural blocks.

Data Availability

The data of this paper can be obtained through the e-mail to the authors.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this work.

Acknowledgments

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Retraction

Retracted: Realization Path of College Students' Network Ideological and Political Teaching System in the New Media Environment

Mobile Information Systems

Received 26 September 2023; Accepted 26 September 2023; Published 27 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] S. Sun, "Realization Path of College Students' Network Ideological and Political Teaching System in the New Media Environment," *Mobile Information Systems*, vol. 2022, Article ID 1593350, 9 pages, 2022.

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Research Article

Realization Path of College Students' Network Ideological and Political Teaching System in the New Media Environment

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Network ideological and political education (This article is abbreviated as IPE) refers to the IPE method that uses Internet technology to conduct open teaching to students or audiences of IPE. New media refers to the use of digital technology to provide users with information and services through channels such as computer networks, wireless communication networks, satellites, as well as terminals including computers, mobile phones, and digital televisions. This paper mainly analyzed the realization path of college students' network IPE system in the new media environment combined with big data technology. In this regard, this paper proposed the K-means clustering algorithm and the ant colony algorithm as the research methods of this paper. Through the questionnaire survey, it is found that the adaptive characteristics of freshman students are more obvious. There are 187 first-year students who are still in the adaptation stage, accounting for 93.5%. These students will have different degrees of difficulties in adapting to psychology, life, and study. These problems affect and restrict the direction and quality of college students' daily life and self-development. In the new media environment, this paper conducted an experimental analysis on the online ideological education of college students. The experimental results have shown that the K-means clustering algorithm and the ant colony algorithm are effective in the research of the college students' network IPE system.

1. Introduction

With the development of new media technology, the Internet has brought great convenience to college students. It enriched campus life and broadened learning channels. However, in cyberspace, all kinds of information are intertwined, and positive concepts and negative or backward concepts have a huge impact on the ideological values of college students. The use of ideological and political knowledge to establish students' correct values is an important means. Therefore, in this case, from the perspective of ideological network and political education, the ideological and political teaching system of college students is comprehensively used to study the relevant algorithms. This has promoted the development and progress of IPE among college students, enabled college students to establish a correct direction in terms of ideology and concepts and improved students' quality and personal ability to screen correct information in a complex network information society.

This paper adopted interdisciplinary research methods and comprehensively used mathematical discipline theory to analyze the phenomenon of online IPE of college students in the new media environment. The innovations of the article are: (1) Using the K-means clustering algorithm to analyze whether network information corresponds to correct values in the context of the current era. (2) Combined with the ant colony algorithm, the implementation path of the network ideological and political teaching system is studied. The research results have illustrated the effective role of this method in the research of the college students' network ideological and political teaching system.

2. Related Work

With the development of the economy, various teaching methods emerge in an endless stream. Using the Internet to educate students is one of the most popular teaching

methods in recent years and many scholars have also conducted research on it. Liu et al. believed that strengthening the psychological construction of students is an important way that can improve the quality of teaching in schools, so as to promote the development of students' ideological education [1]. Wang et al. found that many scholars pay more attention to the use of red resources combined with ideological and political knowledge to influence students' personal thoughts, but the use of red resources in ideological and political courses requires certain objective conditions [2]. Chen thought that in the context of the era of big data, the way of thinking and behavior of college students are more complex and diversified, which put forward higher and stricter educational requirements for IPE [3]. Yao pointed out in his research that IPE for college students is an important part of learning education, which has important value connotations in building rational understanding, strengthening ideals and beliefs, and cultivating college students' enthusiasm [4]. Cheng et al. proposed that the combination of Internet technology and ideological and political courses can improve personal quality and promote the development of civilized society [5]. The above scholars have conducted in-depth discussions on the combination of theoretical knowledge and practice in this area but have not further refined the ideological and political teaching methods in combination with the high technology of the current Internet era.

In recent years, with the continuous progress of science and technology, the emergence of new media technology has added luster to the lives of the public and has also helped people solve many problems. Scholars from all walks of life have also conducted research on it. Meng and Huang proposed to combine this technology with interactive advertising to analyze and have an in-depth understanding of the current situation and characteristics of interactive advertising in the context of the current era. Among them, interactive advertising refers to advertisements that require objects outside the advertising screen to participate, and it is a novel and unique form of advertising [6]. Based on new media technology, Sun proposed a new analysis method to establish the commonly used linearized optimal error estimation [7]. Lv et al. proposed a new technology. For applications such as smart home and smart navigation, this new media method has certain advantages in trajectory prediction [8]. Huang et al. proposed a new method to ensure the stable operation of online classrooms. This method can be combined with new media technology to a certain extent so that online courses would not be limited by time and space. Compared with other schemes, the efficiency of this scheme is higher, and the algorithm is easier to implement [9]. Li believed that in the era of the prevalence of new media technology, offline news interviews and TV broadcasting are no longer the only means of information dissemination, and people can learn about current affairs through the Internet [10]. Although the above studies have analyzed the application of this technology in various fields, but few have analyzed the technology in combination with IPE.

3. Methods of Studying the Path of the College Students' IPE System

3.1. Impact of the New Media Environment on the IPE of College Students. Under the traditional media environment, college students mostly acquire knowledge and information through books, journals, teachers, etc., with a single source of information and a limited amount of information [11–13]. With the gradual maturity of the technology, college students can obtain information resources through network channels, which is also a manifestation of the diversification of information acquisition [14–16]. As shown in Figure 1, college students can obtain information through the network.

The development of new media technology has enriched people's lives and can help college students quickly master life skills and shorten the distance from the outside world [17]. Although the Internet is very convenient for college students, the openness of the Internet also makes college students with weak legal awareness may go astray [18]. For example, when some college students complete their coursework, they search the Internet and see ready-made answers on the Internet, regardless of whether they are correct or not, they just copy and paste them directly. This is not only detrimental to the improvement of the college students' learning level but also an act of directly appropriating the fruits of others' labor, which should be severely criticized. The use of the network for college students is shown in Figure 2.

As can be seen from Figure 2, it is a statistical graph of the use of the Internet by students in a certain university. Among them, the proportion of playing games and browsing information is relatively large, indicating that students still prefer to surf the Internet for entertainment and current affairs. The development of new media technology has changed the way of life and learning of college students. It can be seen that new media technology has brought certain convenience to people's lives. Students can use the Internet to learn knowledge and make friends. At the same time, there are many hidden dangers [19, 20]. Therefore, this technology has both advantages and disadvantages in the impact of people's lives. In this paper, in the current new media environment, it combined with the K-means clustering algorithm and the ant colony algorithm to analyze the realization path of the college students' network IPE system.

3.2. K-Means Clustering Algorithm. K-means clustering algorithm is an iterative method to solve a mean algorithm [21]. The steps are: the data is divided into K groups, then K objects are randomly selected as the initial cluster centers. Then calculating the distance between each object and each seed cluster center, and each object is assigned to the cluster center closest to it. As shown in Figure 3, it is the model diagram of the K-means clustering algorithm.

Figure 3 is a representation of the clustering algorithm model divided by scattered elements by color under the action of the clustering algorithm. Under this algorithm

Figure 1: College students obtain information through the Internet.

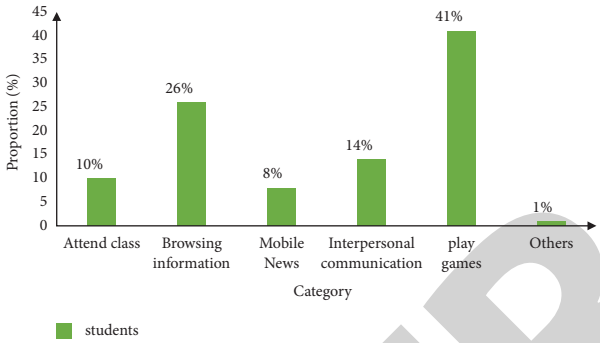

Figure 2: Use of the internet by college students.

condition, logistic regression classification is used for refined analysis. Logistic regression is a binary classification model that can be used to predict probabilities [22]. The logistic regression classification model is shown in Figure 4.

3.2.1. Prediction Function. The prediction function is the algorithm of the third-generation model predictive control and its focus of the prediction function is the Sigmoid function, and the formula is

$$f(o) = \frac{1}{1 + e^{-o}}. \tag{1}$$

Among them, the prediction function is represented by $h(m)$, $o = \alpha^t$.

$$m = \alpha_0 m_0 + \alpha_1 m_1 + +\alpha_y m_y = \sum_{i=1}^{y} \alpha_i m_i. \tag{2}$$

Formula (2) represents the input data of the Sigmoid function.

The prediction function is

$$h_\alpha(m) = f\left(\alpha^t m\right) = \frac{1}{1 + e^{-\alpha^t m}}. \tag{3}$$

Among them, the prediction function represents the probability that the result is 1, so the results for the categories of input m are 1 and 0, respectively, and the probability is expressed as $h_\alpha(m)$ and $1 - h_\alpha(m)$.

3.2.2. Loss Function. The loss function is an operation function used to measure the difference between the predicted value of the model and the real value, and it is a non-negative real-valued function. The cost function $\cos t(m)$ of the loss function is derived based on the maximum likelihood function [23]. The specific derivation formula is as follows:

Assuming that there are independent training samples $\left\{(m_1, n_1), (m_2, n_2), \ldots, (m_y, n_y)\right\}, n = \{0, 1\}$, the probability function obtained is

$$(y, m, \alpha) = \left(h_\alpha(m)^n\left(1 - h_\alpha(m)^{1-n}\right.\right.. \tag{4}$$

The likelihood function is

$$L(\alpha) = \prod_{i=1}^{x} \left(h_\alpha(m\prime)\right)^{n'} \left(1 - h_\alpha(m\prime)^{1-n\prime}\right.. \tag{5}$$

Then the log-likelihood function is

$$\begin{aligned} l(\alpha) = \log(L(\alpha)) = \sum_{i=1}^{x} n' \log(h_\alpha(m')) \\ + (1 - n')\log\left(1 - h_\alpha(m')\right). \end{aligned} \tag{6}$$

The cost function is derived from the maximum likelihood function, that is

$$\cos t\left(h_\alpha(m), n\right) = \begin{cases} -\log\left(h_\alpha(m)\right), \\ -\log\left(1 - h_\alpha(m)\right). \end{cases} \tag{7}$$

The loss function is expressed as

$$J(\alpha) = \frac{1}{x} \sum_{i=1}^{x} \left(h_\alpha(m_i), n_i\right) = -\frac{1}{x} l(\alpha). \tag{8}$$

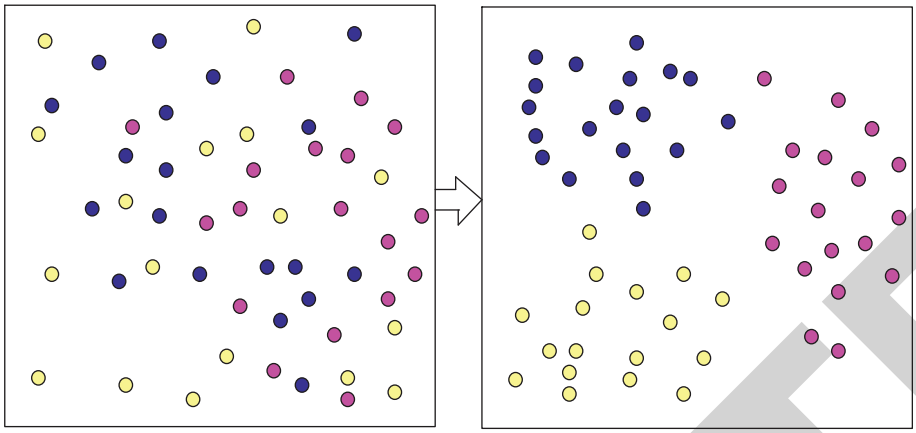

Figure 3: K-means clustering algorithm model diagram.

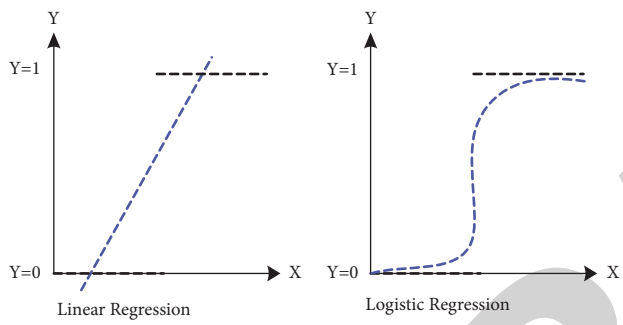

Figure 4: Logistic regression classification model.

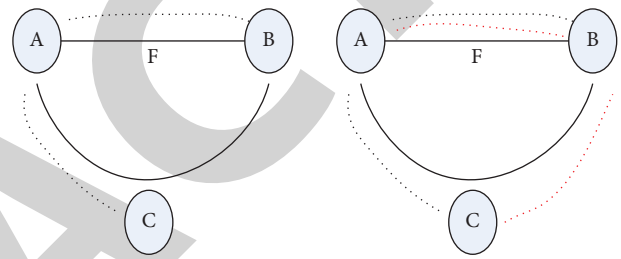

Figure 5: Related model diagram of the ant colony algorithm.

3.2.3. The Largest Parameter. Since the loss function is multiplied by a sparseness of $-1/x$, the gradient descent method is used to find the maximum parameter of $l(\alpha)$:

$$\alpha^{t+1} = \alpha^{t} - \varepsilon \sum_{i=1}^{x} (n_i - h_\alpha(m_i)) \cdot m_i. \tag{9}$$

The logistic regression algorithm is to classify the behavior of each user, and then recommend the same type of user historical preference information to the target user, so the logistic regression classification algorithm is used to recommend information [24].

3.3. Ant Colony Algorithm. Ant colony algorithm is an algorithm that imitates ants to find the optimal path. This algorithm has the characteristics of distributed computing, positive information feedback, and heuristic search and is essentially a heuristic global optimization algorithm in evolutionary algorithms. As shown in Figure 5, it is a related model diagram of the ant colony algorithm.

Figure 5 is a schematic diagram of the changing process of pheromone concentration in an ant colony algorithm. When conducting ant colony search, it is easy to select the attribute items in the discovered rules. Although its optimization ability is improved, the convergence time cannot be well controlled, and the calculation method of attribute selection probability is also relatively complicated. The focus of the algorithm is to update the pheromone, so many scholars have studied the pheromone update rule of this algorithm. Some scholars have proposed a new pheromone update method, which updates the pheromone of the items appearing in the constructed rules, and the update completes the pheromone of the unused items by normalization, as shown in the following formula :

$$\vartheta_{ij}(t+1) = (1-p) \cdot \vartheta_{ij}(t) + \left(1 - \frac{1}{1+Q}\right) \cdot \vartheta_{ij}(t). \tag{10}$$

Among them, Q represents the quality of the rule, and p is the volatilization rate of the pheromone. The adaptive pheromone update rule can avoid the defect that the pheromone update process stops because the value of the rule quality is close to zero. The specific formula is shown in the following formula:

$$\vartheta_{ij}(t+1 = \left(1 - p(t) \cdot \vartheta_{ij}(t) + (1 - p(t) + Q) \cdot \vartheta_{ij}(t). \tag{11}$$

Among them, $p(t)$ is an adaptive pheromone volatilization rate. Its specific definition is as follows:

$$p(t) = \min p_{\max}, \delta p(t-1). \tag{12}$$

Among them, $p_{\max}$ is the maximum value of $p(t)$ used to control the volatilization rate of pheromone and initially, $p(t=0) = 0$. δ is a parameter in the range of [0.9, 1].

When a rule list is searched, the information content of the conditional node appearing in the rule list is updated according to the following formula:

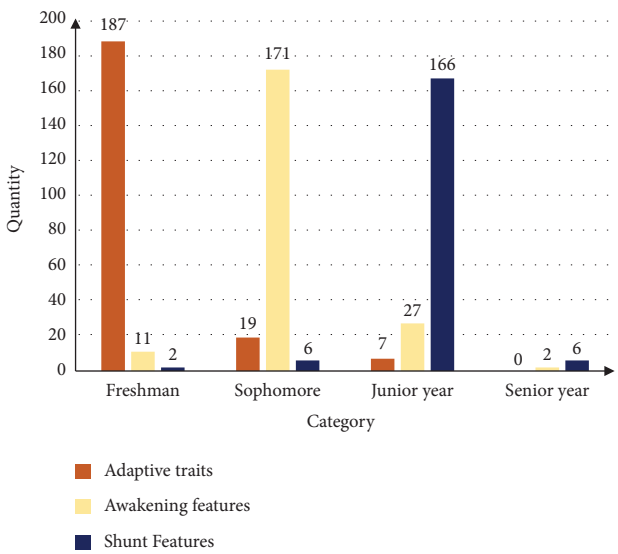

Figure 6: Results of the survey on stage characteristics of students in 4 grades.

$$\vartheta_{ij}(t+1) = \vartheta_{ij}(t) + \vartheta_{ij}(t) \times Q, \forall i, j \in \text{Rule}. \tag{13}$$

It can be seen from formula (13) that the information of the corresponding attribute nodes of the law obtained by the ant colony is strengthened. The degree of pheromone increase correlates with the quality of the rule where the attribute node is located. The larger the value of the rule quality, the higher the density of pheromone. The pheromone of attribute nodes that are not in the rule is reduced by volatilization. For attribute nodes that do not appear in the rules, the volatility factor can be reduced, as in the following formula :

$$\vartheta_{ij}(t+1) = (1-p)\vartheta_{ij}(t). \tag{14}$$

The process of pheromone volatilization in out-of-rule attribute nodes needs to be realized by standardizing the pheromone value of each attribute node, and then removing the sum of the values of all point pheromones with the information of this node. The calculation method is as follows:

$$\vartheta_{ij}(t+1) = \frac{\vartheta_{ij}(t)}{\sum_{i-1}^{a}\sum_{j=1}^{b_i}\vartheta_{ij}(t)}, \forall i, j \notin \text{Rule}. \tag{15}$$

Among them, $\sum_{i-1}^{a}\sum_{j=1}^{b_i}\vartheta_{ij}(t)$ is the sum of the pheromone on all attribute nodes.

4. Experiment on the Network IPE System for College Students

4.1. Questionnaire Survey. For the analysis of the realization path of the online IPE teaching system for college students, the students of four grades of college A were surveyed by questionnaires respectively. 200 people were selected for each grade to carry out the questionnaires, and the stage characteristics of students' network IPE in 4 stages were analyzed, and the specific situation is shown in Figure 6.

It can be seen from Figure 6 that the various performances of freshman students in the adaptation stage are still relatively significant. There are 187 first-year students who are still in the adaptive stage, accounting for 93.5%. These 93.5% of the students have problems of being unable to adapt or have poor adaptability in psychological, learning, social, and other levels. These problems have a certain impact on the normal life of freshmen and their future study and life planning. Among the sophomore students, 171 people have gone through a one-year adaptation period, and the sophomore year is in the stage of awakening, accounting for 85.5%. After a year of gradually adapting to study and life, they began to learn to think rationally and analyze the actual situation of life and the future development direction. The influence of the Internet on students has gradually deepened. Therefore, it is very important to accurately grasp the IPE methods of students and improve the effectiveness of online IPE. Among the third-year students, 166 people entered the triage characteristic stage, which accounted for 83%. This stage is an important period for them to set their life path and work hard for it. Post-graduation development issues such as employment and postgraduate entrance examinations are issues that must be considered by juniors. Therefore, at this stage, the "diversion" of students is an important manifestation of the changes in students' thinking, and it is also the focus of strengthening IPE combined with the Internet. Among the fourth-year students, 192 are in the stage of stress characteristics, accounting for 96%. Students in this stage have experienced three years of life adaptation, awakening, and diversion. They put more emphasis at this stage on what to do after graduation. Under multiple pressures, the ideological situation of seniors is more complicated. Therefore, the main task of IPE for college students at this stage is to understand their stress problems and provide psychological counseling and support using scientific methods.

Next, the characteristics of students in the four grades of college A at each stage are analyzed. As shown in Figure 7, it is a statistical graph of the network usage of students in four grades of the university.

From Figure 7(a), it can be seen that the situation of freshman and sophomore students use the network during their studies. Regarding the network usage of freshman students, 35% of students use the Internet for Internet access, 52% of students use it for study, and 13% of students use the Internet for social entertainment. Through analysis, the first-year students mainly show the following adaptation characteristics: first, they are relatively adaptable to learning. The long-term learning experience of past high school life enables students to adapt strongly to the teaching and learning methods of the university. Second, they are less adaptable to interpersonal communication. Freshmen have relatively weak social skills because they spent most of their time studying and seldom interacting with each other in their past study and life. Moreover, in the face of the new environment, classmates and roommates, it is difficult for them to adapt in the short term. The third is the difficulty in adapting to acting independently and using the Internet frequently, and then making it difficult to make friends with

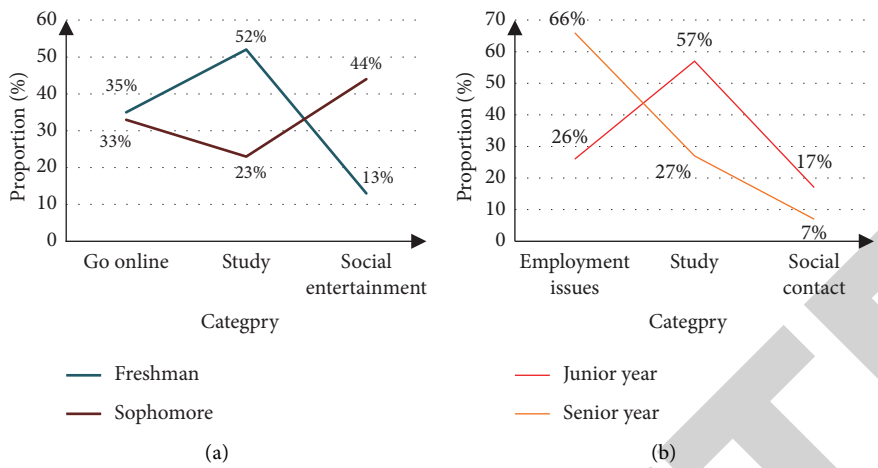

Figure 7: Statistical graph of network usage among four grades of college students. (a) Network usage of freshman and sophomore students. (b) Network usage of third- and fourth-year students.

others outside the Internet. According to the statistics of the sophomore year, 33% of the students use multimedia to access the Internet, and 23% of them use the Internet to study. The number of sophomores in this group is nearly 30% lower than that of the freshman, which shows that the sophomore students are not conscious of using the Internet for learning and like to use the Internet to socialize. Among them, 44% of sophomores use the Internet for social networking. Through the investigation, the self-awareness of sophomore students began to awaken. They begin to have clear learning goals and plans, focus on socializing, and have settled into university life. However, at this stage, because they are more confused about the future, they also begin to seek help in terms of psychological problems.

Figure 7(b) shows the use of the network by junior and senior students during their studies. In the third grade, 26% of people use the Internet to find jobs and solve employment problems. 57% of the people considered postgraduate entrance examination in the "diversion" stage of their junior year to continue their studies, and 17% of the students are still confused and use the Internet to socialize. The survey shows that students at this stage have improved in their learning attitudes and begun to plan their future development paths. The phenomenon of "diversion" of college students is becoming more and more obvious. The uncertainty of life goals makes students more confused and anxious. At this stage, their ideological fluctuations also undergo great changes. In the process of using the Internet for seniors, 66% use it to find a job. The proportion of this part is 40% higher than that of the junior year, indicating that the senior year is imminent in the issue of future planning. 27% of students used it to prepare for postgraduate entrance exams, a 30% drop from the third year. This shows that the students at this stage have roughly defined the direction of their future development. The question of choosing postgraduate entrance examination or direct work has been chosen by the students. In the end, 7% of students use the Internet to socialize. To sum up, the psychological pressure of the fourth-year of college is relatively high. Faced with more confusion about planning after graduation, IPE can be used to help students relieve stress and improve the efficiency of work or study.

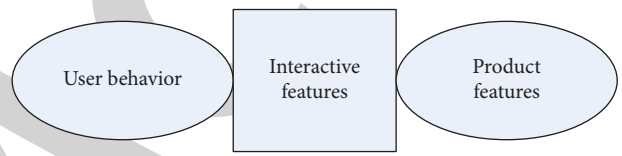

Figure 8: Schematic diagram of feature extraction.

To summarize, in the era of continuous development of high technology, it is feasible for college students to use multimedia technology to carry out network IPE. It is meaningful to use various algorithms to analyze the realization path of the college students' network ideological and political teaching system under big data technology.

4.2. Experimental on Internet IPE in the New Media Environment. According to the data set, some basic user behavior characteristics and commodity characteristics need to be defined, and at the same time, some user interaction characteristics need to be extracted from it. The schematic diagram of feature extraction is shown in Figure 8.

Figure 8 is a schematic diagram of feature extraction, which consists of user behavior, interaction behavior, and product behavior. When students use the network, their activity levels are different, so the number of behaviors they take is very different. The way to reduce the difference in the calculation is to reduce the value of the data, so that the data can be uniformly mapped on the interval [0,1].

The method for reducing the magnitude is as follows:

Min-max normalization: it expresses the original data in a linear way and holds the result in the interval of [0, 1].

$$m' = \frac{m - \min}{\max - \min}. \tag{16}$$

Table 1: Selecting the top 4 prediction results for recommendation.

Users	Item-1	Item-2	Item-3	Item-4
1	99999733	291352451	374774521	222856236
2	4685678	10265895	15246525	223658647
3	560325	8462521	19633251	604233256
4	29332051	30245660	59524523	3155658711

Table 2: Accuracy statistics of parameter comparison.

	0.4 (%)	0.6 (%)	0.8 (%)	1.0 (%)
6	4.33	4.82	4.12	3.11
12	4.66	5.11	4.56	3.32
18	4.69	5.55	5.26	3.43
24	4.37	5.29	4.61	3.21

Table 3: Recall statistics for reference number control.

	0.4 (%)	0.6 (%)	0.8 (%)	1.0 (%)
6	6.77	6.91	6.72	5.77
12	7.66	8.11	7.57	7.33
18	7.91	8.55	7.88	7.51
24	6.87	7.12	7.04	6.72

Among them, max, min represents the maximum and minimum values of the sample data, which need to be redefined when new data is added.

Z-score standardization: it standardizes the mean and standard deviation of the initial value, such as

$$m\prime = \frac{(m-\eta)}{\sigma}. \tag{17}$$

Among them, η is the mean of the initial data and σ is the standard deviation.

After the above analysis, the speculative prediction results are obtained, as shown in Table 1, and the first 4 prediction results are selected for recommendation.

It can be seen from Table 1 that the data of the first-ranked user in the four items are 99999733, 291352451, 374774521, and 222856236, respectively, which indicates that the probability of network recommendation information is recommended as the user clicks on a certain information probability. According to the above experimental results, by adjusting the parameters of the students' behavior weights and cluster centers, the accuracy and recall rates of different parameter situations can be obtained.

This paper analyze its precision and recall rate, as shown in Tables 2 and 3.

4.2.1. Accuracy. It can be seen from Table 2 that the horizontal data represents the behavior weight, and the vertical represents the number of cluster centers. The value range of the above behavior weight is between [0.4, 1]. When the weight coefficient is 0.4 and the number of cluster centers is 6, its accuracy rate is 4.33%. When the value of the behavior weight is 0.6, the number of different cluster centers is higher than other weights. However, when the number of cluster centers is 18, the accuracy rate reaches the highest, which is 5.55%. This shows that in the case of different weight ranges and different number of clusters, the accuracy of the parameters is different.

Table 4: Datasets features.

Data set	Number of instances	Number of attributes	Number of categories
1	899	39	7
2	627	6	5
3	288	11	4
4	699	15	4

4.2.2. Recall Rate. It can be seen from Table 3 that the horizontal data represents the behavior weight, and the vertical represents the number of cluster centers. When the number of cluster centers is different, its recall rate is the highest, when the weight value is 0.6. When the cluster center is 18, the recall rate is the highest, which is 8.55%. This shows that in the case of different parameters, the accuracy of the recall rate is different. It can be seen that the results of precision and recall are optimal when the weight value is 0.6 and the number of cluster centers is 18.

Since the ant colony algorithm is suitable for the classification of discrete attributes, its continuous attributes need to be discretized by the step of preprocessing. This paper used the C4.5 discretization method in the discrete process. There are only two attributes in the discretized datasets: the discretized attribute and the category. As shown in Table 4, it is the characteristics of the datasets.

It can be seen from Table 4 that in the process of classifying the features of the dataset, it takes relatively less time and is more efficient. 4 datasets are selected, the first dataset has 899 instances, 39 attributes and 7 categories, that is to say, the first dataset is divided into 7 types, 39 attributes and the entire dataset is composed of 899 instances.

It can be seen that through the calculation and analysis of various indicators, the effectiveness and feasibility of the ant colony algorithm and the K-means clustering algorithm in this paper are verified. Through the evaluation index of the algorithm, the optimal algorithm accuracy and parameter combination are obtained.

5. Discussion

This paper used two algorithms to analyze the realization path of college students' network IPE in the new media environment. Firstly consult the relevant literature and understand the research directions and research results of various scholars. Second, the method used in the article was explained. Then, through the means of questionnaire survey, a questionnaire was conducted to summarize the use of the Internet by the four-year students of University A during their school days. It understood that students at different stages have different psychological characteristics at different stages. Finally, through the calculation and analysis of various indicators in the experiment, it was verified that the method in this paper is effective in the experiment. This

paper analyzed the realization path of college students' network ideological and the political teaching system by using the ant colony algorithm and the clustering algorithm under the multimedia environment. Due to the lack of research results of scholars in this area in the past, this paper mainly made a new definition of new media technology to further promote its application range.

6. Conclusion

According to the analysis of the full text, the two methods are used to study the network IPE system for college students in the context of the current era. Feature extraction, reference number accuracy, recall, and data sets were analyzed. Through experiments and questionnaires, the following results were obtained. From the data of the questionnaire survey, it can be seen that under the circumstances of different grades and stages, targeted IPE should be given to them, so as to help students get rid of the dilemma form psychological and learning aspects. The feature classification of the data set was more accurate based on the ant colony algorithm, and the time consumption was relatively small; under the cluster analysis algorithm, the optimal algorithm accuracy, and parameter combination were obtained. To sum up, the analysis of the realization path of the college students' network IPE system still needs further in-depth research.

Data Availability

The data of this paper can be obtained through e-mail from the authors.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this work.

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Research Article

Education Evaluation Management Based on Blockchain Technology

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In view of the problems related to the current education evaluation process, such as single evaluation index, unremarkable subject evaluation, inadequate implementation of education management measures, and low recognition of the results of education evaluation, particularly in China, more research is needed to ensure appropriate educational management. Security of the evaluation metrics and communication among institutes is very essential to ensure the education quality. In this paper, we adopt the blockchain technology to evaluate the current education. All-round evaluation of quality makes the whole process of education evaluation transparent and open and solves the defects existing in the process of education evaluation. The blockchain technology establishes a management mechanism for educational evaluation by cooperating with educational institutions and promotes the implementation of quality measures, as well as the implementation of policies. Furthermore, this provides a blockchain information data platform for educational evaluation and prevents the information from being tampered with, either in decentralized or centralized systems, thereby promoting the development of education along with quality. The attained results show that the proposed system can reduce the burden of information on the storage system significantly when compared to other traditional evaluation systems.

1. Introduction

At present, there are still many deficiencies in education evaluation management. The use of blockchain technology can decentralize the education evaluation process, classify and store evaluation data, strengthen the confidentiality of data, and prevent data from being tampered with. The consensus contract reached in this paper makes the data more authentic and reliable and has a wide range of applications in educational evaluation management, providing a reliable source of information for the process of educational evaluation management and improving the quality of educational evaluation. This technology establishes a management mechanism for educational evaluation by cooperating with educational institutions, promotes the implementation and implementation of policies, provides a blockchain information data platform for educational evaluation, and prevents the information from being tampered with and centralized, thereby promoting the development of education.

To evaluate the performance and constraints of these cutting-edge platforms, Pongnumkul et al. [1] performed a performance analysis of two well-known private blockchain platforms, namely I Hyperledger Fabric and (ii) Ethereum (private deployment). It is unfortunate that there are few uses for blockchain technology in the education industry given that it can solve a number of problems, including the lack of user interaction and system interoperability in e-learning systems. By using the blockchain technology to address the aforementioned problems, Zhong et al. [2] present a conceptual model for e-learning systems and utilise the word-learning community as an example. To obtain the practical advantages of the supply chain process design, Chang et al. [3] proposed a blockchain-based architecture coupled with the use of an associated technology, namely, smart contracts. Fast query processing is supported

by the spatio-temporal blockchain technology that Qu et al. [4] developed. Despite these works, this blockchain-based education research still has limitations and implications. The study presented in [5] was created utilising data from three SMEs in India's growing economy, which was then used to assess 15 selected hurdles. The goal of the study finished in [6] is to build a model of a business process based on blockchain technology that can enhance data integrity in academic institutions.

The Internet of Things (IoT), machine learning, and the blockchain technology for supply chain networks were all included in Li et al.'s [7] proposal for a production capability evaluation system. In Meng et al. [8], the author's goal is to look into how well blockchain-based trust management systems perform, which is inspired by the growing popularity of the technology. A trustworthy search system without verification was put up by Li et al. [9] and is based on a consortium blockchain for data storage and sharing. Other works such as [10–13] and [14] have also implemented the blockchain technology in various real-world scenarios. However, we believe, to the best of our knowledge, that the blockchain technology is not maturely used in the education evaluation systems.

In view of the problems of single evaluation index, unremarkable subject evaluation, inadequate implementation of various education management measures, and low recognition of the results of educational evaluation in the current education evaluation process, this paper adopts the blockchain technology to evaluate the current education management system. We design an architecture for the education evaluation system which is based on the blockchain concepts. We then construct a blockchain-based teaching evaluation diagram that is a part of the proposed system. Finally, an education evaluation scheme is presented and evaluated through experiments. The attained results show that the proposed system can reduce the burden of information on the storage system significantly when compared to other traditional evaluation systems.

The remaining part of the manuscript is outlined as follows. The design of the educational evaluation management system is deliberated in Section 2. The application of the evaluation system is discussed in Section 3. Results and discussion are discussed in Section 4. Finally, Section 5 summarizes this paper with several guidelines for future research.

2. Design of Educational Evaluation Management System

2.1. The Overall Design Structure of the System. The infrastructure layer, network layer, consensus layer, data layer, smart contract layer, interface layer, and application layer make up the architecture of the blockchain-based school evaluation system. In the system architecture composed of all layers, each layer undertakes different services role. First of all, the infrastructure layer, as the top layer of the system architecture, mainly provides basic information services for the quality evaluation of the education, collects the relevant information for education evaluation, and organizes and transmits the information to the next layer. The network layer, as the communication transmission layer, provides a platform for information exchange among the nodes in the form of an information hub in the network nodes of the blockchain. The data results of the educational evaluation are packaged and sent out in the form of blocks. The corresponding network nodes will receive the results of the educational evaluation [15]. The so-called consensus layer is to keep the data of all nodes of the blockchain updated and consistent and to reach a consensus, so as to ensure that the data of all nodes of the blockchain are open and transparent, and to achieve data sharing [16].

The data layer stores the timestamp, random number, and encrypted information of the blockchain and stores the information to maintain the integrity of the data. The smart contract layer is to classify the data of the blockchain and divide it into small area modules to prevent the data from being tampered with or deleted [17]. The interface layer provides a channel for data query and access for education departments and universities and can enter the system for consultation and viewing directly through the relevant communication protocol [18]. The application layer can enter or collect educational evaluation information, evaluate related educational and teaching activities, and find the effect of educational evaluation. The system architecture of education evaluation management in this paper is shown in Figure 1.

2.2. Information Chain of Education Evaluation. The composition of the educational evaluation information chain based on blockchain technology is mainly composed of the evaluation subject block, evaluation data block, evaluation method block, weight distribution block, and block database, and the connection between each block is not divided while realizing information transmission and sharing, and each block maintains independent work and close contact [19].

First of all, the objects of the evaluation subject block include education departments, school leaders, teachers, students, parents, educational institutions, and social media. The objects in this block are registered in the blockchain, thereby obtaining authorization in the education evaluation system. The main block can be evaluated and referenced by multiple parties, and the evaluation results obtained have a certain breadth and authenticity, which can reflect the quality and effect of education to a certain extent [20].

The evaluation data block mainly stores all data information, including historical data records, currently collected information records and future data information. The data block system classifies and stores various types of information, and historical data can be recorded. The data of educational evaluation are entered as an important source of reference information [21–23]. In addition, the current data information is mainly that the school enters the current educational evaluation situation into the system so that on the basis of historical data and current data, the school can automatically generate future data based on the two and record the teaching evaluation in real time [24].

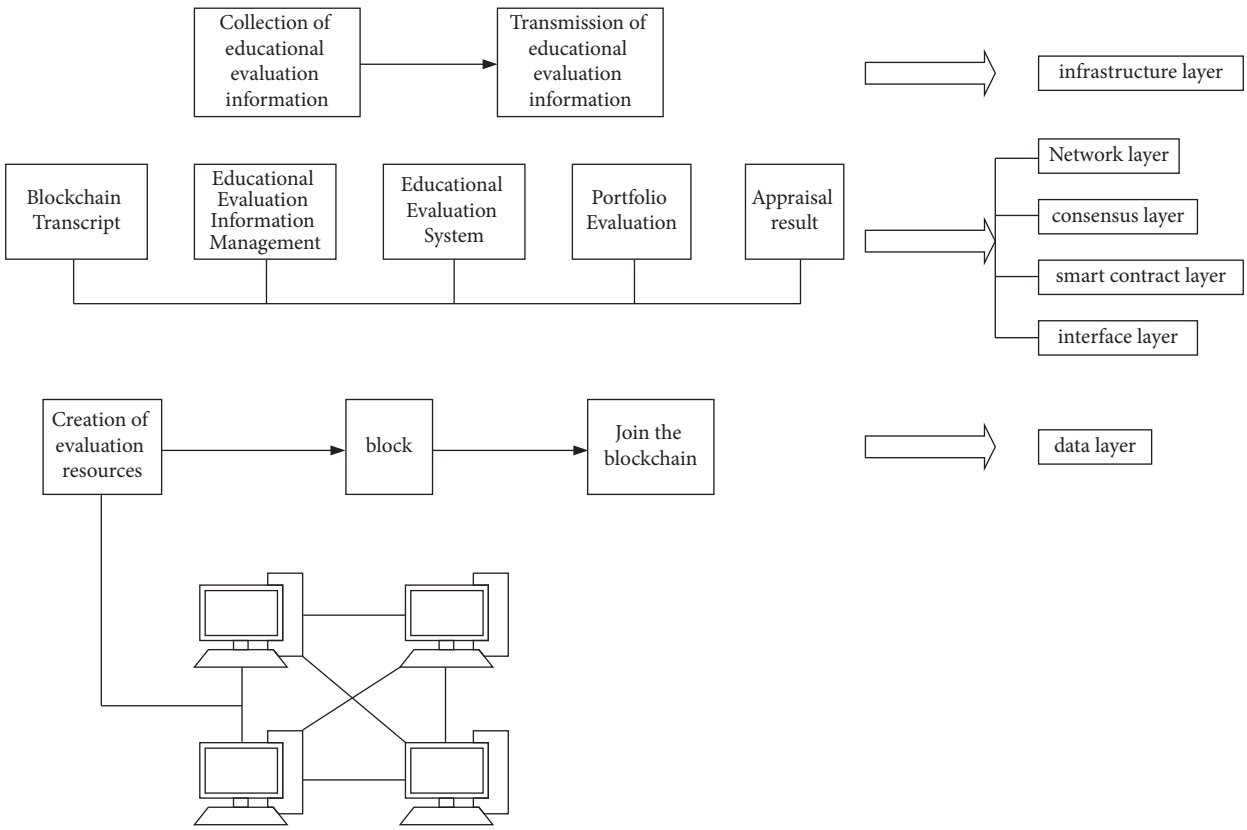

Figure 1: The basic architecture of the proposed education evaluation system.

The evaluation method block can use the fuzzy hierarchy process and the analytic hierarchy process to analyze the educational evaluation, and quantitatively process the evaluation indicators in concept, and then analyze the weight ratio of the educational evaluation indicators by the analytical hierarchy process, and construct a quantitative judgment. Based on the evaluation matrix, the numerical value of the evaluation index is calculated, and on the basis of the educational evaluation model, the multilevel comprehensive evaluation is used to obtain the weighted value, and finally, the result of the educational evaluation is obtained.

The weight allocation block is mainly based on the evaluation object, the evaluation subject, and the different content of the evaluation data, and the size of the weight can be set according to the actual situation. Therefore, after assigning the weights, the evaluation results of education can be obtained.

The database block is composed of evaluation records, evaluation results, and educational evaluation information of the evaluation subject [25]. The timestamp and consensus protocol on the blockchain ensures that the data in the block is not tampered with and maintains the authenticity of the data.

3. The Application of the Evaluation System

The blockchain is the core content of the educational evaluation system. The educational evaluation management system established in this paper along with the blockchain methodology is shown in Figure 2. As shown in Figure 2, the students, teachers, employees of the educational institutes, and testers are basic modules of the proposed blockchain-based education system. In fact, teachers are making the quality of education, whereas the testers are used to evaluate the quality with respect to various metrics including the student's opinion, as well as, the suggestions received from other employers of the education institutes that constitute the blockchain system.

3.1. The Operation of the Educational Evaluation System. From a macro perspective, the decentralized joint mechanism uses the blockchain architecture model to connect various main objects of different functions together to form the main chain, and each main object on the main chain has a protection. The authority of their own privacy, for data sharing, the exchange, and sharing of data is realized on the basis of the consensus mechanism. The different main chains in the evaluation system are connected to each other through network nodes, and each accounting point can be authenticated by the user to form a cogovernance alliance in the field of educational evaluation. In addition, each user obtains the education quality evaluation information on the blockchain through smart contracts to ensure that the data information on each main chain is not tampered with. Various organizations connected to the blockchain complete various transaction requests of users in the rating process through a consensus mechanism. The educational evaluation scheme is

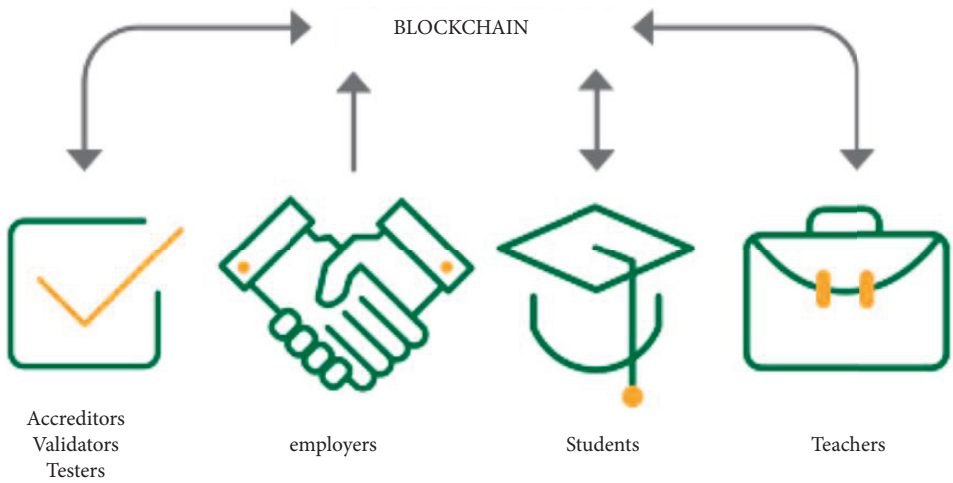

Figure 2: The diagram of the proposed blockchain-based teaching evaluation system.

shown in Figure 3. In the application, tasks such as data analysis and query processing within the database are carried out. In the network acceleration, data movement and secure transmission are ensured between the education institutes. Strong security is the fundamental feature of the blockchain technology, and in this stage, it is guaranteed that the data and information do not tamper with during operation. The value of service (VoS) assures the key services of the blockchain technology such as smart contract and consensus roles.

3.2. System Evaluation Process. The management of educational evaluation must first ensure the authenticity of the data, ensure that the data entered into the system can reflect the real situation, and the collected data must be entered into the system in real time. For example, according to the requirements of educational evaluation, it is necessary to enter the educational evaluation team building, educational evaluation organization construction, and educational evaluation time limit into the system. In addition, the system can collect relevant educational and teaching activity data according to the big data network and use analysis tools to process and analyze the data, so as to ensure that the data can be updated in time.

In addition, improving the credibility of education evaluation management is also an indispensable content; especially, when using big data analysis software to analyze education and teaching, the evaluation report generated should present rich data content, so that the evaluation results are clear. Therefore, the education evaluation of the blockchain needs to open a certain evaluation authority, so that different subjects can evaluate education according to the contract mechanism, and the system will store the results of each subject's evaluation on the node.

Finally, the results of the system assessment should be queried and applied. After the main object of the blockchain logs into the system for verification, it can query the evaluation results of the corresponding main chain and nodes and understand the detailed evaluation process under the guidance of the rule contract. Then, the main object can use the results of education evaluation as the evaluation standard for judging the quality of school education and teaching according to the relevant evaluation indicators, reach a consensus with other smart contracts, and enter the main chain node of the system together to continuously expand the value of education evaluation management.

4. Results

The cloud resource information of the educational evaluation system and the process of operational data in the blockchain environment increase linearly from 1024 B to 1 GB with 10 MB as a unit. According to the above parameter setting results, the storage structure analysis and data information flow model construction of university educational system process operation data under the blockchain environment were carried out, and the cloud resource storage data information flow collection is realized. It can be seen from Figure 4 that using this method for Atlas design and feature extraction can accurately reflect the internal structure information features of the university educational system process operation data under the blockchain environment and improve the cloud storage performance.

To compare the results of the proposed blockchain-based system (denoted by OUR) with other methods, we selected two state-of-the-art techniques, that is, EMD (empirical mode decomposition) and WA (wavelet analysis). Both algorithms were implemented without the blockchain technology. In order to quantitatively analyze the improved performance of this method, the cloud resource storage overhead is taken as the test object, and the comparison results are shown in Figure 4. It can be seen from the figure that using this method can effectively reduce the storage overhead and improve the data throughput. The through of data can be significantly increased as shown in Figure 5. The consensus contract reached in this paper makes the data more authentic and reliable and has a wide range of applications in educational evaluation management, providing a reliable source of information for the process of

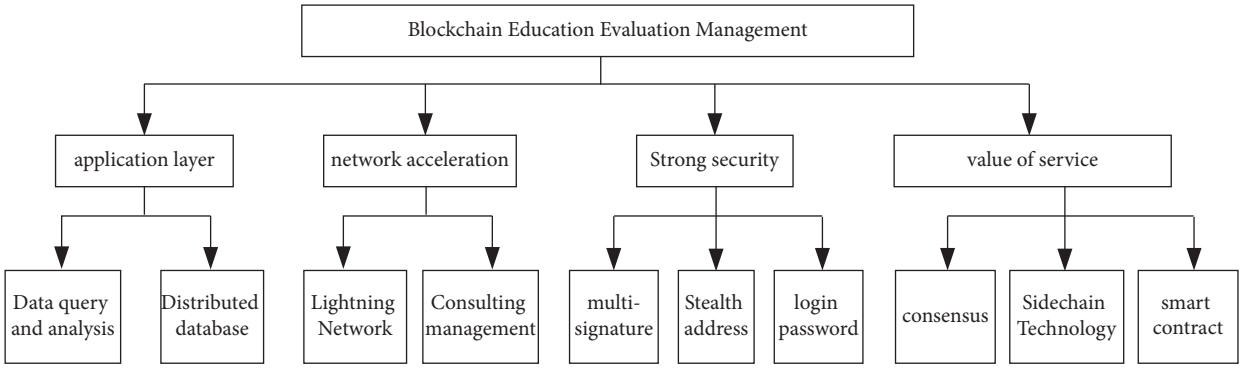

Figure 3: The proposed education evaluation scheme.

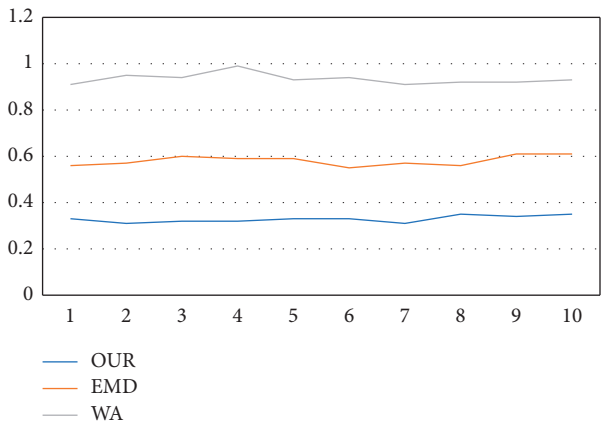

Figure 4: Quantitative analysis of performance comparison (the lower value denotes a more efficient technique).

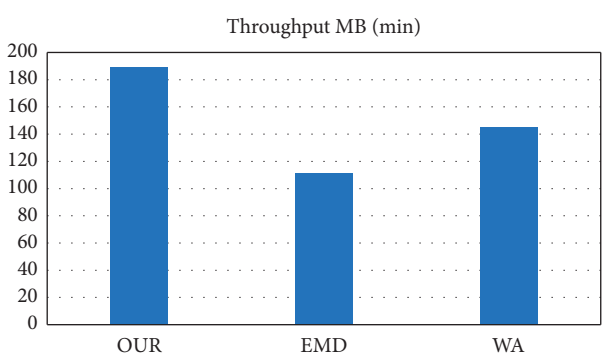

Figure 5: The data throughput measured in MB/min (the higher value denotes a more efficient technique).

educational evaluation management and improving the quality of educational evaluation.

5. Conclusions and Future Work

At present, there are still many deficiencies in education evaluation management. The use of blockchain technology can decentralize the education evaluation process, classify and store evaluation data, strengthen the confidentiality of data, and prevent data from being tampered with other information. The consensus contract reached in this paper makes the data more authentic and reliable and has a wide range of applications in educational evaluation management, providing a reliable source of information for the process of educational evaluation management and improving the quality of educational evaluation. We observed that using the suggested method can effectively reduce the storage overhead and improve the data throughput. In the future, we will adopt other metrics to deeply investigate various measures for the quality evaluation of present educational institutes. We will also investigate how the proposed system can be implemented in a real-life scenario.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
Mobile Information Systems
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Retraction

Retracted: Physical Exercise Improves Academic Performance: Based on CNKI Meta-Analysis Evidence

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] X. Xiang and Q. Wang, "Physical Exercise Improves Academic Performance: Based on CNKI Meta-Analysis Evidence," *Mobile Information Systems*, vol. 2022, Article ID 1106573, 10 pages, 2022.

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Research Article

Physical Exercise Improves Academic Performance: Based on CNKI Meta-Analysis Evidence

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Background. It has long been a major source of debate in academic circles whether physical activity has a positive or negative effect on academic performance. Although this subject has been covered in several studies at various levels, only a small number of researchers have examined and supported the data found in the literature. *Methods*. A meta-analysis is used to thoroughly examine the literature on physical exercise and academic performance included in the China National Knowledge Infrastructure (CNKI) database. After three rounds of searching, screening, and according to the criteria of literature inclusion, 13 valid documents are obtained for analysis with 90 final indicators. *Results*. (1) Physical exercise has a significant effect on academic performance; (2) physical exercise has a significant effect on single-subject performance, and there are no group differences in academic performance between different subjects; and (3) different exercise intensities have a significant effect on academic performance and significant differences in academic performance. *Conclusions*. (1) Physical exercise can improve academic performance and should increase students' physical education participation; (2) physical exercise in different disciplines should hold physical education as equal to other cultural subjects; and (3) sports exercise with different sports intensities has different benefits for academic performance, and sports should be scientifically designed to achieve the maximum effect on academic performance.

1. Introduction

School physical education plays an important role in students' physical and mental health and learning and growth and has become a key factor affecting the future development of young people. It has been a concern of the Chinese national government and of ordinary people in the new era. On September 10, 2018, President Xi Jinping provided important instruction at the National Education Conference to give play to students to "enjoy fun, enhance their physical fitness, improve their personality, and temper their will," summarizing the value and role of sports and pointing out the development direction for an in-depth reform of school sports work in the new era. In the new era, all levels of society, especially sports workers, need to correctly interpret the connotations and practice paths of school sports and other problems. In 2020, the general office of the CPC Central Committee and the State Council issued policies for comprehensively strengthening and improving the new era of school physical education work by deepening the reform of the overall new era education evaluation plan, such as through policy, strengthening school physical education, training, and improved physical education to enhance youth physical health. The policy focuses on strengthening sports evaluation and thoroughly discussing national education. The numerous policy enactments illustrate that the national government and school education and sports departments work in different ways to clearly guide teenagers to participate in sports and exercise in ways conducive to their healthy growth. The earlier issued Opinions on Strengthening Youth Sports and Enhancing Youth Physical Fitness document points out that "the decline in students' physical health is mainly due to the influence of the one-sided pursuit of enrollment rates and the tendencies of intellectual education and physical education in social and school life" [1]. Under the influence of exam-oriented academic pressure, more students in the education system, dedicate more time and energy to their academic performance and sacrifice their

physical exercise, which is due to the influence of traditional education and teaching ideas [2]. At the same time, to improve students' cultural performance, schools often replace physical exercise and education [3]. In response, the General Office of the State Council issued Opinions on Strengthening School Sports and Promoting the All-round Development of Students' Physical and Mental Health to encourage young people to develop good habits of actively participating in physical exercise. However, the country strongly advocates for the current gap between students' active participation in physical exercise and the current social environmental support of students, and the time and intensity students dedicate to participating in physical exercise do not meet the requirements, which not only affects students' physical and mental health but also their academic performance [4].

Can physical exercise improve academic performance, and how do the two affect each other? Academic circles have long paid attention to the associations between physical exercise and adolescent cognitive processing ability and academic performance [5]. Specifically, physical exercise can maintain and improve cognitive ability by enhancing synaptic function, gene expression, and blood oxygen function in cognitive processing-related brain regions [6]. Scholars, using different forms of theoretical speculative elaboration, questionnaires, and empirical classes, have learned about physical exercise and academic performance since the middle of the last century and have combined social science methods in the new era; as a result, academic achievements have improved [7]. Most scholars in this area believe that appropriate physical exercise can positively affect academic performance but that under China's current education system, parents and some school administrators prioritize academic performance and pursue investment in cultural learning such that students do not have enough time for physical exercise. It is urgently necessary to recognize the importance of students' physical exercise at different levels, change the misconception that "physical exercise negatively affects academic performance," and carry out systematic and rigorous verification of long-term, relevant academic research results. As an in-depth empirical means of analyzing existing documents, meta-analysis has been recognized at home and abroad in recent years and has been applied increasingly widely in different fields. From medicine to pedagogy to psychology, the use of this approach in different disciplines is increasing [8]. Thus, we conduct a systematic literature review of early academic research and then code and screen the literature according to scientific standards. We in turn analyze and discuss the logical relationship between physical exercise and academic performance to strengthen scientific and evidence-based research support for students to actively participate in physical exercise.

2. Literature Review

With the continuous development of the sports discipline, many scholars have developed different conceptual definitions and divisions of "physical exercise" for different stages. For example, Caspersen et al. [9] define physical exercise as regular physical exercise; the China Sports Dictionary [10] defines it as a physical activity process that improves physical health and quality through participation in various sports; and Luyuan [11] believe that physical activity can enrich spiritual and cultural activities and promote physical health and development. In sports including ball sports such as basketball and football and long jump and other track and field sports, aerobic and anaerobic activity and low-, medium-, and high-intensity activities are combined in a single sport [12]. Upon searching the literature related to "physical exercise" and "academic performance," it was found that the corresponding literature focuses on the concepts enumerated above. Therefore, the present research is conducted at a macro level. "Physical exercise" includes physical education teaching, after-school physical activities, and extracurricular sports training conducted in school physical education. "Academic performance" mainly covers overall performance, average scores in different disciplines, and results for a single subject.

Foreign researchers believe that 2 hours of physical exercise per week is not enough to have a positive impact on students [13]. Che [14] analyzed the influencing factors of physical exercise time in the realms of school and family and found that an increase in time spent engaged in physical exercise for middle school students helps improve performance; studies show that medium-intensity physical exercise has a positive impact on academic performance over 10 weeks when done 3 times a week, increasing physical education time by approximately 60% [15]. In addition, students with excellent grades engage in a significantly longer period of physical exercise than students with average grades, and short duration, moderate intensity exercise may affect cognition. Crush [16] compared the effects of five different motor skill use durations on cognition and found that significantly increased cognitive function began after 30 and 45 min of exercise without significant alterations. Motor characteristics, including intensity and duration, may play a role in regulating the effects of exercise on motor learning. Although there is some evidence for high-intensity and relatively long-duration exercise, Ana et al. [17] evaluated the effects of long and short-intensity physical activity on memory and found that both long and short-duration exercise favors memory retention and improvement in a time-limited environment. Of course, studies have also found that single sessions of moderate to vigorous exercise have a positive impact on cognitive outcomes in children and adolescents. However, the dose-response effect of exercise duration is largely unknown. Individuals not only do not improve their cognitive performance after physical exercise activity lasting 10, 20, or 30 min, but adolescents also show no significant decrease in cognitive performance than under sedentary conditions [18]. Lingshu and Liu [19] found that the longer primary and secondary school students participate in physical activity, the more they participate in physical activity every week, and the better their academic performance becomes. Because of the positive effect of exercise on the human body and spirit and other aspects, physical exercise enhances the flexibility of the central nervous system, improves the balance of interactions between excitement

and inhibition processes, improves individual response abilities, and then improves learning efficiency. In addition, physical exercise also stabilizes students' emotions and improves their ability to withstand academic pressure.

In conclusion, intervention effects of different exercise intensities on academic performance vary. High-intensity physical activity can cause burnout, resulting in a negative effect on learning motivation and learning states. Moderate-intensity exercise enhances and maintains physical oxygen levels, blood circulation, and learning interest, while low-intensity exercise has the least significant effect on learning. However, domestic and foreign research is still insufficient, and the changing and causal relationships between different exercise intensities and academic performance still need to be more thoroughly and comprehensively researched.

A large number of studies have found that different sports programs have different effects on academic performance. Zhang et al. [20] replaced the traditional physical education teaching mode with instruction in professional sports such as football and aerobics and found that traditional physical education courses have a complex impact on students' academic performance. After short-term physical intervention, students' English and Chinese scores increased, but girls' scores in math decreased; after long-term physical intervention, students' Chinese scores improved, while their English and math scores decreased. Phinikaridou et al. [21] found through a 14-week track and field training program that the music and various language scores of the experimental group were significantly higher than those of the control group; in addition, the self-esteem of the experimental group significantly improved after training. Chinese researchers, through a physical intervention study of high school students, found that engagement in cheerleading gymnastics is significantly related to academic performance among high school students. Cheerleading gymnastics has also significantly improved students' Chinese, math, and foreign language performance [22]. Different ball sports also have different effects on academic performance.

The above research shows that different physical exercise programs have different effects on academic performance, although most studies have found that after an intervention, the change in academic performance does not achieve statistical significance. Studies have shown that physical activity does indeed change structural function, gene expression, hormones, and neurotransmitter function in the brain. However, we found no evidence of a causal relationship between these physiological changes and academic performance [6, 23]. In addition, different physical exercise programs have different requirements for individuals' skills. For example, basketball, football, volleyball, and other team sports require a high degree of cooperation between individuals, and table tennis requires considerable skill. Therefore, why different sports lead to inconsistent research results needs to be explored in more comprehensive studies.

From the above summary of relevant studies conducted at home and abroad, there has been much research on the relationship between physical exercise and students' academic performance, and it has had a positive effect on encouraging teenagers to actively participate in physical exercise. However, in China's social environment, in studies on physical exercise and students' academic performance, relevant issues should be addressed through national policies. Further, future work must explore the logical relationship between physical exercise and students' academic performance. Studies rarely use a meta-analysis of research methods to measure the relationship between physical exercise and students' academic performance. The failure to reveal the intrinsic connections between these variables based on scientific studies makes it impossible to provide theoretical support for parents seeking to actively encourage their children to engage in physical exercise. Finally, regarding study subjects, studies lack a focus on the effects of physical exercise on adolescents and especially the impacts of different sports programs on students' academic performance. Such work can help school departments actively promote physical exercise in youth courses, constituting an important area for further research.

3. Materials and Methods

3.1. Hypothesis. Does exercise have an impact on academic performance? (RQ1)

Can physical activity have an impact on performance in a single subject? (RQ2)

What impact do various exercise intensities have on academic performance? (RQ3)

3.2. Research Type and Data Analysis. Quasi-experimental research documents related to physical exercise and academic performance were searched and screened using the CNKI journal and master's doctoral literature database, data were compiled in strict accordance with the meta-method procedure, and the effect of physical exercise on academic performance was analyzed to further clarify the relationship between the two. In meta-analyses, the standard mean deviation (SMD) and weighted mean deviation (WMD) are usually used. When research methods or interventions are inconsistent, the SMD should be selected as the effect scale index of a meta-analysis. Therefore, the SMD is used as the effective value after combining different documents.

The included literature was used for data analysis using RevMan5.3 software. After obtaining the literature, the data were first tested for heterogeneity; if $P > 0.1$ and $I^2 < 50\%$, a fixed-effects model was used; if $P < 0.1$ and $I^2 > 50\%$, a random-effects model was used. The effect values include the SMD and 95% confidence interval. Forest maps (forest plots) are a common expression form used to directly describe the results of a meta-analysis. A forest map is an intuitive graph based on statistical indicators and drawn from the results of statistical indicators and numerical methods. It judges the relationships between studies by describing the effect sizes and confidence intervals used in studies, and a 95% confidence interval that does not include 0 is statistically significant. A funnel diagram (funnel plot) is used to measure publication bias in the literature, the biased distribution and the graphic asymmetry of the employed design; if at the top

of the funnel there is no publication bias, this denotes a high level of research accuracy [24, 25].

When an original study specifies the mean, standard deviation, and sample size of the experimental group and controls and applies the same operation for the outcome variables (ESIM), the standard mean deviation of the calculation formula, SMD, is as follows:

$$\mathrm{SMD} = \frac{M_1 - M_2}{S_{\mathrm{P}}},$$
$$SP = \sqrt{\frac{(n1-1)s12 + (n2-1)s22}{(n1-1)+(n2-1)}}. \quad (1)$$

M_1 and M_2 are the mean values of the experimental and control groups, S_{P} denotes the combined standard deviation of the two data groups, n_1 and n_2 denote the sample sizes of the experimental and control groups, respectively, and s_1^2 and s_2^2 are the standard deviations of the two groups, respectively. When the sample size was less than 20, a corrected effect size formula was applied to reduce the study bias:

$$\mathrm{SMD}' = \left[1 - \frac{3}{4N-9}\right]\mathrm{SMD}. \quad (2)$$

3.3. Data Sources. To screen for compliant and exhaustive subject-related literature data wherever possible, we applied a three-phase screening process. The first round was conducted through the CNKI China Knowledge Series knowledge database using search terms "physical exercise," "sports," "physical activity," "sports," "physical sports," "sports project," "academic performance," "cultural performance," and "learning performance" for 1949–2020 and for core journals (CSSCI, CSCD, and Peking University Core) and doctoral programs. The second round of study on primary articles eliminated experimental work not involving academic performance test data and other documents, leaving 8 journal papers and 14 master's and doctoral papers. The data extraction table produced in the third round was used for index data extraction, from which incomplete indicators and missing data were removed. A total of 13 documents conforming to the meta-analysis requirements were finally included, and a total of 90 entries were collated.

3.4. Data Exclusion Criteria. The included studies have the following features.

(1) The studies conduct quasi-experimental research that explores the relationship between physical exercise and academic performance; independent variables for physical exercise, physical sports, physical activity, physical activities, and sports; and dependent variables for academic performance, learning performance, and other themes.

(2) The studies' quasi-experimental designs include experimental and control groups.

(3) These studies show no significant differences between the pretest results of the experimental and control groups.

(4) The sample sizes of the experimental and control groups are clear with no obvious differences between the two.

(5) Mean, standard deviation, t value, p-value, and other statistical indicators used are complete.

We exclude the following work:

(1) nonexperimental documents, such as reviews, meeting minutes, and reports;

(2) studies with unclear academic performance indicators (e.g., fair, good, and excellent performance measures used to describe academic performance);

(3) nonexperimental studies set, such as studies with a single experimental group.

(4) studies with missing research data indicators, such as the mean and standard deviation of the pretest data.

3.5. Data Extraction and Encoding. We used Excel 2010 to encode features of each selected study, including the author(s), year of publication, sampling method, sample size, sample grade, duration of physical exercise intervention, physical exercise form, and specific physical items, as detailed in Table 1. Features of the included literature show that the effects of physical exercise on academic performance began to increase after 2015; convenience sampling methods were used to collect study samples; most experimental and control study samples included approximately 30 people; most experimental subjects came from primary and secondary schools; most physical exercise interventions were studied in 8–12-week interval; physical exercise mainly involved classroom exercise; only two studies considered extracurricular training; and studies have explored a variety of sports and physical education classes of varying intensity. The projects included in the literature are relatively comprehensive, but there are still insufficient. Research on primary and secondary schools, vocational colleges, and junior colleges is still limited, and there have been few studies on the impacts of specific sports projects on academic performance.

4. Results

4.1. Publication Bias Test. Since literature with significant results is more susceptible to editing for publication, search terms, search tools, and limitations of the search process, relevant literature on physical exercise and academic performance could not be fully retrieved and included in this meta-analysis. This may lead to an exaggerated association between physical exercise and academic performance. Therefore, literature inclusion bias is considered through publication bias tests. There are multiple ways to assess publication bias, including funnel diagrams and Egger's test. The funnel plot method was used to assess publication bias, and the results are shown in Figure 1. According to the

Table 1: Meta-analysis data collation.

Author	Year	Sampling method	Sample size	Grade	Physical exercise intervention duration	Exercise form	Specific physical exercise items
Ni Qi	2018	Convenience sampling	CG:39IG (1):41IG (2):36	Grade five	IG (1): 3 times/week for 6 weeks; IG (2): 3 times/week for 12 weeks	Classroom exercise	Medium-intensity basketball and synchronized rope skipping combination
Zhou Banglun	2017	Convenience sampling	CG:48IG (1):50IG (2):51IG (3):51	Grade three	12 weeks	Classroom exercise	Physical education class of varying intensity
Sang Hongkun	2017	Convenience sampling	CG:40IG (1):43IG (2):43	Grade one	Three times/week for 10 weeks	Classroom exercise	Physical education class of varying intensity
Yan Yun	2019	Convenience sampling	CG:39IG (1):40IG (2):43	Grade one	12 weeks	Classroom exercise	Physical education class of varying intensity
Zhu Lin	2020	Convenience sampling	CG:31IG(1): 31IG(2):31	Grade five	12 weeks	Classroom exercise	Physical education class of varying intensity
Fan Yarong	2016	Convenience sampling	CG:49IG (1):50IG (2):51IG (3):50IG (4):50	Grade two	3 times/week for 8 weeks	Classroom exercise	Athletics, basketball, and table tennis
Huang Lingling	2016	Convenience sampling	CG:37IG (1):33IG (2):39IG (3):34	Grade one	2 times/week for 8 weeks	Classroom exercise	Basketball project
Yang Dan	2017	Convenience sampling	CG:30IG (1):30	Grades one and two	Ten weeks	Extracurricular training	Cheerleading
Yu Tingting	2016	Convenience sampling	CG:22IG (1):18IG (2):29	Grade six	Ten weeks	Classroom exercise	Basketball
Zhao Yufeng	2016	Convenience sampling	CG (1):12IG (1): 12; CG (1):7IG (1):7; CG (1):6IG (1):6; CG (1):7IG (1):7	Grades one, four, five, and six	Six times/week and 15 weeks/semester for 270 weeks	Classroom exercise and extracurricular training	Volleyball
Zhang Peipei	2016	Convenience sampling	CG:40IG (1):37	Grade five	2 times/week for 8 weeks	Classroom exercise	Soft bar softball
Liu Si-Liang	2017	Convenience sampling	CG:41IG (1):44IG (2):44	Grade one	Three times/week for 10 weeks	Classroom exercise	Physical education class of varying intensity
CAI Yaohui	2020	Convenience sampling	CG:24IG (1):12IG (2):12	Senior class	Nine weeks	Classroom exercise	Table tennis

Note: CG: control group (control group); IG: intervention group (intervention group).

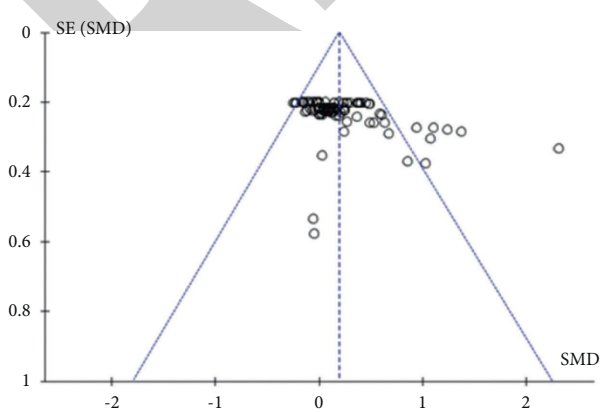

Figure 1: Publication bias funnel plot test.

results given in Figure 1, the data of the included samples are evenly distributed around effect value ES = 0.20, and the data are concentrated in the middle and upper parts of the funnel map with fewer studies outside of the funnel, indicating no obvious publication bias and the high accuracy of this study.

4.2. Effect of Physical Exercise on Academic Performance. To determine the overall effect of physical exercise on academic performance, 13 studies meeting the criteria and a 90 effect size were analyzed. The heterogeneity test results show that $I^2 = 53\%$ ($50\% < I^2 < 75\%$). The samples of the 13 independent studies included reach significance levels according to the heterogeneity test criteria. From the random effect model, combined effect size ES = 0.20, 95% CI = [0.13,0.26], and confidence interval excluding 0, $Z = 5.58$, $P < 0.001$, the results are shown in Figure 2. The analysis

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight (%)	Std. Mean Difference IV, Random, 95% CI
Fun Yarong 2016 (1)	49.11	10.55	49	51.6	9.17	50	1.3	-0.25 [-0.65, 0.15]
Fun Yarong 2016 (2)	49.2	10.93	49	50.76	8.99	50	1.3	-0.15 [-0.55, 0.24]
Fun Yarong 2016 (3)	48.95	10.77	49	51.07	8.2	50	1.3	-0.22 [-0.62, 0.18]
Fun Yarong 2016 (4)	147.28	29.4	49	153.43	23.1	50	1.3	-0.23 [-0.63, 0.16]
Fun Yarong 2016 (5)	50.25	9.35	51	51.6	9.17	50	1.3	-0.14 [-0.54, 0.25]
Fun Yarong 2016 (6)	50.48	9.17	51	50.76	8.99	50	1.3	-0.03 [-0.42, 0.36]
Fun Yarong 2016 (7)	50.54	9.52	51	51.07	8.2	50	1.3	-0.06 [-0.45, 0.33]
Fun Yarong 2016 (8)	151.27	23.94	51	153.43	23.1	50	1.3	-0.09 [-0.48, 0.30]
Fun Yarong 2016 (9)	50.05	10.63	50	51.6	9.17	50	1.3	-0.15 [-0.55, 0.24]
Fun Yarong 2016 (10)	49.17	10.81	50	50.76	8.99	50	1.3	-0.16 [-0.55, 0.23]
Fun Yarong 2016 (11)	49.96	10.43	50	51.07	8.2	50	1.3	-0.12 [-0.51, 0.27]
Fun Yarong 2016 (12)	149.19	29.92	50	153.43	23.1	50	1.3	-0.16 [-0.55, 0.24]
Fun Yarong 2016 (13)	51.45	10.26	50	51.6	9.17	50	1.3	-0.02 [-0.41, 0.38]
Fun Yarong 2016 (14)	52.31	7.06	50	50.76	8.99	50	1.3	0.19 [-0.20, 0.58]
Fun Yarong 2016 (15)	51.03	9.19	50	51.07	8.2	50	1.3	-0.00 [-0.40, 0.39]
Fun Yarong 2016 (16)	154.79	23.94	50	153.43	23.1	50	1.3	0.06 [-0.33, 0.45]
Huing Lingling 2016 (1)	51.53	6.615	33	50.11	10.318	37	1.1	0.16 [-0.31, 0.63]
Huing Lingling 2016 (2)	51.88	8.834	33	50	10.135	37	1.1	0.19 [-0.28, 0.67]
Huing Lingling 2016 (3)	53.66	8.935	33	50.19	10.011	37	1.1	0.36 [-0.11, 0.83]
Huing Lingling 2016 (4)	51.23	9.231	39	50.11	10.318	37	1.1	0.11 [-0.34, 0.56]
Huing Lingling 2016 (5)	52.21	10.436	39	50	10.135	37	1.1	0.12 [-0.34, 0.57]
Huing Lingling 2016 (6)	51.25	8.61	39	50.19	10.011	37	1.1	0.21 [-0.24, 0.67]
Huing Lingling 2016 (7)	52.21	8.673	34	50.11	10.318	37	1.1	0.01 [-0.45, 0.48]
Huing Lingling 2016 (8)	50.22	10.14	34	50	10.135	37	1.1	0.00 [-0.46, 0.47]
Huing Lingling 2016 (9)	50.51	10.044	34	50.19	10.011	37	1.1	0.03 [-0.43, 0.50]
Yu Tmgting 2016 (1)	55.15	10.98	29	44.48	7.91	22	0.8	1.07 [-0.48, 1.67]
Yu Tmgting 2016 (2)	51.83	11.26	29	49.24	9.92	22	0.9	0.24 [-0.32, 0.79]
Yu Tmgting 2016 (3)	52.9	8.84	29	46.08	11.48	22	0.9	0.67 [0.10, 1.24]
Zhao Yufeng 2016 (1)	529.3	217.5	6	543.4	287.2	6	0.3	-0.05 [-1.18, 1.08]
Zhao Yufeng 2016 (2)	525.3	117.5	7	534.9	177.2	7	0.4	-0.06 [-1.11, 0.99]
Zhang Peipei 2016 (1)	50.32	10.15	37	49.7	9.98	40	1.1	0.06 [-0.39, 0.51]
Zhang Peipei 2016 (2)	53.19	5.67	37	47.47	12.26	40	1.1	0.59 [0.13, 1.04]
Zhou Bangkun 2016 (3)	49.31	9.54	37	50.64	10.49	40	1.1	-0.13 [-0.58, 0.32]
Zhou Bangkun 2017 (1)	80.31	9.6	50	78.87	10.7	48	1.2	0.14 [-0.26, 0.54]
Zhou Bangkun 2017 (2)	88.28	8.7	50	86.76	12.1	48	1.2	0.14 [-0.25, 0.54]
Zhou Bangkun 2017 (3)	86.03	7.8	50	83.96	7.3	48	1.2	0.27 [-0.13, 0.67]
Zhou Bangkun 2017 (4)	78.2	11.8	50	73.1	15.4	48	1.2	0.37 [-0.03, 0.77]
Zhou Bangkun 2017 (5)	322.82	37.9	50	322.69	45.5	48	1.2	0.00 [-0.39, 0.40]
Zhou Bangkun 2017 (6)	82.04	10.2	51	78.87	10.7	48	1.2	0.30 [-0.10, 0.70]
Zhou Bangkun 2017 (7)	89.24	8.6	51	86.76	12.1	48	1.3	0.24 [-0.16, 0.63]
Zhou Bangkun 2017 (8)	87.52	9.8	51	83.96	7.3	48	1.2	0.41 [-0.01, 0.81]
Zhou Bangkun 2017 (9)	80.23	14.1	51	73.1	15.4	48	1.2	0.48 [-0.08, 0.88]
Zhou Bangkun 2017(10)	339.03	42.7	51	322.69	45.5	48	1.2	0.37 [-0.03, 0.77]
Zhou Bangkun 2017 (11)	82.62	8.6	51	78.87	10.7	48	1.2	0.38 [-0.01, 0.78]
Zhou Bangkun 2017 (12)	89.92	11.7	51	86.76	12.1	48	1.3	0.26 [-0.13, 0.66]
Zhou Bangkun 2017 (13)	87.9	9.7	51	83.96	7.3	48	1.2	0.45 [-0.05, 0.85]
Zhou Bangkun 2017(14)	80.21	13.7	51	73.1	15.4	48	1.2	0.48 [0.08, 0.89]
Zhou Bangkun 2017(15)	340.65	43.7	51	322.69	45.5	48	1.2	0.40 [0.00, 0.80]
Yang Dan 2017	89.5	2.1	30	87.5	2.1	30	0.9	0.94 [0.40, 1.48]
Sang Hongkun 2017 (1)	52.46	6.77	44	50.65	8.33	41	1.2	0.24 [-0.19, 0.66]
Sang Hongkun 2017 (2)	51.54	8.79	44	50.86	8.87	41	1.2	0.08 [-0.35, 0.50]
Sang Hongkun 2017 (3)	51.6	7.64	44	51.62	8.21	41	1.2	-0.00 [-0.43, 0.42]
Sang Hongkun 2017 (4)	155.59	19.83	44	153.12	22.27	41	1.2	0.12 [-0.31, 0.54]
Sang Hongkun 2017 (5)	51.82	7.64	44	50.65	8.33	41	1.2	0.15 [-0.28, 0.57]
Sang Hongkun 2017 (6)	50.79	9.67	44	50.86	8.87	41	1.2	-0.01 [-0.43, 0.42]
Sang Hongkun 2017 (7)	51.67	9.92	44	51.62	8.21	41	1.2	0.01 [-0.42, 0.43]
Sang Hongkun 2017 (8)	154.28	24.04	44	153.12	22.27	41	1.2	0.05 [-0.38, 0.48]
Sang Hongkun 2017 (1)	52.22	10.55	43	50.52	9.17	40	1.2	0.17 [-0.26, 0.60]
Sang Hongkun 2017 (2)	51.68	8.93	43	50.9	8.99	40	1.2	0.09 [-0.34, 0.52]
Sang Hongkun 2017 (3)	52.02	6.77	43	51.55	4.2	40	1.2	0.08 [-0.35, 0.51]
Sang Hongkun 2017 (4)	155.26	29.4	43	152.43	23.1	40	1.2	0.11 [-0.33, 0.54]
Sang Hongkun 2017 (5)	51.77	9.35	43	50.52	9.17	40	1.2	0.13 [-0.30, 0.56]
Sang Hongkun 2017 (6)	50.08	9.17	43	50.9	8.99	40	1.2	-0.09 [-0.52, 0.34]
Sang Hongkun 2017 (7)	51.5	5.52	43	51.55	4.2	40	1.2	-0.01 [-0.44, 0.42]
Sang Hongkun 2017 (8)	153.27	23.94	43	152.43	23.1	40	1.2	0.04 [-0.40, 0.47]
Ni Qi 2018 (1)	49.74	9.19	41	47.16	12.41	39	1.1	0.23 [-0.21, 0.67]
Ni Qi 2018 (2)	50.29	9.97	41	49.24	12.07	39	1.1	0.09 [-0.34, 0.53]
Ni Qi 2018 (3)	50.54	8.8	41	49.59	10.49	39	1.1	0.10 [-0.34, 0.54]
Ni Qi 2018 (4)	53.37	6.85	36	47.16	12.41	39	1.1	0.61 [-0.14, 1.07]
Ni Qi 2018 (5)	50.5	7.65	36	49.24	12.07	39	1.1	0.12 [-0.33, 0.58]
Ni Qi 2018 (6)	49.84	11.09	36	49.59	10.49	39	1.1	0.02 [-0.43, 0.48]
Yan Yun 2019 (1)	75.31	7.2	40	75.75	6.2	39	1.1	-0.06 [-0.51, 0.38]
Yan Yun 2019 (2)	89.3	14.2	40	87.58	10.5	39	1.1	0.14 [-0.31, 0.58]
Yan Yun 2019 (3)	84.32	4.6	40	84.97	6.7	39	1.1	-0.11 [-0.55, 0.33]
Yan Yun 2019 (4)	248.93	18.2	40	248.32	15.5	39	1.1	0.04 [-0.41, 0.48]
Yan Yun 2019 (5)	75.97	6.2	43	75.75	6.2	39	1.2	0.04 [-0.40, 0.47]
Yan Yun 2019 (6)	90.12	9.6	43	87.58	10.5	39	1.2	0.25 [-0.18, 0.69]
Yan Yun 2019 (7)	84.7	6.1	43	84.97	6.7	39	1.2	-0.04 [-0.48, 0.39]
Yan Yun 2019 (8)	250.83	13.6	43	248.32	15.5	39	1.2	0.17 [-0.26, 0.61]
Cai Yaohui 2020 (1)	89.725	5.038	12	84.971	5.673	24	0.6	0.85 [0.13, 1.57]
Cai Yaohui 2020 (2)	94.083	5.406	12	82.833	12.477	24	0.6	1.03 [0.29, 1.76]
Cai Yaohui 2020 (3)	86.75	4.906	12	86.563	7.114	24	0.7	0.03 [-0.66, 0.72]
Zhu Lin 2020 (1)	80.25	5.4	31	75.9	8.01	31	1.0	0.63 [0.12, 1.14]
Zhu Lin 2020 (2)	82.06	8.4	31	77.03	11.6	31	1.0	0.49 [-0.02, 1.00]
Zhu Lin 2020 (3)	91.74	6.29	31	80.69	9.36	31	0.9	1.37 [0.81, 1.92]
Zhu Lin 2020 (4)	262.06	16.3	31	235.35	25.27	31	0.9	1.24 [0.69, 1.79]
Zhu Lin 2020 (5)	79.55	5.3	31	75.9	8.01	31	1.0	0.53 [0.02, 1.04]
Zhu Lin 2020 (6)	80.41	13.5	31	77.03	11.6	31	1.0	0.27 [-0.23, 0.77]
Zhu Lin 2020 (7)	97.64	4.2	31	80.69	9.36	31	0.7	2.31 [1.66, 2.96]
Zhu Lin 2020 (8)	260.61	19.6	31	235.35	25.27	31	0.9	1.10 [0.57, 1.64]
Total (95% CI)			*3662*			*3596*	*100.0*	*0.20 [0.13, 0.26]*

Heterogeneity : $\tau^2 = 0.06$; $chi^2 = 189.54$, df= 89 ($P<0.00001$); $I^2=53$ %
Test for overall effect: $Z= 5.58$ ($P< 0.00001$)

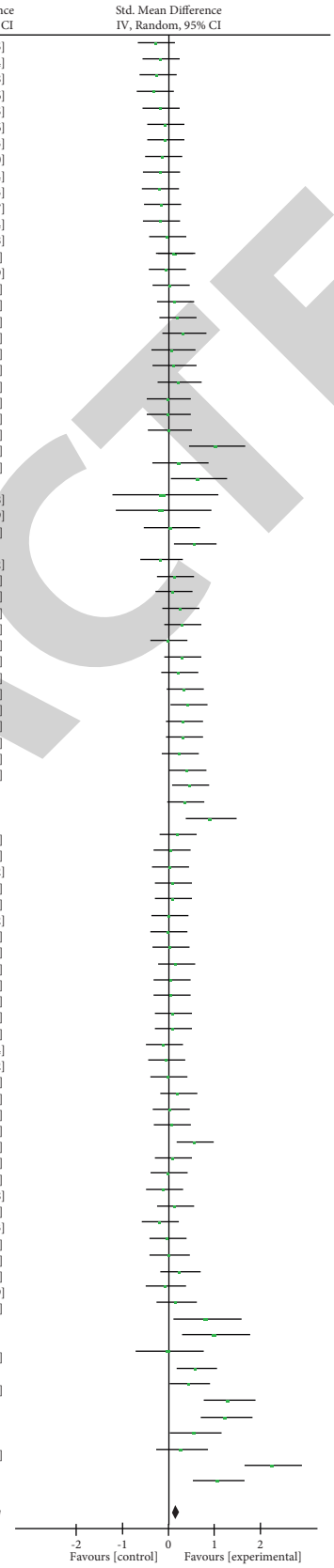

Figure 2: Effect of physical exercise on academic performance.

shows that the overall effect value of the random effect model is greater than 0 and reaches an extremely significant level, indicating that physical exercise significantly improves academic performance.

4.3. Impact of Physical Exercise on Academic Performance in Different Subjects. From the overall analysis, physical exercise has a positive effect in promoting academic performance. To analyze its specific effects, we further analyzed the effect of physical exercise on performance in different disciplines. Analysis data based on the details of the included literature are summarized in Table 2. The results show that a combined effect size of SMD = 0.22, $Z = 2.23$, and $P < 0.01$, and the studies reach significance at the 0.01 level, indicating a positive effect of physical exercise on performance in different disciplines. As shown by the specific effect sizes of different subjects, students showed significant positive improvements in Chinese (SMD = 0.18, $P < 0.01$), math (SMD = 0.26, $P = 0.01$), English (S MD = 0.19, $P < 0.001$), and physical performance (SMD = 0.44, $P < 0.01$). The effect P value between groups is 0.29 ($P > 0.05$), indicating no difference in effects of physical exercise across different disciplines and showing a relatively stable effect. Moreover, most of the effect sizes are small between 0.14 and 0.45, indicating that physical exercise has a small to moderate effect in improving learners' performance in different subjects.

4.4. Regulatory Effects of Different Exercise Intensities on Academic Performance. To further explore the effect of physical exercise on academic performance, the included literature was analyzed by induction. It was found that different exercise intensities have different effects on academic performance. Therefore, to further clarify the variability in the influence of different exercise intensities on academic performance, the literature included in the study was classified by study exercise intensity, a total of 72 effect sizes were included, and the specific data are shown in Table 3 for analysis. The data show a P-group effect P value of different exercise intensities on academic performance of $P < 0.001$, reaching a statistically significant level, indicating that the effects of different physical exercises on students' academic performance vary. The data show that exercise intensity levels of approximately 60% to 80% are more significant than other exercise intensities in improving academic performance.

5. Discussion

According to the above research results, physical exercise has a positive effect on promoting students' academic performance. This finding is consistent with the results of Yannis et al. [5], Xu [23], Getu [26], and Colak et al. [27]. This may be because physical exercise can improve the synthesis of certain neurotransmitters (such as dopamine and acetylcholine), improve nerve conduction speed, and thus improve cognitive processing speed and cognitive performance [6, 23], which has a positive effect on students' academic performance. In addition, physical exercise can effectively relieve students' learning anxiety, change students' emotional states, improve students' learning efficiency and learning effects, and promote the improvement of students' academic performance [28].

However, the above results are inconsistent with the work of Daley and Ryan [29], who argue that it is not that physical exercise that helps students improve their academic performance but rather that better academic performance encourages students to participate in more physical exercise. This finding may be related to the research approach the authors use, which does not involve an experimentally controlled intervention. In addition, Ahamed et al. [30] found a negative correlation between physical exercise and academic performance, but the correlation was very weak and not significant, potentially because the time of exercise and exercise intensity setting are not reasonably related. Deng et al. [31] found that physical exercise performed beyond a certain time and intensity has a negative impact on students' academic performance. However, this article, through a comprehensive combination of literature and meta-analysis, found that physical exercise and academic performance are significantly improved. The influencing mechanism may be such that physical exercise makes abstract learning content visualization, visualization, and knowledge increasingly situational. Students independently explore in a naturally interactive way, which deepens students' understanding of knowledge. Qualitative change influence occurs imperceptibly during the process of prolonged quantitative accumulation [32].

The effects of physical exercise on academic performance in different subjects show that physical exercise has a certain effect on various disciplines, while the differences between different disciplines do not reach a statistically significant level, indicating that the impact of physical exercise on academic performance in different disciplines does not significantly differ. This result is not consistent with the results of Zhang [33] but is consistent with the results of Qi [34], Tingting [35], and Dan [22]. This may be due to the need for physical exercise programs to have a stable and consistent focus on team competitive sports. These sports improve the quality of individual attention [34], increase attention and learning efficiency, and finally, promote academic performance [36]. However, there are no significant differences in the effects of physical exercise on different disciplines, which shows that physical exercise will not significantly improve performance in a certain discipline, and the impact on academic performance is comprehensive.

There are differences in the beneficial effects of different exercise intensities on academic performance, and approximately 60%~80% exercise intensity has an obvious effect on academic performance. This shows that different exercise intensities have different effects on the improvement in academic performance, and moderate-to high-intensity exercise has the most significant effect in improving academic performance. This is consistent with the results of Elizabeth et al. [16], Banglun [37], and Aiguo et al. [38] and partly consistent with the results of Xinnan [39] but not consistent with the results of Jian and Shiliang [15]. This may

Table 2: Differences in effects of physical exercise on academic performance in different disciplines.

Subject	Number of effects	Effect level (SMD)	95% confidence interval		Z	Effect conspicuousness	Differences between groups
			Superior limit	Lower limit			
Chinese	23	0.18	0.07	0.30	3.09	$P < 0.01$	
Mathematics	23	0.16	0.07	0.26	3.40	$P < 0.001$	
English	23	0.19	0.01	0.36	2.10	$P < 0.01$	$P = 0.29$
Physics	3	0.44	0.21	0.68	3.78	$P < 0.001$	
Amount	18	0.22	0.03	0.41	2.23	$P < 0.01$	

Table 3: Differences in the effects of different exercise intensities on student academic performance.

Exercise intensity level (%)	Number of effects	Effect level (SMD)	95% confidence interval		Z	Effect size significance	Differences between groups
			Superior limit	Lower limit			
30	4	−0.21	−0.41	−0.02	2.12	$P = 0.030$	
40	7	0.03	−0.13	0.19	0.33	$P = 0.740$	
50	23	0.16	0.02	0.30	2.29	$P = 0.020$	$P < 0.001$
60	28	0.21	0.08	0.33	3.15	$P = 0.002$	
70	5	0.36	0.18	0.54	3.94	$P < 0.001$	
80	5	0.40	0.22	0.57	4.37	$P < 0.001$	

be because Jian and Shiliang [15] only considered the role of moderate-to high-intensity exercise on learning with no systematic longitudinal comparison of multiple motor strengths, while Elizabeth et al. [16] and Ali et al. [40–42] compared multiple levels of intensity. This result may also be related to the different arousal effects of different sports on learning motivation, with low intensity and low arousal levels having little effect on students' learning enthusiasm. For example, Xinnan [39] found that high exercise intensity had a negative effect on students, moderate exercise intensity was accompanied by positive emotions, and the relation between low exercise intensity and emotional arousal was weak. Considering the above results, different exercise intensities have a positive effect on promoting academic performance. In addition, there are also significant differences between the effects of exercise intensities, with approximately 60%~80% exercise intensity having the best effect on promoting learning.

6. Conclusion and Suggestions

6.1. Conclusions. First, physical exercise can improve academic performance. Through the present in-depth analysis of publication bias, effect size, significance, and other indicators by meta-analysis, we not only confirm that physical exercise proposed in the previous research literature improves learning but also further show that the effect of physical exercise in promoting academic performance is significant and empirical. This strongly refutes the false perception that physical exercise will delay academic performance and provides a better theoretical basis for the dialectical relationship between physical exercise and curriculum learning.

Second, physical exercise improves performance in different subjects. Upon confirming that physical exercise improves overall academic performance, we further analyzed how physical exercise improves performance in different subjects, such as Chinese, mathematics, English, and physics, and no group differences were found between these subjects. Those with a focus on education, including schools, parents, and social training institutions, must stop ignoring the importance of physical education and other subjects and view them as of equal "status," and physical exercise should be prioritized to improve school performance and allow the associated benefits to complement each other.

Third, certain levels of physical exercise intensity are more effective in improving academic performance. The present analysis shows the influence of different sports intensities on academic performance and demonstrates that 60%~80% exercise intensity has the best effect on academic performance. Thus, professionals such as physical education teachers and coaches can refer to this sports theory to enable the maximum effect on academic performance.

6.2. Research Recommendations. First, teachers' application of physical activity technology should be improved. Givent the positive impact of physical activity on overall academic performance, we call to accelerate the application of teaching models for physical activity, incorporate a targeted teaching design, and make full use of the technical characteristics of physical activity to improve students' academic performance. In addition, teachers can introduce physical activity technology into low-level courses to enable teaching content to have targeted and visual effects, stimulate students' learning interest and attitudes, and thus enhance students' subjective initiative. Finally, in view of the unsatisfactory effect of physical activity among middle school students, we recommend increasing the application of and research on physical activity in junior high schools and further exploring the internal logical relationship between physical activity and students' academic performance.

Second, sports subjects should be given the same status as other cultural subjects. As different sports programs have good applications in most disciplines, they have good discipline applicability. This study demonstrates that importance should be attached to deep integration between different movements and disciplines. In addition, teachers should combine discipline characteristics and make full use of the technical advantages of various physical exercises to carry out teaching innovation. For the main subjects of Chinese, mathematics, and English, teachers should make full use of different sports skills, build a rich teaching environment, apply role playing, and build students' personal knowledge. For science courses such as physics, teachers should make full use of different sports techniques to present formula theorems and structures through 3D models and animations to embody and visualize abstract knowledge, reducing students' cognitive burden, and enhancing their information processing, restructuring, and reconstruction capabilities.

Finally, scientifically based physical exercise programs must be developed. Physical sports have an obvious role in promoting students' performance. Thus, schools must constantly develop and apply diversified sports programs and physical exercise activities and enhance students' knowledge of physical exercise programs to encourage students to actively participate in physical exercise and then relieve their negative psychological states and emotions. Such an approach can change students' physiological states, improve their focus, and continue to improve their academic performance.

6.3. Research Limitations. Due to limitations on time and objective factors, we call for a further extension of this study. First, we evaluated the impact of physical exercise on academic performance overall without considering specific processes of learning. Second, we only systematically reviewed the relevant domestic literature and did not examine foreign literature, and we thus conducted no systematic evaluation of the influence of cultural differences. Therefore, future research should refine the impacts of physical exercise on memory, cognition, thinking and other aspects. In addition, domestic and foreign literature should use other methods to further discuss the relationship between physical exercise and academic performance.

Data Availability

The datasets used during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Retraction

Retracted: Research on the College Students' Venture Risk Assessment Model Based on the LightGBM Algorithm

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] B. Feng and L. Zhang, "Research on the College Students' Venture Risk Assessment Model Based on the LightGBM Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 1986679, 11 pages, 2022.

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Research Article

Research on the College Students' Venture Risk Assessment Model Based on the LightGBM Algorithm

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There are numerous risk factors in the school students' entrepreneurial process. In order to advance the accuracy of school students' entrepreneurial risk assessment within entrepreneurial practice background and reduce risk management factors, a model of school students' entrepreneurial risk assessment grounded on the LightGBM algorithm is proposed. We construct the statistical probability density distribution and constraint parameter model of college students' entrepreneurial risk distribution in an entrepreneurial practice environment. Moreover, we adopt the factor hierarchical classification technology of the evaluation index system to realize the framework model construction and big data fusion processing of college students' entrepreneurial risk indicators in the entrepreneurial practice environment. Then, we extract the joint similarity feature set of college students' entrepreneurial risk factors in the entrepreneurial practice environment and adopt the LightGBM feature detection and fuzzy matching technology. The self-adaptive optimization and fuzzy clustering analysis are realized in the procedure of school students' entrepreneurial risk assessment under the entrepreneurial practice environment, and a fuzzy Bayesian network assessment model for school students' entrepreneurial risk assessment under the entrepreneurial practice environment is constructed. The Delphi method is used to determine the pairwise influence relationship between factors, and the LightGBM algorithm is used to optimize the evaluation of college students' entrepreneurial risk factors under the entrepreneurial practice environment and match rough set features. According to the comprehensive evaluation of entrepreneurial risk factors, the intelligent entrepreneurial risk assessment under the entrepreneurial practice environment is comprehended. The simulation outcomes confirm that the intelligence of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is improved, and the precision of risk assessment is greater than other approaches.

1. Introduction

At present, college students' entrepreneurial activities are in full swing. On the one hand, China's economic development mode has changed, the economy has made a soft landing, and modernization and entrepreneurship have come to be the new impelling cause of economic progression. On the other hand, with the influence of the enrollment expansion policy of schools and institutions of higher education, students are generally confronted with employment difficulties. Some college students relieve employment pressure through self-employment, and a private enterprise is also an effective approach for school students to develop themselves and realize their self-worth. Since "mass entrepreneurship and innovation" was put forward in the Davos forum, innovation and entrepreneurship in China have also spread from the original high-level scientific and technical personnel or returned overseas students to the public. It should be noted that everyone can start a business, and the social environment encourages entrepreneurship. From the numerical and statistical exploration of the guiding documents of "mass innovation and entrepreneurship" by our government, we can see that the state ascribes prodigious prominence to different college graduates and entrepreneurial groups of school pupils and learners.

At present, the state and the government highly inspire and care about institutional students to start their personal industries and businesses, give various preferential policies in entrepreneurship support and financial support, and vigorously develop entrepreneurship education. However, since China's entrepreneurial activities are in the initial stage, the research on entrepreneurial activities is still in the exploratory stage, and the government has not paid enough attention to the jeopardies in the entrepreneurial process for institutional students. Experts and scholars generally focus on qualitative analysis of entrepreneurial risks of college students but do not conduct quantitative data research on the problems. At the same time, most of the analysis of entrepreneurial risk factors mainly starts from one aspect and will not systematically study and analyze the risks in the entrepreneurial process [1]. Based on systematic analysis of college students' entrepreneurial risks, the risk analysis model is established and verified by examples, which provides an effective method for college students in order to avoid conventional risks, and has practical significance [2].

In this paper, a scheme for university students' entrepreneurial risk assessment based on the LightGBM algorithm is proposed. Firstly, the statistical probability density distribution and constraint parameter model of college students' entrepreneurial risk distribution in the entrepreneurial practice environment are constructed, and the optimal evaluation and rough set feature matching of college students' entrepreneurial risk factors in the entrepreneurial practice environment are realized by the hierarchical structure analysis method among risk factors. Then, according to the comprehensive relationship evaluation of entrepreneurial risk factors, the intelligent entrepreneurial risk evaluation of college students in the entrepreneurial practice environment is comprehended. To finish, the simulation test exploration expresses the greater performance of this approach in humanizing the college students' entrepreneurial risk assessment ability in the entrepreneurial practice environment. The fundamental contributions of this work are as discussed as follows:

(i) To increase the accuracy of college students' entrepreneurial risk evaluation, a model for university students' entrepreneurial risk assessment which is grounded on the LightGBM algorithm is proposed

(ii) We construct the statistical probability density distribution and constraint parameter model and adopt the factor hierarchical classification technology of the evaluation index system to realize the framework model construction and big data fusion processing

(iii) We extract the joint similarity feature set and adopt LightGBM feature detection and fuzzy matching technology

(iv) Self-adaptive optimization and fuzzy clustering analysis are realized, and a fuzzy Bayesian network evaluation model is constructed

(v) The Delphi method is used to determine the pairwise influence relationship between factors, and the LightGBM algorithm is used to optimize the assessment of school students' entrepreneurial risk factors

The remaining part of the manuscript is organized as follows: The analysis of data structure of college students' entrepreneurial risk factor distribution in the entrepreneurial environment is deliberated in section 2. The optimization of school students' entrepreneurial risk assessment within the entrepreneurial practice environment is offered in section 3. In section 4, the simulation setup, tests, and result analysis are discussed in detail. A brief summary of the related work and approaches is presented in section 5. To conclude this article, section 6 summarizes the paper and provides some interesting points that can be considered for further research and investigation.

2. Analysis of Data Structure of College Students' Entrepreneurial Risk Factor Distribution in the Entrepreneurial Environment

2.1. Overall Framework. The research object of this paper is college students' entrepreneurial processes, and the factors involved in entrepreneurial processes are complex and numerous. Therefore, this paper comprehensively applies risk theory, the decision-making trial and evaluation laboratory (DEMATEL) approach, the structural equation interpretation method (ISM method), the triangular fuzzy number method, and the Bayesian network theory, builds a technical and sensible risk evaluation index scheme that improves the traditional Bayesian network, and comprehensively studies the application scope, advantages, and disadvantages of fuzzy Bayesian, naive Bayesian, and hierarchical Bayesian networks [3]. Then, the toolbox of the Bayesian network is implemented to appraise the jeopardy of college students' entrepreneurial enterprises, which provides some reference for college students' entrepreneurial risk identification. The key exploration contents of this paper are as discussed in the following section:

(1) We collect the pertinent data of school learners' entrepreneurial risk, get the appropriate factors of institution pupils' entrepreneurial failure through comprehensive risk analysis, and determine the final risk evaluation index system by the DEMATEL-ISM method [4].

(2) Based on the causal relationship among the index factors in the evaluation index scheme of institution pupils' entrepreneurial risk, the Bayesian network topology is constructed, the conditional probability of node variables in the topology is determined by triangular fuzzy numbers, and the college students' entrepreneurial risk is evaluated by MATLAB software, thus the fuzzy Bayesian network evaluation model is constructed. The feature matching model of college students' entrepreneurial risk assessment under the entrepreneurial practice environment is assembled, and the data management of university

scholars' entrepreneurial risk assessment under the entrepreneurial practice environment is carried out by using association rule fusion and resemblance feature recognition [5]. According to the assessment results, the visual browsing of college students' entrepreneurial risk factor information under the entrepreneurial practice environment is realized and understood [6], and the overall construction model of the institution learners' entrepreneurial risk assessment under the entrepreneurial practice environment is obtained as shown in Figure 1.

Referring to the overall construction model of school learners' entrepreneurial risk assessment in the entrepreneurial practice environment shown in Figure 1, the YT technology is analyzed by using the Bayesian network model, and the probability of risk occurrence is calculated by using the MATLAB running program. According to the final calculation results, the rationality and scientificity of the model are verified. At the same time, the model can provide guidance for college students who are starting businesses and those who are about to start businesses, find out the hidden risks of entrepreneurial enterprises, make college students' entrepreneurial enterprises realize their own shortcomings and risk sources, and improve and prevent them in time [7, 8].

2.2. Characteristics and Distribution of College Students' Entrepreneurial Risk Factors in the Entrepreneurial Practice Environment. The statistical probability density distribution and constraint parameter model of college students' entrepreneurial risk distribution in the entrepreneurial practice environment are constructed, and the framework prototype of university scholars' entrepreneurial risk index and big data fusion processing are realized by using the factor hierarchical classification technology of the evaluation index system, and the resource load balance model of college students' entrepreneurial risk evaluation in the entrepreneurial practice environment is established. Screening evaluation indexes are the premise of college students' entrepreneurial risk evaluation, and a technical and sensible assessment index scheme of school pupils' entrepreneurial risk can be, therefore, established according to the selection principles and establishment steps of risk indexes. The first step to instituting a technical and sensible risk assessment index scheme for college students is theoretical research and risk analysis. In the subsequent section, this paper discusses in detail the risks existing in the procedure of college students' entrepreneurship in the Republic of China and studies and analyzes various risks. The second step is to build the initial index framework of institutional scholars' entrepreneurial risk [9, 10].

Grounded on the investigation results of experts and academics, combined with the unique characteristics of college students' entrepreneurship in China, this paper analyzes and investigates the risk assessment features and elements of institutional apprentices' entrepreneurship and establishes the index structure framework of initial college students' entrepreneurial risk factors, which includes four dimensions: entrepreneurial environment, school education, core team, and entrepreneurs, that is, the index framework of initial college students' entrepreneurial risk assessment includes four (4) first-level signs and approximately 31 second-level pointers. In the next stage, we get the ranking list of college students' entrepreneurial risk assessment under the entrepreneurial practice environment and see Tables 1 and 2 for the distribution framework of college students' entrepreneurial risk factors under the entrepreneurial practice environment [11].

Thus, the formula for extracting and updating semantic features of college students' entrepreneurial risk assessment under the entrepreneurial practice environment is obtained and illustrated in the following formula:

$$H(r) = \frac{1}{N+1} x(N+1) x^3 (N+1-\tau). \tag{1}$$

According to the information fusion of closed frequent items, the cluster analysis approach is implemented to obtain that the cluster centers of school student' entrepreneurial risk assessment in the entrepreneurial practice environment are M_i and M_j, and the rough set feature resemblance method is adopted to obtain that the reliability matching degree of college students' entrepreneurial risk assessment in the entrepreneurial practice environment and platform is $Clust\ dist\,(M_i, M_j)$. When $(i \neq j, 1 \leq i \leq q, 1 \leq j \leq q)$, then the combined feature functional of the output of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is expressed as follows in the formula:

$$\begin{aligned} F(t) &= X_p (u - v \sin a) \\ &= \frac{3}{(N+1)^2} x(N+1) x^3 (N+1-\tau), \end{aligned} \tag{2}$$

wherein X_p is the source statistics designed for the semantic distribution of college students' entrepreneurial risk factors in the entrepreneurial practice environment, u is the joint distribution characteristic quantity of college students' entrepreneurial risk factors in the entrepreneurial practice environment, and v characterizes the normative fuzzy recognition basis function of the college students' entrepreneurial risk factors in the entrepreneurial practice environment. Based on the semantic information detection results of college students' entrepreneurial risk factors in the entrepreneurial practice environment, the rough set matching coefficients of college students' entrepreneurial risk factors in the entrepreneurial practice environment are $r_x^{(N+1)}(\tau)$ and $c_x^{(N+1)}(\tau)$ values. The probability density function of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is recognized through the mean filtering and scheduling recognition, which is mathematically articulated as follows in the formula:

$$p(r) = \frac{1}{\sqrt{2\pi}\sigma_s} \frac{\partial\left(EE^T\right)}{\partial\tau} = -2E\left(X_1 * \frac{\partial H}{\partial\tau}\right)^T, \tag{3}$$

wherein σ_s is the parameter to be evaluated for college students' entrepreneurial risk assessment in the entrepreneurial practice environment. Through the above

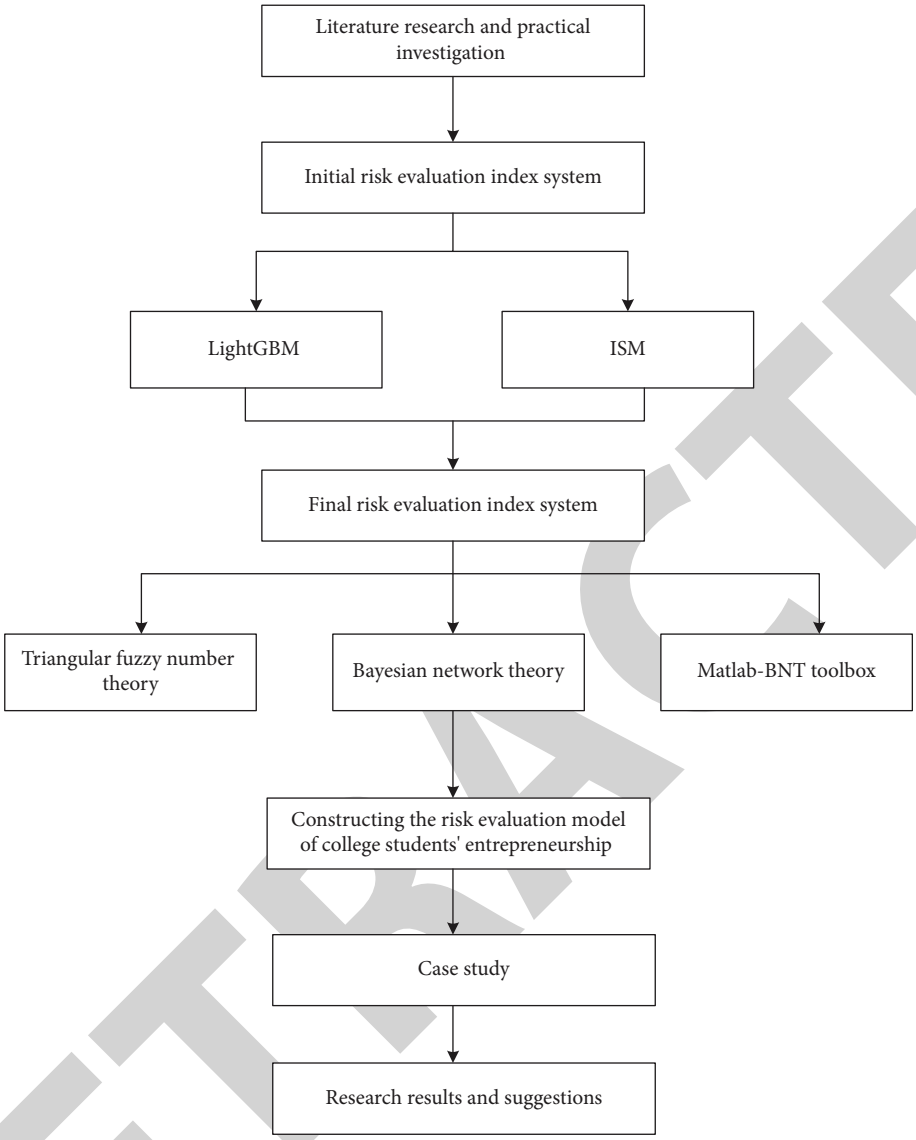

Figure 1: Overall construction prototype of school pupils' entrepreneurial risk assessment in the entrepreneurial practice environment.

processing, the feature compression exploration technology is then familiarized in order to create the ideal decision function of college students' entrepreneurial risk assessment under the entrepreneurial practice environment, which is given as follows in the formula:

$$F = X_2 - X_1 * H$$

$$= \min\left(\sum_{i}^{N} R_i\right) = \begin{cases} \dfrac{s_{ij} - s(i,j)}{s_{ij}} & s(i,j) < s_{ij}, \\ e(i,j) & s(i,j) \geq s_{ij}, \end{cases} \quad (4)$$

wherein s_{ij} represents the storage structure model of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, and if the sampling period is T_s, the data points of college students' entrepreneurial risk factors in the entrepreneurial practice environment included in each period will be obtained, and the semantic feature distribution model of college students' entrepreneurial risk factors in the entrepreneurial practice environment will be obtained [12, 13].

Table 1: First-level indicators of college students' entrepreneurial risk evaluation.

Primary index	Serial number
Entrepreneurial environment	Q1
Entrepreneurship education	Q2
Core team	Q3
Entrepreneur	Q4

2.3. Analysis of Characteristics of College Students' Entrepreneurial Risk Assessment under the Entrepreneurial Practice Environment. The factor hierarchical classification technology of the evaluation index system is used. The framework model of college students' entrepreneurial risk

Table 2: Secondary indicators of college students' entrepreneurial risk evaluation under the entrepreneurial practice environment.

Secondary index	Serial number	Contribution level	Confidence level	Support degree
Government funding	Q11	0.885	0.651	0.898
Industry growth	Q12	0.997	0.317	0.895
Ability environment	Q13	0.911	0.361	0.852
Study, research, and development surroundings	Q14	0.609	0.501	0.448
Economic support	Q15	0.263	0.303	0.383
Transitional facilities	Q16	0.422	0.425	0.560
Marketplace environment	Q17	0.844	0.961	0.141
Innovation popularity	Q18	0.447	0.165	0.975
Laws and regulations	Q19	0.602	0.601	0.681
Educational theory	Q21	0.371	0.487	0.164
Target system	Q22	0.065	0.032	0.519
Curriculum system	Q23	0.964	0.109	0.524
Practice system	Q24	0.014	0.406	0.778
Teachers	Q25	0.783	0.923	0.581
Entrepreneurship education support	Q26	0.899	0.021	0.329
Campus cultural atmosphere	Q27	0.469	0.040	0.391
Consistency of goals	Q31	0.878	0.271	0.352
Values	Q32	0.958	0.741	0.936
Trust or not?	Q33	0.439	0.620	0.188
Benefit distribution mechanism	Q34	0.115	0.391	0.041
Can the advantages complement each other?	Q35	0.289	0.651	0.194
Innovation capacity	Q36	0.307	0.855	0.146
Team experience	Q37	0.746	0.608	0.249
Entrepreneurship motivation	Q41	0.704	0.879	0.131
Entrepreneurial consciousness	Q42	0.825	0.184	0.756
Entrepreneurial psychological quality	Q43	0.178	0.682	0.585
Entrepreneurship knowledge	Q44	0.043	0.562	0.467
Personality traits	Q45	0.267	0.314	0.457
Entrepreneurial practice ability	Q46	0.658	0.892	0.961
Risk resistance capacity	Q47	0.075	0.591	0.578
Personal experience	Q48	0.776	0.538	0.395

indicators under the entrepreneurial practice environment and big data fusion processing are realized [14]. The joint similarity feature set of college students' entrepreneurial risk factors under the entrepreneurial practice environment is extracted, and the delay parameters of college students' entrepreneurial risk evaluation under the entrepreneurial practice environment are as given in the following formula:

$$\begin{aligned} t_i &= \varphi\left(\mathrm{X}_k, t_i\right) \\ &= G\left(\left\|\mathrm{X}_k - t_i\right\|\right) \\ &= \exp\left(-\frac{1}{2\sigma_i^2}\left\|\mathrm{X}_k - t_i\right\|^2\right) \\ &= \exp\left(-\frac{1}{2\sigma_i^2}\sum_{m=1}^{M}\left(x_{km} - t_{im}\right)^2\right), \end{aligned} \tag{5}$$

wherein $t_i = [t_{i1}, t_{i2}, \cdots, t_{iM}]$ is the discrete sequence of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, and σ_i is the spatial scattering charge of college students' entrepreneurial risk assessment in the entrepreneurial practice environment. Let $y(n)$ be the rough set feature amount of college students' entrepreneurial risk assessment in the entrepreneurial practice environment. Conferring to the rough set feature equivalent results, the fuzzy matching and rough set detection results are obtained. Rendering to the aforementioned exploration, a feature investigation model of institution scholars' entrepreneurial risk assessment in the entrepreneurial practice environment is assembled, and the interval function of feature discovery of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is obtained. Furthermore, conferring to the aforementioned exploration, the feature study and investigation model of institution scholars' entrepreneurial risk assessment under the entrepreneurial practice environment is constructed, and the dispersed information fusion of collected works risk assessment is comprehended agreeing to the feature extraction outcomes [15].

3. Optimization of College Students' Entrepreneurial Risk Assessment under the Entrepreneurial Practice Environment

3.1. Rough and Fuzzy Clustering of College Students' Entrepreneurial Risk Factors in the Entrepreneurial Practice Environment. By using LightGBM feature detection and fuzzy matching technology, the self-adaptive optimization and fuzzy clustering analysis of college students' entrepreneurial risk assessment in the entrepreneurial practice environment are constructed, and the fuzzy Bayesian network

evaluation model of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is constructed [16]. The rough fuzzy detection probability of college students' entrepreneurial risk factors in the entrepreneurial practice environment is obtained as follows in the formula:

$$P_{TX} = \frac{P_{T-elec}}{R} \cdot L_{\mathrm{DATA}} + \frac{P_t}{R} \cdot L_{\mathrm{DATA}} + \frac{P_{R-elec}}{R} \cdot L_{ACK} + P_{T-\mathrm{start}} t_{T-\mathrm{start}} + P_{R-\mathrm{start}} t_{R-\mathrm{start}}. \tag{6}$$

The joint distributed fusion method of college students' entrepreneurial risk factors in the entrepreneurial practice environment is used, the time length t of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, and using the vector $x = [\, x_1, \ x_2 \ \ldots \ x_k \,]$ to express the statistical characteristics of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, according to the clustering of M_1, $M_2 \cdots M_N$, the detection statistical characteristics of college students' entrepreneurial risk assessment in the entrepreneurial practice environment are given as follows in formulas:

$$Rs = \left(\frac{P_{T-elec} + P_{R-elec} + P_t}{R}\right) \cdot \left(L_{\mathrm{DATA}} + L_{ACK}\right) = \sum_{i=0}^{N} \left(DIFS + C_R^{(i)} \times t_{\mathrm{slot}} + t_{\mathrm{DATA}} + SIFS + t_{T-\mathrm{start}}\right), \tag{7}$$

wherein

$$k_1 = \frac{\left(P_{T-elec} + P_t\right) + P_{R-elec}}{R}, \tag{8}$$

$$k_2 = P_{T-\mathrm{start}} t_{T-\mathrm{start}} + P_{R-\mathrm{start}} t_{R-\mathrm{start}}. \tag{9}$$

According to the random distribution of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, the precision rate of optimized assessment is $x_i r_i(x) p_i^j(x)$, and the hierarchical clustering function of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is as follows in the formula:

$$Cl = \frac{k_1 \cdot l}{E_{comm}} \cdot \left(1 - p_{\mathrm{drop}}\right) = SIFS + t_{T-\mathrm{start}}. \tag{10}$$

Conferring to the hierarchical detection outcomes of college students' entrepreneurial risk assessment in the entrepreneurial practice environment and the hierarchical distribution characteristics of indicators in the entrepreneurial risk index system, the fuzzy set distribution of college students' entrepreneurial risk factors in the entrepreneurial practice environment is obtained as follows in the formula:

$$f(v) = \frac{\cos(\pi v) - \sin c(v)}{v}. \tag{11}$$

Combining the fuzzy clustering results of college students' entrepreneurial risk factor information in the entrepreneurial practice environment and using the DEMATEL method and the ISM method together, the joint feature matching function of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is expressed as given in the following formula:

$$P_{k+1|k+1} = P_{k+1|k} - G_{k+1} P_{k+1|k}^{z} G_{k+1}^{T}. \tag{12}$$

Then, n_z is set as the node amount of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, and the correlation coefficient $\rho(k)$ of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is analyzed by the grouping sample detection method. By covariance rectification, the arithmetical features of rough uncertainty recognition of college students' entrepreneurial risk assessment in the entrepreneurial practice environment are as given in the following formula:

$$H_{SCOT}(f) = L^{-1} \sum_{j=k-L+1}^{k} \tilde{z}_j \tilde{z}_j^T - \left(P_{k+1|k}^{z} + R_k\right). \tag{13}$$

Then, the rough fuzzy set of ϕ_k obeys the χ^2 distribution with the degree of freedom of n_z, and the fuzzy set of college students' entrepreneurial risk factors under the entrepreneurial practice environment is constructed, and the fuzzy information components are q_k, Q_k, r_k and R_k. Based on statistical feature analysis, the rough fuzzy evaluation set of college students' entrepreneurial risk factors under the entrepreneurial practice environment is S, and $\{v_1, \ldots, v_M\}$ represents the rough fuzzy state detection and analysis of college students' entrepreneurial risk factors under the entrepreneurial practice environment. The rough modulus matching function of college students' entrepreneurial risk factors under the entrepreneurial practice environment is as follows in formulas:

$$\hat{r}_{k+1} = (1 - d_k)\hat{r}_k + d_k \left[z_{k+1} - m^{-1} \sum_{i=1}^{m} h_{k+1}\left(X_{i,k+1|k}, u_{k+1}\right) \right], \tag{14}$$

$$\hat{R}_{k+1} = (1 - d_k)\hat{R}_k + d_k \left[\tilde{z}_{k+1} \tilde{z}_{k+1}^T - m^{-1} \sum_{i=1}^{m} \left(Z_{i,k+1|k}^{*} - \hat{z}_{k+1|k}\right)\left(Z_{i,k+1|k}^{*} - \hat{z}_{k+1|k}\right)^T \right]. \tag{15}$$

In fact, allowing for the aforementioned exploration, the rough fuzzy clustering investigation model of college students' entrepreneurial risk factors in the entrepreneurial practice environment is constructed to improve the risk assessment ability [17].

3.2. Output of College Students' Entrepreneurial Risk Assessment under the Entrepreneurial Practice Environment. The fuzzy Bayesian network evaluation model of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is constructed, and the optimal evaluation and rough set feature matching of college students' entrepreneurial risk factors in the entrepreneurial practice environment are realized by the hierarchical

structure analysis method among risk factors so as to construct college students' entrepreneurial risk assessment in the entrepreneurial practice environment. The entropy function of information distribution of college students' entrepreneurial risk factors in the entrepreneurial practice environment is as follows in the formula:

$$\begin{aligned} H &= -\sum_{i=0}^{N}(1-p_i)\ln(1-p_i) \\ &= \beta\sigma_{x1}^2(k-1)+(1-\beta)x_1^2(k). \end{aligned} \tag{16}$$

Conferring to the law of entropy distribution, collectively with the mean function recognition approach, the optimization assessment of college students' entrepreneurial risk factors in the entrepreneurial practice environment is carried out, and the following results are obtained through the following formula:

$$\begin{aligned} \widehat{D}(k+1) &= \frac{1}{n_j}\sum_{i=1}^{k}X_i^j \\ &+ \int 2\mu e(k)\sum_{i=-p}^{p}x(k-i)f(i-\widehat{D}(k)) \\ &(j=1,2,\ldots,k). \end{aligned} \tag{17}$$

The relationship between the risk factors of college students' entrepreneurial failure is determined by a questionnaire survey, and the self-adaptive optimization and fuzzy clustering analysis in the procedure of institution scholars' entrepreneurial risk assessment under the entrepreneurial practice environment are realized by using the LightGBM feature detection and fuzzy matching technology, and the fuzzy Bayesian network evaluation model of college students' entrepreneurial risk assessment under the entrepreneurial practice environment is constructed. The optimization process and flowchart are shown in Figure 2.

4. Simulation Tests and Analysis of Results

In order to accurately identify the degree of direct influence among the factors, the survey objects were identified as school pupils who had potentially failed to start a business, teachers of entrepreneurship education, and experts in entrepreneurship parks. A total of 100 inquiry forms and questionnaires were distributed, and approximately 85 were recovered. Through the statistical processing of the questionnaire, the direct influence matrix X is established.

In the next step, we fixed the time span of scattered sampling of college students' entrepreneurial risk factors in the entrepreneurial practice environment to 1,200, out of which the training set is fixed to 24. Furthermore, the locality magnitude of statistics and facts' location of college students' entrepreneurial risk factors in the entrepreneurial practice environment was fixed at 7, while the similarity coefficient was predefined as equal to 0.35. Finally, the joint feature distribution coefficient is assumed to be 0.14, and then based on these parameters, we build a comprehensive relationship table of entrepreneurial risk factors, as shown in Table 3.

According to Table 3's descriptive statistical analysis of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, the hierarchical structure of risk assessment indicators is established. According to the design process of this paper, the DEMATEL-ISM method is used to investigate institution scholars' entrepreneurial risk, and the degree of importance of risk factors to college students' entrepreneurial success or failure is judged by integrating the centrality and influence degree of each influencing factor obtained by DEMATEL and the multilevel hierarchical structure among the factors described by the ISM method. According to the results in Table 3, we can get the degree of stimulus, degree of reason, and degree of significance of entrepreneurial risk features of school scholars, among which the centrality of entrepreneurial risk index dynamics and features of institutional scholars indicates the proportion of this risk factor in all risk factors.

The degree of cause indicates the degree of influence of the risk factor on other factors, and the degree of cause has positive and negative points. If the degree of reason is greater than 0, then it demonstrates that the risk indicator has great stimulus on other risk indicators, which is the key and fundamental cause dynamic. Similarly, if the degree of reason is a smaller amount than 0, then it means that the risk indicator is not very important and is greatly influenced by other risk indicators. At the same time, the cause degree and center degree of the factors are depicted by curve images, as shown in Figure 3.

According to Figure 3, 13 risk factors, including government support, industrial development, talent environment, financial support, policies and regulations, educational theory, target system, teaching staff, entrepreneurship education support, complementary advantages, team experience, personality characteristics, and personal experience, are the cause factors. Among the cause factors, government support, financial support, and entrepreneurship education support rank the top three and play the biggest role. As can be seen from Figure 3, the degree of government support, educational theory, and the degree of the cause of personality characteristics coincide with the degree of centrality, indicating that their degree of influence is 0, and this factor is the fundamental reason.

The cause and center degree of the R&D (research and development) environment, innovation popularity, implementation degree, and antirisk ability are nearly symmetrical about the zero line, which indicates that their influence degree is relatively small and is greatly influenced by other factors. On this basis, risk assessment is realized. According to the occurrence frequency of risk factors in the process of scientific and technological entrepreneurship, the occurrence frequency represents the occurrence probability, the prior probability of root node variables corresponding to the cause factors can be obtained, and the risk assessment probability outcomes are made known in Figure 4. In fact, conferring to the exploration and investigation of Figure 4, the probability density of college students' entrepreneurial

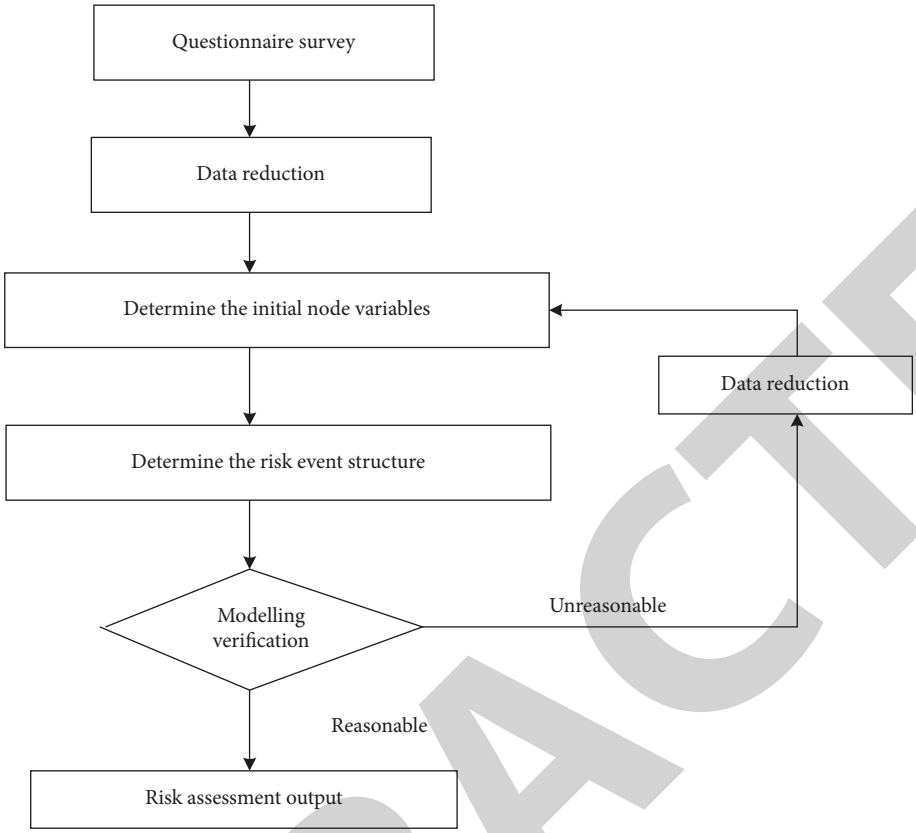

Figure 2: Structure and process of college students' entrepreneurial risk assessment.

risk assessment under the entrepreneurial practice environment is high, and the assessment confidence level is good.

5. Related Work

A comprehensive and systematic exploration of the present situation of institution students' entrepreneurship is completed because (i) it adopts scientific methods, (ii) correctly identifies risk factors, and (iii) establishes an index scheme of school students' entrepreneurship risk so that college learners have a perfect understanding of entrepreneurship risks and make adequate preparations for entrepreneurship [18]. In fact, we further examine and appraise the risks of school learners professionally, find out the hidden risks in the progression of university scholars' entrepreneurship, and make entrepreneurial enterprises realize their own shortcomings and risk sources. Similarly, we improve and prevent them in time, provide guidance and help for college students' self-employment activities, and help entrepreneurial enterprises develop more healthily and rapidly. Shamsul (2016) used the PLS exploration approach to examine the influence of psychosocial factors (social support, work experience, and guidance) on entrepreneurs' entrepreneurial quality. At the same time, it was proposed that entrepreneurs' quality is a key factor that affects business potential and increases the survival of enterprises. Shinnar analyzes the behavior traits of entrepreneurs, judges whether individuals have entrepreneurial traits, and analyzes and predicts the possibility of becoming entrepreneurs [6]. The education experts Pruett and Shinnar set up a model of entrepreneurial inclination, deeply studied entrepreneurs' entrepreneurial quality and entrepreneurial ability, and verified their important influence on entrepreneurial success.

Kakapour discussed the importance of resource integration ability for entrepreneurial success, and resource integration ability originated from outstanding social skills, so entrepreneurs should give appropriate consideration to the improvement and development of social skills. In fact, the design of college students' entrepreneurial risk assessment in the entrepreneurial practice environment is grounded on the investigation of information organization features of college students' entrepreneurial risk factors. The fuzzy semantic analysis and feature reconstruction technology are adopted to establish the joint feature quantity of college students' entrepreneurial risk assessment in the entrepreneurial practice environment, and the joint association rule mining approach is implemented to realize college students' entrepreneurial risk assessment in the entrepreneurial practice environment [19]. At present, the evaluation methods of institution learners' entrepreneurial risk in the entrepreneurial practice environment mainly include the semantic ontology restructuring method, joint association rule mining method, and others. The joint feature matching model of university learners' entrepreneurial risk assessment in the entrepreneurial practice

Table 3: Descriptive statistical examination outcomes of college students' entrepreneurial risk factors in the entrepreneurial practice environment.

Number	Influence degree	Affected degree	Center degree	Cause degree
Q11	0.293	0.691	0.793	0.818
Q12	0.150	0.414	0.927	0.946
Q13	0.749	0.311	0.926	0.807
Q14	0.020	0.970	0.054	0.214
Q15	0.024	0.955	0.536	0.927
Q16	0.937	0.883	0.214	0.969
Q17	0.265	0.156	0.487	0.426
Q18	0.342	0.034	0.588	0.057
Q19	0.548	0.090	0.193	0.339
Q21	0.187	0.812	0.865	0.590
Q22	0.189	0.960	0.279	0.064
Q23	0.399	0.138	0.489	0.033
Q24	0.149	0.103	0.635	0.522
Q25	0.729	0.888	0.035	0.843
Q26	0.595	0.422	0.405	0.594
Q27	0.547	0.689	0.980	0.964
Q31	0.369	0.286	0.713	0.577
Q32	0.032	0.808	0.112	0.910
Q33	0.116	0.286	0.673	0.410
Q34	0.948	0.076	0.739	0.465
Q35	0.095	0.117	0.116	0.231
Q36	0.440	0.519	0.404	0.138
Q37	0.480	0.241	0.796	0.154
Q41	0.945	0.771	0.734	0.086
Q42	0.387	0.058	0.834	0.050
Q43	0.947	0.960	0.556	0.159
Q44	0.575	0.476	0.681	0.199
Q45	0.099	0.473	0.198	0.167
Q46	0.751	0.416	0.799	0.220
Q47	0.926	0.710	0.292	0.669
Q48	0.965	0.056	0.350	0.540

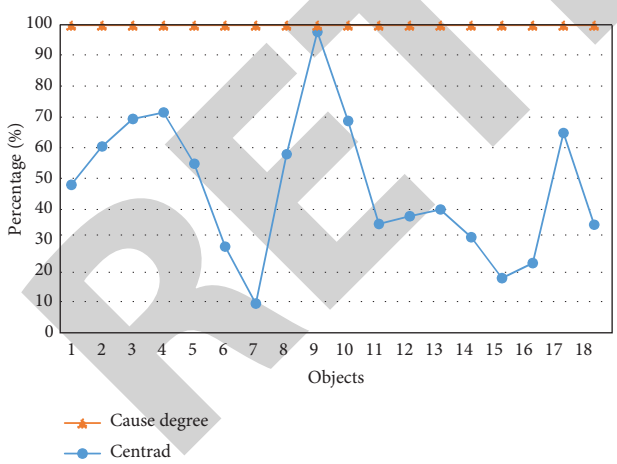

Figure 3: The cause and significance of risk factors.

environment is established, and the assessment of institution learners' entrepreneurial risk in the entrepreneurial practice environment is realized over the ambiguity detection and semantic analysis. However, the clustering of traditional methods for college students' entrepreneurial risk evaluation in the entrepreneurial exercise environment is not good, and the precision degree is not high enough and, therefore, unsatisfactory [20].

The evaluation of educational effects directly affects the quality of school students' modernization and entrepreneurship education [21, 22]. Bednyi and Plekhova investigated and analyzed entrepreneurship schooling in academies and institutions of higher education and proposed to dig deep into the curriculum and establish an educational system combining classroom teaching with entrepreneurship practice. After studying the key influencing factors of the success or failure of entrepreneurial activities, Timmons proposed to set up a curriculum system of college education combining with practice the following: entrepreneur, market opportunity, entrepreneurship plan, enterprise establishment, and enterprise development, which can cultivate students' entrepreneurial practice ability and start a business in advance. Alain studies how to evaluate the performance of entrepreneurship education and uses the theory of planned behavior to analyze its entrepreneurial motivation, entrepreneurial intention, core technology, personal characteristics, and entrepreneurial behavior. Donald Kuratko put forward that entrepreneurial behavior lags behind entrepreneurial education because he believes that college students generally start their own businesses after their studies have been completed, hence the entrepreneurial behavior ll4. It can be perceived that western entrepreneurship schooling pays more attention to educational practice, and

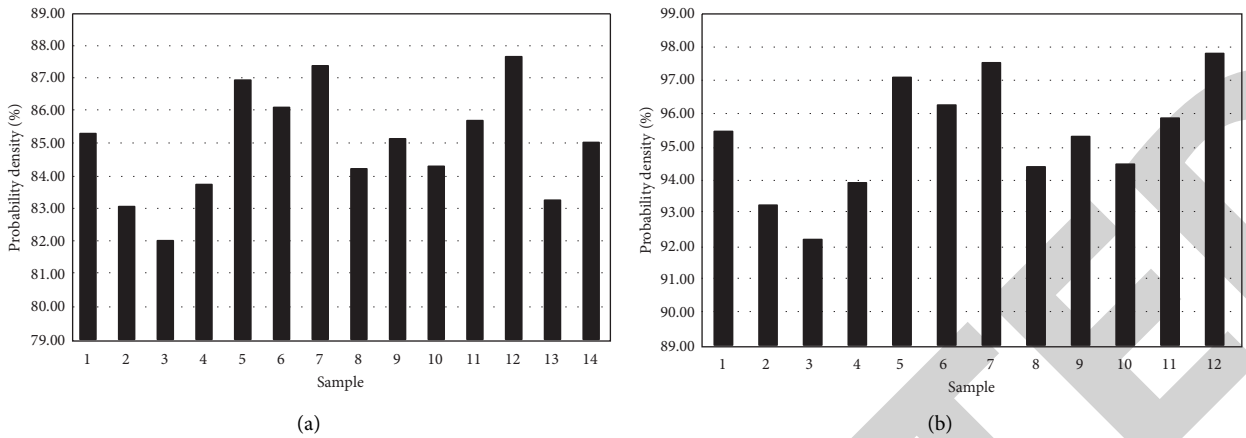

Figure 4: Probability density distribution of risk assessment. (a) Traditional model. (b) The model of this paper.

entrepreneurship practice is the measure of educational achievements [23].

6. Conclusions and Future Research

The risk assessment of university pupils' entrepreneurship is a comprehensive evaluation designed for school pupils' entrepreneurship. In fact, in the early stage of constructing the evaluation system and model, it is indispensable to accurately recognize the risk influences that disturb the accomplishment or failure of university learners' entrepreneurship. When evaluating the actual risk of school learners' entrepreneurship, it is also very imperative to accurately obtain various risk indicators in the progression of institution learners' entrepreneurship. Through the investigation into the present situation of institutional learners' entrepreneurship, in this paper, we select the key factors that affect college students' entrepreneurial failure by using the DEMATEL-ISM integration method and construct a college students' entrepreneurial risk evaluation model by combining the triangular fuzzy number method and Bayesian network. Taking YT Technology Co., Ltd., a college students' entrepreneurial enterprise in Xuzhou, as a case study, it verifies the accuracy and scientificity of the model. The evaluation model of the fuzzy Bayesian network shows that the probability of YT technology venture is 0.5500, the risk level is "medium," and the risk events with the highest probability are the complementary factors of core team, team experience, personal experience, and financial support risk factors.

By applying the risk assessment model, we can find the hidden risks in the entrepreneurial process, and college entrepreneurs can rectify and improve according to the found risk links and take targeted preventive measures to reduce the risks of enterprises. By using the methods of big data information structure reorganization and semantic parameter analysis, the model of college students' entrepreneurial risk assessment under the entrepreneurial practice environment is established to advance the accuracy of school pupils' entrepreneurial risk assessment under the entrepreneurial practice environment. This paper suggests an approach for institution students' entrepreneurial risk assessment under the entrepreneurial practice environment based on the LightGBM algorithm. The association rule fusion and resemblance feature recognition approaches are adopted to accomplish and appropriately manage the data of college students' entrepreneurial risk assessment in the entrepreneurial practice environment. By analyzing the hierarchical structure of risk factors, the optimization assessment of college students' entrepreneurial risk factors and rough set feature matching are realized, and the entrepreneurial risk assessment ability of college students is improved. Analysis shows that the confidence level of risk assessment by using this method is high.

Entrepreneurship schooling is an organized project. As a basic instruction, the entrepreneurship education helps to advance school students' groundbreaking spirits, exploration abilities, and comprehensive quality. At present, social school education does not pay much attention to entrepreneurship education, which may indirectly lead to the lack of entrepreneurship education for YT technology enterprises. YT Technology can improve its own entrepreneurial knowledge and accomplishment through enterprise training, such as filing and filling out patent applications for training and learning, personalized exploration of information collection, improvement of employees' ability to resist stress and risks, and competition activities such as employee technology innovation contest, which can stimulate employees' innovation enthusiasm, create a good innovation atmosphere, and shape the company's innovation culture and core values. In the future work, we will design a new model to address these issues.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Cloud Computing-Based Online Sharing Method of Mass Resources in Public Libraries

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In order to realize the online sharing of massive resources and capitals in public libraries under the circumstances of network environment and cultural construction, it is desirable to invent new sharing policies. In this paper, we put forward a method of online sharing of massive resources in public libraries which is established on cloud computing. Cloud computing technique is implemented to collect the statistical information characteristics of public library's massive resources under the condition of network environment and culture construction, and an adaptive fusion clustering processing model of public library's massive resources under the condition of network environment and culture construction is constructed. Moreover, the correlation statistical feature detection approach is used to accomplish fuzzy scheduling and feature mining of public library's massive resources under the condition of network environment and culture construction. The information storage center management database of public library's massive resources under the condition of network environment and culture construction is established. The fuzzy *C*-means clustering approach is implemented in the database to cluster the massive resources of public library under the condition of network environment and culture construction. Combined with cloud computing technology, the sharing and classified management scheduling of massive resources of public library under the condition of network environment and culture construction are comprehended. The simulation outcomes confirm that the adaptive performance of public library's massive resource sharing management under the condition of network environment and culture construction is better, and the adaptive scheduling performance of resources is better. The data clustering of public library's massive resources under the condition of network environment and culture construction is stronger, which improves the online sharing level of public library's massive resources under the condition of network environment and culture construction.

1. Introduction

The public library's information service, resource construction, and other projects should not stagnate at the traditional level but should be increasingly integrated and comprehensive with the development of the times. As modern society belongs to the era of knowledge economy explosion, people's demand for social information is increasing. At present, library resources cannot reasonably meet the public's demand for cultural information, but it is unrealistic for libraries to expand their scale [1]. Combining the national conditions and foreign practical experience, we should make effective use of Internet resources, so that the public can enjoy equal rights to use resources. The total resources of public libraries are huge, and they can be equipped with relevant literature retrieval technology, which is the advantage that other social libraries do not have in terms of professionals, technical equipment, etc., and can provide new resource power for the development of local social economy and culture. University libraries should serve public utilities, improve citizens' quality, and promote social progress. Obviously, it is far from enough for a library to rely solely on its own collection resources, and "closing the country to the outside world" only brings backwardness. Modern era is an era of knowledge economy and sharing economy. Sharing economy is popular in recent years. Sharing economy takes the platform created by a third party as its primary feature and digital information technology as its foundation. Nowadays, we can see bike-sharing and shared charging treasures everywhere, which not only bring

benefits to businesses but also bring benefits to society. Obviously, in the field of information, if we want to realize the maximum utility of information and achieve the purpose of informationization, we must constantly share resources [2, 3].

With the development of public library's massive resource management technology under the condition of intelligent network environment and culture construction, the intelligent information management system is adopted to classify, manage, and share public library's massive resources under the condition of network environment and culture construction, to improve the utilization efficiency of public library's massive resources under the condition of network environment and culture construction, and to carry out the optimal design of public library's massive resource management under the condition of network environment and culture construction under the cloud computing environment [4]. This paper extracts the big data distribution features of public library's massive resources under the condition of network environment and culture construction and combines the methods of correlation feature information detection and fuzzy cluster analysis to design the management and sharing of public library's massive resources under the condition of network environment and culture construction, so as to promote the upgrading of public library's massive resources information management level under the condition of network environment and culture construction [5]. In fact, it is of utmost importance to study the sharing technology of mass possessions in public libraries under the condition of network environment and cultural construction. Under the condition of network culture construction, the massive resources of public libraries refer to the construction of a unified platform for all university libraries, the mutual assistance of resources in all libraries, the mutual cooperation and coordination of resources, the use of different technologies and methods, the assistance and utilization of information resources among all libraries, and the joint construction of information resources when cooperating with each other, so as to meet the readers' demand for comprehensive information resources activities to the greatest extent [6, 7].

On the basis of intelligent information processing and integrated scheduling of public library's massive resources under the condition of network environment and culture construction, the method of cloud integration and adaptive scheduling of public library's massive resources under the condition of network environment and culture construction is studied, and the fuzzy association rule set of public library's massive resources under the condition of network environment and culture construction is extracted to realize the optimal management of public library's massive resources under the condition of network environment and culture construction [8]. This paper constructs an adaptive fusion clustering processing model of public library's massive resources under the condition of network environment and culture construction, adopts correlation statistical feature detection method to carry out fuzzy scheduling and feature mining of public library's massive resources under the condition of network environment and culture construction, establishes the information storage center management database of public library's massive resources under the condition of network environment and culture construction, and realizes the sharing design of public library's massive resources under the condition of network environment and culture construction. Finally, it makes an experimental analysis and draws an effective conclusion. The key contributions are summarized as follows:

(i) We put forward a method of online sharing of massive resources in public libraries which is established on cloud computing and implemented to collect the statistical information characteristics of public library's massive resources under the condition of network environment and culture construction.

(ii) An adaptive fusion clustering processing model of public library's massive resources under the condition of network environment and culture construction is constructed.

(iii) The correlation statistical feature detection approach is used to accomplish fuzzy scheduling and feature mining of public library's massive resources under the condition of network environment and culture construction.

(iv) The fuzzy C-means clustering approach is implemented in the database to cluster the massive resources of public library under the condition of network environment and culture construction. Combined with cloud computing technology, the sharing and classified management scheduling of massive resources of public library under the condition of network environment and culture construction are comprehended.

The remaining sections of the paper are organized in the following manner. The distribution and big data analysis of scheduling nodes for sharing mass resources in public libraries are deliberated in Section 2. In Section 3, we discuss the mass resource sharing optimization of public libraries. The suggested model is also presented in this section. Simulation tests and results are given in Section 4. The major conclusions are drawn in Section 5 along with some discussion over the extensions of this work.

2. Distribution and Big Data Analysis of Scheduling Nodes for Sharing Mass Resources in Public Libraries

2.1. Distribution of Scheduling Nodes for Mass Resource Sharing in Public Libraries under the Condition of Network Environment and Cultural Construction. In order to comprehend and understand the intelligent sharing and optimal management and scheduling of public library's massive resources under the condition of network environment and culture construction within the context of big data and cloud computing, it is indispensable to construct the storage structure model of public library's massive resources

database under the condition of network environment and culture construction and adopt the directed graph analysis method to design the distribution of public library's massive resource sharing and scheduling nodes under the condition of network environment and culture construction [9]. Assume that the attribute set of the shared scheduling node graph model of public library's massive resource base under the network environment and cultural construction is [s], and use the decision tree and directed graph analysis model to split the binary tree of public library's massive data under the network environment and cultural construction, so that we can get different attribute sets and the distributed storage structure model of public library's massive resources under the condition of network environment and culture construction is shown in Figure 1. In Figure 1, the distribution pattern of public library's massive resource sharing scheduling chart under the condition of network environment and culture construction consists of nodes and edges [10–12]. Through principal component analysis and modeling method, a hierarchical adaptive hierarchical planning model of public library's massive resources under the condition of network environment and culture construction is formed, and the dataset classification and information fusion of public library's massive resources under the condition of network environment and culture construction are carried out in combination with statistical feature distribution.

Let us assume that the primitive vector of the useful data test set in the massive resources of public libraries under the condition of network environment and cultural construction is expressed mathematically as follows:

$$E_{i,j} = \langle e_1, e_2, \cdots, e_m \rangle, \tag{1}$$

where $e_i \in \{1, 0\}$ is the main feature of the spatial planning dataset of public library's massive resources under the condition of network environment and culture construction, and four tuples are used to represent the main feature decision tree of public library's massive resource sharing scheduling under the condition of network environment and culture construction. (E_i, E_j, d, t) are entities (i.e., nodes and sums) of public library's massive resources in the directed graph under the condition of network environment and culture construction, $S_{i,j}(t)$ is the subspace clustering distribution of public library's massive resources under the condition of network environment and culture construction, and $T_{i,j}(t)$ is the information exchange time of file sharing scheduling. In order to reduce the time of public library's massive resource sharing and scheduling under the condition of network environment and culture construction [13, 14], it is necessary to model the main characteristics of public library's massive resource distribution under the condition of network environment and culture construction and define the graph model attribute set of public library's massive resource sharing and scheduling nodes under the condition of network environment and culture construction, where d represents the ontology object of public library's massive resource distribution under the condition of network environment and culture construction, and p represents the ontology distribution concept related set of public library's massive resource sharing under the condition of network environment and culture construction. The calculation expression is as follows:

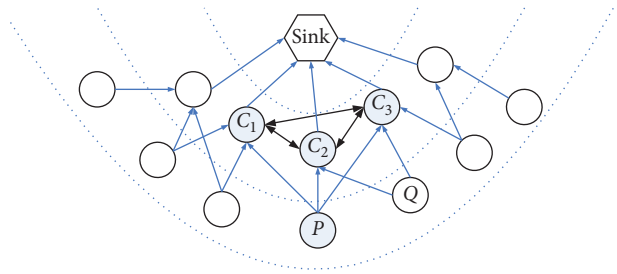

Figure 1: Distribution model of shared scheduling nodes of public libraries under the condition of network environment and cultural construction.

$$T_{i,j}(t) = \frac{\left| p_{i,j}(t) - \Delta p(t) \right|}{p_{i,j}(t)}. \tag{2}$$

The decision similarity (correlation) of public library's massive resources under the condition of network environment and cultural construction is expressed by $U_{i,j}(t)$. The following feature vector sets are used to analyze the autocorrelation feature quantity of public library's massive resource sharing under the condition of network environment and cultural construction, which is described as [15]

$$V = \left\{ v_{ij} \mid i = 1, 2, \cdots, c, j = 1, 2, \cdots, s \right\}, \tag{3}$$

where V_i is the correlation analysis measurement value of massive resources of public libraries under the condition of network environment and cultural construction, and the calculation formula is illustrated in the following equation:

$$U_{i,j}(t) = \exp\left[-b\left[z_i(t) - z_j(t) \right]^2 \right]. \tag{4}$$

Therefore, the similarity measurement factor between the scheduling nodes of mass resource sharing in public libraries under the condition of network environment and cultural construction is modeled as

$$S_{i,j}(t) = \frac{p_{i,j}(t) - sp_{i,j}(t)}{p_{i,j}(t)}, \tag{5}$$

where $p_{i,j}(t)$ is the probability of cross-distribution of useful features in public library's massive resources at all times under the condition of network environment and cultural construction; $\Delta p(t)$ is the relevant weight of massive resources of public libraries under the condition of network environment and cultural construction; $sp_{i,j}(t)$ is the fuzzy decision increment value of the scheduling node of public library's massive resource sharing under the condition of network environment and cultural construction; and $z_i(t)$, $z_j(t)$ are, respectively, expressed as the distribution weight coefficients of mass resource sharing scheduling nodes of public libraries under the condition of network environment and cultural construction. Conferring to the aforementioned examination and discussion, the data collection and cluster investigation of public library's massive resource sharing

scheduling under the condition of network environment and cultural construction are realized [16].

2.2. Big Data Analysis of Massive Resources of Public Libraries under the Condition of Network Environment and Cultural Construction. The linear mapping approach is implemented to build the balanced control model of public library's massive resources under the condition of network environment and culture construction. Under the condition of double fusion decision [17, 18], the fuzzy decision function of public library's massive resource sharing big data distribution under the condition of network environment and culture construction is as follows:

$$x(t) = \mathrm{Re}\{a_n(t)e^{-j2\pi f_c \tau_n(t)} s_l(t - \tau_n(t)). \tag{6}$$

Assuming that there are P sampling channels for public library's massive resource sharing big data under the condition of network environment and culture construction, the relevance decision function of public library's massive resource distribution under the condition of network environment and culture construction is as follows:

$$\begin{aligned}(\bar{s}, \bar{a}) &= \varphi_2(((s_1, a_1), (\omega_1, a_1')), ((s_2, a_2), (\omega_2, a_2')), \ldots, ((s_n, a_n),\\ &(\omega_n, a_n'))) = \Delta\left(\frac{\sum_{j=1}^{n} \Delta^{-1}(\omega_j, a_j')\Delta^{-1}(s_j, a_j)}{\sum_{j=1}^{n} \Delta^{-1}(\omega_j, a_j')}\right) = \Delta\left(\frac{\sum_{j=1}^{n} \beta_j \beta_j'}{\sum_j^n \beta_j{}'}\right),\end{aligned} \tag{7}$$

where $\sum_{j=1}^{n} \omega_j = 1, \bar{s} \in S, \bar{a} \in [-0.5, 0.5]$. Therefore, the sharing scheduling problem of distributed data in public libraries under the condition of network environment and culture construction is transformed into a decision-making problem with binary semantics. Assume that the semantic indicator set of massive resource allocation of public libraries under the network environment and cultural construction is [TF], the graph model of public libraries' massive resources information cross scheduling under the condition of network environment and culture construction is $E_k \in E(k = 1, 2, \ldots, t)$, and the endogenous fusion scheduling method is adopted. Mining the association rules of public library's massive resources information under the condition of network environment and culture construction, when the condition $P_i \in P(i = 1, 2, \ldots, m)$ is satisfied, then the corresponding fuzzy evaluation value of public library's massive resource sharing scheduling under the condition of network environment and culture construction meets the criteria $r_{ij}^{(k)} \in S$, and then extracting the semantic association and regular feature set of public library's massive resources under the condition of network environment and culture construction is possible through the method as follows:

$$TF(t, c_i) = \frac{P(t|c_i)}{\sum_{j \longrightarrow n} P(t_j|c_i)}, \tag{8}$$

where T is the statistical characteristic quantity of public library's massive resource data currently accessed under the condition of network environment and culture construction and c_i is the ith category of public library's massive resources classification attribute set under the condition of network environment and culture construction. Furthermore, j is the jth category attribute set in public library's massive resources database under the condition of network environment and culture construction, and n is the total number of data classification in public library's massive resources under the condition of network environment and culture construction. Using the cross-compilation control method, the mass resources of public libraries are shared and scheduled under the condition of network environment and cultural construction, and the difference fusion feature quantity is obtained through the following equation:

$$J_m(U, V) = \sum_{k=1}^{n} \sum_{i=1}^{c} \mu_{ik}^m (d_{ik})^2, \tag{9}$$

where m is the limited dataset index of public library's massive resource decision-making variable under the condition of network environment and culture construction, and the variable $(d_{ik})^2$ is the related variable of public library's massive resource distribution under the condition of network environment and culture construction. This should be noted that the variable SD indicates that the decision-making independent variable of public library's massive resources under the condition of network environment and culture construction is given by (10) and (11) [18]:

$$(d_{ik})^2 = \|x_k - V_i\|^2, \tag{10}$$

and

$$\sum_{i=1}^{c} \mu_{ik} = 1, k = 1, 2, \cdots, n. \tag{11}$$

Therefore, a big data analysis model of public library's massive resources under the condition of network environment and culture construction is constructed and established. Moreover, through combining the cloud computing and big data environment, the public library's massive resource sharing and remarkable characteristics analysis are accomplished. Furthermore, conferring to the positive correlation characteristics analysis method, the resource sharing scheduling is carried out [19].

3. Mass Resource Sharing Optimization of Public Libraries

3.1. Self-Adaptive Fusion Clustering Processing of Massive Resources of Public Libraries under the Condition of Network Culture Construction. On the basis of extracting the statistical information features of public library's massive resources under the condition of network environment and culture construction by cloud computing, this paper designs the sharing of public library's massive resources under the condition of network environment and culture construction. In particular, the aim of the work is to put forward the sharing method of public library's massive resources under the condition of network environment and culture construction based on cloud computing technology. The anticipated approach, in fact, adopts the correlation statistical feature detection method to carry out fuzzy scheduling and feature mining of public library's massive resources under the condition of network environment and culture construction [20]. This should be noted that the suggested approach obtains the multiple regression constraint expression of adaptive fusion clustering of public library's massive resources under the condition of network environment and culture construction using equations (12) and (13), respectively:

$$\mu_{ik} = \frac{1}{\sum_{j=1}^{c} \left(d_{ik}/d_{jk}\right)^{2/m-1}}, \tag{12}$$

$$V_i = \frac{\sum_{k=1}^{m} (\mu_{ik})^m x_k}{\sum_{k=1}^{n} (\mu_{ik})^m}. \tag{13}$$

According to the above constraint parameter index system construction, the statistical information features of public library's massive resources under the condition of network environment and culture construction are extracted by cloud computing method, assuming that the total number of categories of public library's massive resources under the condition of network environment and culture construction is M, and the mutual information feature quantity is used to express the concentration of public library's massive resource data T in c_i category under the condition of network environment and culture construction, which is given in the following equation:

$$CON(t, c_i) = \log \frac{P(d|t, c_i)}{P(d|t)} = \log \frac{P(d|t, c_i)}{\sum\limits_{i \longrightarrow m} P(d|t, c_i)}, \tag{14}$$

where $P(d|t, c_i)$ is the distribution probability of public library's massive resource sharing scheduling under the condition of c_{i} network environment and culture construction. In the statistical feature distribution model, the vector set of public library's massive resource distribution under the condition of network environment and culture construction is not = $\{xf1, xf2, \ldots, xfr\}$ T. In the next stage, we explicitly express the statistical feature vector of the storage area d_i of public library's massive resources under the condition of network environment and culture construction, in fact, combine the fuzzy association rule scheduling method to match the autocorrelation features of public library's massive resources under the condition of network environment and culture construction, and get the feature matching model as follows:

$$l_{d_{ij}} \longrightarrow c_x = \left(\frac{\sum_{v=0}^{|c_x|} \mathrm{cosin}_{ij \longrightarrow x}\left(d_{ij}, d_{xv}\right)}{|c_x|} \right)^{-1}, \tag{15}$$

where $\mathrm{cosin}_{ij \longrightarrow x}(d_{ij}, d_{xv})$ is the fusion clustering feature set of public library's massive resources under the condition of network environment and cultural construction. Note that the well-known sigmoid function is used to normalize the feature mapping formula of public library's massive resources under the condition of network environment and cultural construction using the following relationship [21]:

$$s_i = sigmoi\,d\left(Md_i\right) = \frac{1}{1 + e^{-a\left(Md_i + b\right)}}. \tag{16}$$

At this time, the correlation data vector di of public library's massive resources under the condition of network environment culture construction is adaptively optimized by fuzzy correlation constraint matrix M, and the shared scheduling set and the directional distribution vector set S_i of public library's massive resources under the condition of network environment culture construction are obtained, where A and B are adjustable coefficients. Suppose that the fuzzy center vector of adaptive fusion clustering of massive resources of public libraries under the condition of network environment and culture construction is v_i, and $v_i = ((w_1, t_1), (w_2, t_2), \cdots, (w_j, t_j))$. According to the directional factors of readers of public libraries' massive resources under the condition of network environment and culture construction, the judgment criteria of public libraries' massive resource sharing scheduling under the condition of network environment and culture construction are determined as follows:

$$\mathrm{S}(\mathrm{i}, \mathrm{j}) = \frac{\sum_{u \in U_{\mathrm{ij}}} \left(V_{u,i} - 3\right)\left(V_{u,j} - 3\right)}{\sqrt{\sum_{u \in U_{ij}} \left(V_{u,i} - \overline{V_{.i}}\right)^2} \sqrt{\sum_{u \in U_{ij}} \left(V_{u,j} - \overline{V_{.j}}\right)^2}}, \tag{17}$$

where the priority clustering model of mass resource sharing scheduling data of public libraries under the condition of network environment and cultural construction is given as illustrated in the following mathematical model:

$$V_{u,i} = \frac{D_i^-}{D_i^+ + D_i^-}, \overline{V_{.j}} = \frac{R_i^+}{R_i^+ + R_i^-}. \tag{18}$$

To sum up, an adaptive fusion clustering processing model of public library's massive resources under the condition of network environment and culture construction is constructed, and the fuzzy scheduling and feature mining of public library's massive resources under the condition of network environment and culture construction are accomplished through implementing the

correlation statistical feature detection technique [22, 23], so as to improve the sharing level of public library's massive resources under the condition of network environment and culture construction [24].

3.2. Sharing and Scheduling of Mass Resources in Public Libraries. Under the constraint of association rules, cloud computing is adopted to obtain the association rule distribution parameter set Y and fuzzy C-means clustering center vector of public library's massive resource information under the condition of network environment and cultural construction. Thus, obtaining the similarity distribution mapping function of public library's massive resource information under the condition of network environment and cultural construction under cloud computing is computed using the following equation:

$$Sim(X,Y) = \mathrm{Cos}(X,Y) = \frac{C(X)\cdot C(Y)}{|C(X)|\cdot|C(Y)|}. \tag{19}$$

The information storage center management database of public library's massive resources under the condition of network environment and culture construction is established, and the fuzzy C-means clustering scheme and procedure are implemented in the database to cluster the massive resources of public library under the condition of network environment and culture construction, and the adaptive updating formula of public library's massive resource sharing scheduling under the condition of network environment and culture construction is obtained as follows:

$$R_d^i(t-1) = \min\left\{R_s, \max\left\{R_d^i(t) + \beta\left(n_t - \left|N_i(t)\right|\right)\right\}\right\}, \tag{20}$$

$$N_i(t) = \left\{j\colon \left\|x_j(t) - x_i(t)\right\| < R_d^i; l_i(t) < l_j(t)\right\}. \tag{21}$$

where $x_j(t)$ represents the distribution position of public library's massive resource sharing big data prior data in the h sensor node of the t generation under the condition of network environment and culture construction. In the same way, the variable $l_j(t)$ represents the mutual information feature quantity of the first sensor node of the generation. Combined with the fuzzy decision classification model, the adaptive scheduling of public library's massive resource sharing under the condition of network environment and culture construction is carried out, and the scheduling formula is as follows:

$$x_i(t) = x_i(t-1) + s\left(\frac{x_j(t-1) - x_i(t-1)}{\left\|x_j(t-1) - x_i(t-1)\right\|}\right). \tag{22}$$

The autoregressive moving average model is adopted to design the distributed database of public library's massive resource sharing under the condition of network environment and culture construction, and the probability confidence interval and rejection interval are constructed. Combined with the cloud computing technology, the sharing and classified management scheduling of public library's massive resources under the condition of network environment and culture construction are realized.

4. Simulation Tests and Results

In order to examine the application performance of the anticipated technique in the scheduling of mass resource sharing in public libraries under the condition of network environment and culture construction, an experimental analysis was carried out. The Matlab simulation software was used to design the algorithm of mass resource sharing in public libraries under the condition of network environment and culture construction, and the initial check frequency of mass resource sharing and big data sharing in public libraries under the condition of network environment and culture construction was set as 120 Hz [25]. Under the condition of network environment and culture construction, the directional statistical feature distribution set of public library's massive resources association rules is 400. Moreover, the information embedding dimension of feature space is $m = 40$, and the sampling time delay of public library's massive resources under the condition of network environment and culture construction is $\omega = 30$ ms; the self-adaptive scheduling weight of public library's massive resources under the condition of network environment and culture construction is 0.9. Similarly, we use fuzzy correlation coefficient and sample mean square error (RMSE) to test the sharing performance of massive resources of public libraries under the conditions of network environment and cultural construction [26]. The RMSE metric is defined as follows:

$$RMSE(\overline{x}_k) = \sqrt{\frac{1}{N_{MC}}\sum_{i=1}^{N_{MC}}\left(x_k^i - \overline{x}_k\right)^2}, \tag{23}$$

where N_{MC} represents the number of public library's massive resources samples under the condition of network environment and culture construction. Similarly, the variable x_k^i represents the original sample value of public library's massive resource sharing under the condition of network environment and culture construction, and x_k represents the average value of public library's massive resource sharing under the condition of network environment and culture construction [27, 28]. Conferring to the aforementioned simulation parameters, assumptions, environment, and parameter settings, the mass resource sharing design of public libraries under the condition of network environment and culture construction is accomplished, and the original mass resource big data distribution model of public libraries under the condition of network environment and culture construction is obtained as shown in Figure 2.

Taking the massive resource data of public libraries under the condition of network environment and culture construction in Figure 2 as the sample set, the fuzzy scheduling and feature mining of massive resources of public libraries under the condition of network environment and culture construction are performed through implementing the correlation statistical feature detection scheme, and the

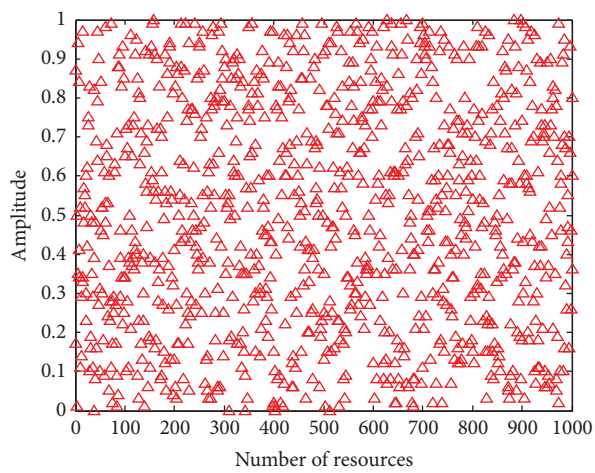

Figure 2: Spatial distribution of massive resources and big data in public libraries under the condition of network environment and cultural construction.

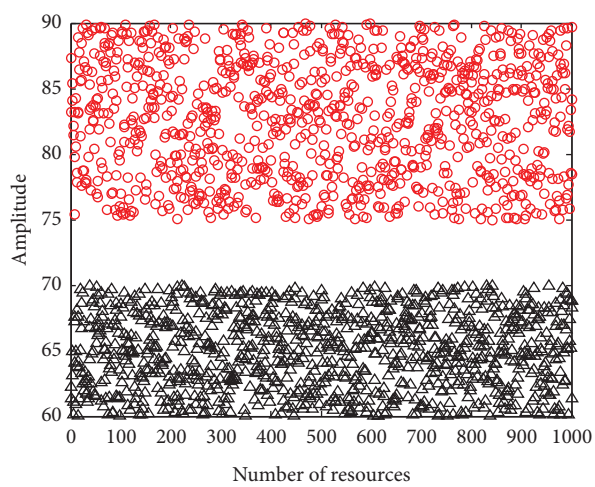

Figure 3: Clustering results of massive resources of public libraries under the condition of network environment and cultural construction.

information storage center management database of massive resources of public libraries under the condition of network environment and culture construction is established. In the database, the fuzzy C-means clustering scheme is implemented to cluster the massive resources of public libraries under the condition of network environment and culture construction, and the data clustering outcomes are given in Figure 3.

Figure 3 shows that the clustering of public libraries' massive resource sharing under the condition of network environment and culture construction is good, and the sharing level is improved. By testing the sharing level of public libraries' massive resources under the condition of network environment and culture construction by different methods, the RMSE comparison outcomes are made known in Figure 4. Figure 4 displays that the error of public libraries' massive resource sharing under the condition of

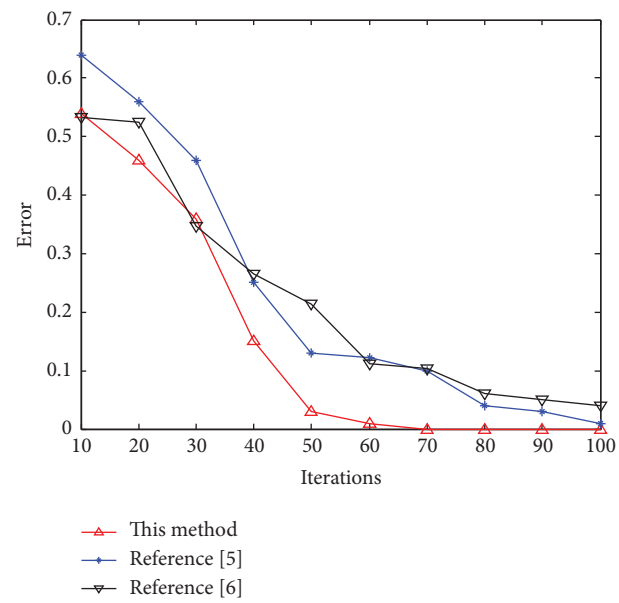

Figure 4: Comparison of sharing level.

network environment and culture construction by the proposed method is low, indicating that the sharing level is high.

5. Conclusions and Future Work

Under the cloud computing background, the optimization design of public library's massive resource management under the condition of network environment and culture construction is carried out, and the large data distribution features of public library's massive resources under the condition of network environment and culture construction are extracted. Combined with correlation feature information detection and fuzzy cluster analysis, the design of public library's massive resource management and sharing under the condition of network environment and culture construction is carried out, and the sharing method of public library's massive resources under the condition of network environment and culture construction based on cloud computing technology is put forward. Cloud computing scheme is implemented to collect the statistical information characteristics of public library's massive resources under the condition of network environment and culture construction, and an adaptive fusion clustering processing model of public library's massive resources under the condition of network environment and culture construction is constructed.

The correlation statistical feature detection approach is implemented to carry out fuzzy scheduling and feature mining of public library's massive resources under the condition of network environment and culture construction. The information storage center management database of public library's massive resources under the condition of network environment and culture construction is established. The fuzzy C-means clustering technique is also implemented in the database to cluster the massive resources

of public library under the condition of network environment and culture construction. Combined with cloud computing technology, the sharing and classified management scheduling of massive resources of public library under the condition of network environment and culture construction are realized. The research outcomes demonstrated that the anticipated approach has good performance and low error in sharing and classifying management of mass resources in public libraries under the condition of network environment and cultural construction.

The deep learning network is still under development; thus, it is required to update the suggested assessment model in accordance with the most recent advancement in order to evaluate a huge quantity of data. The goal is to offer crucial technical assistance to increase the effectiveness of scheduling for enormous amount of resources. Similar to this, future study should examine deep neural networks and the effects of model activation functions. Although it is also possible that the deep learning algorithms are conducted in parallel, using the Spark framework, however, we believe that the computational time is still constrained on a single online machine. To increase the training efficiency in terms of computational times, big data technologies like edge computing should be leveraged, in the future.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Evaluation of Private Enterprises Based on Deep Learning

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In this paper, we conduct an in-depth research on the corresponding enterprises, combined with some problems existing in the process of data processing and use. We establish a deep learning model on the extensive collection and comprehensive investigation of the research results of domestic and foreign enterprises in all aspects of the process of data processing and use, and determine the research directions. Firstly, in view of the increasing complexity and dimension of enterprise data, and the difficulties of enterprise data application, this paper studies the related data preprocessing methods. Secondly, aiming at the problems of enterprise cost control and customer relationship management, this paper studies the prediction based on enterprise data through the analysis of practical problems and the processing of corresponding data. Finally, in order to progress and advance the efficiency and scientific usefulness of enterprise management, we in this paper study the evaluation based on enterprise data. The model is verified through simulations and compared with several models i.e. cross hybrid and sequential hybrid models. Using certain assumptions, the attained outcomes confirm that the accuracy of the deep learning structure of the single model is sophisticated and greater than that of the cross hybrid model, but lower than that of the sequential hybrid model.

1. Introduction

With the continuous improvement of the development level of social technology, especially the rapid growth and extensive application of information technology (IT), big data, deep leaning, Internet technology, communication technology, computer technology, and other technologies, the data growth in various fields presents a "explosive exponential development" trend. At the same time, the form of data also tends to be increasingly complex, people have more and more ways and means to obtain data, and the cost of data acquisition is reduced accordingly; the data acquisition speed is greatly accelerated. Giving to the exploration and investigation outcomes report of International Data Corporation (IDC) organization, the amount of data generated worldwide was approximately 0.49 zb in 2008 and roughly equal to 0.8 zb in 2009. In the next year, this figure was noted approximately 1.2 zb in 2010 and 1.82 zb in 2011. The amount of data generated in 2011 is equivalent to 3.7 times that of 2008. The company predicts that by 2020, the global amount of data will reach 35 zb. In 2013, itl68, together with ITPUB and CHINAUNIX, conducted a survey on the monthly new data of some enterprises and found that 18.11% of the enterprises with a monthly new data scale of more than 500 g, an increase of 8.64% year-on-year compared with 12.67% in 2012.

Although there is still a big gap between this data and the growth rate predicted, on the whole, the growth of data is very huge, especially for Internet enterprises, such as Baidu, the world's largest Chinese search engine, whose daily new data can reach 10 TB, and the daily data that needs to be processed reaches 100pb; for Tencent, it has 800million users in 2013, and the data stored in its data warehouse has reached 4,400 sets of single cluster data, and its daily new data is about 200 tb to 300 tb. In addition to the Internet, the data volume of the telecommunications industry, manufacturing industry, financial industry, power industry, and other fields has also reached the Pb level. According to GSMA prediction, the global mobile data traffic will increase at a compound growth rate of 50% every year from 2012 to 2018. With the continuous progression of data, the problem of data processing and application has quickly received great

attention. In recent years, the global academia, industry, and governments have paid great attention to data processing technology and set off a research upsurge similar to the information highway in the 1990s. Some European and American developed countries even put forward a series of data research plans from the national science and technology strategy and national security level. In 2007, Jim gray, the Turing prize winner, mentioned "scientific discovery based on dense data" in a speech, which expanded scientific research from three paradigms to four paradigms.

Data science has become a new science after experimental science, theoretical science, and computational science. It can be seen that data shows a very imperative part in the current growth of science and technology. In the face of huge data, how to use data and how to deal with data has undoubtedly become one of the primary problems to be solved by enterprises. Using the data of corresponding industries for relevant prediction is an effective application of data processing. In 2009, an influenza A (H1N1) virus appeared, which spread rapidly in just a few weeks. However, through its huge data resources, combined with the corresponding data processing methods and mathematical models, Google can very timely determine where and how the flu spread, thus winning valuable processing time for public health institutions in epidemic control. The rational and effective use of data not only serves the public but also brings great commercial value to enterprises and industries, so as to improve the economic benefits of enterprises and industries. Therefore, data is also known as "new oil in the future," and the future competition focus will be on the possession, control, and application of data.

Although data has been greatly reused in many enterprises, due to the unbalanced development of information technology, many domestic enterprises still cannot enjoy the high added value that data brings to enterprises, and the use of data in many enterprises is still in the initial stage. At present, the current situation of many enterprises is that they have spent a lot of money on the construction of information systems and saved a lot of historical data, but these data have not been well used, and even some data are still in a "sleeping" state. One of the purposes of this paper is to make these data play its due role. In the investigation of some enterprises, it is found that a common problem is that in the face of a large amount of data saved by enterprises, they do not know how to use it. Data preservation and maintenance increases the operating costs of enterprises but makes data a burden on enterprises.

At present, the generation methods of data are ever-changing, and the existence forms of data are diverse. Data often needs to be processed before use; otherwise, the relevance of data dimensions or the internal incompleteness of data will affect the accuracy of the final result. Moreover, the structure of data not only has linear structure but also has a nonlinear structure. Different methods are used to process data with different structures, and it can improve the efficiency of data use and has an important impact on the later data application. Due to the increasing amount of data, it brings opportunities as well as challenges to enterprises. How to effectively use these data to support enterprise decision-making and even create new value for enterprises has become one of the goals pursued by enterprises. However, due to the surge in the quantity of data, the rise and growth in dimension, and the complexity of data, enterprises are tired of increasing costs to save data, but they are unable to effectively use data. This should be noted that with the increasing socialization of information interaction, both for enterprise customers and enterprises themselves, they have more choices.

For enterprises, they can collect all kinds of supplier information through multiple channels. By using this information, enterprises can effectively evaluate their suppliers and select some suppliers that meet the requirements of enterprises to serve them. For enterprise customers, they have the same right to choose, which makes it more difficult for enterprises to retain existing customers, but it also provides opportunities for enterprises to attract new customers. By analyzing and processing the operation data of enterprises, enterprises can conduct in-depth research on their consumer groups so as to continuously improve the product and service experience, improve the loyalty of enterprise customers, and reduce the loss rate of enterprise customers. Similarly, for the maintenance service industry, because it has a big amount of historical data of maintenance services, the effective use of these data can diminish the inventory cost of enterprises and develop the service level of enterprises. In view of the increasing number and dimension of enterprise data and the current situation that enterprises cannot effectively use their historical data to optimize enterprise management, this paper hopes to use the corresponding data dimensionality reduction methods to process enterprise data reasonably and effectively, and apply these data to the prediction and evaluation of enterprises and other management activities, so that enterprise data can play its due role and serve the production and operation management of enterprises. The fundamental contributions of our research study can be shortened and briefed as follows:

(1) We establish a deep learning model on the extensive collection and comprehensive investigation of the research results of domestic and foreign enterprises in all aspects of the process of data processing and use, and determine the research directions.

(2) In view of the increasing complexity and dimension of the enterprise data, and the difficulties of enterprise data application, in this paper, we study and investigate the related data preprocessing methods.

(3) Aiming at the problems of enterprise cost control and customer relationship management, this paper studies the prediction based on enterprise data through the analysis of practical problems and the processing of corresponding data.

The rest sections of this paper are systematized in the following way. Existing state-of-the-art approaches and deep learning techniques are discussed in Section 2. The anticipated enterprise prediction method with deep learning is deliberated in Section 3. Simulations, numerical experiments, and tests are achieved in Section 4. To end with, Section 5 summarizes this paper and put forward some directions for further research.

2. Related Work

In recent years, due to the sharp growth in the amount of data and the scale of data attributes, data processing and application have become more difficult [1]. The method of reducing the data dimension under the condition of ensuring the loss of data information as little as possible shows an imperative part in data analysis and application. In order to create a compact low-dimensional expression of the original dataset, the primary method of data dimensionality decrease is to, in fact, map the high-dimensional dataset to the low-dimensional space [2]. Data dimensionality reduction can not only solve the problem of "dimension disaster," but also alleviate the current situation of "rich information and lack of knowledge," which is conducive to reducing the complexity of data and improving the ability to recognize and understand data [3]. According to different perspectives of understanding problems, there are many kinds of dimensionality lessening approaches. Dimensionality reduction techniques may be further broken down into linear and nonlinear techniques depending on the properties of the data organization system. Moreover, according to whether to consider the relationship between data points and their nearest neighbors, the global and local dimensionality reduction techniques are two categories of dimensionality reduction techniques.

According to whether to introduce the category information of samples, the dimensionality lessening methods can be distributed and classified into: (i) supervised dimensionality lessening methods and (ii) unsupervised dimensionality lessening methods. After years of research by scholars [4, 5], there have been many different branches of dimensionality reduction algorithms, among which the most traditional dimensionality lessening procedures are: (1) principal component analysis and (2) linear discriminant investigation. Both of these methods deal with the data from a global perspective. For the data whose samples are from Gaussian distribution, these two methods have certain effectiveness. In order to expand the application scope of these two methods, the work in [6] applies the concept of kernel to PCA method and extends it to KPCA, so that the principal component method can also be applied in high-dimensional nonlinear space.

According to similar ideas, Mika et al. proposed the KLDA procedure to decrease the dimension of corresponding data nonlinearly. In order to break through the constraint of the global linear assumption of data, the authors in [7] proposed a self-organizing mapping (SOM) method, which uses self-organizing neural network to map high-dimensional data to low-dimensional space on the premise of preserving the topological attributes of data space; other corresponding methods include mapping and principal curves proposed by Hastie et al. [8]. With the deepening of the research on dimensionality reduction algorithms, some manifold learning algorithms have also been used in the nonlinear dimensionality reduction of data. The LLE algorithm, in fact, uses and takes into account the idea of saving local information of data to apply the reconstruction information of data in high-dimensional space to low-dimensional space.

The ISOMAP [9] algorithm uses the geodesic distance information between points. The algorithm assumes that linearity only exists locally, while the global is a nonlinear geometric structure; Le algorithm achieves the purpose of dimensionality reduction by retaining the local nearest neighbor information of data with the help of thermonuclear equation; other manifold learning algorithms used for data dimensionality reduction include the method based on Hessian matrix and the method using local tangent information. In order to better apply manifold learning algorithm to real data, some scholars have studied the linearization expansion of dimensionality reduction algorithm based on spectral analysis. Typical methods of this kind of algorithm include LPP, NPE, and ONPP [10].

The scholars in [11] provide a brief introduction and explanation of the topic writing before using empirical analysis to confirm the model's validity and drawing a conclusion. The authors of [12] talk about how private institutions make use of the ability to delegate the authority to evaluate in order to create applied teaching teams. The research that was released in [13] also examined the ownership structures of Russian businesses and organizations. Similar to this, [14] uses Company A as an example and designates the workers in the company's workplace as the research subject. These elements interact and are challenging to correctly separate. To assess the whole economic advantages of coastal firms, the AHP and fuzzy comprehensive assessment approach are integrated in this context [15]. It should be noted that the authors of [16] want to offer a simple way for assessing the system health of a private cloud. In fact, [17] summarizes the factors that affect the development of business environment and puts forward the evaluation index of business environment from the perspective of private manufacture enterprises. Based on the above findings, the work in [18] presents countermeasures and suggestions for the high-qua. Other influential work includes [19, 20].

3. Enterprise Prediction Method with Deep Learning

With the economy of China continuing to grow and science and technology continuing to advance, the market competition in the telecommunications industry is intensifying. Enterprises gradually realize that fully exploring the potential value of customers is the key to improve the core competitiveness of enterprises. In recent years, the telecommunications industry has been fully developed [21]. At the same time, its corresponding enterprises are also facing great opportunities and challenges. Through the investigation of a telecom enterprise, it is found that with the continuous expansion of business, the enterprise has accumulated a large amount of data, but these data have not been well used. This section will carry out the corresponding prediction research on customer loyalty by extracting the data and combining the corresponding model.

The data used in this section mainly comes from some data in the Oracle database of a telecommunications enterprise, involving a total of 84 data tables [22]. The tables are

denoted with T-1 to T-84 as given away in the following Table 1. These data tables mainly include customer information, business code, detailed business, user status, historical arrearage, consumption details, consumption account, and historical arrearage. The amount and quantity of data contained in the corresponding data tables is shown in Table 1.

These original data tables have not been processed, and they are full with noisy information. Additionally, various application goals require various data to support them. As a result, this component initially processes and screens this data as is necessary [23]. In order to evaluate the efficacy, we first start with the fundamental customer data and filter out users with inaccurate or missing identification information so that the users utilized in this part have accurate information. Then, the user's gender information and age information are added by using the user's identity information; third, we calculate the corresponding customer's online time according to the customer's online time. Fourth, according to the status information of customers, product information used, business area information, etc., the relevant data should be screened accordingly. Fifth and finally, according to the customer's consumption information and business code information, the customer's consumption information of various businesses is separated and summarized, and the customer's consumption trend information and average consumption level and other data are calculated. According to the above data processing and other data statistics, a dataset containing data attributes such as customer basic information and various consumption details of customers is finally obtained. The dataset is randomly selected, and approximately 8000 pieces of data are selected as the data training set of this model, and 2000 pieces of data are selected as the test set.

3.1. Relevant Principles and Algorithms of Deep Learning. After determining the dataset, let us introduce the relevant deep learning models. Since the concept of artificial intelligence was put forward in 1956, as a new discipline, although it has made great progress, it still has a long distance from the idea of Turing experiment, which once made people frustrated with artificial intelligence. With the prompt growth of science and technology, popularity and great use of mobile devices, and the unremitting efforts of scholars, a breakthrough was finally made in the field of machine learning in 2006. Hinton et al. anticipated the idea of deep learning algorithm. According to the idea of this algorithm, people found a feasible method to simulate the conceptual abstraction of human brain in a certain sense.

In medicine, the working mechanism of the human brain has been puzzling many scientists and scholars until David Hubei and Torsten wieselt found that the information processed by the visual system is hierarchical. External things reach VI through the retina through LGN (forming a simple visual form), then reach V4 through V2 (forming some intermediate visual forms), then reach AIT through pit (forming a high-level object description), and then continue

Table 1: The number of data in different tables.

Code	Data size
T-1	1849488
T-2	2940942
T-3	1032506
T-4	1979137
T-5	3879651
T-6	3590
T-7	13
T-8	46
T-9	258
T-10	693072
T-11	786278
T-12	1927577
T-13	33
T-14	46605
T-15	186025
T-16	23595
T-17	7663280
T-18	956
T-19	2033
T-20	2973171
T-21	442
T-22	1562042
T-23	*24*
T-24	14645148
T-25	776778
T-26	731443
T-27	761023
T-28	781701
T-29	787945
T-30	773766
T-31	767055
T-32	724338
T-33	721399
T-34	732679
T-35	734079
T-36	732032
T-37	732226
T-38	723509
T-39	730645
T-40	744274
T-41	742688
T-42	743496
T-43	742628
T-44	745069
T-45	749056
T-46	764186
T-47	13813226
T-48	14495570
T-49	15152618
T-50	14656449
T-51	14318690
T-52	14747203
T-53	5311209
T-54	5252359
T-55	5348132
T-56	5263237
T-57	5108584
T-58	5195895
T-59	5203739
T-60	5526673

Table 1: Continued.

Code	Data size
T-61	5542578
T-62	5346537
T-63	5330405
T-64	5303363
T-65	5312362
T-66	5221583
T-67	5375522
T-68	549992
T-69	576633
T-70	550611
T-71	556241
T-72	567526
T-73	566926
T-74	571366
T-75	574541
T-76	692812
T-77	546383
T-78	576856
T-79	564529
T-80	570453
T-81	560236
T-82	561220
T-83	540268
T-84	585837

to pass on. This step-by-step propagation mechanism of visual signals in the brain makes people further think that the working process of the brain may be a continuous iterative and abstract process. After people receive the original signal, the brain first carries out low-level abstraction and then iterates to high-level abstraction level by level. Therefore, what we perceive is a highly abstract concept. Deep learning algorithm cleverly simulates this process of brain. In essence, deep learning algorithm is actually a network model, but one of the differences between it and artificial neural network is that deep learning adopts layer by layer initialization, that is, only one layer of the network is trained each time [24].

As mentioned earlier, the training mechanism of deep learning algorithm is trained layer by layer. This training method avoids the gradient diffusion phenomenon when the traditional neural network uses BP for residual transmission because there are many layers in the network. The training process of deep learning algorithm can be summarized into two steps: one is Pretrain, and the other is adjustment and optimization [25].

(1) Unsupervised learning from the bottom up. Use the unlabeled data X to train the first layer first, and its goal is to make the output X' consistent with the input x as much as possible (if the training uses the auto-encoder model, it needs to make the output of the decoder consistent with the input as much as possible), so that the parameters of the first layer can be obtained. Then, take the output of the first layer as the second input, and go down to the nth layer in turn, so that the parameters of each layer can be obtained.

(2) From top to down supervised learning. The corresponding parameters of the multilayer model are obtained through step (1), but these parameters are obtained through unsupervised learning. In order to make the model more optimized, this step can use labeled data to optimize the model.

From the previous introduction, we can know that for the pretrain stage of the deep learning algorithm, it uses the available unlabeled data. However, according to the traditional neural network method, we also know that labeled data can, in fact, train the parameters of every layer of the network rendering to the error amongst the output and the label, but how to determine the training error for unlabeled data is the key of the stage [26].

The autoencoder method 4 consists of two parts, one is encoder and the other is decoder. In fact, the original data gets an output through the encoder. This step is called encoding, and then the encoded result is passed as input into the decoder. In this way, we can get a reconstruction of the original input. By comparing the error between the original data and its reconstruction, we can train the first layer, as shown in Figure 1.

Through the training of the first layer, we can get the current final result of the encoder. Taking this result as input, and using the same method to train the second layer, and so on, we can get the training results of all layers of autoencoder, as shown in Figure 2.

The next is the stage of network fine-tuning. Through adding a classifier module at the upper layer of the established network, and then using the labeled data to fine tune the system, fine-tuning is divided into two methods, one is to fine tune only the last classifier, and the other is to fine tune the whole system. There are many variants of the autoencoder method. For example, sparse auto-encoder can be obtained by introducing the concept of sparsity, and denoising autoencoder can also be obtained.

Boltzmann machine originally originated from statistical physics. It is a method based on energy function. Its network structure includes visual layer and hidden layer. The relationship between numerous units is expressed by weight. The interaction between the nodes of a restricted Boltzmann machine only occurs amongst the hidden layer and the visible layer, whereas the nodes of the hidden layer and the visible layer are, in fact, independent. This is the major distinction between a restricted Boltzmann machine and a Boltzmann machine.

The full probability distribution $P(y, h)$ of the nodes in the Boltzmann machine is restricted to obey the Boltzmann distribution. Assuming that $V \in \{0, 1\}$ is a visible layer element and $H \in \{0, 1\}$ is a hidden layer element, the energy function of the model can be defined as given in (1):

$$E(v, h; \theta) = -\sum_{ij} W_{ij} v_i h_j - \sum_j a_j h_j, \tag{1}$$

where $\theta = \left\{\vec{a}, \vec{b}, \vec{w}\right\}$ is a model parameter. The joint distribution of the corresponding visible layer units and hidden layer units can be defined as illustrated in (2):

$$p(v, h; \theta) = \frac{1}{Z(\theta)} \exp(-E(v, h; \theta)), \tag{2}$$

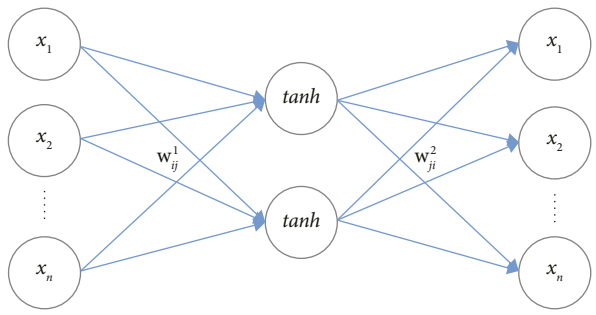

Figure 1: The single layer process of Autoencoder.

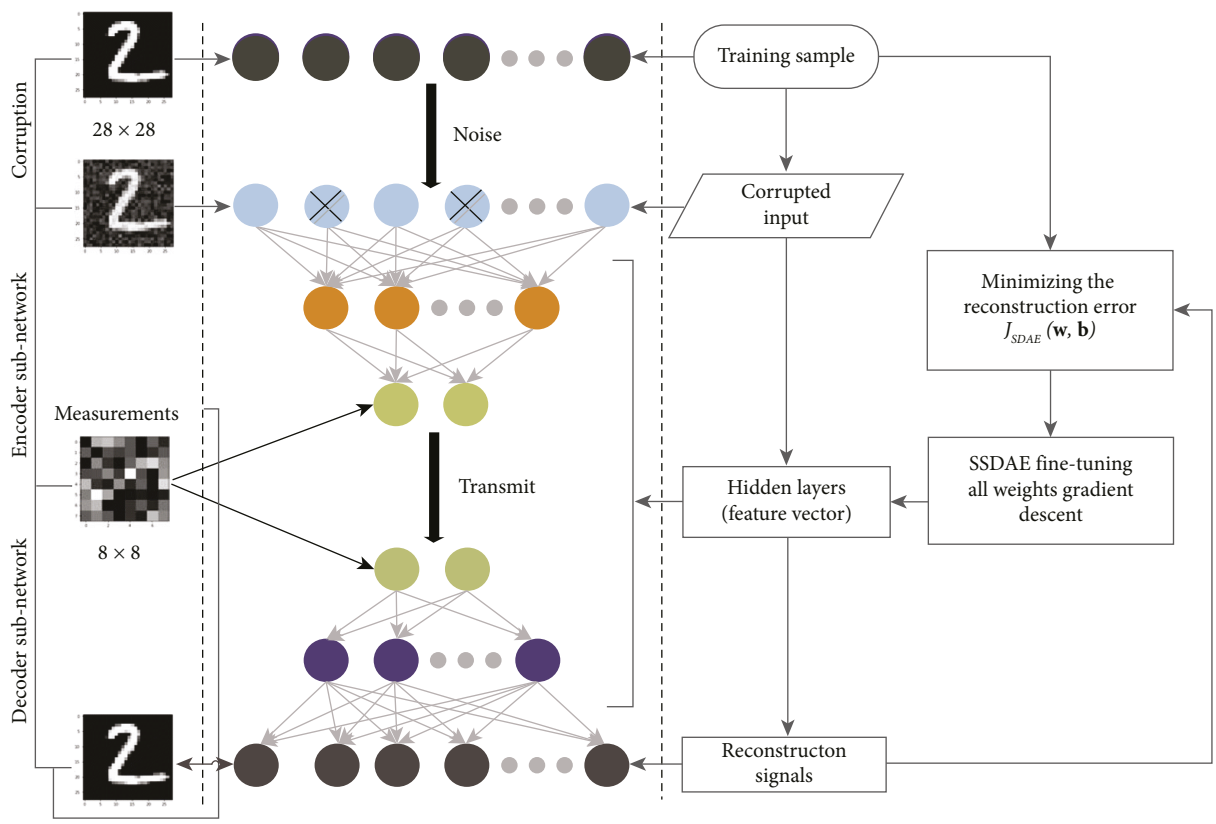

Figure 2: The assembly of Autoencoder technique.

where $Z(\theta) = \sum_{v,h} \exp(-E(v, h; \theta))$ is the partition function.

Since, the nodes in the Boltzmann machine layer are independent of each other, therefore the conditional probability distribution of the hidden layer in the known visible layer state is $P(h \mid v) = \prod_j P(h_j \mid v)$, and the probability of a single hidden unit is given in (3):

$$P(h_j = 1 \mid v; \theta) = \sigma\left(\alpha_j + \sum_i W_{ij} h_j\right) = \frac{1}{1 + \exp\left(-b_i - \sum_j W_{ij} h_j\right)}, \tag{3}$$

where $\sigma(\chi)$ is the sigmoid function.

Because the mechanism of the restricted Boltzmann machine is symmetrical, similarly, when the hidden unit is known, the conditional probability of the visible layer is $P(h \mid v) = \prod_i p(v_i \mid h)$, and the probability of the corresponding visual unit is mathematically modeled using (4):

$$p(v_i = 1 \mid h; \theta) = \sigma\left(b_i + \sum_j W_{ij} h_j\right) = \frac{1}{1 + \exp\left(-b_i - \sum_j W_{ij} h_j\right)}. \tag{4}$$

Similarly, very similar to the autoencoder method, the RBM is also trained layer by layer by comparing the original

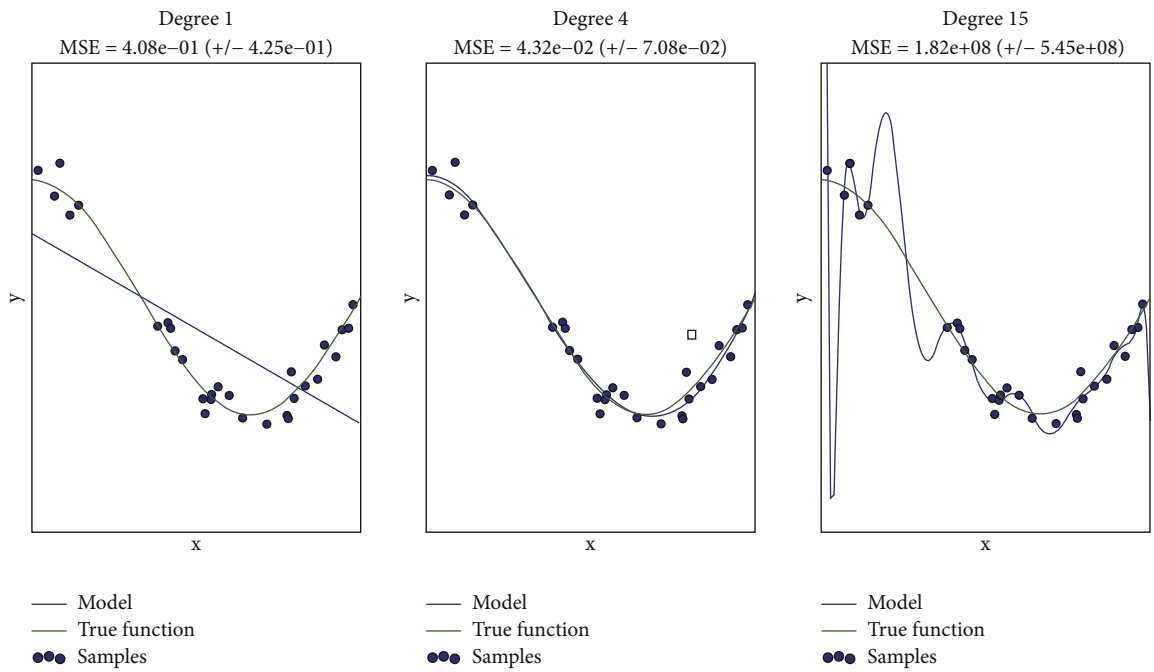

Figure 3: The average means square error of models.

data with its reconstruction so as to establish the whole model. Using KL distance, it is deduced that the objective function of the RBM model is maximized likelihood estimation $P(v \mid h)$, and the parameter value of the model can be finally calculated by Gibbs sampling and other methods.

3.2. Model Construction. After the above simple understanding of deep learning, now let us build the model used in this section. In the deep learning model, the organizational structure of the whole model is like a stack of blocks, and a layer of network is like a building block. The traditional depth model is formed by stacking similar building blocks. This paper calls it the depth structure of a single model, but because different models have different advantages, for example, the assumption of the autoencoder model is to make the input and output of the model equivalent, while the RBM model is based on the energy function, it is a probability model. In order to make comprehensive use of the advantages of different models, this paper constructs the deep learning structure of the hybrid model. In the construction strategy, this paper adopts two different forms, one is cross mixing, and the other is sequential mixing.

At the same time, in order to improve the performance of the model, this paper uses the sparsity limit and dropout method in the constructed model. In addition, when training and optimizing the parameters of the model, this paper uses different methods to deal with different models. For the autoencoder model, this paper uses the random gradient descent method to adjust the parameters, while for the RBM model, this paper uses the method of specific divergence to adjust the parameters. The model used in this section consists of eight layers, the first layer is the input layer, the eighth layer is the output layer, and the intermediate structure of the network is 1000.800-500.300-150.30. For the deep learning structure of a single model, the RBM model is used in each layer model; for the deep learning structure of hybrid model, we use RBM model and autoencoder model.

To test and compare various deep learning approaches, we use three well-known metrics. The following equations (5), (6), and (7) are the formulas for calculating the precision, recall, and the F1-Measure score, respectively:

$$Precision = \frac{TP}{TP + FP}, \tag{5}$$

$$Recall = \frac{TP}{TP + FN}, \tag{6}$$

$$F1 - Measure = \frac{2\,x\,Precision * Recall}{Precision + Recall}, \tag{7}$$

where FP denotes the ratio of false positive outcomes to projected outcomes and TP denotes true positive results. Like FN, the false negative is described by FN.

4. Experiment and Result Analysis

Through the construction of the above model, in order to authenticate the effectiveness of the anticipated model, in this paper, we practice the enterprise data processed in Section 3 to carry out the corresponding simulation experiments. Through the training of the model, we get the corresponding mean square error change trend, as revealed in Figure 3. In the figure, model 1 characterizes the deep learning structure of a single model, model 2 represents the deep learning structure of a cross hybrid model, and model 3 represents the deep learning structure of a sequential hybrid model.

Table 2: The prediction accuracy of various learning model.

Models	Test set accuracy (%)
Traditional neural network	80.11
Deep learning structure of a single model	89.55
Deep learning structure of cross hybrid model	85.61
Deep learning structure of sequential hybrid model	95.87

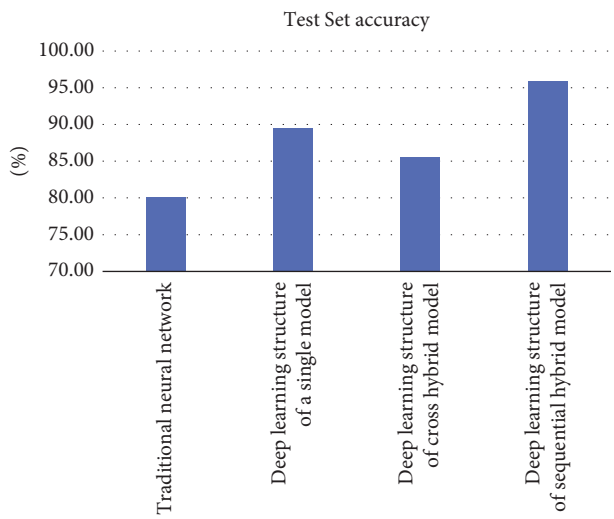

Figure 4: Comparison diagram of test set accuracy.

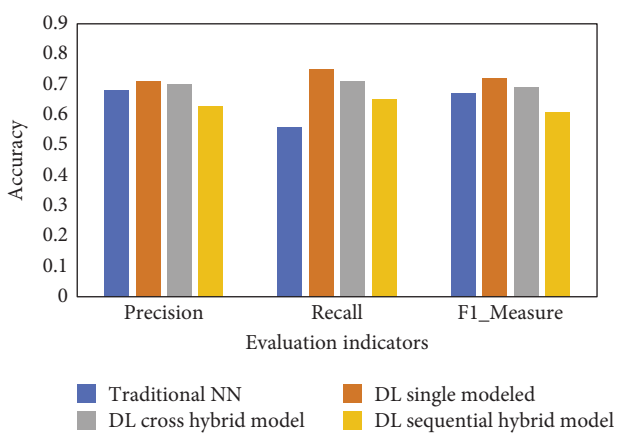

Figure 5: Comparison diagram of test set accuracy in terms of Precision, Recall, and F1-Measure.

At the same time, we input the corresponding test set data into each trained model, and we can get the prediction accuracy of each model, as given away in Table 2. This should be noted that other metrics, in terms of precision, recall, and the F1-measure metrics along with their associated score are discussed in later sections.

From Table 2 and Figure 4, we can see that the prediction accuracy of the three models designed in this paper is better than the traditional neural network model. In fact, this could be understood that the model used in this section is effective. In addition, the accuracy of the deep learning structure of the single model is higher than that of the cross hybrid model, but lower than that of the sequential hybrid model. In addition, for the cross hybrid deep learning structure, it is found in the corresponding experiments in this paper. The model is unstable, and there is error jitter in the hidden layer of the model during training. Although, the deep learning model has been well applied in many fields, whether the enterprise management data can also play its excellent characteristics needs further simulation experiments on more enterprise management data sets. Figure 5 shows the comparison diagram of test set accuracy in terms of Precision, Recall, and F1-Measure for various techniques. Using certain assumptions, the attained outcomes confirm that the accuracy and precision of the deep learning structure of the single model is sophisticated and greater than that of the cross hybrid model but lower than that of the sequential hybrid model. Moreover, the traditional model has the lowest recall rate than other methods that were compared in the experiments.

5. Conclusions and Future Work

The usage of data is becoming increasingly comprehensive and in-depth in today's society as a result of the advancement of science and technology. Many domestic and foreign enterprises are constantly mining new businesses from their own data. However, due to the imbalance of industrial structure and technological development, many domestic enterprises are still in the initial stage of data utilization, and there are a large number of idle data in enterprises that have not been developed and utilized. How to use these data to serve the development of enterprises is an urgent problem for these enterprises, which is also the only way for enterprises to connect with the world. The effective and rational use of enterprise data must be problem-oriented, and data also serves to solve problems. Different problems need different data, and different data solve different problems, which requires reasonable processing after data collection.

Through the on-the-spot investigation of enterprises, this paper finds the following problems: (1) enterprises are facing the problem of how to effectively use huge data due to the continuous expansion of data; (2) customers are of great significance to enterprises; (3) various enterprises have customers' consumption data, basic information data, etc. can we find customers' behavior patterns, consumption habits, etc. from these data, so as to predict customers' loyalty and loss intention; and (4) how to use enterprise data to optimize the management process, reduce enterprise costs, and improve enterprise efficiency. These problems prompted the research interest of this paper, so the main research focus of this paper focuses on the processing of enterprise data and its application in prediction and evaluation. Using certain assumptions, the attained outcomes confirm that the accuracy of the anticipated deep learning structure of the single model is sophisticated and

greater than that of the cross hybrid model, but lower than that of the sequential hybrid model. The neural network model that has been constructed and proposed in this paper is entirely fictitious and has not been extensively used in practical applications. Later, practice and application are required. The focus of our upcoming investigation will be these limits. We will also think over how the training and prediction duration can be shortened so that the algorithm converges as quickly as possible.

Data Availability

The corresponding author can provide the datasets used and analyzed during the current study upon reasonable request.

Conflicts of Interest

The authors of this paper declare that they have no conflicts of interest.

Acknowledgments

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Retraction

Retracted: The English Teaching Mode under the Environment of Computer Technology

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] W. Liu and W. Shi, "The English Teaching Mode under the Environment of Computer Technology," *Mobile Information Systems*, vol. 2022, Article ID 1510057, 8 pages, 2022.

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Research Article

The English Teaching Mode under the Environment of Computer Technology

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The development of Internet information technology has opened up new potential for the education sector, encouraging the development of innovative teaching and learning methods as well as the optimal use of available educational resources. In this environment, the online plus offline mixed teaching model emerged, which can not only get around time and space restrictions and link smoothly inside and outside the classroom but also enhance the form of teaching and learning and strengthen teacher-student relationships. However, to assure the quality of instruction, this research first examines the successful ways of developing an online plus offline hybrid teaching mode from the perspective of college English professors. Second, in this paper, the support vector machine and particle swarm method are used to build an evaluation model of the English teaching effect. The model has the potential to increase the accuracy and efficiency of English teaching impact evaluation while also meeting the standards of English teaching effect evaluation. The experimental findings show that, while evaluating the effects of college English instruction, the technique beats the comparison algorithm in terms of evaluation accuracy and algorithm time consumption.

1. Introduction

Artificial intelligence, cloud computing, monitoring and prediction, and zero-knowledge proofs are examples of information technology advancements. Online and offline hybrid Internet-based teaching modes primarily refer to the mode of teaching activities on the network platform and in the classroom. As a result, it is a logical progression from traditional classroom instruction, which calls for open dialogue between students and instructors as well as active participation in class debates as a means of transferring knowledge [1, 2]. Regular (synchronous) instruction takes place offline with the teacher and all students present in the same space at the same time (also known as face-to-face, on-site, and campus teaching.) Online instruction is delivered entirely online utilizing a video platform like Zoom, Microsoft Teams, or Kaltura Live Room. With hybrid instruction, instruction is delivered on campus to a physical class while an online class watches via a video tool. When it comes to teaching college English, the use of online and offline mixed teaching methods is the best way to integrate tradition and modernity, fully demonstrate students' dominant position, enable them to form a good academic quality in participation and exploration, and contribute to the improvement of English teaching quality [3–5].

In addition to offering face-to-face instruction and online support, hybrid teaching methods that mix offline systematic instruction with online specialized training and online fragmented coaching can successfully connect students within and outside of the classroom. When students participate in a range of activities, they learn more. Students can make use of MOOCs, micro-courses, and other online learning possibilities at this time, or they can do it on their terms. Teachers can aid and guide students in real time online, allowing for more diversified and adaptable online learning. The authors in literature [6–10] proposed the method of gradually improving teaching quality. Teaching online and offline at the same time necessitates the use of big

data technology by teachers to monitor students' progress and accurately record how well they perform in various learning links and grasp their mastery of each piece of knowledge. Provide clear instructions and control teaching accordingly, tally students' attendance by checking in and punching into the system, and require them to input various learning data online, including the use of mind maps to sort knowledge and the outcomes of assignments they have accomplished [11–13]. Professors can use objective and detailed evaluation to urge students to always improve themselves.

In the past, students had little opportunity to learn supplemental information, such as textbooks and workbooks, due to a limited amount of teaching time [14]. Combining online and offline teaching approaches can assist in integrating resources and providing learners with a variety of high-quality online resources, such as educational films and software, to help them understand the topic being taught in the classroom. As they continue to study and grow, they can improve themselves as educators by employing a variety of tools to lay a firm foundation of academic literacy, which in turn helps students learn more effectively while also boosting classroom standards [15, 16]. Given that each student is unique, teachers who utilize the same teaching technique with each of their courses risk stunting their students' progress and failing to meet their individual learning needs. It is feasible to increase the relevance of teaching activities at this time by employing an online plus offline hybrid teaching mode, in which teachers can adjust learning objectives and tasks for students based on data analysis findings and students' daily performance [17–20]. Consolidate the foundation, break through the self, and establish a good learning ability for long-term study and accumulation, as well as contribute to general quality improvement.

Some college English teachers are still significantly influenced by outdated educational ideals, and the teaching methods they use are generally traditional and narrow-minded [21]. As a result, students are never inspired to participate in the actual learning process and are unwilling to collaborate with their lecturers to research and examine the content. Students' talents and reading levels are also biased one way or the other. Using the same teaching method repeatedly limits pupils' personal development and hampers their ability to learn, resulting in a lack of progress in their education. The outcome was not what we had hoped for. The effectiveness of college English teaching is currently being examined as an important research topic in college education evaluation. Teachers can change their plans and progress depending on real-time feedback from students using real-time evaluation data. Schools use evaluation outcomes to assess English instructors' complete teaching abilities, and a scientific and acceptable evaluation process helps to achieve this goal. The study found that assessing the efficiency of college English education is laden with difficulties. For example, the original evaluation procedure places an overwhelming focus on the evaluator's competence. When personal prejudices of an evaluation subject are considered, outcomes can be unfairly impacted. To assess the efficiency of collegiate English instruction, quantitative measurements must be used.

Hybrid teaching is distinct from blended learning. In a blended learning environment, students get ready for the class using online resources at their own pace (referred to as asynchronous). Instead of using traditional lectures, classes engage with the syllabus through a variety of active work modalities. Combining online and hybrid instruction is possible. Traditionally, the effectiveness of college English education has been assessed using a relatively limited set of criteria. For example, in the instance of the BP neural network for evaluating college teaching quality, researchers studied and modified the model [22–24]. There is an issue with the accuracy of effect evaluation. Gray target choice categories have been investigated by researchers as a means of weighting teaching evaluations [25, 26]. The efficiency of college English teaching effect evaluation is low due to the intricate calculating process of this method [27, 28].

When a big number of people from all over the world collaborate to share and transmit data, this is referred to as particle swarm optimization. Each particle searches for the population's global and individual extremes during each iteration to update its position and velocity [29–33]. The least squares support vector machine (LSSVM) is an SVM extension that speeds up the solution process by reducing the number of parameters that must be chosen [34, 35]. Because the evaluation of college English teaching effectiveness using particle swarm and SVM algorithms is the emphasis of this research, it is thoroughly investigated in this paper. To avoid the influence of subjective thinking and random factors, this method assesses the impact of college English education on students objectively and scientifically.

The rest of the paper is organized as follows: Section 2 gives teaching strategies in computer environment, Section 3 gives the proposed method, Section 4 gives the results, and the conclusion is given in Section 5.

2. Teaching Strategies in Computer Environment

The first step is to put flipped classroom instruction into action. Flipping the classroom is a sort of blended learning that uses both online and offline resources to improve student learning. By having students read from home and work on real-world problems, the flipped classroom is an instructional method and kind of blended learning that tries to boost student engagement and learning. College English professors will be able to gain from blended learning if it is employed in higher education. The purpose is to improve students' ability to study independently, think critically, and undertake research, as well as to aid in their general growth. English teachers, for example, can use textbook chapter material to create instructional activities that can be electronically converted and shared via an Internet-based learning platform. After that, students can use these resources to continue their education outside of the classroom. As a result, teachers can better understand the self-study condition of their students and pinpoint the most prevalent problems and obstacles. To more exactly and intuitively assess their students' understanding, teachers might also design some exam questions. College English teachers must

provide opportunities for students to discuss and analyze test questions they have created, as well as their learning outcomes, to increase their students' learning effectiveness during offline education. Finally, teachers must thoroughly assess their students' online and offline learning and provide timely further training to assist students in identifying any omissions or knowledge gaps that may have occurred during the course. They should also thoroughly study a variety of difficult issues to assist their students in comprehending the stuff they have learned and build a more comprehensive framework for understanding it. In mixed learning scenarios, the use of a knowledge system might be advantageous.

The second stage comprises doing a thorough evaluation of the pupils' learning environment. College English professors can use the Internet to better understand their students' learning environments and pinpoint their students' areas of weakness in grammar, reading, writing, vocabulary, and sentence structure. It then creates targeted lesson plans that are suitable for its students' requirements. It is possible to provide hierarchical guidance by combining online and offline mixed educational modes. Instead of having students do online learning assignments during class, have them complete them in their own time using several network platforms, allowing the coach to collect real-time learning and practice data. Create micro-lecture teaching or practice courseware based on the topic to be taught. Its objective is to accomplish a thorough but constrained instructional purpose. "Micro-lectures" are teaching strategies or methods that use videos as the primary carrier, which captures the instructor's pedagogical style around a specific subject, such as a recorded or videotaped course or duplicated blackboard writing. After developing these resources, undertake a thorough examination to discover their strengths and weaknesses before categorizing them. As a result, they will be more successful in completing both online and offline hierarchical learning tasks. By using this strategy, teachers can alter their lessons to better meet the requirements of all students, even those who may struggle with English literacy in hierarchical inquiry. As a result, they can provide more enriching learning experiences to pupils that are suited to their specific learning styles. By establishing a sense of achievement, enhancing self-confidence in learning, and developing a more positive attitude toward following learning activities, it is feasible to enhance the impact of English education while also optimizing the benefits of a hybrid online/offline teaching technique.

Numerous cross-cultural tools are also readily available. It is also essential to incorporate cross-cultural education into English instruction since it increases learning effectiveness, encourages students to form healthy cultural habits, and aids in the retention of information. Cross-cultural learning improves students' knowledge of cultural norms, beliefs, and behaviors as well as their comprehension of their own and other cultures. Additionally, it enables the learner to recognize and confidently explain cultural differences. College English professors should aim to supplement rich cross-cultural materials with the online and offline hybrid teaching method to help students develop excellent academic literacy in the area of study under examination. Teachers can use online learning in conjunction with tutorial courseware to encourage students to look for cross-cultural components in the content before delivering a new course. As a result, they will be able to gather more detailed information during the integration process. Offline college English training should contain cross-cultural resources and guide students through the examination of contrasts between Chinese and Western festival customs, communication etiquette, and linguistic thinking to broaden students' cognition and assist them in learning more efficiently. As a result, they are more successful at memorizing more information, developing their correct value orientation, and enhancing the correctness of their learners' English language abilities by gaining a better awareness of the cultural setting in which they teach.

Your kids' learning outcomes should be your top goal. The significance of keeping an eye on the process and results when organizing college English teaching activities using the online plus offline mixed teaching mode cannot be emphasized. This will enable teachers to provide students with targeted instruction while also motivating them to continue to grow and make significant progress in their studies. Online evaluation can be advantageous for English teachers, for example, who can monitor their student's progress and provide constructive criticism and growth suggestions in the form of scores and comments. Teachers can respond to students' practice activities promptly to help them improve their online learning, they can also submit their analyses and comments on the themes in the form of annotations, and they can post a voice to evaluate each student's online learning outcomes. Educators can instill in students a positive learning attitude, teach them more scientific learning procedures, and even use motivational techniques to help students overcome their learning hurdles. When teaching offline, you can conduct evaluations by observing students' facial expressions and then measuring their body movements, language, and other qualities. Teachers can also provide specific feedback to students following the evaluation to help them improve their performance and keep their strengths throughout the learning process. Professors' feedback is regularly used to inform the development of our learning techniques and concepts. This enables us to progress forward. Through online and offline evaluation and feedback, it is possible to continuously boost students' self-recognition, allowing them to learn and develop more effectively and contributing to the advancement of their English literacy [23, 26, 31].

A framework for evaluating digital literacy has been created by several groups, and it is in line with the direction that artificial intelligence and education are currently taking. A new sort of literacy is necessary in a world run by artificial intelligence. Seven competency blocks comprise the assessment framework: hardware and software fundamentals, information and data literacy, communication and collaboration, digital content creation, security, problem solving, and career-related competencies. A critical goal of AI and education is to ensure that students receive a high-quality education. The growth of pupils' entire quality, which

includes critical awareness, knowledge, and ability, will be emphasized. The effectiveness of education will depend on how well it satisfies the requirements of the community and the individual.

Big data, high-performance computing, the Internet of Things, and related software and hardware are all essential elements of evaluating artificial intelligence. The algorithm examines all of the information gathered about a student throughout their education, enabling self-learning, self-adaptation, self-optimization, and optimal outcomes while eliminating the influence of teachers' arbitrary preferences.

The artificial intelligence algorithm is capable of self-learning, self-adaptation, and self-optimization. The algorithm can adjust the weight of each parameter based on various inputs, allowing it to produce the best possible output. Due to the integration of artificial intelligence and standardized testing in educational settings, educators should be able to make more humane decisions about their student's educational experiences. By applying self-decision to the entire teaching process, intelligent algorithms can achieve precise intervention, process optimization, and personalized learning. To be fair, self-decision is based on data from intelligent systems, which means the analysis results may be excessively objective and rigid. Teachers can consider emotional and experiential factors when making humanistic learning decisions [36].

Finally, a system for measuring pupils' academic achievement as well as the performance of teachers must be put in place. To develop an artificial intelligence evaluation model, large amounts of data from the learning process are evaluated, and real-time feedback on students' progress is sent to the researchers. It is our goal to use artificial intelligence's intelligence and flexibility to follow and acquire information about student learning behavior in real time and then analyze and evaluate that information. Students' abilities are assessed, learning process data are collected, a database of personal behavior characteristics of students is created, and then the data are processed using educational algorithms to extract students' deep learning behavior characteristics from the data. Students' evaluations should be used to inform judgments about the children's educational future. The SVM and particle swarm algorithms are used in this study to increase the evaluation accuracy and modeling speed of an English teaching evaluation system, which is currently under development. Various approaches to dealing with these difficulties will be described in greater detail in Section 3.

3. Proposed Method

It is not enough to just study students' test scores to establish a comprehensive assessment index system for English education and instruction. Furthermore, it is vital to guarantee that the assessment indicators are both reliable and easy to use in their functioning. Along with their universality, the indicators' individualization must be taken into account, and this must be done carefully. For instance, the authors of the study categorize learning achievement markers, learning emotion indicators, learning attention indicators, learning engagement indices, comprehensive quality indicators, and many more. They can contribute to enhancing the objectivity, fairness, and logic of evaluations by introducing multi-dimensional assessment indicators into the process. Exam scores of students are utilized to derive markers of learning accomplishment and emotion, while cameras record students' facial expressions to discover how they feel about courses or teachers. Data from the recording equipment, as well as student voice recordings, are evaluated and compiled. The camera observes and records students' classroom behavior and posture to assess their level of attention and participation in the classroom. Performance, mood, and focus are all taken into account while calculating the overall quality index. When compared to the previous system, the identification and analysis of student assessment indicators using an artificial intelligence algorithm improve the objectivity and fairness of the evaluation.

The training sample set is described by $s = \{x_i, y_i\}$, and the regression function of SVM in the d-dimensional space is

$$y = W^T x + b, \tag{1}$$

where b is the bias vector and W^T is the weight vector.

When the spatial dimension is higher, (1) is transformed into

$$f(x) = W^T \omega(x) + b, \tag{2}$$

where $\omega(x)$ is the nonlinear mapping.

The objective function of SVM is

$$\min \frac{1}{2}\|W\|^2 + \frac{1}{2}c\sum_{i=1}^{l} e_i^2, \tag{3}$$

$$s.t. \quad y_i = W^T \omega(x) + b + e_i. \tag{4}$$

where c is the regularization parameter and e_i is the error variable.

By introducing Lagrange multipliers λ_i, (4) is transformed into

$$\min \frac{1}{2}\|W\|^2 + \frac{1}{2}c\sum_{i=1}^{l} e_i^2 - \sum_{i=1}^{l}\lambda_i\left(W^T\omega(x) + b + e_i - y_i\right). \tag{5}$$

The process of solving the optimal value is as follows:

$$\begin{cases} \dfrac{\partial J}{\partial W} = 0 \longrightarrow w = \displaystyle\sum_{i=1}^{l}\lambda_i\omega(x_i), \dfrac{\partial J}{\partial b} = 0 \longrightarrow \displaystyle\sum_{i=1}^{l}\lambda_i = 0, \\ \dfrac{\partial J}{\partial e_i} = 0 \longrightarrow \lambda_i = ce_i, \\ \dfrac{\partial J}{\partial \lambda_i} = 0 \longrightarrow W^T\omega(x_i) + b + e_i - y_i = 0. \end{cases} \tag{6}$$

Then, we have

$$y = \sum_{i=1}^{l}\lambda_i K(x_i, x_l) + b, \tag{7}$$

where $K(x_i, x_l)$ is the radial basis function, which is calculated as

$$K(x_i, x_l) = \exp\left(-\frac{\|x - x_i\|^2}{\sigma^2}\right), \tag{8}$$

where σ is the width of the kernel function.

Improve the least squares support vector machine's generalizability by using c and σ to represent two parameters. Particle swarm optimization is used in the least squares support vector machine parameter optimization problem. The process of using a least squares support vector machine to create the evaluation model for college English teaching effectiveness is as follows:

Step 1: input the teaching effect evaluation data.

Step 2: solve c and σ and use the particle swarm algorithm to search.

Step 3: select the appropriate kernel function.

Step 4: calculate the optimal solution as follows:

$$Q = (q_1, q_1^*, \cdots, q_l, q_l^*). \tag{9}$$

Step 5: construction of decision function by

$$y = \sum_{i=1}^{l} (q_i^* - q_i) K(x_i, x_l) + b. \tag{10}$$

Step 6: implement the evaluation.

The updated formula of particle position and velocity in particle swarm optimization is as follows:

$$x_{io}^{k+1} = x_{io}^{k} + v_{io}^{k+1}, \tag{11}$$

$$v_{io}^{k+1} = w v_{io}^{k+1} + c_1 r_1 \left(p_{io} - x_{io}^{k}\right) + c_2 r_2 \left(p_{go} - x_{io}^{k}\right), \tag{12}$$

where p_i represents the optimal position, v_i represents the speed, w is the inertia coefficient, c_1 and c_2 are the acceleration coefficients, and r_1 and r_2 are the random numbers.

The steps to optimize the SVM are as follows:

Step 1: normalize the evaluation data.

Step 2: set the parameter values and initialize the particle swarm algorithm.

Step 3: initialize the particle swarm.

Step 4: solve the fitness value of each particle in the new population.

Step5: compare the optimal speed and optimal position of the previous population and update them in time.

Step 6: find the fitness value f of each particle in the new population.

Step 7: search for the optimal solution for parameters σ and c.

4. Results

Data are considered the foundation of intelligent analysis. For this study, two types of data were collected: online learning process data (images, texts, web page clicks, and video streams) and offline (smart classroom) multi-modal learning behavior data (images, sounds, and eye movement data). The effectiveness of pupils in the classroom can be evaluated using a range of metrics, including attendance, attitude, attention span, the number of head-ups, and the frequency of dialogues and exchanges. The monitoring of learning behavior is inevitably hampered by problems like missing reading, excessive reading, incorrect reading, and poor real-time performance brought on by hardware and software. To address this problem, this study proposes to model the data quality and evaluate the real-time behavior data of heterogeneous multi-source and multi-modal students using four data quality criteria. Select different data transmission networks based on the precision provided by the user. Reduce network resources with the assumption of ensuring data quality. Align data based on time and then based on data type (e.g., a timestamp). After being stored in the database following the time series, the data are intelligently analyzed.

The research object should be a computer major at a university, and sample data should be collected following the evaluation index of college English teaching effect. The actual situation of college English classroom teaching and expert evaluation of the effect of college teaching should be used to determine the quality grade value of college English

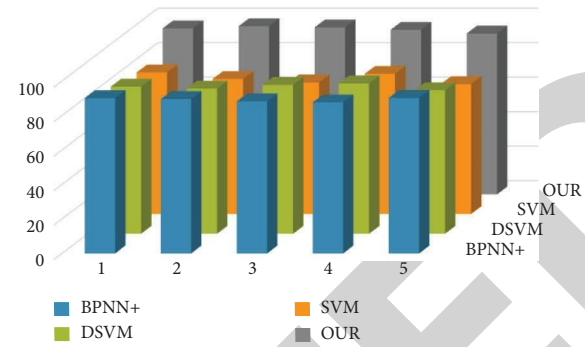

Figure 1: Comparison of the accuracy of four algorithms on five datasets.

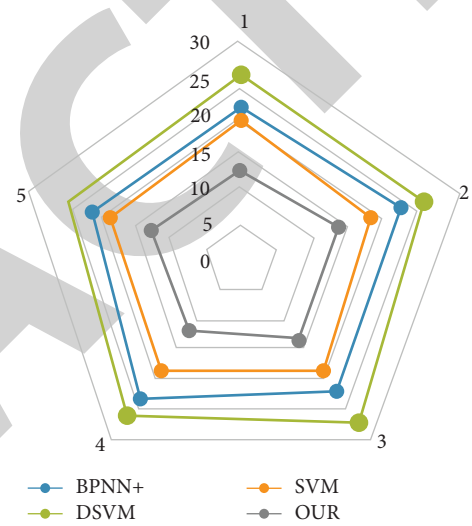

Figure 2: Comparison of results of training time.

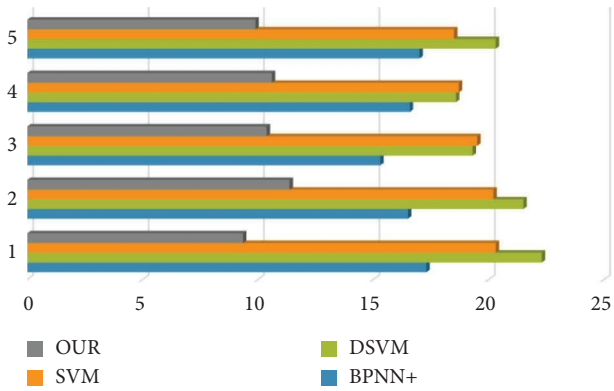

Figure 3: Test time comparison results.

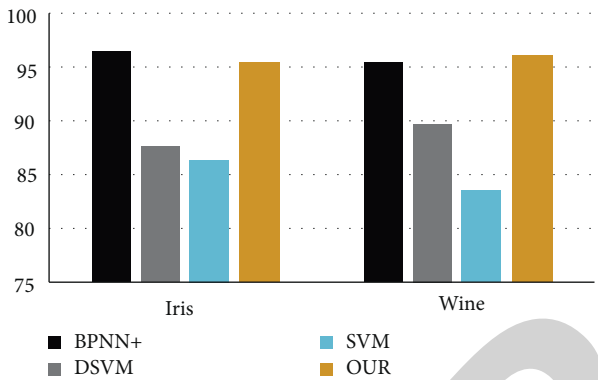

Figure 4: Comparative experiments on artificial datasets.

classroom teaching. For testing, we collected 1000 data samples and divided them into five groups of datasets, each of which contained 200 data samples. The experimental comparison method is based on the BPNN+, DSVM, and SVM methods described in this paper as well as methods described in the literature [21, 23, 24]. The accuracy calculation results from three methods used to test the experimental dataset are shown in Figure 1.

Three methods were used to conduct 10 experiments on 5 sets of datasets. The comparison results of the test time and training time of the four methods are shown in Figures 2 and 3, respectively.

From the comparison results of Figures 2 and 3, it can be seen that the method in this paper has obvious advantages over the other three methods in terms of time efficiency. The training time and testing time of the method in this paper are the least time-consuming, among which the training time is as low as 13 ms and the test time is as low as 9.59 ms. Among the four methods, BPNN+ is the slowest, followed by DSVM. DSVM is better than its improved loss function. Although it can get higher classification accuracy, it increases the running time of the algorithm.

Further, this paper conducts experiments on common UCI classification datasets and selects Iris and Wine datasets for algorithm comparison experiments. The results are shown in Figure 4. It can be seen that the algorithm proposed in this paper is on par with BPNN+, reaching a classification accuracy of more than 95%, which is better than the traditional SVM method and the improved SVM method.

5. Conclusion and Future Work

The education sector now has more prospects for growth because of Internet information technology, which has also sparked innovation in teaching and learning techniques. Among other things, it supported the most effective distribution and utilization of instructional resources. Due to this, a hybrid online-offline teaching approach has been developed that may bridge the gap between the classroom and the outside world, while also boosting the actual learning process and fortifying the relationship between teachers and students. An initial step is to consider how college English teachers can best implement an online/offline mixed teaching mode to ensure that students receive high-quality instructional materials and instruction. Second, support vector machines and particle swarm algorithms are used to develop an evaluation model for the impact of English language instruction on students. Because of the model's ability to meet the requirements, it is possible to conduct more accurate and efficient evaluations of English teaching effects. In particular, the technique surpasses the comparison algorithm in terms of accuracy and processing time while evaluating collegiate English education.

There are still some flaws that must be addressed due to time and energy constraints. The following are some possible future research directions.

(1) To conduct future research on the effectiveness of college English instruction, a more scientific method of evaluating students' performance on the evaluation index system will be required.

(2) The techniques described in this paper can be applied to assess instruction in other fields.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Effects of Carbon Emission on the Environment of High-Speed Vehicles on Highways for Intelligent Transportation Systems

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The emergence of intelligent applications of the Internet of things (IoT) is facilitating human beings up to a great extent. However, numerous applications of the IoT have an adverse impact on our society and environment as well that needs to be dealt with properly to provide smart services to the end-users. For instance, the carbon emissions of vehicles from intelligent transportation systems (ITS) driving on highways are high due to low-carbon traffic management. Therefore, this paper studies the impact of high-speed vehicles on the road causing carbon emissions. For this purpose, Ford, Volkswagen, and Toyota models were used as test subjects to count relevant parameters during May and October 2020. Carbon emissions and vehicle speed on highways were calculated. The relationship between vehicle speed and fuel consumption on the expressway was also analyzed. The results confirm that the fuel consumption of Ford, Volkswagen, and Toyota is the lowest when the vehicle speed is 70 km/h, 80 km/h, and 90 km/h, respectively. The relationship between vehicle speed and carbon emissions in sunny and rainy weather is also analyzed based on the proposed model. It was concluded that the carbon emissions of Ford, Volkswagen, and Toyota are 6.24 mg/1000 km, 6.52 mg/1000 km, and 9.29 mg/1000 km, respectively, under sunny weather conditions. In contrast, the emissions continue to increase when the car accelerates. The driving speed range corresponding to the minimum carbon emissions per hundred kilometres of the three vehicles is 60–120 km/h. However, the carbon emissions of the three vehicles change in rainy weather. The minimum carbon emission of Ford is 6.07 mg/1000 km when the driving speed is within the range of 80–100 km/h. In comparison, Volkswagen and Toyota have the lowest carbon emissions of 6.23 mg/1000 km and 9.15 mg/1000 km, respectively, when the vehicle speed is in the range of 80–120 km/h. The results obtained in this paper establish a unique relationship between vehicle speed, type of vehicle, weather, and highway conditions for any application of the ITS.

1. Introduction

The Internet of things (IoTs) has found its presence in almost every application, e.g., smart farming, healthcare, smart surveillance systems, and intelligent transportation systems (ITS). Among these applications, the vehicles of ITS emit too much carbon into the environment, which has an adverse impact on health and wellbeing of the individuals. Various artificial intelligence techniques will have a pivotal role in this context [1]. In the future, delivering totally driverless vehicles and seamlessly integrated urban transportation will depend heavily on the application of these artificial intelligence techniques. However, we do not have to wait until tomorrow to profit from fourth-generation technology like artificial intelligence and machine learning. They are already in use in a variety of transportation-related applications, reducing CO_2 emissions. Currently, vehicle emissions are frequently evaluated using mobile emission factor models, which are prone to model mistakes. Furthermore, the spatial and temporal accuracy required for the evaluation procedure is lacking in these emission factor models. To address these shortcomings, relevant agencies are looking towards these artificial intelligence and machine learning techniques.

At present times, the global industrial economy has developed rapidly. The population continues to grow. The rate of car usage is increasing. The amount of greenhouse gases

emitted into the atmosphere by daily human life activities and industrial production is also rising, leading to increased global warming [2]. For this condition, the transportation and air quality managers are responsible for creating and assessing transportation control measures and various transportation improvement projects. Individual signalized junctions, traffic control devices, highway facility upgrades (e.g., ramps and roundabouts), improved incident response and management, and other tactics are some of the benefits of such models at the microlevel. It is critical to detect hot spots along routes to assess the air quality advantages of such initiatives. Therefore, countries worldwide have begun to pay attention to "low-carbon." They want people to minimize greenhouse gas emissions in production and life [3]. Transportation is the field that emits an enormous amount of greenhouse gases. According to relevant data, the energy consumed by transportation in 2020 was 1916.9 billion tons of oil equivalent. It accounts for 25% of global energy consumption. Similarly, the transportation industry accounts for 14% of the worldwide greenhouse gas emissions, and its conversion into carbon dioxide equivalent reaches 5.8×109 tons. Most of these gases contain carbon dioxide [4]. To resolve the problem of excessive carbon dioxide emission from highways, we maximize energy conservation and emission reduction and minimize the adverse impact on the ecological environment caused by inappropriate highway policy management; it is necessary to revise the policy of speed restriction of vehicles to lower the carbon emission.

The innovations of this paper are as follows: first, it analyzes the main factors affecting vehicle carbon emissions. It collects the average speed and fuel consumption data of different vehicles (cars and trucks) at different speeds (80–120 km/h for cars and 60–100 km/h for trucks). Secondly, the initially collected fuel consumption data are converted into carbon dioxide emissions through the traditional international carbon emission accounting method. The relationship model between the two parameters is established by using the regression analysis method. It also removes irrelevant variables' influence in the research process and controls the main objective facets. It will help clarify the influence law of different speed limit conditions on vehicle carbon emissions, take the carbon emission rate as an important reference index for the setting of the speed limit value, and provide a reference for the speed management strategy in the process of highway operation. It will also provide data support and a theoretical basis for the construction of green transportation.

The remaining paper is organized as follows: Section 2 explains the related work linked to this study. Section 3 gives us an insightful analysis of the influence of speed limit on fuel consumption. The construction of the carbon emission model affected by vehicle speed on expressway and results and analysis are presented in Sections 4 and 5. Finally, the concluding remarks are added in Section 6.

2. Related Work

The change of the speed limit value usually affects motor vehicle speed and traffic flow density in various ITS applications of the IoT. It can further affect fuel consumption and exhaust emissions. Therefore, this section will analyze the factors affecting the carbon emission of motor vehicles based on the influence of different factors on speed and fuel consumption [5, 6]. Britain was the first country to count the energy consumption of its residents, such as natural gas and oil. It quantitatively converted energy consumption into CO_2 emissions. Based on these data, it intuitively reflected British residents' daily life and future carbon emissions. Britain had to start with residents' lifestyles and production modes to carry out low-carbon and formulate low-carbon standards for family life [7]. Japanese scholars focus on studying the carbon emissions of the domestic transportation industry and residents' lives. It developed corresponding emission reduction schemes according to each industry's energy technology and industrial distribution [8]. Chinese experts use the leap model to predict Shanghai's carbon emissions and energy consumption. It analyzed the impact of low-carbon measures on the environment and energy. According to the results, the comprehensive development of low-carbon transportation can effectively alleviate the energy supply problem. If the amount of carbon dioxide and air pollutants emitted is reduced, it can improve the air quality and the greenhouse effect to a certain extent [9, 10]. Environmental protection has become the development goal of all countries worldwide. The transportation sector needs to formulate a green policy to achieve the purpose of low-carbon [11]. Highway carbon emissions account for the most significant proportion of the transportation industry. China has built large-scale highways. They have become the core of transportation [12]. Therefore, there is an urgent need to study highway carbon emissions. This paper analyzes highway carbon emissions from a vehicle's driving speed. It establishes the highway vehicle speed and the carbon emission model, examines the impact of vehicle fuel consumption on carbon emissions, and determines the driving speed with the lowest carbon emissions of different models. It has become essential for relevant departments to formulate highway management measures.

3. Analysis of the Influence of the Speed Limit on Fuel Consumption

In this section of the study paper, we will study the effects of the speed limit on drivers and the influence of the speed limit on V_{85} and V_{50}. It will help us analyze the speed limit's impact on the fuel consumption of vehicles. The details are as follows.

3.1. Effect of the Speed Limit on Drivers. It is necessary to conduct a preliminary analysis in order to provide technical routes and method guidance for follow-up research. It will also help study the impact of speed restriction on fuel consumption.

According to the highway management policy, speed limit signs have a certain restraining and warning effect on drivers [13]. Due to drivers' physiological and psychological

complexity, scholars at home and abroad mainly study drivers' behavior under speed limit signs using simulation and questionnaires. Relevant research shows that when the driver passes the speed limit sign, he quickly processes the sign information. The brain will produce three decisions: the actual driving speed is lower, equal to, or higher than the speed limit value. Finally, the driver will perform operations according to the vehicle's initial speed and driving habits [14]. According to the existing literature investigation, if other factors and the interference of the actual road conditions are not considered, drivers will behave differently in the decision-making process. In the road section without speed limit signs, drivers often drive at a higher speed to pursue travel efficiency.

In contrast, while passing a speed limit sign on a road segment with speed limit signs, drivers frequently drop their driving speed abruptly to avoid the punishment and poor record produced by speeding. They will, however, accelerate rapidly after reaching the speed limit road stretch [15]. Based on the above analysis, drivers' frequent deceleration and acceleration before and after the speed limit sign will lead to a sharp increase in fuel consumption and carbon emissions.

3.2. Influence of the Speed Limit on V_{85} and V_{50}. According to the existing research, the vehicle running speed is closely related to the speed limit. The influence of the speed restriction on vehicle speed cannot be ignored, according to highway management policy [15]. Speed restrictions have an impact on vehicle functioning and driver behavior. In general, the driver travels at a fast speed in open regions with a higher defined speed value. In contrast, when the speed limit value is low, drivers tend to reduce their speed during driving. Therefore, we can predict that the higher speed limit and vehicle speed increase fuel consumption and carbon emissions and vice versa [16]. To further verify this assumption and show the relationship between the limited speed and the driving speed of motor vehicles, researchers continuously collect the traffic flow speed data at the speed values of 80–120 km/h through field tests. They also study the impact of the speed limit on V_{85} and V_{50}. The research shows that in the free flow state when $v/c \leq 0.55$, the traffic flow successively passes through the sections with different speed limit schemes. The increasing running speed conforms to the law of the rise of the speed limit scheme [17]. When drivers drive freely on the highway, they are greatly affected by the limited speed value. The majority of drivers will go strictly according to the speed limit.

4. Construction of the Carbon Emission Model Affected by Vehicle Speed on Expressway

This section of the paper explains the establishment model of vehicle speed and carbon emission on expressway, data selection for model construction, and the carbon emission calculation method. Together, they will highlight the structure of the carbon emission model affected by the speed of vehicles on highways. The details are as follows.

4.1. Establishing the Vehicle Speed Model and Carbon Emission on the Expressway. This paper takes Ford, Volkswagen, and Toyota vehicles as the research object. It analyzes the relationship between their driving speed and carbon emissions on the highway. It establishes a model of vehicle speed on roads and carbon emissions with a slope value of 0%. The following formula is used to calculate the carbon emissions generated by fuel consumption:

$$C_i = T_{iz} \cdot Q_{i,\text{fuel}}. \tag{1}$$

In the abovementioned formula, T_{iz} represents the carbon emission coefficient of vehicle type i (kg/L); C_i refers to the carbon emission of model I (kg/100 km); $Q_{i,\text{fuel}}$ means the fuel consumption per 100 km of the model i (L/100 km).

We can calculate the carbon emissions of vehicle types i at various speeds in the abovementioned formula. It sets a relationship between the driving speed and carbon emissions of the three vehicle types through software R. The calculation formula is as follows:

$$C_{i,v} = T_{iz}\left(a + bV + cV^2\right), \tag{2}$$

where $C_{i,v}$ refers to the carbon emission generated by the i model driving at various speeds (kg/100 km) and V relates to vehicle running speed (km/h).

It can be inferred that there is a direct correlation between different vehicle speeds and the fuel required for combustion. Therefore, to select a higher simulation accuracy and more suitable quadratic function as the fitting function, the following highway vehicle speed carbon emission model can be obtained:

$$E_3CO_2 = 0.0103X^2 - 0.7762X + 41.275. \tag{3}$$

In the abovementioned formula, E_3CO_2 represents the carbon emissions (kg/100 km) at different driving speeds on the expressway and X represents the limited speed of the expressway section [60100].

4.2. Data Selection for Model Construction. In this paper, the number of vehicles driving on the highway is statistically analyzed. For this purpose, Ford, Volkswagen, and Toyota are selected as study subjects. The carbon dioxide emissions of three types of vehicles at the instantaneous speed on the highway were recorded. During the study, the three cars were filled with the same gasoline model from the gas station. The time of statistical data is from May to October 2020. This period can reduce the impact of large traffic volume on data accuracy. The vehicle is tested with the help of a survey method. The vehicle exhaust tester detects the amount of carbon dioxide emitted. Table 1 shows the basic parameters of vehicles selected for this study.

4.3. The Carbon Emission Calculation Method. This subsection will help us calculate the carbon emission and vehicle speed. Also, it will show the relation of these parameters. The details are as follows.

Table 1: Basic parameters of vehicle.

Vehicle brand	Model	Driving years	Displacement	Power
Ford	Carnival	4	1.5	76.9
Public	Langyi	3	2.0	89.5
Toyota	Prado	3.5	4.0	180

4.3.1. Calculating Carbon Emissions. The carbon emission factor refers to the carbon emissions generated per unit of energy during the combustion or use of energy. It is usually obtained using energy consumption and carbon emissions [18]. When it comes to environmental pollution, China has yet to develop an autonomous system that is in keeping with its national circumstances. As a result, research into energy emission factors is still in its infancy. Therefore, the emission factors that represent global climate change issued by the United Nations IPCC committee are used as China's road energy emission factors. They are shown in Table 2.

The International Energy Agency analyzes global climate change and puts forward the net calorific value. It is statistically selected by combining the characteristics of energy combustion. The default static calorific value of energy during vehicle driving is listed in Table 3.

In this paper, the carbon emission during fuel combustion is calculated based on the default emission factor of fuel, the net calorific value, and the fuel characteristic factor. The following is the calculation formula:

$$E = \sum_{i=1}^{n} m \times \rho \times N \times Fi \times Ii. \quad (4)$$

In the above formula, E represents the carbon emission (mg); ρ indicates the density of gasoline or diesel (kg/l); m refers to gasoline or diesel consumption (L); N refers to the default net calorific value of gasoline or diesel (MJ/kg); L_i represents the distinguishing factor; and F_i means the net calorific value emission factor (mg/MJ).

4.3.2. Calculating Vehicle Speed and Carbon Emissions. The relation between vehicle speed and energy consumption is represented by a quadratic parabola. The relationship between carbon emissions and vehicle speed is constructed based on the calculation method of carbon emissions from energy combustion [19]. It is expressed in the following formula:

$$E = \sum_{i=1}^{n} (0.0025v2 - 0.2554v + 31.75) \times \rho \times N \times Fi \times Ii. \quad (5)$$

In the above equation, E shows a quadratic parabola relation between the carbon emission of 100 km [mg/100 km] and the vehicle speed. When the vehicle is driven at average speed, the energy consumption and carbon emission are low. Based on this phenomenon, the carbon emissions of 100 kilometres in 20–80 km/h are calculated.

5. Results and Analysis

In this part of the paper, we will study the development results of the expressway in China and analyze the results of vehicle speed, fuel consumption, and carbon emission on the expressway. It will help us analyze and understand the results extracted from this study's proposed methodology. The details are as follows.

Table 2: Thedefault emission factor of vehicle driving energy (mg/MJ).

Fuel type	Emission factor		
	CO_2	CH_4	N_2O
Gasoline/diesel	74200	3.2	0.7

Table 3: Thedefault net calorific value and confidence interval limit of energy (MJ/kg).

Fuel type	Net calorific value	Net calorific value limit	
		Upper limit	Lower limit
Gasoline/diesel	43.2	43.4	41.5

5.1. Development Results of the Expressway in China. China has vigorously built expressways since the late 1980s. The driving section starts from Shanghai to Jiading, with a total length of 18.5 kilometres. Until 1997, China's expressway building distance was 4771 kilometres. China reached a milestone in expressway development in 2002, with expressway traffic exceeding 25000 kilometres. China's highway development speed has overtaken that of industrialized countries for the first time in more than 40 years in only a few years. Highway length rose by 1.1648 million kilometres between 2005 and 2010, compared to the preceding five years. The mileage of highways has also increased from 41000 kilometres to 74000 kilometres in 2005. The mileage of highways in China ranks second in the world. The total mileage of highways built in 11 provinces is more than 3000 kilometres. Table 4 lists China's highway mileage statistics from 2015 to 2020. Figure 1 shows the energy consumption of various transportation modes in the transportation industry in 2020.

5.2. Analyzing the Results of Vehicle Speed and Fuel Consumption on Expressway. The vehicle's fuel consumption is directly related to its weight and change in the driving speed. When measuring the fuel consumption of vehicles, a road section similar to the highway, with a distance of 1000 meters, is selected. Ford, Volkswagen, and Toyota will drive back and forth constantly. The fuel consumption of the three vehicles during driving will be calculated. The measured vehicle speed range is 40 to 120 km/h. This measurement is carried out at an interval of 10 km/h. These three models involve most of the vehicles running on the highway. To ensure the measurement data's accuracy and avoid human factors' impact on the data's accuracy, two groups of analysts complete this measurement, respectively, after which the average value of the measurement data will be taken. Through this measurement, we can find the relationship and fundamental law between vehicle speed and fuel

Table 4: Statistical table of highway mileage in China from 2015 to 2020.

Particular year	2015	2016	2017	2018	2019	2020
Highway mileage (10000 km)	12.36	13.2	13.64	14.26	14.96	15.23
Mileage of class highway (10000 km)	404.65	422.66	433.87	446.60	469.88	485.37
Highway mileage/class highway mileage	3.05%	3.12%	3.14%	3.19%	3.18%	3.14%

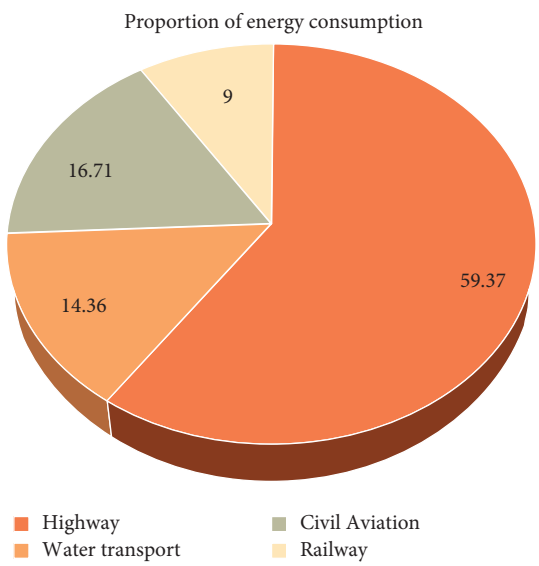

Figure 1: Proportion of energy consumption of different transportation modes in the transportation industry in 2020.

consumption. The speed and fuel consumption of the three brands of vehicles are shown in Figure 2.

According to the graph of three brands of vehicles in Figure 2, there is a direct relationship between the constant speed of vehicles and the fuel consumption per 100 kilometres. The lowest fuel consumption of Toyota cars per 100 kilometres is with a speed of 90 km/h. The fuel consumption per 100 kilometres continues to rise after the vehicle is given acceleration. The displacement of Toyota cars selected in this paper is 4.0 t; therefore, the fuel consumption per 100 kilometres is higher. The lowest fuel consumption of Volkswagen is 6.6 l/100 km, and the corresponding driving speed is 80 km/h. After that, the fuel consumption per 100 kilometres increases slightly. The minimum fuel consumption of Ford Motor is 5.7 l/100 km. When the fuel consumption is the lowest, the vehicle's driving speed is 70 km/h. When the vehicle's going speed increases to 120 km/h, the fuel consumption per 100 kilometres is the highest in this speed range, with a value of 8.5 l/100 km. From this, it can be seen that the vehicle's driving speed directly affects the fuel consumption of the vehicle per 100 kilometres. Through the analysis combined with the carbon emission, the vehicle's carbon emission when driving at a faster speed is low. However, fuel consumption increases when reduced to the lowest value. Therefore, from the perspective of environmental protection, when analyzing the impact of highway vehicle speed on carbon emissions, it can be seen that there is no direct relation between vehicle speed and carbon emissions.

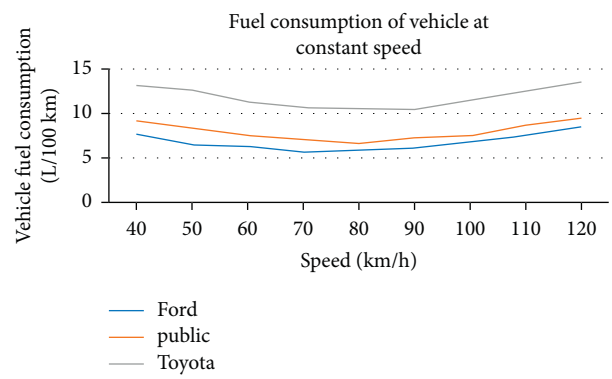

Figure 2: Constant fuel consumption and speed of three brands of vehicles.

5.3. Analysis of Vehicle Speed and Carbon Emission on Expressway. There is a direct relationship between fuel consumption and road traffic conditions during vehicle driving. Generally, changing traffic conditions and road environment will also shift vehicle driving fuel consumption accordingly. The main research section of this paper is the expressway. It features smooth roads, rapid vehicle speeds, and no challenging spots and uses little gasoline. There is a direct link between the vehicle carbon emission coefficient, fuel consumption per 100 kilometres, and carbon emissions, according to formula (3) mentioned above. According to the vehicle carbon emission coefficient and fuel consumption per 100 kilometres, the carbon emissions of highway vehicles at different driving speeds can be calculated. The carbon emission factors of various vehicles are listed in Table 5.

5.3.1. Relation between Vehicle Speed and Carbon Emissions on Sunny Highways. In this paper, by consulting the carbon emission coefficients of three types of vehicles, namely, Ford, Volkswagen, and Toyota, the fuel consumption per 100 kilometres of the three types of vehicles at different speeds on the highway is counted. The instantaneous speed of the data sample is 0–120 km/h, divided according to different vehicle speed ranges. The intervals are (0–20), (20–40), (40–60), (60–80), (80–100), and (100–120), respectively. The fuel consumption per 100 kilometres corresponding to the instantaneous speed in each interval is selected, the data of three vehicles are counted, and to calculate the carbon emissions, it is substituted into formula (4). Due to many reasons for the studied models and vehicle speeds, formula (4) is more accurate. The calculated carbon emission results of three vehicles in different speed ranges on sunny days are drawn as a broken line diagram. It is shown in Figure 2.

According to the abovementioned Figure 3, the carbon emissions of three vehicles, namely, Ford, Volkswagen, and

Table 5: TheCarbon emission coefficient of different models.

Vehicle type	Displacement	Carbon emission coefficient (kg CO_2 e/km)
Large gasoline vehicle	>2.0 L	0.298
Medium-sized gasoline vehicle	1.4–2.0 L	0.208
Small gasoline vehicle	≤1.4 L	0.166

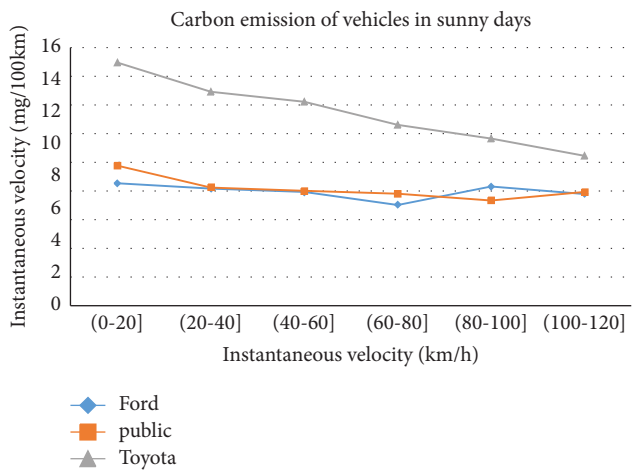

Figure 3: Carbon emissions of three vehicles in different speed ranges on sunny days.

Toyota, are different at different speeds. The broken line shows that the highest speed range of carbon emissions is 0–20 km/h, and the carbon emissions of Ford, Volkswagen, and Toyota are 7.59 mg/1000 km, 8.68 mg/1000 km, and 15.07 mg/1000 km, respectively. With the increase of the vehicle instantaneous speed, the carbon emissions per 100 kilometres of the three vehicles continue to decline. Among them, Ford has the lowest carbon emission in the speed range of 60–80 km/h. It is 6.24 mg/1000 km. The carbon output increases somewhat as the vehicle's instantaneous speed increases, while the instantaneous speed reduces significantly in the range of 100–120 km/h. The carbon emission of Volkswagen is the lowest in the immediate speed range, which is 6.52 mg/1000 km, and the carbon emission of the vehicle grows after 100–120 km/h. After Toyota continues accelerating the vehicle's instantaneous speed, the carbon emission per 100 kilometres continues to decline. When the carbon emission per 100 kilometres is the lowest, the instantaneous speed of the vehicle is 100–120 km/h. Its carbon emission is 9.29 mg/1000 km. Through the above data analysis, it is concluded that the fuel consumption per 100 kilometres and the vehicle carbon emission coefficient directly determine the vehicle carbon emission. Toyota has the highest carbon emission coefficient per 100 kilometres among the three vehicles selected in this paper.

5.3.2. Relation between Vehicle Speed and Carbon Emission of Expressway on Rainy Days. Under the premise of a certain vehicle speed, the weather will also directly affect the carbon

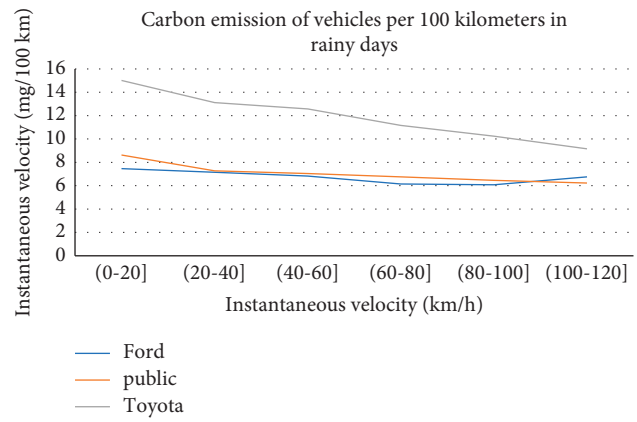

Figure 4: Carbon emissions of three vehicles in different speed ranges on rainy days.

emission during vehicle driving. On rainy days, the road surface is wet and slippery. The driving resistance between the vehicle and the road surface is reduced, and the carbon emission is lower than that on sunny days. At the same time, there is a significant difference between the vehicle driving speed and the speed range with the lowest carbon emission. Here, six vehicle speed ranges 0–20 km/h, 20–40 km/h, 40–60 km/h, 60–80 km/h, 80–100 km/h, and100–120 km/h are selected. The fuel consumption and carbon emission coefficients of three automobiles per 100 kilometres are replaced to compute the associated carbon emissions using the highway vehicle speed and the carbon emission model developed in this research. Figure 4 depicts the carbon emissions of three automobiles travelling 100 kilometres at various speeds on wet days.

Figure 4 shows the carbon emissions of three vehicles at different meteorite speeds on rainy days. According to the broken line chart, the lowest value of carbon emissions per 100 kilometres of Ford, Volkswagen, and Toyota vehicles on rainy days changes the vehicle speed range. The carbon emissions are lower than those on sunny days. Among them, the lowest carbon emission of Ford is 6.07 mg/1000 km when the instantaneous speed of the vehicle is within the range of 80–100 km/h. The carbon emission will increase after the vehicle accelerates. When the carbon emission is the lowest, the instantaneous speed ranges of Volkswagen and Toyota are the same, that is, 00–120 km/h. The corresponding carbon emissions are 6.23 mg/1000 km and 9.15 mg/1000 km, respectively, and the two curves continue to decline. It shows that the speed and weather of highway vehicles directly impact carbon emissions. The most acceptable vehicle speed is also different for different models. Therefore, the highway should integrate various vehicles to set the best speed to reduce carbon emissions and realize low-carbon transportation.

6. Conclusion

This study successfully produced an empirical method for detecting hot spots along roads for gasoline-powered light-duty vehicles of intelligent transportation systems (ITS). To

show insights generated from recorded tailpipe emissions data, the approach was used to sample case studies involving various automobiles and study corridors. The geographical distribution of emissions example research indicated that emissions from a single signalized junction contributed considerably to overall emissions for a certain corridor. Furthermore, emissions during idling were significantly lower than in other driving modes. An empirical approach was utilized in this effort to measure microscale occurrences. Three automobiles that drive mostly on the highway were chosen for testing purposes in order to investigate their influence. These three vehicles involve three kinds of daily vehicle displacement, namely, Ford, Volkswagen, and Toyota. In this paper, the carbon emissions during fuel combustion are calculated based on the default emission factor, the net calorific value of fuel, and the fuel characteristic factor. At the same time, the relationship between vehicle speed and energy consumption is a quadratic parabola. Based on the carbon emissions of energy combustion, the vehicle speed and carbon emissions are calculated. The highway vehicle speed and carbon emissions model are also established. The carbon emission coefficients of Ford, Volkswagen, and Toyota are examined using the highway vehicle speed and the carbon emission model. The fuel consumption per 100 kilometres of various vehicles is computed. The results show that the driving speed of vehicles directly affects the fuel consumption of vehicles. The minimum fuel consumptions per 100 kilometres for Ford, Volkswagen, and Toyota are 5.710.5 l/100 km, 6.610.5 l/100 km, and 10.5 l/100 km, respectively, with the corresponding vehicle driving speeds of 70 km/h, 80 km/h, and 90 km/h, respectively. After continuously accelerating the driving speed, the fuel consumption per 100 kilometres is increased as it is directly proportional to the driving speed of vehicles. The findings of the vehicle fuel consumption per 100 kilometres, the highway vehicle speed, and the carbon emission model are used to examine the highway vehicle speed and carbon emission. The carbon emission coefficients for several emission models are provided.

The data are substituted into the carbon emission model for calculation. The minimum carbon emissions of Ford, Volkswagen, and Toyota in a sunny environment are 6.24 mg/1000 km, 6.52 mg/1000 km, and 9.29 mg/1000 km, respectively. The corresponding speed ranges are 60–80 km/h, 80–120 km/h, and 100–120 km/h. On rainy days, the minimum carbon emissions of Ford, Volkswagen, and Toyota are 6.07 mg/1000 km, 6.23 mg/1000 km, and 9.15 mg/1000 km, respectively. The speed range of Ford was 80–100 km/h, while the speed range of both Volkswagen and Toyota was 100–120 km/h.

Data Availability

Data are available on reasonable request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Artificial Intelligence Evaluation for Mathematics Teaching in Colleges under the Guidance of Wireless Network

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Comprehensively improving the quality of teaching is the highlight of current higher education. Also, it meets the basic needs of China's current transformation into a country for strong education. Mathematics is one of the most important subjects in education these days, which is widely applied in research, social life, and understanding various science theories and laws. Hence, improving the quality of teaching mathematics in colleges becomes an important task in modern college teaching. In particular, the wireless integration of information has enriched and diversified the teaching methods of higher education. Vigorously promoting the application of wireless network technology in mathematics teaching is not only an effective way to solve the insufficient supply of educational resources but also a bold attempt to innovate the mathematics teaching mode in colleges and universities. Firstly, this work proposes an IACO-BP (improved ant colony optimization-based backpropagation) network to evaluate teaching quality for higher level mathematics in a wireless network environment. It improves the traditional ant colony optimization algorithm from three aspects, namely ant colony pheromone adaptive volatility coefficient, pheromone iterative elite selection strategy, and population iteration, adding a variation factor to construct IACO. Then, we use IACO to optimize initial weight and threshold to solve the issue of BP network's falling into local optimum and improve network performance. Secondly, this work puts forward a series of countermeasures for the construction of mathematics teaching system in colleges. The correctness and superiority of the proposed strategy are verified by comparing the mathematics teaching quality in colleges before and after using the proposed strategies. Various aspects of mathematics teaching, such as teaching objectives, teaching content, and teaching process, are evaluated before and after using these strategies. These features are improved by a significant margin, up to 2.6%, after applying the proposed strategies.

1. Introduction

Science and education are the means by which a nation could be revitalized, and the 21st century's competition is a contest of economic might and science and technology. In the end, it is all about the competition of skills, and education is the key to cultivating those talents. Hightech is the key factor to maintain the comprehensive strength and competitiveness of a country. Hightech is essentially a mathematical technology, and the knowledge-based economy is marked by the successful use of mathematics. Therefore, strengthening mathematics education is important for implementing science and education to rejuvenate a country. At present, in addition to its own continuous improvement and development, mathematics also penetrates into other fields and combines with other disciplines to form many marginal disciplines. Therefore, mathematics not only plays a big role in the development of science and technology but also has an irreplaceable role in economic science, environmental science, social science, and even humanities [1–5].

Judging the current mathematics teaching system in colleges, there are relatively prominent issues, which can be summed up in two aspects. Firstly, students do not have a good attitude toward learning mathematics. Because of the deep influence of the current society, students are more inclined to more practical subjects while choosing major subjects. Many of mathematics students at the earlier stages think it has little to do with practical problems. Hence, it is difficult for them to establish a correct learning attitude.

Because there is no good learning attitude as the foundation, some problems have arisen in the development of mathematics teaching. Secondly, in mathematics teaching activities, because of the slow update speed of teaching content and teaching methods, students are prone to fatigue in the process of receiving knowledge, and this fatigue will lead to a further decline in students' interest. In the process of learning, interest and passion play an important role. Low interest and insufficient passion will result in low learning efficiency when comprehensively reflected in mathematics learning. There are two main issues. Firstly, from the perspective of curriculum setting and selection of teaching materials, the classification of mathematics teaching in colleges is not detailed enough, and there are situations where the focus is unclear in specific learning and research. The school's setting of mathematics courses is mainly based on theoretical teaching. Even in the teaching of applied mathematics, the practical curriculum setting is obviously too small, which leads to the inability to carry out mathematics practice effectively [6–10]. In terms of the selection of teaching materials and content of the course, the timely update is insufficient, which makes the teaching content lag. Secondly, in terms of the construction of the teaching team, as the school does not consider the construction of the teaching team, the teaching level of the teachers in the team is uneven. The management problems existing in the mathematics teaching system also influence the teaching quality. Firstly, the teaching sequence is unreasonable. The teaching of mathematics was originally a step-by-step process. However, in the actual teaching process, to complete some teachers' teaching courses, the teaching sequence is often confused, which affects its continuity and breaks the students' learning rules. Secondly, there are unreasonable situations in the arrangement of courses and class hours. In actual mathematics teaching, there should be a certain proportion of theoretical class hours and practical class hours, and their arrangements should be relevant. However, in the current teaching, not only the proportion is chaotic but also the correlation setting is broken, resulting in the chaos of the management of the whole teaching system [11–15].

The wireless integration of information has enriched and diversified the teaching methods of higher education. The combination of wireless network and mathematics teaching has the following advantages: firstly, it has high mobility and flexible teaching time and space. The wireless network has the characteristics of three-dimensional coverage and high mobility. Users can collect and process information at any location and at any time covered by the network. High mobility provides great convenience for education and teaching. Students can easily and quickly collect and utilize information in places with wireless network coverage, such as school teaching buildings and libraries. Teaching and learning are more flexible in time and space. Secondly, the operating cost is low, and the allocation of teaching resources is reasonable and effective. Wireless networks can reduce the need for wiring and related expenses, have a short construction period, and are simple and convenient to upgrade and retrofit with low costs. Colleges and universities vigorously promote the construction of wireless networks, which can reasonably allocate and effectively utilize teaching resources. Thirdly, it is easy to expand and adapt to teaching needs. A wireless network can be competent from a small local area network with only a few users to a large network with thousands of users, and it is easy to expand. Students can make full use of the network signal in the area covered by the wireless network to concentrate or disperse study and discussion. It can effectively alleviate the problems that cannot be solved by the traditional wired network in the construction of the campus network and make up for the insufficiency of the wired network [16–20].

Our work proposes an IACO-BP network to evaluate the teaching quality of mathematics and suggest a number of countermeasures to improve it. The main contributions of our work include the following:

We discuss the importance of and the research status regarding mathematics teaching at college level in detail. Then, we introduce the improved ant colony optimization (IACO) algorithm and propose an IACO-BP network to evaluate the teaching quality in a wireless network environment. The traditional ACO (ant colony optimization) algorithm is improved in a number of ways by introducing pheromone adaptive volatility coefficient (PAVC), pheromones update elite selection (PUES), and population variation factor (PVF) strategies. The IACO algorithm is used to optimize the BP network so that it does not fall into a local optimum. A number of countermeasures are introduced to improve the quality of mathematics teaching, and a number of data features, such as teaching contents and teaching method, are defined to assess the effectiveness of the proposed methodology.

2. Related Work

Gong and Liu [21] analyzed the perspectives, abilities, and experiences of different evaluation subjects and expounded the advantages and disadvantages of each subject in teachers' classroom teaching evaluation. It suggests that colleges and universities should reasonably select the evaluation subject for different evaluation purposes and establish and improve the operation mechanism to improve the effectiveness of teaching evaluation work. Onwuegbuzie et al. [22] pointed out that in the game evolution of the interest demands of stakeholders in evaluation system, the main subjects of evaluation are teachers, students, and teaching administrators. It uses the stakeholder theory as an analytical framework to explain and reveal the problems and related reasons of the student evaluation system. It believes that the participation of stakeholders in the governance model can reflect the governance attributes of the teaching evaluation system and can also express the teaching character that the system should uphold. Spooren et al. [23] clarified the actual role of each evaluation subject in teaching evaluation by empirically analyzing the reality of multisubject teaching evaluation in colleges and difference mechanism of teaching evaluation subject evaluation. It reveals the existing problems and summarizes the characteristics and differences of each subject in the teacher's teaching evaluation. It puts

forward the suggestion of establishing a developmental multisubject teaching evaluation system, and then, it stimulates the internal force of the reform of the teacher evaluation system in colleges. Tsao and Lin [24] proposed that there were many issues, such as backward ideological concept, extensive organization and management, and the dislocation of system orientation in the current colleges and universities, to carry out students' teaching evaluation work. Based on the student-centered concept, it scientifically develops a student evaluation index system, comprehensively improves the management of evaluation organizations, and optimizes the student evaluation system. Bianchini et al. [25] and Boysen et al. [26] use AHP to establish the hierarchical relationship of the evaluation index system for classroom teaching quality. On the basis of hierarchical relationship and weight vector, a more comprehensive evaluation model is established by the fuzzy comprehensive evaluation method for student evaluation, peer teacher evaluation, expert evaluation, and teacher self-evaluation systems.

The analytic hierarchy approach was utilized to calculate the weight of each index, and the fuzzy method was employed to conduct a full evaluation [27]. Finally, the scientificity and operability of the evaluation method are verified by examples. Wines and Lau [28] introduced the cloud model into the field of uncertain linguistic multicriteria decision-making, and the qualitative and quantitative transformation of knowledge and the aggregation of linguistic values were carried out. It establishes a multicriteria group decision-making for uncertain language teaching quality evaluation model for college teachers and builds an evaluation index system based on questionnaire survey and analytic hierarchy process. Smith [29] draws on the student evaluation questionnaire of a certain university and uses the AHP to process and establish the structure of the student evaluation system. A quantitative analysis model based on fuzzy mathematics for students' evaluation of teaching is given. The model is practical and effective, easy to apply, and easy to implement on the computer. Uttl et al. [30] employed the grey system theory technique and created a matching evaluation model with the output of college and university teaching quality. Based on the data from university teachers' evaluations, it also conducts empirical analysis. The empirical data shows that it has good effect, high precision, and wide applicability. Hassad [31] draws on the fourth-generation evaluation theory and total quality management theory to sort out the two-core content of quality assurance in management and evaluation. It puts forward the concept of student-centered teaching quality assurance. According to this concept construction, three characteristics of student-centered teaching quality assurance are obtained. Then, put forward the teaching quality assurance and improvement strategies, such as organizational strategy, goal construction strategy, service support strategy, and evaluation feedback strategy.

Our work contributes to the existing research and puts forward some important countermeasures for the betterment of mathematics teaching at college level. We collect data about the various aspects of mathematics teaching, including teaching method, teaching process, teaching attitude, contents etc., and use the state-of-the-art artificial intelligence algorithm and assess the performance of the proposed approach. We use the improved ant colony optimization algorithm and propose an IACO-BP network to evaluate the teaching quality in a wireless network environment. The traditional ant colony optimization algorithm is improved by introducing a number of strategies to enhance the performance of the deep learning algorithm.

3. Method

Firstly, this work proposes an IACO-BP network to evaluate teaching quality of higher mathematics in a wireless network environment. The traditional ant colony optimization algorithm is improved in the following three aspects: ant colony pheromone adaptive volatility coefficient, pheromone iterative elite selection strategy, and population iteration adding variation factor to construct IACO. The initial weight and threshold of the BP network can be optimized using IACO to avoid the problem of the BP network falling into a local optimum, and hence, the network performance is enhanced. It also proposes a number of solutions to the problem of math education at colleges and universities. The proposed technique's correctness and superiority are demonstrated through a comparison of the quality of mathematics instruction in universities and colleges before and after the implementation of the strategy.

3.1. Backpropagation Algorithm. BP network is a feedforward network, which can use error backpropagation to train its own network. First, there is the the input layer, followed by a hidden layer or many hidden layers, and finally, there is a third-layer output. BP networks typically have a three-layer structure. As long as the number of nodes in the hidden layer is sufficient, the 3-layer BP network may simulate arbitrary complicated nonlinear mappings. The BP structure is demonstrated in Figure 1.

When information from the outside world enters the input layer and is then sent to the next layer, there is no link between any two neurons in that layer. Only the input and output layers can link to the hidden layer, which is located between the input and output layers. Each neuron node can only receive information from the previous layer's input layer and pass it on to the following layer's output layer. Despite the fact that information travels in a forward direction, the weightings and thresholds that connect the various levels might have an impact on the relationship between the input and output. When the hidden layer receives an error, the output layer accepts it and returns it to the previous layer [32, 33].

Supervised learning and unsupervised learning are the two main types of learning algorithms. A set of training sets are sent into the network, and the connection weights are modified based on the difference between the network's actual output and its anticipated output. From the input layer, the neuron is triggered and the neuron activation value propagates through each intermediate layer to the output layer, where the network's final output result can be

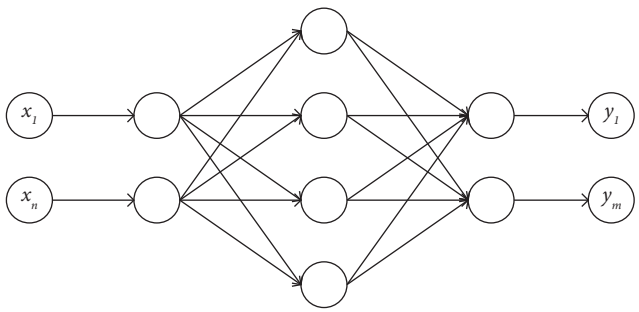

Figure 1: BP structure.

obtained. As a result, each connection weight is rectified layer by layer through each intermediate layer to reduce the mean square error between the expected output and the network output. The error signal can be reduced to a level near to the objective if the process of study and adjustment is repeated over and over. Network training is terminated and data is analyzed using the least mean square error research approach. The output, loss, and reverse update strategy of the BP network are as follows:

$$y_i = f\left(\sum_{i=1}^{N} w_i x_i + b_i\right), Loss = \sum_{i=1}^{N} (y_i - o_i)^2, w' = w - \Delta w, b' = b - \Delta b. \tag{1}$$

There are a number of advantages to backpropagation networks. The first is nonlinearity. When the neurons of the neural network are all nonlinear neurons, the neural network at this time also belongs to the nonlinear neural network. For these nonlinear neurons, the BP network still has a strong mapping ability. The second is the mapping function. After the research and training of the network, the BP network can map the input neuron nodes to the output neuron nodes, which can solve various linear and nonlinear problems well. The third is strong research ability. In the process of neural network training, it can continuously adjust and change the weights and thresholds, so as to continuously study the data in the neural network and get the law between the data to improve the correctness of the neural network.

The BP network also has some disadvantages. The first is that it is easy to get stuck in local minima. The BP network adopts the gradient descent method, and the training process is constantly changing from one point along a slope, and gradually, it tends to the minimum error. The more complex the network, the more its error function will resemble a surface in a multidimensional space, which has a minimum point. Since the surface of the multidimensional space is uneven, when the neural network is trained, it is possible to find a local optimum. The second is the slow convergence rate of the algorithm. The BP network uses the gradient descent method to correct the connection weights, and the calculation process of the gradient descent method is very complicated. With the continuous training of the network, the error that can be reduced by each training in the later stage becomes smaller and smaller. To achieve the predetermined error range, the number of training times of the network will inevitably increase [34]. The BP network can be combined with other algorithms for optimization and improvement, and the ACO algorithm optimizes the prediction model of the BP network to improve the convergence speed of the traditional BP network prediction model, and it can achieve high accuracy. Therefore, in data prediction, the combination of the ACO algorithm and BP network has great advantages [35, 36].

3.2. ACO Algorithm. The ant colony algorithm is inspired by the foraging behavior of ants. To find food, the ants randomly search the area around the nest initially. When they find a food source, if the food is too big, they take part of it and leave a chemical smell as a marker along the way. After a period of transportation, it can be found that the transportation path is getting shorter and shorter, and slowly, this path becomes the shortest path between the ant colony's nest and the food source. When other changes occur in the path, the ants quickly adjust to find the new shortest path. The chemical smell is called a pheromone, which gives the ants a direction, however, the pheromone will slowly evaporate over time. Ants perceive this odor in the environment, and the odor stimulates the ant to respond and subsequently produce new odorants themselves. The new odorant produced guides other individuals in the entire population. Communication and cooperation are carried out through this direct or indirect communication method. This collaborative approach has two notable features. Each individual can modify existing odorants according to environmental conditions by releasing new odorants, and the odorants can only be perceived by individuals with peripheral access.

During the foraging process, when there is no pheromone around the ant or the surrounding pheromone concentration is the same, the direction chosen by the ant is random. When the pheromone concentrations around the ants are different, the ants tend to move forward in the direction of stronger concentration. Ants have poor eyesight and simple behavior, while colonies can find the shortest path between their nest and food in complex terrain. When there is no obstacle between the ant's nest and the food source, the path found by the ants is often close to a straight line, and there will be no curved and redundant routes, which is convenient for the ants to carry the food with the highest efficiency. When obstacles are added to the transport route, if the length of the obstacles is the same length on both sides of the path, the ants will randomly search on both sides of the obstacles. After a period of searching, if the number of ants on both sides is roughly the same, the ants will eventually randomly select a path. If the number of ants on both sides shows a significant difference, the ants will tend to take the path with more ants and higher pheromone content. If the length of the obstacle is not equal on both sides of the path, the ants will choose the path at both ends of the obstacle with equal probability at first. After a period of searching, with the positive feedback mechanism of the ant colony, the longer path takes longer, and the pheromone is more volatilized and less retained. With the passage of time,

pheromone accumulates continuously, increasing the possibility of ants choosing shorter paths. The number of ants on both sides will show a significant difference, and eventually, the ant colony will choose the shortest path to carry food [37].

The core of the ant colony algorithm in path search is mainly reflected in the state probability transition and pheromone update during path selection.

$$p_{ij}^{k} = \frac{[\tau_{ij}]^{\alpha}[\eta_{ij}]^{\beta}}{\sum[\tau_{is}]^{\alpha}[\eta_{is}]^{\beta}}. \tag{2}$$

Over time, as the number of ants increases, the residual pheromones continue to accumulate, resulting in the ineffectiveness of heuristic information. When the ants complete a path optimization, they need to update the pheromone in time.

$$\tau_{ij}(t+n) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij}(t). \tag{3}$$

3.3. IACO-BP Algorithm. The ant colony algorithm has good global optimization ability, and considering that the BP network is prone to fall into extreme values during training, the ACO and BP network are integrated, and the global optimization ability is used to overcome the defects. Pheromone is significant in the process of finding solutions in the ant colony algorithm. The pheromone volatilization coefficient of the ant colony algorithm is constant, however, the volatilization speed is different in the early stage and the later stage [38–41]. Hence, this paper adopts the pheromone adaptive volatilization parameter to replace the fixed value. Every time the ant population is updating the pheromone, the elite retention strategy is adopted, the individuals that meet the standard are retained, and those who do not meet the requirements are not directly discarded. Moreover, this work adds a variation factor and reiterates the cycle.

Firstly, IACO uses a pheromone adaptive volatility coefficient (PAVC) strategy. In the process of using the ant colony algorithm to construct the solution, the idea of constructing the adaptive volatility coefficient is used to determine the weight threshold of the BP neural network. An initial value is given during initialization, and the fixed value is no longer used in subsequent iterations, however, adaptive changes are made at each update iteration.

$$\rho = \rho_{start} * \left(1 - \frac{T}{T_{\max}}\right). \tag{4}$$

If the volatility coefficient is too large, it may directly lead to the appearance of oscillation. If the volatility coefficient is too small, the convergence speed is relatively slow. Hence, an adaptive volatility coefficient is used. In the early stage, the convergence ability can be enhanced, and the larger the volatility coefficient in the later stage, the more the oscillation phenomenon can be avoided.

Secondly, IACO uses pheromones update elite selection (PUES) strategies. When the global pheromone is updated, the population needs to be selected according to the demand, and the individual fitness of the ant colony is judged as the pheromone concentration. If the fitness is greater than the average, the update iteration is continued. For the part smaller than the average value, a variation factor is added to make the new population join the loop, and the iterative optimization continues. The formula for judging fitness is as follows:

$$fitness = \begin{cases} \alpha * fitness, & fitness < P, \\ fitness, & fitness \geq P. \end{cases} \tag{5}$$

Using the elite selection strategy can make the ant system quickly find the optimal solution. If the number of ants is too large, the search will quickly gather near the optimal value, resulting in the premature convergence of the search. Therefore, choosing an appropriate number of elite ants is beneficial to avoid the algorithm falling into extreme values during iteration.

Thirdly, IACO uses a population variation factor (PVF) strategy. For the population with poor calculation results, adding a variation factor to increase the diversity of variables provides more possibilities for finding solutions later.

$$\alpha = 5 * Rand(0, 1). \tag{6}$$

When the ant colony algorithm iterates to the later stage, it is easy to fall into the local extreme value. The main purpose for adding the variation factor is increasing the diversity and provide more possibilities for finding solutions.

The IACO-BP algorithm can be optimized using the IACO algorithm's approach of optimizing the parameters of the BP algorithm. Once IACO has optimized the weights and threshold values, the search for better solutions can begin. The BP algorithm then goes through the process of learning and training under the influence of the optimal value. Its corresponding program flow is demonstrated in Figure 2.

3.4. Countermeasures for Constructing the Mathematics Teaching System. Aiming at the mathematics teaching in colleges under a wireless network environment, this work proposes some countermeasures to construct the mathematics teaching system in colleges.

Firstly, rationally guide and change students' attitudes. In constructing the mathematics teaching system in colleges, it is very important to guide students reasonably to change their learning attitudes. Changing students' attitudes needs to be done from two aspects. First of all, educate and cultivate the importance of mathematics to students. Secondly, in the normal classroom teaching, we should use more examples of solving practical problems with mathematics to analyze and explain, so that students can understand the practical value of mathematics to realize the practical significance of mathematics.

Secondly, make use of the students' subjective nature to pique their interest in studying. Students are the major body of learning in teaching. Hence, it is vital to encourage the main body to exert its force. In teaching, teachers should

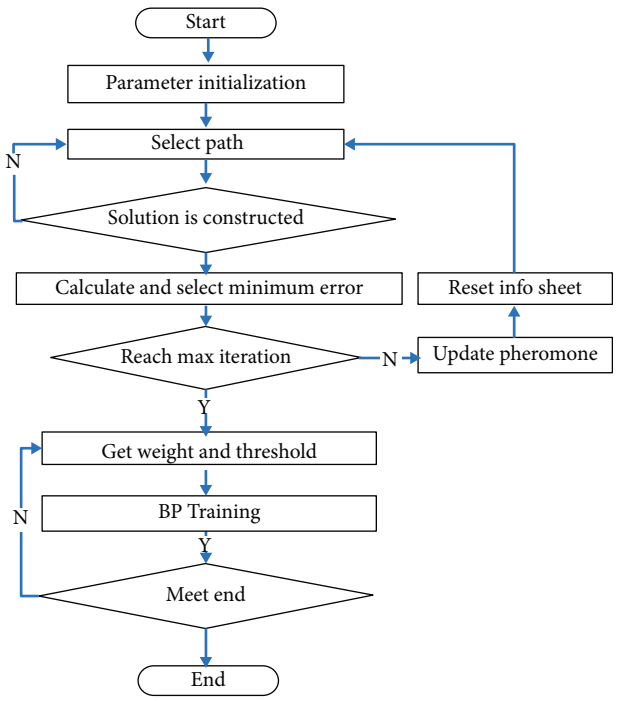

Figure 2: IACO-BP pipeline.

actively reform teaching methods, such as using inquiry-based teaching, multimedia teaching, etc., to encourage students to become the leader of the classroom, and to conduct in-depth discussions on topics to promote understanding of teaching knowledge. Using this method, students' enthusiasm for learning is stimulated, and the classroom atmosphere will also change. In a good atmosphere, the teaching effect will be greatly improved.

Thirdly, improve overall quality of teachers. It is necessary to strengthen the teaching ability of teachers. The strengthening of teaching ability mainly includes professional knowledge reserve, classroom atmosphere mobilization, and classroom on-site control. The reserve of professional knowledge is to lay a solid foundation for a high quality of teaching, and the mobilization and control of classroom atmosphere is mainly to create a good teaching environment. Through the cultivation of scientific research and innovation ability, teachers' research ability can be improved to strengthen the ability to answer students' questions.

Fourth, build a quality assurance system for mathematics practice teaching. In the mathematics teaching system, practicing teaching occupies an important position. Hence, the quality of practice teaching must be guaranteed in teaching. The guarantee of practical teaching quality needs to start with the construction of a complete system, and this system mainly includes three aspects. First of all, it is necessary to establish a perfect research system, i.e., there must be clear requirements for the raising of questions, the collection of data, and the research. Secondly, establish the standardization of the research process. In the process of problem research, there must be professional guidance for the research strategies and methods of different problems to achieve standardization. Finally, establish a sound evaluation standard. To realize the evaluation of the quality of teaching practice, it is necessary to carry out standard construction for each project, and the final quality will be reliable.

4. Experiment

4.1. Analysis on IACO-BP. This work collects relevant mathematics teaching data from colleges to construct the dataset required for IACO-BP training and testing. The data feature distribution of each sample is shown in Table 1, and the corresponding label is the quality of mathematics teaching in colleges under wireless network environment. Precision and recall are evaluation metrics.

Firstly, this work analyzes the training loss of the network because the training of the network is the basis for subsequent testing, and the training loss is demonstrated in Figure 3.

The loss of IACO-BP first gradually decreases with the training of the network, and when the number of iterations reaches 60 epochs, the network converges.

IACO-BP uses PAVC to improve ACO. The volatility rate of pheromone trail is one of the main parameters in the ant colony optimization algorithm and is usually set experimentally for the application of the algorithm. It helps to converge the algorithm to the global optimal solution. To verify the effectiveness of this improvement measure, the performances without PAVC and when PAVC are used are compared, as demonstrated in Figure 4.

After using the PAVC strategy, the precision and recall are improved by 1.6% and 1.8%, respectively, which verifies the superiority of the PAVC strategy.

Another strategy used to enhance the performance of the ACO algorithm is the pheromones update elite selection (PUES) strategy, which increases the pheromone on the edges of the shortest path and accelerates the convergence of the algorithm. To verify the effectiveness of this improvement measure, the performances without PUES and when PUES are used are compared, as demonstrated in Figure 5.

After using the PUES strategy, precision and recall are improved by 1.3% and 1.6%, respectively, which verifies the superiority of the PUES strategy.

IACO-BP uses PVF to improve ACO. To verify the effectiveness of this improvement measure, the performances without PVF and when PVF are used are compared, as demonstrated in Figure 6.

After using the PVF strategy, the precision and recall are improved by 1.1% and 1.2%, respectively, which verifies the superiority of the PVF strategy.

4.2. Analysis on Countermeasures for the Mathematics Teaching System. This work puts forward a series of countermeasures for the construction of mathematics teaching system in colleges under the wireless network environment. To verify the effectiveness of these strategies, the quality for mathematics teaching in colleges is compared before and after using these strategies. The comparison

Table 1: The data feature distribution of each sample.

Index	Feature
x_1	Teaching objective
x_2	Teaching content
x_3	Teaching attitude
x_4	Teaching process
x_5	Teaching method
x_6	Coursework
x_7	Student interest
x_8	Test score

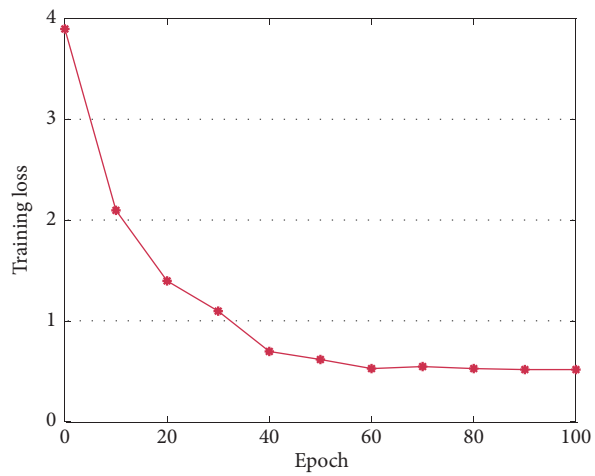

Figure 3: Training loss analysis.

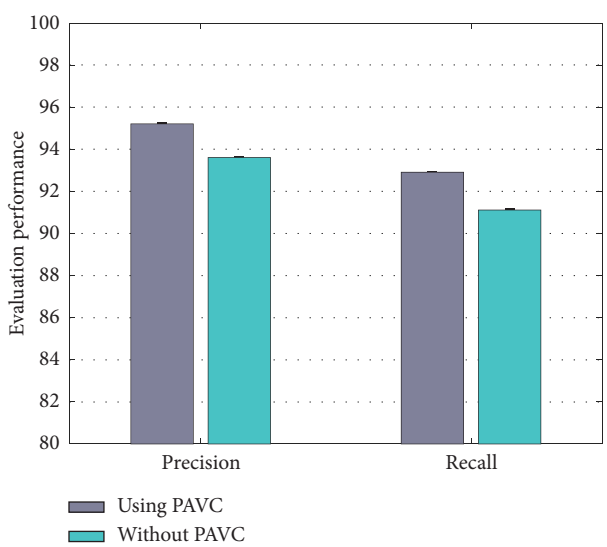

Figure 4: Analysis on PAVC strategy.

indicators are from Table 1, and the comparison results are demonstrated in Table 2.

As demonstrated in the table, after using the countermeasures proposed in this work to build a mathematics teaching system in colleges, the scores of each teaching quality index have been improved significantly. For example,

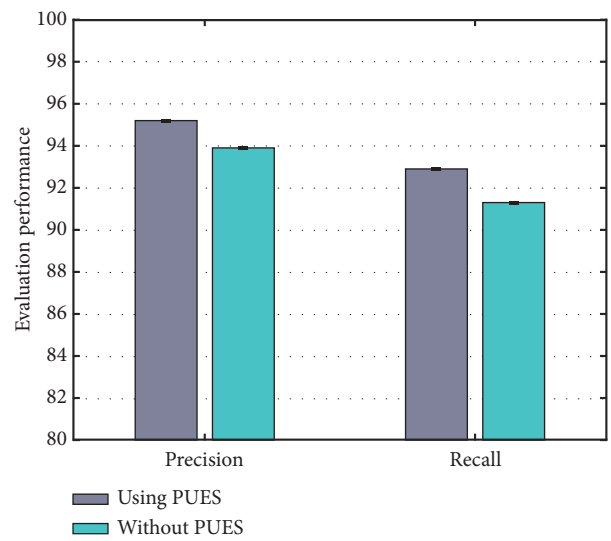

Figure 5: Analysis on PUES strategy.

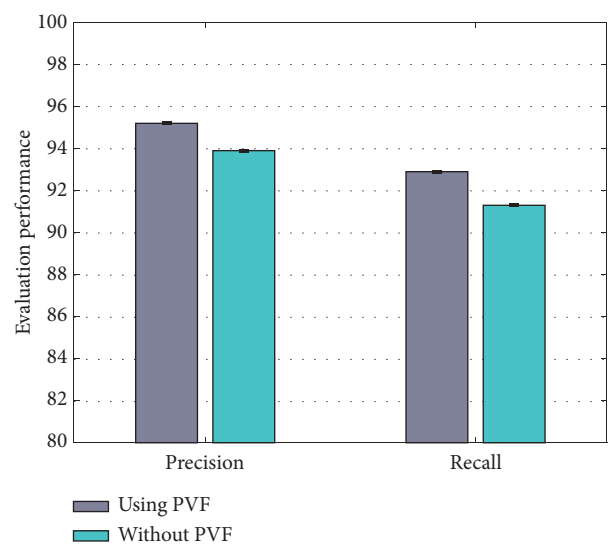

Figure 6: Analysis on PVF strategy.

Table 2: Analysis on countermeasures.

Item	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
Before	89.2	85.7	91.3	90.7	85.9	88.2	92.5	91.1
After	90.4	86.9	93.5	92.1	88.5	90.1	94.3	91.9

the score of teaching method (x5) has been improved by 2.6% and that of teaching attitude is improved by 2.2%. It verifies the feasibility and the effectiveness of the proposed countermeasures.

5. Conclusion

Mathematics teaching in colleges under a wireless network environment is more extensible, autonomous, and flexible than the traditional method of mathematics teaching. To

realize this new learning environment that is learner-centered, cooperative, continuous, and ubiquitous, in addition to seeking the support of software and hardware conditions, it is more important to pay attention to the transformation of teachers and students' teaching. Only when the concept of teaching and learning is updated with development for wireless network, the function and advantage of wireless network in teaching can be truly reflected. The application of wireless network is a great supplement and improvement to the time, space, and usage of wired network. Under this background, it has become an important subject to effectively evaluate the quality of mathematics teaching in colleges under a wireless network environment. Firstly, this work proposes an IACO-BP network to evaluate the teaching quality of higher mathematics in a wireless network environment. The traditional ant colony optimization algorithm is improved by introducing various strategies, including ant colony pheromone adaptive volatility coefficient, pheromone iterative elite selection strategy, and population iteration adding variation factor, to construct IACO. The backpropagation network is easy to fall into local optimum. This issue is resolved using IACO, which optimizes the initial weight and threshold, thus improving the performance. Secondly, this work puts forward a series of countermeasures for the construction of mathematics teaching system in colleges. We collected the relevant data from a number of colleges and constructed a dataset to assess the performance of our approach. We compared the different aspects of teaching quality before and after using the suggested countermeasures. The results verify the correctness and superiority of the proposed strategy.

Data Availability

The datasets used during the current study are available from the author on reasonable request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Research Article

Mobile Geographic Information Service for 4G Terminal

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The mobile geographic information service (GIS) is the key technology to realize mobile navigation. In this study, a transmission method of mobile geographic information services under the 4G terminal grounded on the channel Porter interval equalization algorithm is proposed. The multisensor information collection method of vehicle networking is adopted to realize data collection and data structure characteristics analysis of mobile GIS under the 4G terminal. Subsequently, the transmission channel model of mobile GIS under the 4G terminal is constructed. Furthermore, the interference suppression in the transmission process of mobile GIS under 4G terminals is realized by using an autocorrelation matching filter and an adaptive association rule mining algorithm. According to the symbol feature distribution of the mobile GIS channel under the 4G terminal, the Porter interval equalization approach is implemented to realize the segmented equalization adjustment of mobile GIS. The K-means clustering procedure is also implemented to coordinate the data packet adjustment in the process of mobile geographic information service transmission within the background of a 4G terminal. According to the dynamic distribution characteristics of the clustering center, the mobile geographic information service transmission under the 4G terminal is adaptively controlled to reduce the influence of channel fading and intersymbol interference caused by channel spreading. The simulation outcomes express that the suggested technique has strong anti-jamming ability, reduces the communication error rate, significantly diminishes the end-to-end delay performance, and improves the stability and accuracy of the mobile geographic information service transmission under the 4G terminal.

1. Introduction

Since its birth, geographic information system (GIS), following the pace of the development of the times, has integrated many disciplines and related technologies, combined with traditional science and modern technology. It has been widely used in geographic mapping, environmental assessment, urban planning, regional sustainable development, military applications, government office management and decision-making, and plays a progressively imperative character in the national defense construction and national economy. The 21st century is a new century with high development of informatization, networking, digitalization and intelligence. The places where people use the Internet gradually shift from indoors and offices to outdoors, and from fixed time to anytime and anywhere, which greatly promotes the birth of mobile GIS. The breakthrough of computer and information technology makes all kinds of embedded devices not only cheaper than large electronic devices such as computers, but also occupy a huge advantage in volume and weight, so that users can carry them with them, and their ability to process data is faster and faster, which is just mobile. The emergence and development of embedded intelligent mobile terminals, such as PDA, smart phones, etc., has just become the best choice for mobile GIS. Since its birth, geographic information system (GIS), following the pace of the development of the times, has integrated many disciplines and related technologies, combined with traditional science and modern technology. It has been widely used in geographic mapping, environmental assessment, urban planning, regional sustainable development, military applications, government office management and decision-making, and plays a progressively imperative character in the national defense construction and national economy [1].

The interference suppression and filtering analysis in the transmission process of mobile geographic information service under 4G terminal are carried out by autocorrelation matching filter and adaptive association rule mining device.

Combined with error compensation, the stability and real-time performance of mobile geographic information service transmission under 4G terminal are improved, but the packet reception performance of this method is poor in the strong interference background [2]. The authors in [3] have put forward the control method of mobile geographic information service under 4G terminal with direct sequence spread spectrum. It uses direct sequence spread spectrum transmission method to transmit mobile geographic information service under 4G terminal with spatial multipath channel, which reduces the output bit error rate, but the computational load is high. A control method of mobile geographic information service under 4G terminal is proposed which is based on the autocorrelation matching filter and adaptive association rule mining in [4].

To resolve the aforementioned issues, in this paper we put forward and suggest a transmission approach for mobile geographic information service under the 4G terminal which is grounded on the channel Porter interval equalization algorithm. Firstly, the multi-sensor information collection method of car networking is adopted to realize the data collection and data structure feature analysis of mobile geographic information service under the background of 4G terminal. In the next stage, according to the symbol feature distribution of the mobile geographic information service channel within the background of 4G terminal, the Porter interval equalization method is adopted to realize the segmented equalization adjustment of the mobile geographic information service transmission under the 4G terminal, and adaptive error compensation and channel fading suppression are adopted. Finally, the K-means clustering procedure is implemented to coordinate the data packet adjustment in the process of mobile geographic information service transmission under the 4G terminal. To assess the results, the Matlab simulation investigation approach is implemented to understand the transmission quality of the mobile geographic information service under the 4G terminal, which displays the greater performance of the suggested approach in enhancing the control aptitude of the mobile geographic information service under 4G terminal. The major contributions of our research are as follows:

(i) A transmission method of mobile geographic information service under the 4G terminal which is grounded on the channel Porter interval equalization algorithm is proposed.

(ii) The multi-sensor information collection method of vehicle networking is adopted to realize data collection and data structure characteristics analysis of mobile GIS under the background of4G terminal, and the transmission channel model of mobile GIS under the 4G terminal is constructed.

(iii) The interference suppression in the transmission process of the mobile GIS under the 4G terminal is realized by using the autocorrelation matching filter and the adaptive association rule mining algorithm.

(iv) The K-means clustering procedure is finally implemented to coordinate the data packet adjustment in the process of mobile geographic information service transmission under the 4G terminal.

The rest of the paper is summarized as follows. Channel model and signal analysis of mobile geographic information service under 4G terminal are deliberated in section 2. transmission optimization of mobile geographic information service under 4G terminal is presented in Section 3. The proposed model is also discussed in this section. Experimental results and evaluation of the model is sketched in section 4. summary of the related work is given in section 5. lastly, section 6 summarizes the major outcomes of this study and discuses some future work.

2. Channel Model and Signal Analysis of Mobile Geographic Information Service under 4G Terminal

2.1. The Channel Model. In order to understand the transmission and optimization control of mobile geographic information services under 4G terminal based on channel Porter interval equalization algorithm, the mobile geographic information service channel model under the 4G terminal is constructed by combining the routing protocol control and channel model equalization design of the 4G terminal, and the transmission channel model of the mobile geographic information service under 4G terminal is reorganized by single copy routing algorithm SimBet [5]. Combining the passive time reversal mirror (PTRM) and the BPSK modulation technology, the mobile geographic information service channel model under the 4G terminal is established. According to the attenuation of the transmission bandwidth of mobile geographic information service under the background of 4G terminal in communication network, the weighted vector of the channel and the frequency component of the output signal are obtained. Combined with the convolution operation, the transmission and equalization design of mobile geographic information service under the 4G terminal is realized. The structure model of the data input and output is shown in Figure 1.

According to the structural model of data input and output of mobile geographic information service under 4G terminal shown in Figure 1, the optimal distribution control of time series of mobile geographic information service data under 4G terminal is carried out according to the attenuation of transmission bandwidth of mobile geographic information service under 4G terminal of communication network, and the multi-sensor information collection method of vehicle networking is adopted to realize data collection and data structure characteristic analysis of 4G terminal [6]. Assuming that the mobile geographic information service data signal $p(t)$ under the 4G terminal, the coordinated communication data sequence transmitted by PS after waiting for a period of time is $S(t)$, combined with Wigner-Ville distribution detection, through time reversal, the output processed by the reverse mirror is as follows in (1):

$$p_{ri}(t) = p(t) * h_i(t) + n_{pi}(t). \tag{1}$$

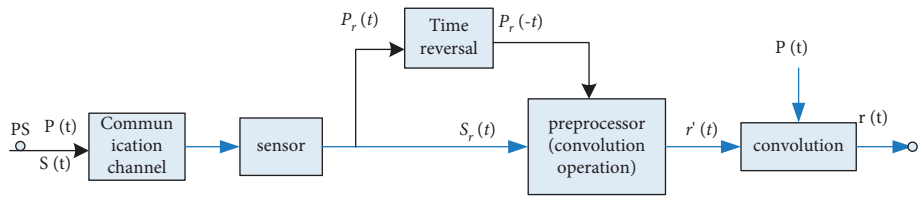

Figure 1: Structure model of data input and output of mobile geographic information service under 4G terminal.

In the above formula, $h_i(t)$ characterizes the attenuation coefficient of response of the impulse characteristic quantity for the mobile geographic information service data under the 4G terminal in the multipath channel. Moreover, the mobile geographic information service transmission channel equalization control under the 4G terminal is carried out on the continuous sliding window to obtain the symbol sequence after the matched filtering processing of the mobile geographic information service data under the 4G terminal. The formula is illustrated in the following (2):

$$S_r(t) = S(t) * h(t) + n_s(t), \tag{2}$$

wherein, $n_s(t)$ is the interference noise on the data collection bandwidth of mobile geographic information service under 4G terminal. After it is processed by pre-processor $P_r(-t)$, the relevant autocorrelation matching filter and adaptive association rule mining output are as follows in (3):

$$S_{ri}(t) = S(t) * h_i'(t) + n_{si}(t), \tag{3}$$

wherein, $h_i'(t)$ is the response function after filtering on $S(t)$, and the bandwidth of mobile geographic information service transmission array element sequence under 4G terminal is estimated using (4):

$$r_i'(t) = S_{ri}(t) * p_{ri}(-t) = S(t) * p(-t) * h_i'(t) * h_i(-t) + n_{1i}(t), \tag{4}$$

wherein, $S(t)$ is the local signal, $S_{ri}(t)$ is the multipath signal, $p_{ri}(-t)$ is the power spectral density, and $r(t)$ is used to characterize the noise component. The signal component in the extended signal of mobile geographic information service under the 4G terminal of spatial multipath channel is approximately the information signal waveform, and the output interference suppression component is given in (5):

$$\begin{aligned} n_{1i}(t) = {} & S(t) * h_i'(t) * n_{pi}(-t) + n_{si}(t) * p(-t) * h_i(-t) \\ & + n_{si}(t) * n_{pi}(-t), \end{aligned} \tag{5}$$

wherein, the variable $n_{pi}(-t)$ characterizes the noise element of the p symbol sequence, and the variable $n_{si}(t)$ exemplifies the noise element of the s symbol sequences. According to the above processing, a transmission channel model for the mobile GIS under the background of 4G terminal is constructed, and the anti-interference design of signal transmission is realized by using the autocorrelation matching filter and the adaptive association rule mining algorithm [7].

2.2. Transmission Signal Analysis. Assuming that the mobile geographic information service under the 4G terminal transmits each node b_i, and the number of pulse frames of the channel impulse response is N_f frames. Furthermore, the time required for the diffusion stage is obtained as $T_{\text{spray}} = \max(t_i)$by using the autocorrelation matching filtering and the adaptive association rule mining. In this way, the extended signal output by the mobile geographic information service data under the 4G terminal is as follows in (6):

$$\begin{aligned} r(t) &= \sum_{i=1}^{M} r_i'(t) * p(t) \\ &= S(t) * p(t) * p(-t) \\ &\quad * \sum_{i=1}^{M} h_i'(t) * h_i(-t) + \sum_{i=1}^{M} n_i(t). \end{aligned} \tag{6}$$

In the above formula, $n_i(t)$ is also the noise interference term of the flower girl in the transmission channel of the mobile geographic information service under the background of 4G terminal: $n_i(t) = n_{1i}(t) * p(t)$, and the forwarding delay depends on the diffusion delay. Therefore, in the transmission process of the mobile geographic information service under the 4G terminal, the fuzzy matching degree function of mobile geographic information service transmission under the 4G terminal is obtained by introducing the fuzzy degree function and adopting the feature clustering algorithm which is given as illustrated in (7):

$$\begin{aligned} H(t) &= \widehat{h}(t) * p(t) * p(-t) \\ &= \left(\sum_{i=1}^{M} h_i'(t) * h_i(-t) \right) * p(t) * p(-t), \end{aligned} \tag{7}$$

wherein, $\widehat{h}(t)$ and $p(t) * p(-t)$ are similar to the impulse response function, $p(t)$ and $p(-t)$ represents the spectrum components of the impulse response signal in the forward and negative sequences respectively, and $*$ is convolution operation. By using the time-frequency analysis method, the signal components of the mobile geographic information service channel under the background of 4G terminal are processed by feature focusing through calculation, and the following results are obtained using (8):

$$|s(f)| = A\sqrt{\frac{1}{2k}}\left\{[c(v_1) + c(v_2)]^2 + [s(v_1) + s(v_2)]^2\right\}, \tag{8}$$

wherein, $A(t)$ is the amplitude of mobile geographic information service signal under the 4G terminal, and f_0 is the initial transmission frequency of mobile geographic information service channel under the 4G terminal. Similarly, $k = B/T$ is the BPSK modulation component of mobile geographic information service under the background of 4G

terminal, and B is the frequency modulation signal bandwidth [8]. This should be noted that the spread spectrum algorithm is adopted to acquire the statistics and other information flow of the output signal in the delay time interval, therefore, subsequently the data clustering algorithm is adopted and implemented in order to obtain the transmission gain of the mobile geographic information service under the 4G terminal as follows in (9):

$$E = \|x(t)\|^2 = \sum_j \sum_k \left|C_j(k)\right|^2 = \sum_j E_j, \tag{9}$$

wherein, $x(t)$ is the time series of mobile geographic information service transmission signal under the background of 4G terminal, $C_j(k)$ is the data delivery delay, and the variable E_j is the amplitude modulation parameter. According to the above channel and signal analysis statistics, conferring to the symbol feature distribution of the mobile geographic information service (GIS) channel under the background of 4G terminal, the Porter interval equalization method is adopted to realize the segmented equalization adjustment of the mobile geographic information service transmission under the 4G terminal.

3. Transmission Optimization of Mobile Geographic Information Service under 4G Terminal

3.1. Mobile Geographic Information Service Transmission Channel Equalization under 4G Terminal. The channel equalization model of mobile geographic information service under 4G terminal is established by adopting adaptive control of link forwarding protocol and Porter interval equalization control [9]. In the process of forward transmission and reverse transmission [10], the time-frequency characteristic components of mobile geographic information service signal received by the receiver under 4G terminal are as follows in (10):

$$s(t) = \cos\left[2\pi f_0 t + \pi\beta t^2 + \psi_0\right], \tag{10}$$

wherein, f_0 and $\psi_0$are the initial frequency and initial phase of the multipath channel of the mobile geographic information service under the 4G terminal, respectively. In the next stage, we estimate the statistical characteristics of the unit to be detected, and construct the spread spectrum distribution model of the mobile geographic information service channel under the 4G terminal. In fact, we obtain the extended bandwidth loss as follows in (11):

$$X' = \sum_{v=1}^{V} b_v X_v, \tag{11}$$

wherein, $\{b_v, v = 1, 2, \ldots, V\}$ is the impulse weighting coefficient of the mobile geographic information service transmission channel under the background of 4G terminal, and $X_v$represents the distance ambiguity parameter. As the propagation attenuation coefficient, the multipath spectrum bandwidth of mobile geographic information service under the 4G terminals is $p(t)$, and the channel equalization control model of mobile geographic information service under multiple 4G terminals in multidimensional road network space is constructed by adopting iterative learning and adaptive control methods [11]. Moreover, the channel equalization adjustment output is as follows in (12):

$$H(z) = Am \cdot \frac{1 + 2z^{-1} + z^{-2}}{\left(1 - \rho e^{j\phi} z^{-1}\right)\left(1 - \rho e^{-j\phi} z^{-1}\right)}, \tag{12}$$

wherein, z is the transfer function of mobile geographic information service under the 4G terminal, A is the amplitude of path loss, and m is intersymbol interference. Using the pole estimation, the mobile geographic information service signal output under the background of 4G terminal located in road network is as follows in (13):

$$x(n) = A\cos(0.3\pi n + \varphi) + v(n), \tag{13}$$

wherein, φ is the output extension phase of the mobile geographic information service under the 4G terminal, and $v(n)$ is the intersymbol interference caused by path extension. By introducing the multi-scale characteristics of channel transmission, combined with man-machine interaction control, the transmission control and adaptive adjustment of mobile geographic information service under the background of 4G terminal are carried out.

3.2. Data Clustering and Transmission Optimization of Mobile Geographic Information Service under 4G Terminal. Adaptive error compensation and channel fading suppression are adopted, and the data packet coordination adjustment in the transmission process of mobile geographic information service under the 4G terminal is carried out through K-means clustering algorithm. According to the attenuation of the transmission bandwidth of mobile geographic information service under the 4G terminal of communication network, the optimal distribution interval sampling of data time series of mobile geographic information service under 4G terminal is carried out [2], and the clustering function is as given in (14):

$$s(t) = \sum_i b_j \sum_{j=0}^{N_f - 1} p\left(t - iT_s - jT_f - c_j T_c\right), \tag{14}$$

wherein, b_j is the interference item of mobile geographic information service data under 4G terminal, T_s is the time sampling interval, and c_j is the transmission bandwidth of mobile geographic information service under 4G terminal. Moreover, it is assumed that the similarity of mobile geographic information service data under the 4G terminal is $h(n)$, the nonlinear equilibrium parameter of mobile geographic information service under terminal is $n(n)$, the time domain loss is $\tilde{x}(n)$, and the intersymbol interference is $y(n)$. Under the limited symbol rate, the channel is overlapped by convolution, and the K-means clustering of mobile geographic information service data under terminal, as shown in Figure 2, is adopted [12].

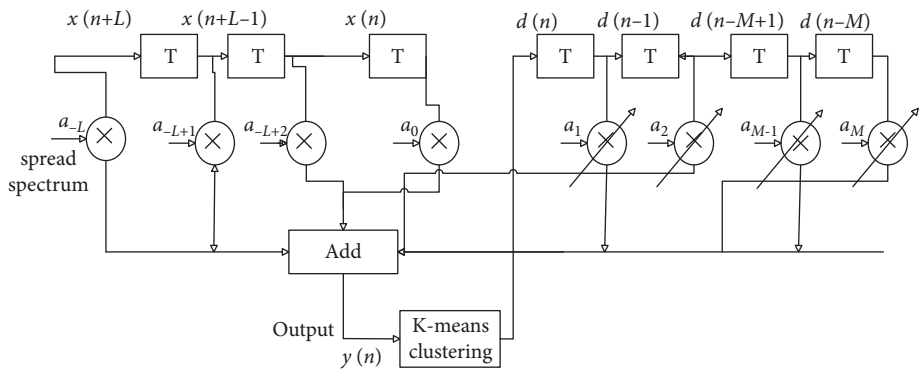

Figure 2: The K-means clustering of data.

According to the clustering result of mobile geographic information service data under the 4G terminal in Figure 2 as the output, the spectral components of communication data output are as follows in (15):

$$\begin{aligned} S(n_j) &= (E_{elec} + E_{DF})l\delta + E_{Tx(l,d_j)} \\ &= l\delta + lE_{elec} + l\varepsilon_{fs}d_j^2 \\ &= \left[(E_{elec} + E_{DF})\delta + E_{elec} + \varepsilon_{fs}d_j^2\right]l, \end{aligned} \tag{15}$$

wherein, E_{elec} is that superposition component of mobile geographic information service in 4G terminal at the identical period and in the matching phase. Furthermore, E_{DF} is the attenuation loss of multipath extension of mobile geographic information service in 4G terminal. Note that the variable $E_{Tx(l,d_j)}$ is the channel impulse characteristic quantity of mobile geographic information service transmission in the 4G terminal, ε_{fs}s the frequency spectrum parameter, l is the fuzzy information sequence, and d_j is the multipath component of probe signal. In the subsequent phases, we adjust the tap coefficient of mobile geographic information service transmission system in the 4G terminal, and the blind equalization method is adopted to suppress interference. Similarly, the adaptive control of mobile geographic information service transmission under the background of 4G terminal is carried out according to the dynamic distribution characteristics of the cluster centers, so as to reduce the channel fading and intersymbol interference which is potentially caused by the channel spread spectrum.

4. Simulation Experiment

In the experiment, the mobile geographic information output platform is built on the vehicle networking platform, and the moving vehicle navigation is used as the mobile geographic information service object. The vehicle driving cluster is kept at 24~100 m, and the speed on the line is 120 km/h. The RFID technology is used as the sensor in the motorcade, and 100 receiving array elements are set to form the array transmission array of mobile geographic information service under 4G terminal. The independent variable of mobile geographic information service transmission under 4G terminal indicates the distance between two nodes in the link establishment time, and the vehicle transmission

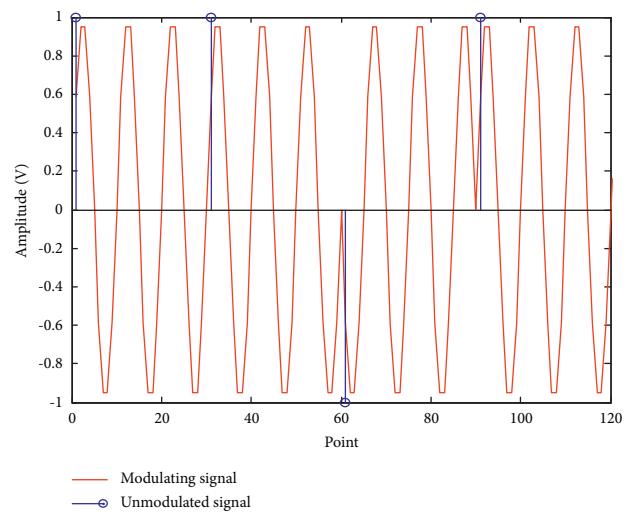

Figure 3: Distribution of transmission elements of mobile geographic information service under 4G terminal.

is divided into The symbol transmission rate of mobile geographic information service under 4G terminal is set to 1 kBaud, the maximum delay of mobile geographic information service transmission under 4G terminal is set to 25 ms, the symbol distance is 100 m, the waiting time of mobile geographic information service data under 4G terminal is fixed at 10 dB, and the number of snapshots is changed from 200 to 2000. Rendering to the aforementioned simulation setting and parameter sceneries, the optimization simulation analysis of mobile geographic information service transmission under 4G terminal is carried out, and the results are as follows.

According to the array element distribution, as given away in Figure 3, the transmission model of the mobile geographic information service signal under the background of 4G terminal is constructed, and the output time series of mobile geographic information service data under the 4G terminal is obtained by taking the input signal-to-noise ratio of −10 dB, −5 dB and 0 dB, respectively, as exposed in Figure 4.

This should be noted that taking the output time series of the mobile geographic information service data under the background of 4G terminal shown in Figure 4 as a sample, cluster the mobile geographic information service data under 4G terminal, and get the clustering results as shown in Figure 5.

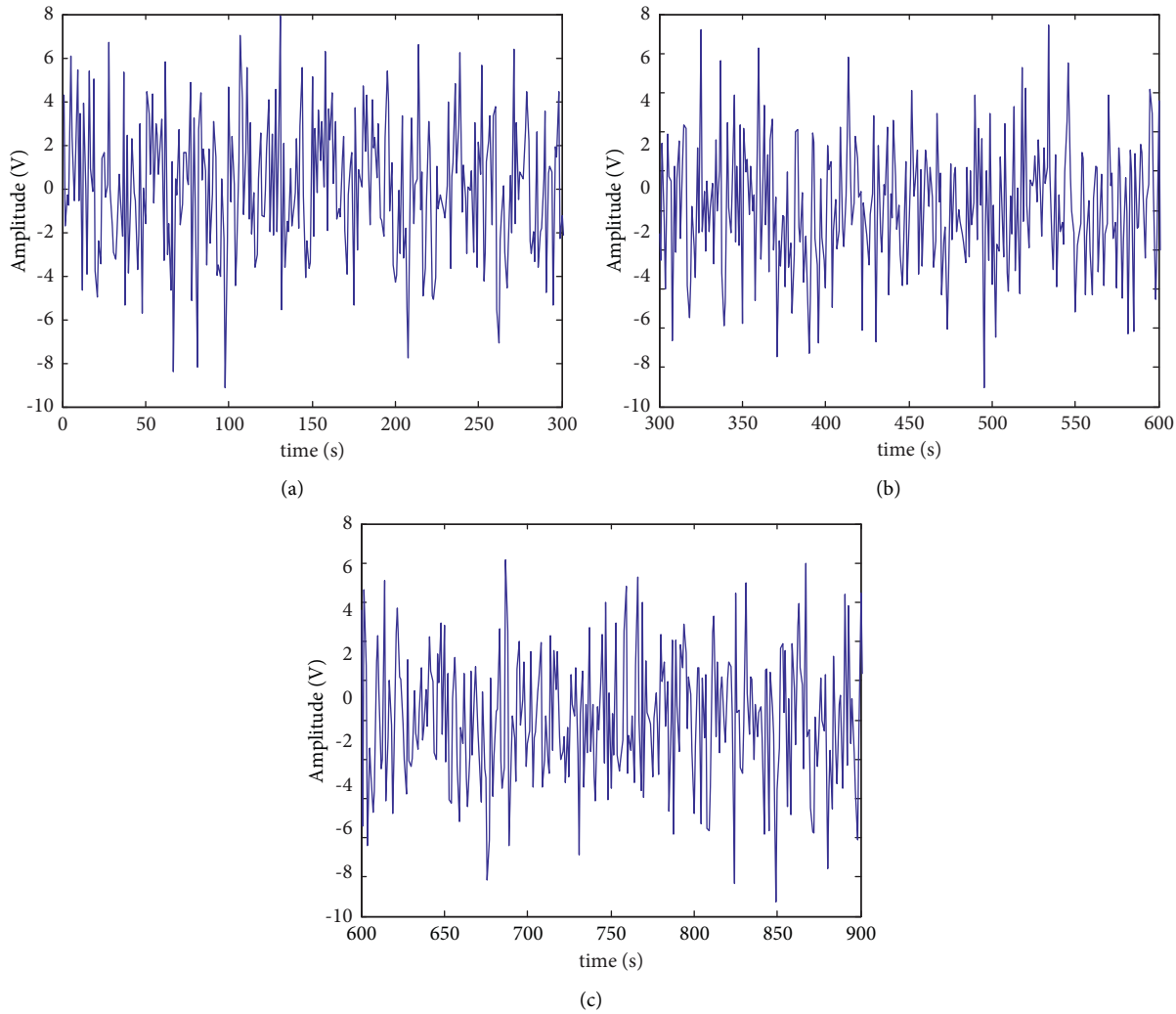

Figure 4: Output time series of the mobile geographic information service (GIS) data under the background of 4G terminal. (a) Transmission data sample 1 (SNR = 0 dB), (b) Transmission data sample 2 (SNR = −5 dB), (c) Transmission data sample 3 (SNR = −10 dB).

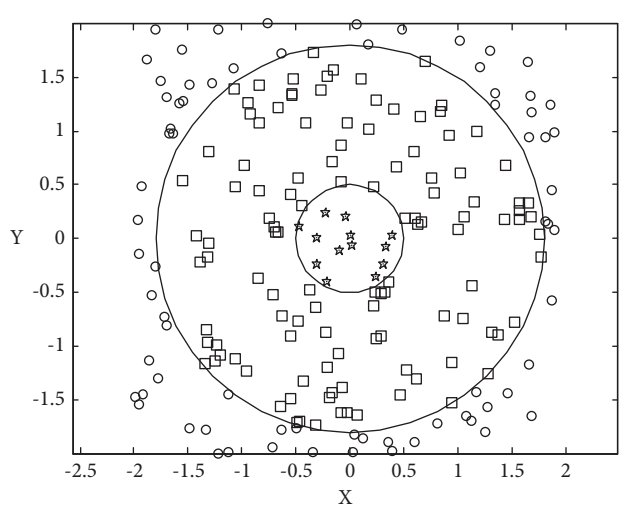

Figure 5: The 4G data clustering technique and attained results.

According to the analysis of outcomes given in Figure 5, the clustering of mobile geographic information service transmission under the 4G terminal is good, and the segmentation detection ability is enough strong. On this basis, the mobile geographic information service transmission under the 4G terminal is realized, and the speed and bit error rate of mobile geographic information service transmission under the 4G terminal are tested, and the comparison outcomes are given away in Figures 6 and 7, respectively. Through investigating the outcomes of Figures 6 and 7, it is found and easily comprehended that the anti-jamming ability of mobile geographic information service transmission under the 4G terminal is enough strong. The communication error rate is reduced, the end-to-end delay performance is reduced, the rate is high, and the stability and accuracy of mobile geographic information service transmission under 4G terminal are improved.

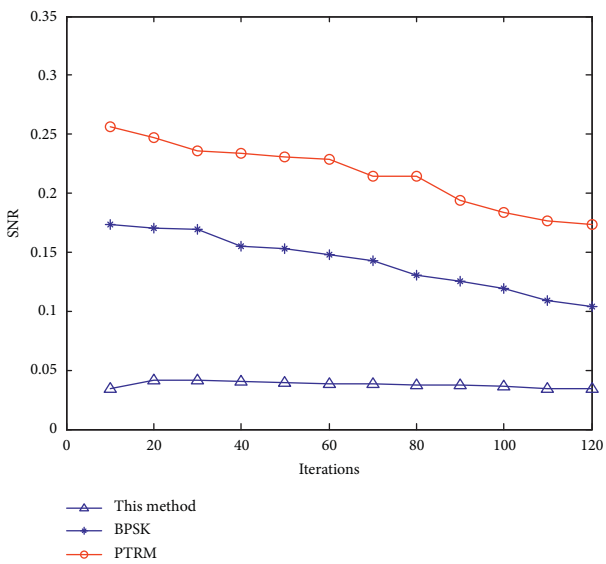

Figure 6: The error rate comparison of various approaches.

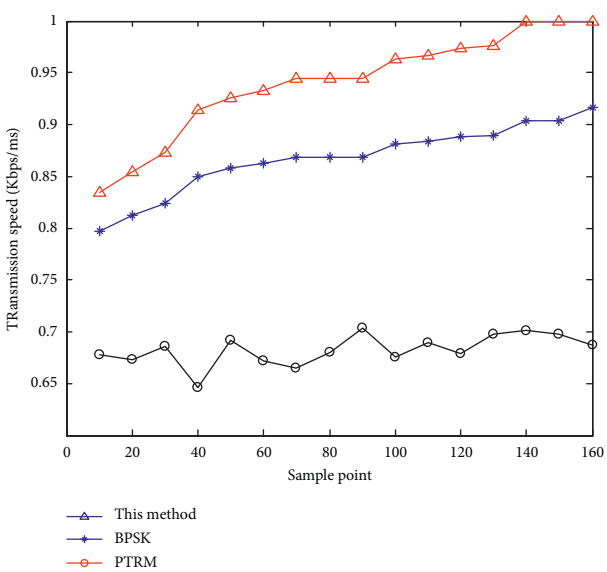

Figure 7: Comparison of the transmission rates of mobile geographic information service (GIS) under the background of 4G terminal.

5. Related Work

The 21st century is a new century with high development of informatization, networking, digitalization and intelligence. The places where people use the Internet gradually shift from indoors and offices to outdoors, and from fixed time to anytime and anywhere, which greatly promotes the birth of mobile GIS [13]. The breakthrough of computer and information technology makes all kinds of embedded devices cheaper than large electronic devices such as computers, and they have a huge advantage in volume and weight, so that users can carry them with them, and their ability to process data is faster and faster. The emergence and development of embedded intelligent mobile terminals, such as PDA, smart phones, etc., has just become the best choice for mobile GIS [14–16].

People attach great importance to the research on the security and stability of mobile geographic information service transmission under 4G terminal. Combining with the channel balance control of mobile GIS within the background of 4G terminal, the mobile GIS transmission method under the 4G terminal with high stability and strong anti-interference is adopted to realize the optimal control of mobile geographic information service under the 4G terminal and improve the cooperative control ability of mobile geographic information service transmission under 4G terminal. It is of prodigious importance to study the transmission technique of the mobile geographic information service under the 4G terminal in the design of Mobile Ad hoc NETwork (MANET) for vehicle-road collaborative control and vehicle networking [17]. This should be noted that the transmission of mobile geographic information service under 4G terminal is characterized by no stationarity and multipath, which leads to intersymbol interference and multipath, and the output stability is not good [12].

On the basis of the above assumptions and investigations, we believe that it is necessary and essential to design and suggest a transmission control model for mobile geographic information service under the background of 4G terminal, and improve the transmission stability of mobile geographic information service under 4G terminal by combining channel equalization adjustment. At present, the transmission methods of mobile geographic information service under 4G terminal mainly include transmission control method of mobile geographic information service under 4G terminal based on orthogonal frequency division multiplexing, BPSK modulation method, and PSK modulation method, etc. [18]. Through time-frequency feature analysis and equalization control, the transmission control of mobile geographic information service under 4G terminal is realized. In [19], the authors have put forward a method of mobile geographic information service and interference suppression under 4G terminal based on PTS-Clipping algorithm. In fact, the suggested method adopts piecewise fitting control method to design channel balance and suppress intersymbol interference during the transmission of mobile geographic information service under the 4G terminal, which improves the output signal-to-noise ratio and reduces intersymbol interference. However, the stability and real-time performance of mobile geographic information service transmission under 4G terminal with this method are not good.

In [3], the researchers have suggested and put forward the control method of mobile geographic information service under the background of 4G terminal with direct sequence spread spectrum. The suggested method uses direct sequence spread spectrum transmission method to transmit mobile geographic information service under 4G terminal with spatial multipath channel, which reduces the output bit error rate, but the computational load is high. A control method of mobile geographic information service under 4G terminal is proposed based on autocorrelation matching filter and adaptive association rule mining in [4]. The interference suppression and filtering analysis in the transmission process of mobile geographic information service under the 4G terminal are carried out by autocorrelation matching filter

and adaptive association rule mining device. Combined with error compensation, the stability and real-time performance of mobile geographic information service transmission under the 4G terminal are improved, but the packet reception performance of this anticipated technique is significantly poor in the strong interference background [2, 20].

6. Conclusions and Future Research

In this paper, a transmission control model of mobile geographic information service under the 4G terminal is designed, and the stability of mobile geographic information service transmission under the 4G terminal is improved by combining channel equalization adjustment. This paper proposes a transmission method of mobile geographic information service under the 4G terminal which is grounded on the channel Porter interval equalization algorithm. The single copy routing algorithm (SimBet) is used to reconstruct the transmission channel model of mobile geographic information service (GIS) under the 4G terminal, and the transmission channel model of mobile geographic information service under the background of 4G terminal is constructed. Moreover, the autocorrelation matching filter and the adaptive association rule mining procedures are implemented in combination to further comprehend and understand the anti-interference design of the signal transmission.

According to the symbol characteristic distribution of the mobile geographic information service channel under the background of 4G terminal, this paper adopts: (i) the Porter interval equalization approach in order to realize the segmented equalization control of mobile geographic information service transmission under the 4G terminal, (ii) designs a channel equalization model, (iii) uses the K-means data clustering procedure to cluster mobile geographic information service data under the 4G terminal, and (iv) samples the optimal distribution interval of mobile geographic information service data time series under the 4G terminal. In fact, the distribution interval is made according to the attenuation of mobile geographic information service (GIS) transmission bandwidth under the 4G terminal in communication network, so as to improve the transmission stability of the mobile geographic information service under 4G terminal. The test shows that the suggested approach has high transmission rate, good stability and low bit error rate for mobile geographic information service under the 4G terminal. In the future, we will consider machine learning approaches to increase the learning capability of the suggested approach. Also, we will investigate the use of cloud and edge computing concepts to enhance the transmission rate and reduce the bit error rate.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors Declares that The authors have no conflict of interest.

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Research Article

Tchaikovsky Music Recommendation Algorithm Based on Deep Learning

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In recent years, digital music is becoming more and more popular as mobile Internet and streaming media technology advance. Traditional music indexing technology mainly uses keywords to query. To find their favorite music, people must search through the vast amount of music available on the Internet nowadays, much like hunting for a needle in a haystack. In the era of mobile Internet, people's pace of life is very fast. Devices can access the network anytime and anywhere. Users have the habit of listening to music in their daily work, study, or sports. Facing the vast music library, personalized music recommendation can help users quickly and accurately find music tracks that meet their interests, which is also the focus of current music recommendation technology. According to the characteristics of Tchaikovsky music, in this paper, we establish and build an approach that can understand situations and recommend by using the additional information of labels to describe Tchaikovsky music and realize a structure on this foundation. Through user involvement, the system can deliver services akin to network radio and complete the evaluation of the Tchaikovsky music recommendation algorithm's efficacy.

1. Introduction

Today is an era of vigorous development of the Internet, but it is also an era of information overload. People's lives are increasingly inseparable from the Internet. However, in the face of massive Internet information, manual screening has also become a problem. Recommendation system plays an important role in the process of finding useful information. At present, it has been widely used in e-commerce, social networks, multimedia entertainment, information portal, mobile location services, and other fields. Music is also very suitable as a recommended item. On the one hand, due to the massive amount of digital music and the overload caused by the rapid growth trend, on the other hand, because users sometimes do not listen to specific songs, they just want to find a kind of music that conforms to the mood and environment at that time or just want to meet the novelty and find new songs that conform to their preferences. According to the 2013 China online music market annual report, the online music market revenue reached 7.41 billion yuan, an increase of 63.2% over 2012. Among them, online music revenue accounted for nearly 60%, an increase of 140% over 2012. The number of online music users increased to 450 million, with a growth rate of 4.6% [1]. Because the Internet has become the source and marketing channel of diversified digital music, which enables people to access more music. Using search engine to search the music you want to listen to is extremely time-consuming, and user preferences will change with the situation. This dynamic factor must be considered when providing music services.

Nowadays, there are two kinds of Internet music platforms. One is online on-demand service platforms, such as QQ music, baidu music, shrimp music. The homogenization of this kind of products has been very serious, and the copyright cost of entering the industry is extremely high. The second is the radio music service platform. The biggest feature of this kind of products is to make full use of the recommendation algorithm to make customized and disorderly recommendations to users. However, people's demand for music will change very suddenly with the change of mood or environment, and the means of description is very ambiguous. Because there are few people who specialize in music, most people can only express their music through piecemeal descriptions. These have led to a more profound

thinking: in the past ten years of the development of Internet music, although the sound quality is higher, the transmission rate is faster, and the interaction is more friendly, the improvement of service quality in the music field is not obvious.

North and Hargreaves pointed out that users' living conditions will affect their music preferences, but most studies on music recommendation systems focus on analyzing the attributes of music itself, users' historical data, and users' basic information, and there are few studies on contacting users' environment and state [2]. Pandora researchers pointed out at the RESYS conference that music recommendation has the following 11 characteristics: large space for items, low consumption cost, rich types of items, less time spent listening to a song, high reuse rate of items, high user enthusiasm, context related, orderly, many playlist resources, no need for user concentration, and high socialization [3]. Another study shows that there is an increasing demand for additional information in music retrieval, mainly to improve the quality of situational music retrieval [4]. Therefore, the music recommendation system with context awareness can enable users to obtain more personalized recommendation services on the growing digital music service platform.

Most of the music recommendation systems are based on collaborative filtering or content-based recommendation methods, and many improvements are based on these two methods. For example, last FM music network radio uses user tags to cluster users and then recommend them, optimizing the collaborative filtering algorithm [5]. Pandora's classification of music is mainly based on the music genome created by a group of musicians and engineers, which assists in the calculation of similarity between music and optimizes the collaborative filtering algorithm [6]. Domestic emerging music network radio stations such as Douban also imitate last FM tag system to achieve the recommended [7]. Furthermore, more websites of this kind of music service generally only use simple classification according to artists and types and user statistics to realize simple recommendation. This paper mainly has the following contributions and completes the subsequent work:

(1) The context aware music recommendation system based on neural network hybrid algorithm of deep learning is designed and implemented in three modules. The system is composed of data module that provides basic data model for deep learning, its core part hybrid algorithm module, and user interaction module using MVC architecture.

(2) The experimental scheme is designed in terms of performance, as well as, function tests. The effectiveness of the algorithm based on the deep learning approach and the influence of the scheme recommendation grounded on this procedure are verified. The outcomes have indications that the recommendation system deliberated with the scheme based on deep learning, in this paper, has a certain improvement in recommendation quality.

The remaining paper is arranged as follows. A summary of the associated works and state-of-the-art literature is provided in Section 2. In Section 3, a hybrid recommendation algorithm of Tchaikovsky piano music which is, in fact, grounded over the collaborative filtering approach and case-based reasoning is presented. In Section 4, system test and outcomes assessment are discussed. Lastly, Section 5 concludes this article along with several directions for the future research.

2. Related Work

Last FM and Pandora have started to apply the recommendation system, and the pace of music recommendation research abroad has not stopped. Baccigalupoclaudio and Plaza Enric believed that sometimes what is recommended is not just a song, but a group of carefully selected song lists. Therefore, they used case-based reasoning technology to design a system that can recommend meaningful song lists, emphasizing the relationship between songs, so as to improve the overall satisfaction of users with the output results [8]. Using social network tags, Kaminskasmarius and Riccifrancesco designed a service platform that can recommend music according to places of interest, verifying the relevance between user preferences and location [9]. Lampropoulosaristomenis and others have cascaded collaborative filtering and content-based recommendation algorithms and implemented a recommendation system to obtain corresponding recommendations by uploading music files on the mobile service platform [10]. Liqing et al. used the probability model to consider the user score as Gaussian distribution, grouped the music, and then made recommendations through collaborative filtering, which effectively alleviated the problems of nonrelevance, user bias, and cold start [11].

Dmitrybogdanov et al. obtained the user model by semantic modeling of audio content and showed user preferences explicitly to facilitate users to evaluate more intuitively [12]. Domestic research on recommendation system started late, especially in the digital music service platform, which is basically imitating some methods of foreign mainstream websites. But in academic research, there are also some new ideas. Li Ruimin and others used three methods to extract music features, establish music genome, model users' singer, region, and music feature preferences, and finally realize music recommendation in mobile applications in combination with neighbor nodes [13]. Zhang Yan et al. proposed a new method to describe music features, which simplified the original feature matrix into feature vectors, improving the efficiency of the recommendation algorithm [14]. Kongxu et al. extracted the characteristic values from the sound spectrum, converted the music into the characteristic matrix, and returned the list of the most similar n music components for recommendation by calculating the similarity between the retrieved music and the music in the database [15].

For the recommendation of situational awareness, Parkhan SAEM used fuzzy Bayesian network and utility theory to model situational information, then made corresponding recommendations, and proved the usefulness of

this method through actual situation tests [16]. LEEJIN-CHUN and LEEJAESIK combined pervasive data mining and case-based reasoning methods to implement a recommendation system for music recommendation based on context (mainly considering the time factor here), which improves the personalized service of mobile platforms [17]. Baltrunaslinas et al. took traffic conditions and driver's status as situational information and used matrix decomposition method to model, which improved the personalization of on-board mobile music recommendation [18]. Haririnegar and others used communal dockets and identifiers in order to categorize the music topics and mine the current user's situational information from music topics through playback sequences, so as to optimize the recommendation list [19].

3. Hybrid Recommendation Algorithm of Tchaikovsky Piano Music Based on Collaborative Filtering and Case-Based Reasoning

3.1. Algorithm Analysis. The algorithm design idea proposed by Chedrawy et al. is shown in Figure 1. In this way, we can not only make use of historical records to recommend, but also guide the selection of items according to the current situation of active users. In the first stage, we first use collaborative filtering based on items to calculate the similarity and list the top n items that are consistent with the user's taste. As long as the user has evaluated at least one item, a certain output can be obtained; that is, first of all, the impact of the user's cold start problem is reduced. In the second stage, feature-based information selection method is used to extract finer grained solutions (i.e., recommendation results) from the n items screened by collaborative filtering [20]. The recombined output not only considers the user's initial preference model, but also imitates the customer's current concentration in items with certain attributes, so the recommendation is more focused.

This scheme is designed according to the idea of cascade mixing. The following discusses the specific process of hybrid recommendation algorithm design. First, we use the user item scoring data to calculate the similarity between items. The measurement method has been introduced above. Considering that the article has attributes, we need to extend the similarity to each attribute item of the article and use sim (q_i, q_j) to represent the similarity between q_i and q_j under attribute t. Each user also shows different preferences for different attributes, expressed by weight wt. In this way, the user model not only has a scoring vector $(r_{p_i,q1} r_{p_i,q2}, \ldots)$ that indicates the degree of preference for items, but also includes the tendency for each attribute $(w_{t_1}, w_{t_2}, \ldots)$. The actual similarity of items considering attributes is calculated by formula (1), where t is the attribute set selected by the user in a search [21].

The actual similarity of items is calculated by formula (1), where t exemplifies the set of attributes nominated by the customer in a search.

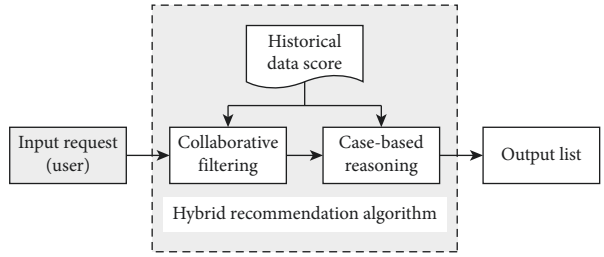

Figure 1: The algorithm design idea.

$$\operatorname{sim}\left(q_i, q_j\right) = \frac{\sum_{t \in T} w_t \cdot \operatorname{sim}_t\left(q_i, q_j\right)}{\sum_{t \in T} w_t}. \tag{1}$$

Then, in the collaborative filtering stage based on items, Top-N items will be selected rendering to the customer's preference model and the calculated resemblance of items [22]. The numerous screening steps are as follows:

(1) Find the item set Q_i that the user p_i has scored

(2) Find the K objects that are most comparable to each item in Q_i

(3) These items constitute set s

(4) Remove the items whose p_i has been scored from s

(5) Calculate the similarity between each item q_j in S and the set Q_i by weighted summation of the similarity between q_j and all items scored by the user p_i, and the weight is the scoring value

(6) Sort by the similarity between each item in s and Q_i, and output the top n items

Next, take this Top-N item as the retrieved case, and adjust the composition structure through the case-based reasoning stage. The adjustment process is to decompose the solutions of multiple groups of cases and then synthesize a composite explanation to better encounter the requirements of current active users. The decomposition process is mainly grounded on the evidence object of the issue, which is matched accurately by segments, so that each subsolution in the final solution can correspond to the customer's inclinations on each specific attribute [23]. The adjustment strategy is based on two points: (1) the first is the frequency of a subsolution in similar cases and (2) the second is the relevance between user information and cases. The steps to form a composite solution are as follows:

(1) Calculate the distance $Distc_i$ between the retrieved case c_i (i.e., items) and the user request (described as user preferences and ratings), which has been calculated in the screening step (5) of the collaborative filtering stage (i.e., the similarity between the case/item and the user's rated set)

(2) Use formula (2) to calculate the normalized distance $NDistc_i$ of case c_i under the whole search set c.

$$\mathrm{N\,di\,st}_{c_i} = \frac{1}{\mathrm{di\,st}_{c_i} \cdot \sum_{c_i \in C}\left(1/\mathrm{di\,st}_{c_i}\right)}. \tag{2}$$

(3) Determine the applicability of each subsolution. Comp is used to represent the subsolution that constitutes the initial solution, and ADComp is used to represent the applicability of the subsolution. The way to calculate ADComp is as follows: for the set c∗ that comp has appeared in the solution of case c_i, we have

$$AD_{\text{Comp}} = \sum_{c_i \in C^*} N\text{dist}_{c_i}. \quad (3)$$

(4) Integrate the subsolution comp that reaches the predetermined threshold of ADComp into the final solution. If the final solution meets the needs of users, then the new case will be saved to the original case database. Finally, after the two-stage calculation, the recommended solution not only considers the user's overall preference model, but also reflects the current user's interests.

3.2. Deep Learning Algorithm Complexity Analysis and Optimization. In the deep learning collaborative filtering stage, similarity calculation is the most time-consuming process, so the algorithm complexity of this process is mainly analyzed. Assuming that the magnitude of the scoring matrix is denoted as m∗n, where the number of users is m and the quantity of items is n, the complexity of calculating the similarity matrix of items is O(m∗n∗n∗d), and d is the data sparsity. As soon as the number of items is large, then the similarity between various items is basically $O(n^2)$. Then, the process of calculating the prediction score and listing the first n items for each user basically only needs o (m∗logn), so the efficiency of the first stage mainly depends on the similarity calculation. In the second stage, because the similarity of items calculated in the first stage is used, this part of time is saved. The main calculation focuses on the matching process between tags and tag clusters. There are K clusters, each cluster has t labels, and N' is the component numeral figure of the label vector, that is, the quantity of all items recorded with labels [24].

The complexity of calculating the similarity between the tag and the topic cluster provided by the user to describe the problem is O (k∗t∗n'∗d'), and d' is the sparsity of the tag item composition matrix. After determining the similar clusters, the cluster center vector is sorted and the proposed solution process is O (logn'). The complexity of the process of calculating the score of the proposed solution according to user preferences and forming the recommendation list of the confirmed solution by the final normalization, merging, and sorting is only related to the length of the two initial recommendation lists, so the overall and whole computational complexity of the two-stage procedure is given by O (max (m∗n∗n∗d, k∗t∗n'∗d')). That is, as soon as the number of songs is large and the total quantity of tags is essentially equal to the number of songs, then the complexity of $O(n^2)$ is basically presented. However, similarity calculation is generally intensive, especially for nonusers, which can be completed offline. Therefore, using distributed computing can effectively reduce computing time. Two schemes of distributed similarity calculation are given below.

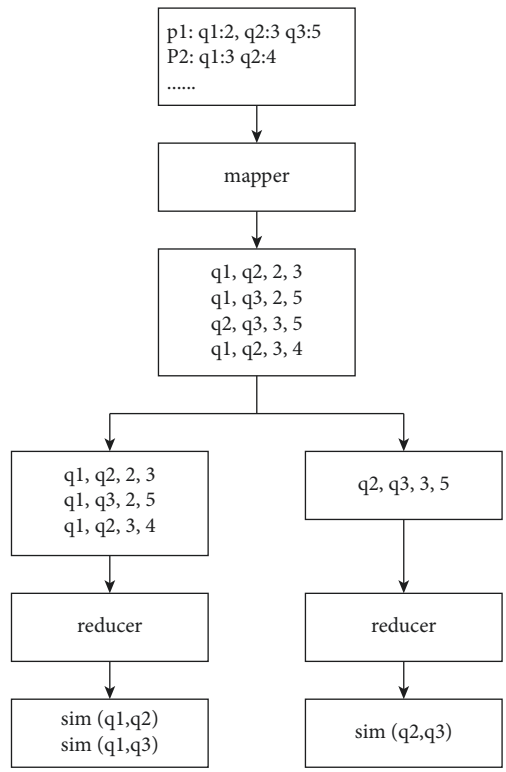

Figure 2: The schematic diagram of distributed reverse calculation process.

3.2.1. The Inverted Calculation. The specific process diagram is presented in Figure 2.

In the map phase of MapReduce, the rated items of each user are combined into *pair* < *left, right, leftscore, rightscore* > output, with left as the distribution key and *left* + *right* as the sorting key. In the reduce stage, the similarity of all items can be obtained by scanning the data from the map (this method can also be used to change the user into a label and the score into a label vector component). The advantage of this method is that there is no calculation cost of similarity between unrelated items. The disadvantage is that if some users have more scoring data, the generated pair will be very huge, and there will be a great i/o cost between mapper and reducer.

3.2.2. The Matrix Block Calculation. In the matrix block calculation approach, we cut the scoring matrix R into several small blocks, and each small block and the transposed matrix of the original matrix perform matrix multiplication operations (according to the similarity calculation formula, rather than the vector inner product) and finally merge the calculation results. The specific process diagram is shown in Figure 3, and the calculation of label similarity is similar. The advantage of this method is to avoid a large amount of cache between mapper and reducer. The disadvantage is that the transposed RT of matrix R needs to be

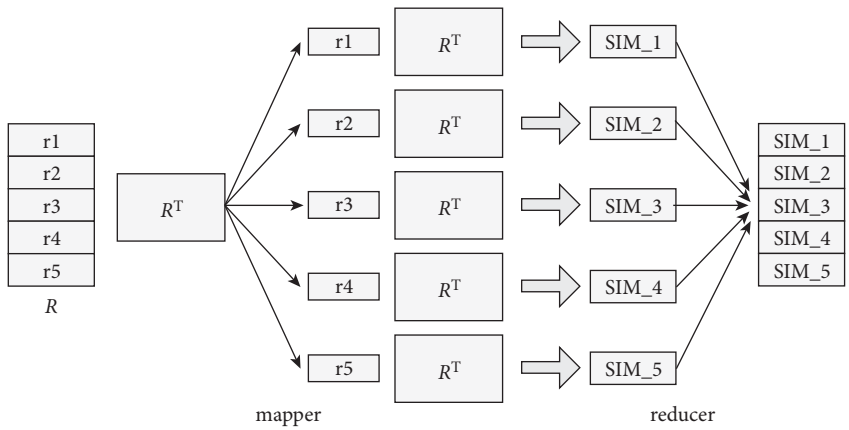

Figure 3: Schematic diagram of distributed matrix block calculation process.

cached in each computing node before the task starts to calculate. When the matrix R is large, it will affect the starting efficiency of the task.

The two approaches, as deliberated above, have their own benefits and shortcomings. When accurately calculating the similarity, we need to choose the appropriate calculation method according to the actual data characteristics.

4. System Test and Result Evaluation

4.1. Experimental Design and Evaluation Criteria. This paper carries out system testing in two different ways: (i) performance testing and (ii) function testing. In the performance test, we mainly distribute the public dataset into a training dataset and a testing dataset and subsequently practice the training dataset to establish the preference technique and model. In the next phase, we then use the test dataset to assess the performance of the recommendation algorithm. The assessment indicators selected in this paper are as follows:

(1) The MAE refers to the average of the absolute value of scoring error, which is generally used to measure the accuracy of scoring prediction of the recommendation system. The calculation formula is as follows:

$$\mathrm{MAE} = \frac{1}{|R|} \sum_{rp,q \in R} \left| \hat{r}_{p,q} - r_{p,q} \right|, \tag{4}$$

where R is the total score set, $\hat{r}$ is the predicted score value, and r is the actual score value.

(2) The precision refers to the proportion of the number of highly praised items in a group of recommendations to the entire number of recommended objects. Let $R(p)$ be the list of objects that are recommended to customers, and let $\mathrm{T}(p)$ be the aggregate quantity of objects that are essentially praised by users in the test set; then, the calculation formula of accuracy is as follows:

$$\text{precision} = \frac{\sum_{p \in P} |R(p) \cap T(p)|}{\sum_{p \in P} |R(p)|}. \tag{5}$$

(3) The recall refers to the proportion of the number of items highly praised by users in a group of recommendations to the aggregate number of objects that are essentially highly praised by customers in the test dataset. It should be noted that the calculation formula is as follows:

$$\text{recall} = \frac{\sum_{p \in P} |R(p) \cap T(p)|}{\sum_{p \in P} |T(p)|}. \tag{6}$$

The system function test refers to testing the functions of each module of the system online and designing different schemes to compare the recommended effects. The environment for building the system is shown in Table 1.

4.2. Performance Test. The algorithm considered in this paper for performance comparison is the traditional collaborative filtering algorithm. The data used for offline testing is the music dataset on Tchaikovsky music. A total of 1,000 user information screened in the Tchaikovsky music group, 437,428 effective evaluation records, and 172,469 different song records are crawled. Based on these Tchaikovsky songs, 245,6821 tag records were obtained, and 254,626 valid tags were extracted. 4,566 tag topic clusters were formed by clustering, and 1,472 clusters were selected as the initial records of the case base according to the sorted vocabulary. In fact, this is vital to assess the impact of collaborative filtering under various measurement methods on the Tchaikovsky music dataset because the algorithm described in this research involves the selection of similarity measurement methods in the initial step. Figure 4 compares the MAE metric values for various training dataset proportions for the collaborative filtering stage using the Pearson and Euclidean metrics.

It can be comprehended that the forecasting score precision and correctness using the Pearson similarity are not as high as those using the Euclidean similarity. Furthermore, the prediction score error using the Pearson similarity calculation inclines to drop along with the rise and growth of the proportion of training sets, while the

Table 1: The system experimental environment.

Hardware	Servicer	Intel(R) Core(TM)2 duo CPU P7350 4G RAM 320G+500 G
Software	OS	Ubuntu 14.01
	DS	EclipseJ2EE Juno
	Servlet	Apache Tomcat 7.0.55
	Database	MySQL Server 5.6
	Algorithm AIDS	Apache Mahout0.6,Hadoop1.2.1

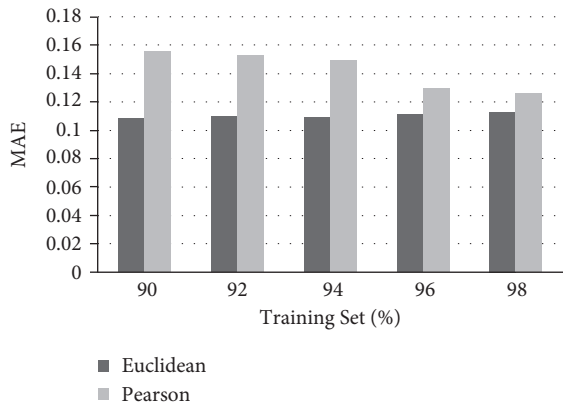

Figure 4: Assessment of forecast scoring precision using the Pearson and Euclidean similarity.

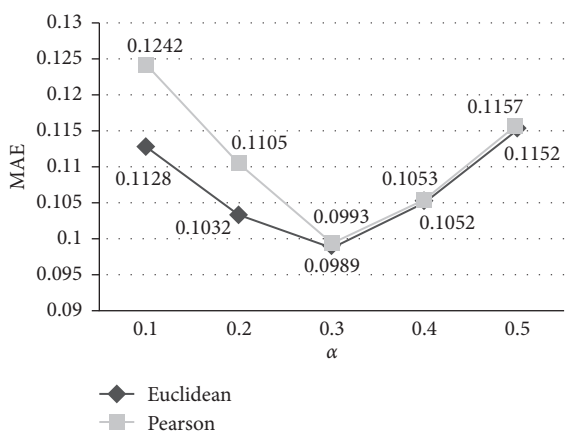

Figure 5: Different α MAE change curves of prediction score refined by case-based reasoning under parameters.

prediction score error using Euclidean similarity calculation has been increasing. Therefore, when the whole dataset is used for tangible and real recommendation, then the Pearson similarity measurement model should be more accurate. We also observed that subsequent to the second stage of filtering, the MAE rate and value fluctuations in line with the α parameter changes are given away in Figure 5.

The test shows that case-based reasoning can improve the prediction score when considering certain situational factors. Nevertheless, with the α parameters and the improvement, the extrapolation and forecast will swerve and diverge from the original customer model more and more and developed so that it is merely dependent on the recommendation of situational topics. In the collaborative filtering stage, the impact of different similarity measurement methods on the calculation of extrapolation and precision scores will also grow into less significant.

5. Conclusions and Future Research

Deep learning has been recommended in digital music for more than ten years, but how to effectively use this algorithm to recommend the music information of a composer is currently not tried by scholars, especially to solve the personalized recommendation process. Grounded on the facts and aforementioned exploration, in this paper our aim was to establish a Tchaikovsky music library, grasp user preferences through in-depth learning, and recommend Tchaikovsky music with situational bias. This paper mainly completes the following work. (1) The context aware music recommendation system based on neural network hybrid algorithm of deep learning is designed and implemented in three modules. The system is composed of data module that provides basic data model for deep learning, its core part hybrid algorithm module, and user interaction module using MVC architecture. (2) The experimental scheme is designed in terms of performance, as well as, the function tests. The effectiveness of the algorithm based on deep learning and the influence of structure of recommendation founded on this procedure are verified. The outcomes attained through empirical study express that the recommendation system that is established and built with the scheme based on deep learning in this paper has a certain, but, significant improvement in recommendation quality.

We are also investigating how to train a prediction model on the gathered dataset using learning algorithms like deep neural networks (DNNs). In that case, big data technologies like cloud and edge computing will mostly aid in storing, processing, and training the model if the data amount is large. Although the deep learning algorithms are conducted in parallel by the map reduction framework, the computational time is still constrained by the resources of a single online system. Additionally, in order to further increase the prediction accuracy, we plan to apply deep learning techniques like CNN and DNN. In actuality, the amount of data gathered to train the model has a significant impact on how accurate it is. Accuracy will increase with more data, and vice versa. Large data, however, will require a lot of computational power, which will also ensure that predictions are made in the anticipated amount of time. To increase the training efficiency in terms of computational times, big data technologies like cloud and edge computing should be leveraged.

Data Availability

The datasets used and analyzed during the current study are available from the author upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

IoT for Agricultural Information Generation and Recommendation: A Deep Learning-Based Approach

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Agriculture is the foundation of national economy. Therefore, countries all over the world—developed and developing countries—attach great importance to the sustainable development of agriculture. With the rapid development of Internet of Things (IoT) technology, advance applications are being designed to enhance agricultural economy. With the application of IoT, the production mode of traditional agriculture has been restructured and rationalized. Based on the applications of IoT in agriculture, this paper presents a method to automatically classify and recommend agricultural information. The standard domain-related theories and information service system are exploited to promote IoT technology in the construction of agricultural informatization. A convolutional neural network (CNN) model is used to classify agricultural information based on the vector file generated after preprocessing textual agricultural data. With the clustering method, the influence of unbalanced number of documents in the dataset is minimized. Finally, an information recommendation method based on multimodal interaction behavior is proposed for agricultural information recommendation. Potential features from textual information are extracted which are then fed to long short-term memory (LSTM) in connection with the interaction behavior. LSTM is used for the prediction of the possibility of interaction with respect to the information recommendations system. The experimental results show the feasibility of CNN in agricultural information classification problem. A commendable clustering accuracy is obtained for the agriculture category containing a large number of documents. However, the category with fewer documents is less clustered. The model may be used to effectively extract and classify agricultural information and has great significance in structuring and shaping agricultural information for convenient use in agricultural decision-making.

1. Introduction

In the current era of IoT and agricultural development, a new agricultural model, *precision agriculture*, is getting focus. In traditional agriculture development, there were various problems, such as scarcity of resources, environmental pollution, and poor quality of agricultural products. These problems severely hindered agriculture productions. The emergence of precision agriculture has brought new development opportunities in modern agriculture. Based on information technology, we can develop farming operation technology and management system to realize the management of production-related information and improve the growing environment of crops, maximize the profit, realize the efficient use of various agricultural resources, and guarantee economic and ecological benefits.

In the process of modern agricultural construction and development, IoT technology brings powerful technical support and has been widely used in agricultural production. First, it can realize the goal of building intelligent agriculture. Through the application of IoT technology, remote monitoring of agricultural production process can be realized and the level of intelligence can be improved [1]. The main monitoring objects are protection of climate change, pest control, crop growth, etc. Through the application of corresponding technical means, a systematic monitoring system can be established to enhance the effectiveness of monitoring, as shown in Figure 1. Moreover, the system supports

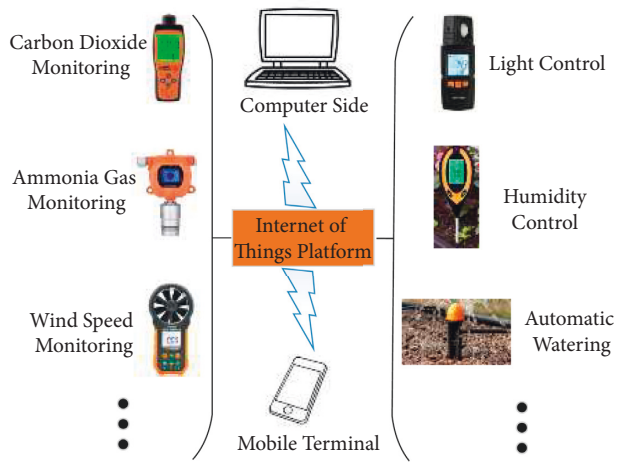

Figure 1: Agricultural information monitoring system based on IoT.

remote monitoring of agricultural production through the use of intelligent equipment. At the same time, consumers may use the system to independently check the relevant information. This can also be more effective in combating various counterfeit and shoddy products.

With the strong national investment in agricultural information infrastructure, new technologies are widely applied in the domain of agriculture for agricultural monitoring and production management. While meeting the growing information needs of agriculture, emerging technologies have provided new opportunities for the transformation and development of agricultural information services [2]. With the development and promotion of various high-tech applications, many industries dominated by information technology are undergoing revolutionary changes and breakthroughs.

With the addition of IoT, the efficiency of crude agricultural production has been improved and the quality of agricultural products has been ensured, thus contributing to the increase of farmers' income [3]. Unlike traditional farming, IoT is used to take emergency measures in case of disease, epidemic, and disasters. The modern era intelligent farming framework based on IoT is shown in Figure 2. IoT technology can be used to monitor in real time the agricultural growth, crop irrigation, poultry breeding, sensing humidity, rainfall, carbon dioxide concentration, etc. As a result, appropriate measures are taken for regulating inputs of water, fertilizers, and medicines.

However, in the process of agricultural informatization combined with IoT, it is difficult to realize the rapid classification and accurate recommendation of agricultural information. In this context, it is crucial to choose an optimized agricultural information classification method to assist in achieving fast filtering and accurate recommendation of agricultural information [4]. In this paper, classification and recommendation methods of agricultural information are presented and a deep learning method is proposed for automatic classification and recommendation of agricultural information.

2. Related Works

The rapid development of the IoT industry has led the world's major economies to elevate industrial revitalization to a strategic level. Industrial Internet, Industry 4.0, and Made in China 2025 are the industrial strategies of the three major economies of the world—USA, Germany, and China. These initiatives mainly necessitate the use of IoT in public health, smart grid, intelligent transportation, waste management, smart home, smart cities, smart agriculture, and energy management. By 2022, there will be 28.6 billion IoT devices worldwide [5]. By 2025, the value created by the IoT will reach to trillions of dollars annually.

IoT promotes the creation of smart cities, realizing fine management and optimal services in the fields of transportation management, traffic control, and video monitoring; enhancing urban efficiency; and benefiting people's lives [6]. To ensure efficient security, IoT includes sensing terminal, sensing layer gateway, sensing layer access, and data transmission [7]. For modest use of energy, IoT devices are designed to be small in size and have limited inherent resources (battery, processing, and storage) [8]. At present, IoT technology has been widely used in agriculture in the stages of crop cultivation, harvesting, storage, and sales, realizing digital and visual management of agricultural information [9]. At present, the cross-seasonal demand for agricultural products cannot be fully satisfied under the traditional agricultural production mode. Therefore, the greenhouse farming method has been widely used in agricultural production [10]. Pests and diseases have always been the main pests in agriculture, forestry, and animal husbandry. According to relevant data, the average annual loss of pests and diseases is nearly 50 billion pounds of food and poses a great threat to forest vegetation [11]. Besides various environmental factors, diseases and epidemics can also bring a lot of uncertainty to the farmers' income [12]. The monitoring, early warning, and prevention of pests and diseases are a matter of urgency.

As stated in [13], focus should be paid to current and long-term interests of farmers, to the process of informatization, and to the contents of agricultural informatization. With the continuous investment in IoT research funds, some ideal scientific research results have been achieved. So, it is necessary to actively promote cooperation with universities and fully combine high-tech and traditional industries, so that the relevant scientific researchers in universities are oriented to practical applications and enhance the effectiveness of research [14]. At the same time, the standard system should be reasonably formulated within the relevant industry.

Text classification refers to taking a set of texts preclassified by experts as the training set, preprocessing the training set, using the classification algorithm to train the discriminative formula or classifier, and using the obtained classifier to classify other texts into predefined categories. Researchers have proposed a landmark text classification method using Bayesian formula to promote research work on text classification [15]. Subsequently, many famous intelligence scholars, in the field of classification research, after

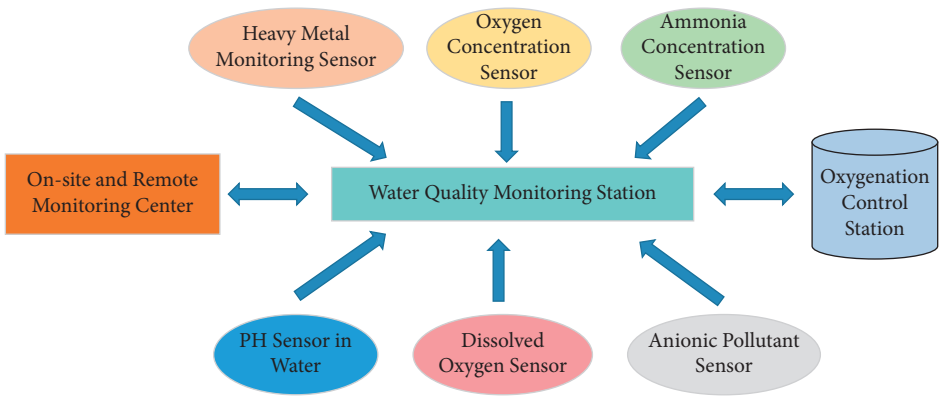

Figure 2: Structure of intelligent breeding and monitoring system based on IoT.

a long time of research have now achieved fruitful progress. The development of foreign automatic classification has gone through the stages of feasibility study, experimental research, and so on, and has now entered the stage of practicalization. So far, automatic text classification technology has been widely used in the fields of mail classification, electronic conference, information filtering, and so on.

Despite the fact that text classification has made great progress, research on text classification in the field of agriculture is still relatively small. At present, an important problem of agricultural information classification research is that there are a few standard and open agricultural datasets. Most of the researchers have built their own datasets for agricultural information classification [16]. Some researchers have implemented an agricultural information acquisition system based on Web classification technology and realized the application of Chinese web classification technology to an agricultural knowledge acquisition system, which combines Web crawling technology, information extraction technology, and information retrieval technology [17, 18].

In deep learning-based recommendation systems, the commonly used deep learning techniques include neural networks such as RBM, MLP, AE, CNN, and RNN. Among them, CNN and AE and their variants are often used for feature engineering to extract features from multimodal data such as text, images, and videos, RBM and MLP are often used for latent factor models, and RNN and its various variants (e.g., long short-term memory networks, gated recurrent units, etc.) are often used for recommendations based on sequence information [19]. The research on deep learning-based recommendation systems is an evolving process. Early on, traditional recommendation methods were mainly combined with deep learning techniques, and as the research continues, many algorithms and models using only deep learning techniques for recommendation have now emerged.

3. Methods

In this paper, the CNN deep learning model is utilized for classification of agricultural information and a hybrid multi-model system for the recommendation of agriculture information. In the agriculture text classification, initially information acquisition is carried out from the available agriculture documents. Next in the training process, the DL model is trained after selecting the appropriate features. Finally, by inputting text and representing it in vector form, classification is performed. The entire process is depicted in Figure 3.

3.1. Preprocessing. A text processing algorithm requires preprocessing of textual data for efficient extraction of the features and classifications. In pretraining phase, a word separation tool is used to classify the dataset documents. At the completion of word separation and removing the stop words, feature selection is performed using a feature evaluation function. Finally, a word list is generated so as to build a text vector that can be directly processed by a computer system. The preprocessing process of text classification using CNN model is different from the models which are based on decision tree and Bayesian network.

For a Chinese document, word separation is an essential operation in the preprocessing process. The subsequent classification operations need to characterize the text. Although English phrase segmentation is difficult, Chinese is much more complicated than English in the word layer. At present, the development of Chinese word separation technology has been relatively mature, and many word separation tools exist [20]. In the process of word separation, the characteristics of agricultural information should be taken into account, especially the problem of dividing agricultural vocabulary. Therefore, custom words can be added according to the characteristics of agricultural information during word separation to improve the accuracy of word separation. However, the *min_freq* parameter was set to 3 in order to include into the corpus only those words that appear at least 3 times in a document.

After the text is divided into words, the next work that needs to be done is to de-stop words. The purpose of deactivating words is to remove some punctuation, numbers, single words, and some other meaningless words from agricultural information documents. It is because numbers or characters cannot characterize a text; hence, words should be removed from the subset file. The word separation (stop word removal) process is shown in Figure 4. Finally, each

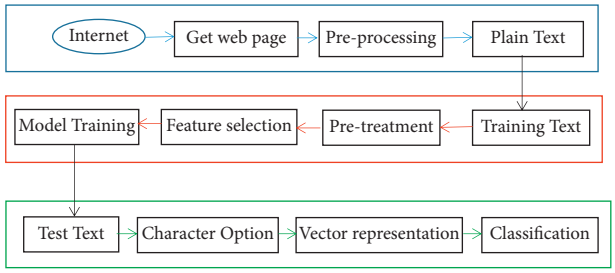

Figure 3: The operation of agriculture information system.

word in the generated file is transformed into word vector representation. It is observed that execution time of the word-level segmentation is directly proportional to the file size; time in execution increases as the file size increases and vice versa. An average 3.2 s increase was observed for 1 kB increase in the size of file.

3.2. Information Classification Method Based on CNN Model. An agriculture category classification algorithm accepts input as a text vector. The new instance of text is checked whether it is a new category. If it is a new category, then the weight of the category feature is updated. In else case, the center vector of the class and the eigenvalues are modified. Schematic of the system is shown in Figure 5.

The CNN model is used to achieve agricultural information classification, and the experiment is implemented with reference to the classical paper using a five-layer network structure. The first data input layer, which receives the word vector sequence generated after preprocessing, is connected to the convolutional layer, activation layer, and down-sampling layer, where three convolutional layers are placed in the parallel direction due to the difference in the size of the convolutional window. Three layers (convolutional layer, activation layer, and down-sampling layer) are placed in the vertical direction. The fifth layer is the output layer used to output the probability that the text belongs to a certain class. The network structure is shown in Figure 6.

After receiving a text as input data, the input layer of the neural network is convolved by the convolutional kernel of the first convolutional layer to produce three features. The configuration of each parameter in the convolutional neural network is shown in Table 1.

Neural networks can be divided into guided learning networks and unguided learning networks. Guided learning networks are mainly used for pattern recognition, while unguided learning networks are more often used for clustering analysis. When using guided learning networks for pattern recognition, because the category of each sample is known, the distribution of samples in space is no longer divided according to their natural distribution tendency, but rather, a suitable spatial division method is found according to the distribution of samples of the same category in space and the degree of distance between samples of different categories, or an appropriate classification boundary is found so that samples of different categories are located in in different regions. This requires a complex learning process

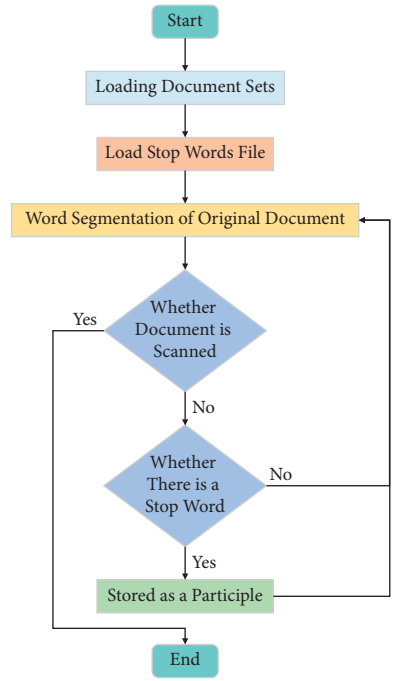

Figure 4: Flowchart of participle (stop word).

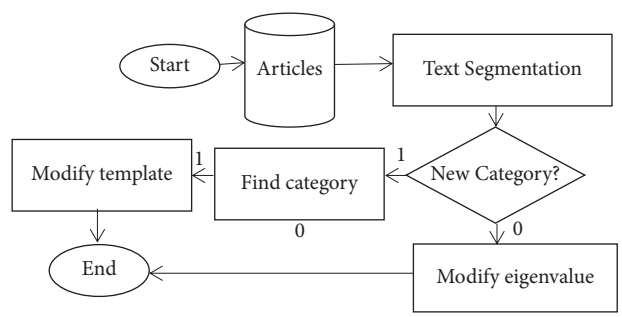

Figure 5: Schematic of agriculture information classification system.

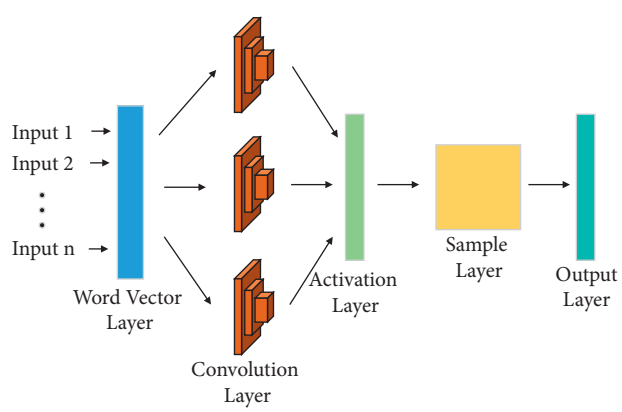

Figure 6: Network structure of text information classification based on CNN.

Table 1: Parameter of convolutional neural network.

Layer number	Name of layer	Kernel number	Feature size
0	Input layer	—	100143 ∗ 50
1	Convolution layer	128	100139 ∗ 1
2	Convolution layer	128	50069 ∗ 1
3	Convolution layer	128	100140 ∗ 1
4	Activation layer	—	50070 ∗ 1
5	Sample layer	28	100138 ∗ 1
6	Output layer	—	50069 ∗ 1

and takes a long time, and the position of the classification boundary used to divide the sample space needs to be constantly adjusted to reduce the result of samples being classified into nonidentical regions [21]. The work of these two phases is controlled by the accuracy requirement as the error measure of the network about the p sample. And the error measure of the network about the whole dataset is defined as

$$E_p = \frac{1}{2}\sum_{j=1}^{m}\left(y_{pj} - o_{pj}\right)^2. \tag{1}$$

As mentioned above, the reason why this stage is called the backward propagation stage is relative to the normal propagation process of the input signal. This is because when the connection weights of the neurons are adjusted at the beginning, only the error of the output layer can be found, while the errors of the other layers can be obtained by back-propagating this error in reverse, layer by layer. The outputs of the units in the intermediate layer are

$$h_j = f\left(\sum_{i=0}^{N-1} V_{ij}x_i + \phi_j\right). \tag{2}$$

The outputs of the output layer cells are

$$y_k = f\sum_{j=0}^{L-1} W_h h_j + \theta_k, \tag{3}$$

where ϕ_j and θ_k are the thresholds for the hidden and output units.

3.3. Information Recommendation Methods Combining Multimodal Interactions. In existing research, it is usually assumed that potential features are static and unchanging, but such an assumption is not consistent with the real scenarios. In reality, users' preferences change continuously according to their own experiences, so the latent features should also be dynamic. The emergence of recurrent neural networks provides an effective solution for modeling dynamic user latent features. Potential feature representation using LSTM, a long short-term memory network, updates potential features after each generated interaction and is a way to model users and potential features dynamically. However, LSTM keeps adding new user preferences and gradually forgetting the previous preferences, and the further away from the current moment, the greater the forgetting is. In fact, users are not always "new and old" in the process of changing user preferences. Some of the users' inherent preferences may persist for a longer period of time, while for some new items, users may not necessarily like them even if they have interactions. That is, while users' preferences are constantly changing, some preferences change to a lesser degree and some preferences change to a greater degree [22].

Being able to obtain accurate representations of potential user characteristics is of great value to the improvement of recommendation results. In order to solve this problem, a recommendation method based on multimodal interaction behavior information is proposed. Firstly, the textual auxiliary information of each item is extracted as its item latent features using convolutional neural network. Then, the user's rating data and the corresponding item textual auxiliary information in the user-item interaction behavior are combined. The user's interest change process is effectively modeled by the LSTM to obtain a more accurate potential feature representation. Finally, the sigmoid function is used to fuse user and potential feature vectors to predict the likelihood of user interactions, which is ranked and formed into a recommendation list. Multimodal data can provide richer user and item information and help alleviate the sparsity problem of scoring data. Compared with the traditional bag-of-words model, the multi-layer convolutional operation of CNN is able to capture the interconnections between words in the text and obtain a more accurate representation of item potential features. In other words, after the convolution operation, each description text can generate three overall contextual features. The three overall contextual features are stitched together to obtain the final description text contextual features. The potential feature space is mapped by the activation function tanh.

$$v_j = \tanh\left(W_2\left(\tanh\left(W_1 e_{\text{pooling}} + b_1\right)\right) + b_2\right), \tag{4}$$

where tanh denotes the nonlinear function, and W_1, W_2, b_1, and b_2 are weights and biases of the fully connected layers in the CNN structure.

In practical application scenarios, user preferences change continuously over time and to different degrees. Therefore, we hypothesize that (1) users' preferences change over time, and recent interaction items better reflect users' preferences. (2) In the user's interaction behavior, higher rated items have a slower decaying effect on user preferences, and lower rated items have a faster decaying effect on user preferences. This user dynamic latent feature is modeled using LSTM. The update process of user latent features is shown in Figure 7. The model considers the latent features of user interactions as user preferences and uses them as input to the LSTM of the long short-term memory network. In the LSTM, new user preferences will be added continuously, while the previous preferences will be gradually forgotten. Therefore, the first assumption of the model can be satisfied by using LSTM.

The forgetting gate is used to control the information discarded from the potential features of the current user, which reads the potential features of the user and transmits

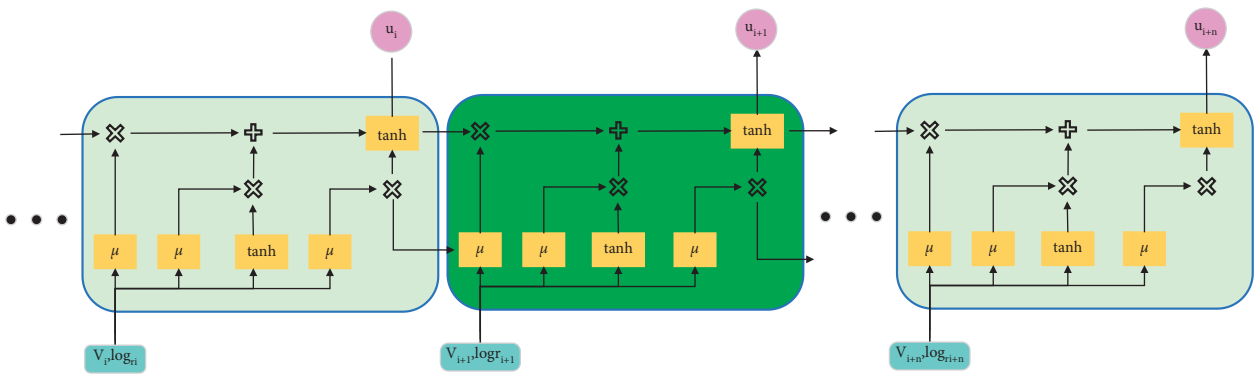

Figure 7: The LSTM operational pipeline.

them to the output gate through a sigmoid function. The input gate, which controls the information received from the current input, also determines updates to the user's potential features via the sigmoid function and creates a new candidate vector to add to the cell state using the tanh function. Then, the old cell state is multiplied with the forget gate to determine the discarded information, and the new candidate state information is multiplied with the input gate to determine the new input information, completing the update of the cell state and obtaining the new cell state. If i_t, f_t, and o_t represent the *input, forget, and output* gates, then the LSTM gate equations are given as follows:

$$\begin{aligned} i_t &= \sigma \ldots (w_i[h_{t-1}, x_t] + b_i), \\ f_t &= \sigma\left(w_f[h_{t-1}, x_t] + b_f\right), \\ o_t &= \sigma(w_o[h_{t-1}, x_t] + b_o), \end{aligned} \tag{5}$$

where σ represents the sigmoid activation function, w_x the weight of the respective neurons, h_{t-1} previous LSTM block output, x_t input to the current gate, and b_x bias of the current gate. Equation of the tanh activation function used for regulating the values in between 1 and −1 is given as

$$\tan h(t) = \frac{[\exp(t) - \exp(-t)]}{[\exp(t) + \exp(-t)]}. \tag{6}$$

4. Experiments

The proposed system is evaluated by an open dataset. Dedicated experiments were performed for analyzing the accuracy and clustering effectiveness of the method, and details are as follows.

4.1. Experimental Dataset. The text training set plays a decisive role in the performance of the final generated text discriminative formula or classifier. To conduct research on text classification methods for agricultural information, we need to consider how to design and establish a text training library for agricultural information first. The quality of the text training set will directly lead to the classification accuracy of the classification method, if the training set is not good, even if the classification algorithm is accurate, it may lead to unsatisfactory classification results. A good text training set should have obvious category characteristics, accurate representation of documents in each category, and uniform distribution of documents in each category under feature values.

At present, there is a lack of research on agricultural information datasets in China, and an open and standard agricultural information dataset has not been formed. Therefore, the dataset used for agricultural information text classification using deep learning methods in this paper is a small agricultural information text dataset established by ourselves. To build the agricultural information text dataset, firstly, the need for category refinement in the field of agricultural information is established, and the agricultural crops are divided into category characteristics, technology, and market information. Secondly, the training samples of the training set for each category of agricultural information text are selected, and the number of feature words of each sample is controlled so that each sample in the dataset has good category representation, and finally the text dataset is built. The agricultural information dataset is obtained from the online dedicated platform [23, 24]. A crawler program is written in Java language in Eclipse IDE for the purpose of auto-collection of agriculture data from the Web.

The agricultural information used by the category classification network includes soil quotations, drought forecasts, crop pests and diseases, and aquatic pests and diseases. In this study, we select the categories that people pay more attention to as the research object, and study a total of 10 categories such as pest and disease, analysis and forecast, price quotation, detection and early warning, etc., to establish the dataset, and the specific number of documents contained in each category is shown in Table 2. The total 8637 documents were split into 10 : 4 train-test ratios. As per the ratio, 635 documents were used for training and 254 for testing. Aim behind keeping a large training set was to effectively train the model.

4.2. Experimental Results of Information Classification. The first experiment is the binary classification experiment, and the blue curve in Figure 8 shows the loss drop curve for 10 iterations. From the loss drop curve in Figure 8, it is clear that the loss value of the network drops to the lowest point after the 3rd iteration. The misclassification curve does not change much during the training process, and the network

Table 2: Distribution of the number of agricultural information documents contained in each category.

Category	Category name	Document number
1	Plant diseases and insects	260
2	Price quotation	2751
3	Analysis of forecast	410
4	Policies and regulations	153
5	Monitoring and early warning	837
6	Rural culture	998
7	Rural tourism	957
8	Practical technology	474
9	Information construction	1336
10	Investment promotion	461

model tends to be stable and reaches the convergence state as proceeded. From the experimental results, we can see that the network model has good recognition ability for dichotomous text. The network model has a more satisfactory classification effect when it is dichotomized. The dataset of documents/articles is arranged into group of tens—decile classes for appropriate training and testing. The decile class experiments are conducted for all the agricultural information texts in the training set using the model. The results of the decile class experiments are shown in the red curve in Figure 8. In ten iterations of the text decile class, the loss value still decreases more in the second iteration than the first one, and the loss value gradually becomes smaller as the number of iterations increases. In the text decile class, due to the larger dataset and longer training time of the model, the results of text classification in the decile class are not as obvious as those of the binary classification, the category ability of the classifier for text is not ideal, and the recognition of text in ten categories is not as good as that of the binary classification experimental data.

To better validate the model classification method, clustering experiments were conducted to analyze the model's classification accuracy for each category of information. The purpose of the clustering experiment is to gather similar texts together and classify dissimilar texts into different categories, so as to see the distribution of categories in the dataset. The experimental results are shown in Figure 9, which shows that those containing more documents are well clustered. However, the category with fewer documents is more likely to be less clustered or left un-clustered. Thus, it is easy to imagine that the difference in the accuracy of the network model in dichotomous and decentralized categories is probably due to the uneven number of documents contained in each category in the dataset.

4.3. Information Recommendation Experiment Results. In this section, two publicly available rating datasets are used: MovieLens-100K and MovieLens-1m. Two methods are used for comparison experiments: neural matrix factorization (NeuMF) and NeuMF+. NeuMF is to personalize ranking task with implicit feedback, whereas NeuMF+ is the improved version of the model. In the proposed research work, NeuMF is used for mapping nonlinear interactions between user and embedding items via a multi-layer

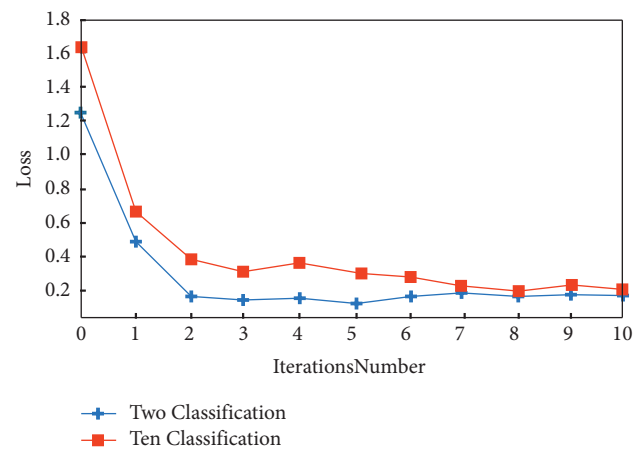

Figure 8: Loss curve of two classifications and ten classifications.

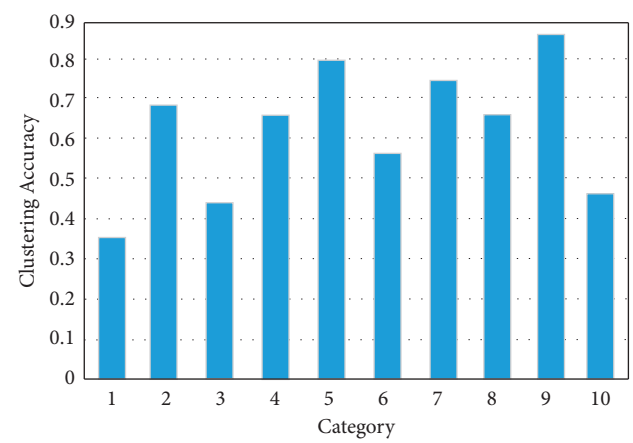

Figure 9: Clustering experiment results.

perceptron (MLP) [25]. NeuMF+ assumes that both user and item potential features obey Gaussian distribution. The distribution of the number of user interactions is given in Table 3.

Hit ratio (HR) and normalized discounted cumulative gain (NDCG) [26–28] are the commonly used methods for the assessment of the effectiveness of a recommendation system. In this paper, HR and NDCG are used to evaluate metrics of the model, and equations for the same are given as

$$\mathrm{HR} = \frac{\text{No. of hits}}{\text{No. of users}},$$
$$\mathrm{NDCG} = \frac{1}{\text{No. of users}} \sum_{i=1}^{\text{No. of users}} \frac{1}{\log_2 (p_i + 1)}. \tag{7}$$

HR can be considered as a recall-based evaluation method, which indicates the percentage of successful recommendations, and NDCG is an accuracy-based evaluation method, which is closely related to the position of the test case in the ranking list. The higher the ranking position of the case, the higher will be the value of NDCG. The experimental results are shown in Figure 10. Under the evaluation criterion of HR, except for the lower value of HR

Table 3: User interaction number distribution.

Interactive distribution	MovieLens-100K (%)	MovieLens-1m (%)
<10	0.05	0
11–20	17.83	7.26
21–40	26.15	21.34
41–80	22.09	22.74
81–160	22.58	23.15
161–320	13.26	16.81
321–640	2.42	8.42
>641	0	1.69

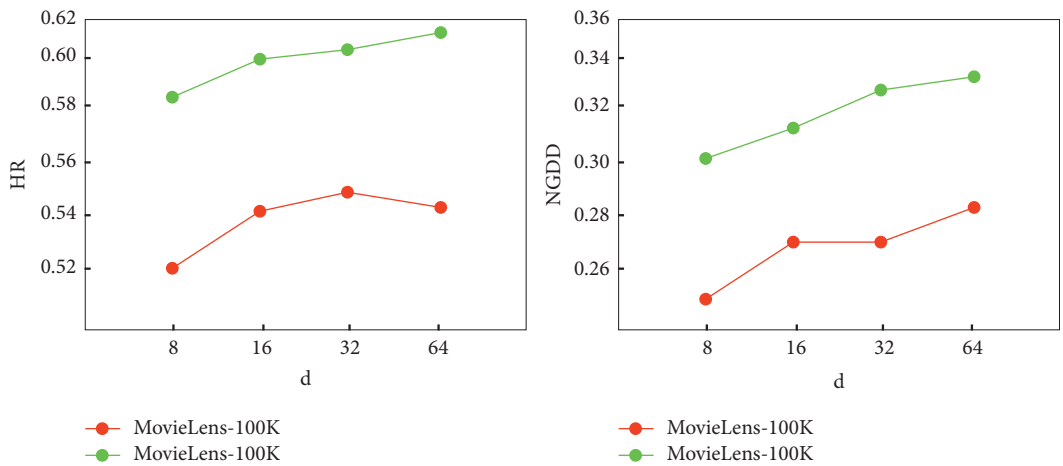

Figure 10: Influence of potential feature dimension d on model effect.

at $d = 64$ than at $d = 32$ on the MovieLens-100K dataset, both MovieLens-100K and MovieLens-1m datasets show an increasing trend, and the larger the dimensionality, the higher the value of HR. Under the NDCG criterion, an increasing trend is shown on the MovieLens-100K and MovieLens-1m datasets, and the increasing trend is more obvious on the MovieLens-100K dataset. In general, when the latent feature dimension is very small, the corresponding model effect is poor, while when the latent feature dimension is very large, the overfitting phenomenon is easy to occur, which increases the computation and the model training time.

5. Conclusion

Agriculture elevation is the basis for sustainable development of economy and society. In the entire history of mankind, the common goal pursued by man is to promote agriculture. However, due to the relatively slow construction of agricultural information technology, it directly or indirectly affects the sustainable development of economy. In recent years, with the continuous and rapid development of modern information technology in China, IoT has been widely used in the process of agricultural production. Through the application of IoT, the transformation and upgrading of agricultural informatization are promoted. To further enhance the process of agricultural informatization, this research work proposes a classification and recommendation method. For the agricultural information classification, word separation, feature dimensionality reduction, and vectored representation techniques are studied. The automatic classification of agricultural information using deep learning CNN models is presented, and a recommendation method based on multimodal interaction behavior information is proposed. The method uses CNN to extract potential features of all items from text information, and potential features of user interactions are used as the source data for user feature construction. Finally, a fully connected layer with sigmoid activation function is used to fuse user and item latent features. The experimental results show that the text classification method based on CNN model can effectively classify agricultural information. The findings revealed that performance of the model is better than the traditional method. The information recommendation method combined with multimodal interaction can recommend agricultural information which helps the construction of agricultural informatization.

Data Availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Convolutional Neural Network Based Energy Consumption Management Model for the Full Life Cycle of Buildings and Information System Design

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With the continuous improvement in China's economy, the construction industry has developed and rampantly progressed. Besides the wastage of resources and energy, the development has caused serious pollution to the environment. This makes the construction industry a high energy-consuming and highly polluting industry. There is a pressing need to reduce the wastage of resources and to adequately manage consumption of energy throughout the life cycle of buildings. This paper explores an effective method of building life cycle energy management by appropriately utilizing information system and the emerging deep learning technology. To achieve energy saving in buildings, a feasible model is proposed for predicting, analyzing, and building energy consumption based on neural networks. By analyzing the massive data stored in the building information system, the operation of each subsystem in the building is guided and regulated to achieve energy deployment and build energy optimization. Focusing the key meters, the average generalization ability of the proposed model (R-Squared = 1.9, MSE = 1.02) is better than the other contemporarily used models, LightGBM, LSTM, and SVR. Moreover, the method can effectively predict the energy consumption of the whole life cycle of the building and has higher prediction accuracy. The method proposed has great significance in research related with improving building energy performance and designing decision support tool.

1. Introduction

In recent years, with strong advocacy and active promotion of the Ministry of Housing and Construction and local building energy efficiency authorities, constructions of large public buildings are increasing adamantly [1–3]. Buildings are the major energy consumers, and many buildings in China are high energy-consuming buildings, which impose a heavy energy burden on society [4–6]. The annual energy consumption of public and civil buildings is also increasing with the passage of time. According to a recent research [7], the energy consumed by buildings accounts for 40% of the whole energy consumption, causing a major chunk of atmospheric emissions (40%) and greenhouse gas emission (33%).

However, building energy management is a systematic project, and the actual energy consumption after the building is put into operation may be reduced. By extending building energy management to multiple stages, such as project, design, construction and operation, and covering the whole life cycle of the building, can achieve the goal of controlling and saving energy. The goal is put into practice through the promotion of energy-saving indicators and technical measures at each stage. Effective management of energy consumption during the whole life cycle of a building is just getting started in China. The information on energy consumption during each construction phase is distributed among different departments for apt compliance. However, the collection of relevant data and the standards of information system construction are yet to be established.

At present, people mainly focus on the improvement and optimization of energy consumption during building use, including energy consumption in heating, air conditioning, lighting, household appliances, and cooking utensils. In fact, each stage of the building life cycle, from design to construction completion, delivery, and use until demolition, is

constantly consuming energy. Moreover, with the continuous emergence of new materials, technologies, and techniques, the proportion of energy consumed in the building materials and construction process is relatively higher. Therefore, it is not enough to consider only the energy consumption in the operation phase of a building but the energy consumption in the whole life cycle of a building should be systematically considered. According to the life cycle theory of buildings, the life cycle of a building includes five stages: the preparation stage of building materials, the building construction stage, the building use stage, the building demolition stage, and the disposal stage of used building materials, see Figure 1.

Systems engineering is a dedicated domain which deals with materials, construction techniques, and other factors of construction. Systems engineering requires a system perspective, focuses on the interconnectedness, interaction, and mutual constraints between the whole and its parts, and between the whole and the outside [8–12]. The openness, relevance, and dynamics of building systems determine that energy saving in building systems must consider the whole process from energy and resource acquisition to transmission and distribution. For example, double-glazed windows are better insulated than ordinary wood windows and doors, but double-glazed windows consume more energy in the production process than the production of ordinary wood windows and doors. Therefore, when choosing building solutions, the energy consumption of the whole life cycle should be considered from a system perspective.

Building information system is a digital technology to simulate the real information of the building by constructing digital information system through information technology. The information description is to clearly and intuitively obtain the energy consumption in different seasons and to provide guidance for building construction and environmental protection. The information system provides guidance for building construction and environmental protection, thus controlling energy and resource waste and saving construction costs, which is important for the sustainable development of the construction industry [13]. Moreover, the technology may be used to dynamically reflect building information in real-time. The application of building information system for the whole life cycle of building focuses on the continuity of information. The whole life cycle of building contains four stages such as planning and design, construction, operation, and maintenance, and it is very important to keep the continuity and connection of the four stages [14]. The building information system contains a lot of data and information related to building performance, so the building information system software needs to export the relevant data first and then import them into the building information system database for integration and analysis after conversion. Following that, the indicators are integrated and adjusted to control energy requirements of the building. The data and parameters related to energy consumption are imported into the comprehensive database of the building information system to form quantitative index parameters [15–17].

In 2012, in the deep learning (DL) technology, convolutional neural network (CNN) emerged in the field of image recognition that attracted the attention of research scholars all over the world. The CNN technology has a wide range of applications in the field of computer vision, natural language processing, and other research fields. Compared with ordinary neural network technology, CNN has powerful data feature extraction ability with convolutional layers and has better generalization ability. The model proposed in this paper for the whole-life energy consumption management is based on CNN. The aim behind the research study is to provide preliminary findings and relevant technology preparation for further research and practice in the field of construction. To realize the whole-life energy consumption management of buildings, firstly, it is necessary to determine the monitoring target, i.e., to split the comprehensive control target of the whole-life energy consumption of buildings into several implementable, measurable, and controllable indicators, to choose a suitable management stage, and then to refine and decompose each of the indicators. Secondly, it is necessary to determine the implementation path, integrate requirements of energy consumption, and design a suitable energy consumption management process.

In this paper, we sort out the logical relationships among the monitoring objects, implementation paths, and expected results of energy consumption in the whole life cycle. A model for energy consumption management for the whole life cycle of buildings is proposed to provide guidance for the development of information systems. The model construction schematic is shown in Figure 2.

2. Related Work

Building construction is a compound process encompassing various phases and plans [18]. Energy consumption control requirements in the preproject stage and indexes in the project planning stage are used as the baselines for the design stage. The data linkage with the building energy consumption control requirements is established during the project planning phase. Moreover, analysis about investment, sales, social benefit analysis, risk, project investment, and financing are also performed in the planning phase. In the design phase, dedicated software technology, comprehensive database, and system model are used to improve the efficiency of related building energy consumption, green building, and other analysis tools and also to reduce the huge workload during the whole process. Moreover, the building information system is used to achieve dynamic output of building energy analysis such as electromechanics, architecture, Heating, Ventilation, and Air Conditioning (HVAC), and curtain wall and to provide a basis for parametric design. Quantitative indicators in the information system like system indicators, equipment parameters, and operation parameters are helpful to integrate and adjust the energy consumption of a building [19–24].

The construction phase is an important stage where design of the building energy management is meticulously brought into actuality. Integration and adjustment may be performed in the comprehensive database of the building

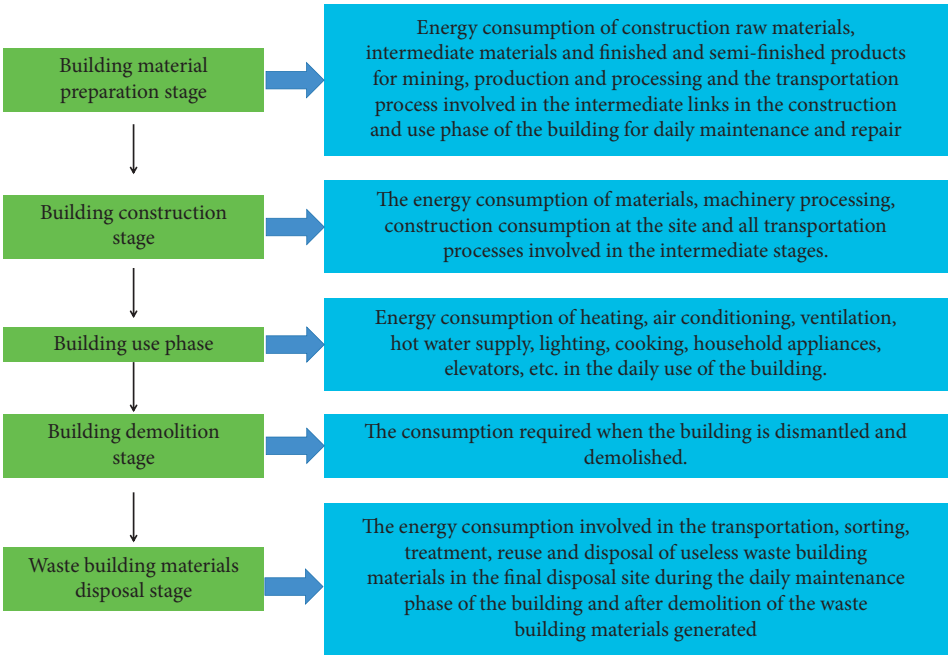

Figure 1: Energy consumption in all phases of the building life cycle.

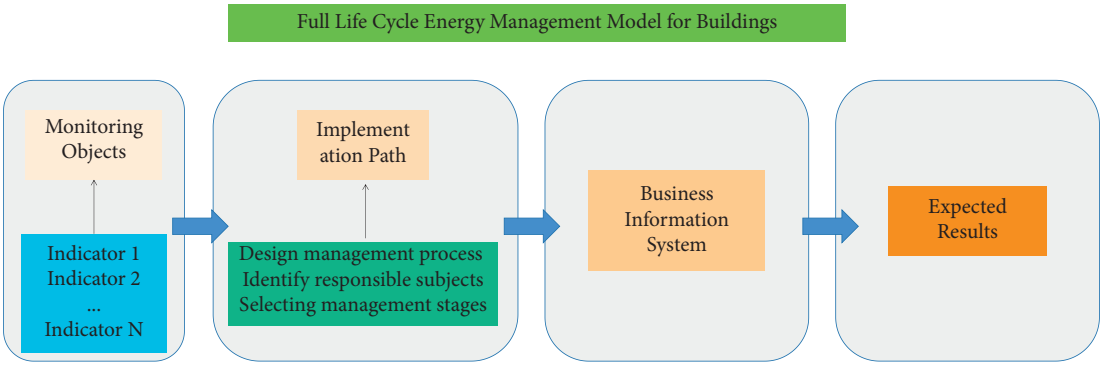

Figure 2: Schematic of the building life cycle energy management models.

information system. However, special attention is paid to include the comparison of equipment parameters binding indexes with actual procurement according to the comparison, actual installation, piping, and construction drawings. At the same time, since a project may undergo relevant changes due to uncontrollable factors such as equipment manufacturers, construction environment, and building layout, the energy consumption and control parameters are kept adjustable [25–28]. The key inputs (or constraints) in the construction phase include various parameters of electromechanical equipment (performance, equipment life, and index), installation location, supplier information, operation monitoring and control index, the correlation of electromechanical systems (piping diagram, logic of the cooling, heat source system and air conditioning system), variable air volume (VAV) system, and area space layout.

The operation phase is the phase to test the results of building energy management and to adjust and optimize building energy management in conjunction with other information about building operation. On the basis of real-time collection of dynamic data information such as human flow, environment, and operation of facilities and equipment, it integrates real-time data and historical data of various types of energy consumption in the building, extracts relevant information from the building information system model. Data simulation and analysis techniques may be used to carry out simulation estimation of operational energy consumption under various conditions. After the building operation is stabilized (generally two heating and cooling cycles), the building energy management system collects dynamic data such as the optimal performance curve of equipment operation, the optimal life curve of equipment operation, and the monitoring data of the operating equipment [26].

With the development of information technology, a huge amount of complicated information is flooded around all the time. However, the information that human beings can

receive is limited, and researchers have discovered that the human visual system has a huge visual information processing capacity with a limited field of view [27–29]. Mimicking the human visual system, researchers have developed the idea of attentional mechanisms. The core idea of the attention mechanism is to obtain the importance of each feature map by certain means and devote more computational resources of the neural network to more important tasks and use the results of the tasks to guide the update of weights of the feature maps so that the corresponding tasks can be completed efficiently and quickly [30].

Convolutional neural network (CNN) is a widely used model in deep learning, which is an important part of target detection algorithm and plays the role of feature extractor in target detection algorithm mainly completing the feature extraction task and outputting the feature map containing rich feature information, which lays the foundation for the subsequent classification and regression tasks in target detection. In 2012, the AlexNet network was proposed to focus research in the field of computer vision on convolutional neural networks and deep learning. With the emergence of various advanced frameworks in 2014, improved AlexNet and ZFNet were introduced [31–33]. In the same year, RepVGG, which consists of only 3×3 convolutions with ReLU activation functions further enhances the feature extraction performance of the VGG network through a simple branchless structure [34–36]. To realize the deployment of CNN models in miniaturized mobile and embedded platforms, scholars have also conducted in-depth research on how to reduce the number of CNN model parameters and the complexity of CNN structures. Among them, SqueezeNet utilizes many 1×1 convolutional kernels to replace 3×3 convolutional kernels while reducing the number of channels of 3×3 convolutional kernels to reduce the number of parameters.

3. Methods

Machine learning models work as a black box discovering the relation between various features of building and generate outputs about the energy performance. In this paper, the supervised ML approach used adequate data about building to predict targets for unseen samples.

3.1. Model Architecture. As any ML model works on data, initially, the historical number of buildings and meteorological data are collected to have a dataset for the model training. The algorithm is used to identify the building run cycles as the time steps of the model. Finally, the hybrid model is trained based on the convolutional neural network algorithm. The optimal hyperparameters of the hybrid model are found using the grid search algorithm. The structure of the proposed model is shown in Figure 3.

3.2. Big Data Information System. With the continuous development and wide application of big data technology, the platform architecture of big data is extending. The architecture is divided into two basic types: (1) master-slave and (2) P2P. The former storage architecture is developed by Google and represented by GFS and BigTable. The main representative of master-slave is Hadoop. The later storage architecture is developed by Amazon whereas its main representative is Dynamo. The Hadoop master-slave architecture is mainly reflected in the architecture design of HDFS (Hadoop Distributed File System).

3.3. Feature Embedding. Word embedding refers to a kind of word representation where words with similar meaning have a similar representation. Word embedding is normally used in natural language processing. The embedding layer maps sparse word vectors to a low-dimensional and compact feature space. The vectors in this feature space can be used to measure the similarity between features by computing their relative distance. Since the feature space is a feature compression of the original vector space, its dimensionality is much smaller than that of the original vector space. Hence, the complexity of distance calculation can be greatly reduced. Moreover, the undesirable effects of expanded feature vectors are avoided.

In the N-dimensional word vector space VERX, the relationship between its features can be expressed in terms of conditional probabilities as

$$p(v_1, v_2, \cdots, v_n \mid v_i) = \prod_{j \neq i}^{N} p(v_j \mid v_i), \tag{1}$$

where $v_i$is the target feature and v_j is the other features in the feature space. In the neural network, $p(v_j \mid v_i)$ can be expressed as

$$p(v_j \mid v_i) = \frac{\exp s_j}{\sum_{j'=1}^{M} \exp\ s_{j'}}, \tag{2}$$

where H is the hidden layer, M is the dimension of the original N-dimensional feature mapping to the feature space S, s_j is the j-th component of the weight W of the hidden layer H to the feature mapping space S, and h and W is the weight of the original feature input to the hidden layer H. Therefore, given the target feature v_i, the loss function of the network can be obtained as

$$\begin{aligned} L &= -\sum_{i=1}^{N} \ln\ p(v_1, v_2, \cdots, v_N \mid v_i) \\ &= -\ln \prod \frac{\exp s_j}{\sum_{j'=1}^{M} \exp\ s_{j'}} \\ &= -\sum_{j=1}^{N} s_j + N \ln \sum_{j'=1}^{M} \exp_{j'}. \end{aligned} \tag{3}$$

As clear from the equation, after the word embedding layer, the relevance of the classification features can be fully extracted, and the new features are embedded in a layer of network. This reduces the dimensionality of the input data, and the layer may be used for solving the problem of feature discretization. There are categorical features in building metainformation, such as features related with the use and location of buildings. Though the features have obvious effects on the energy consumption of the building, they do not exist in numerical form. If the categorical features are

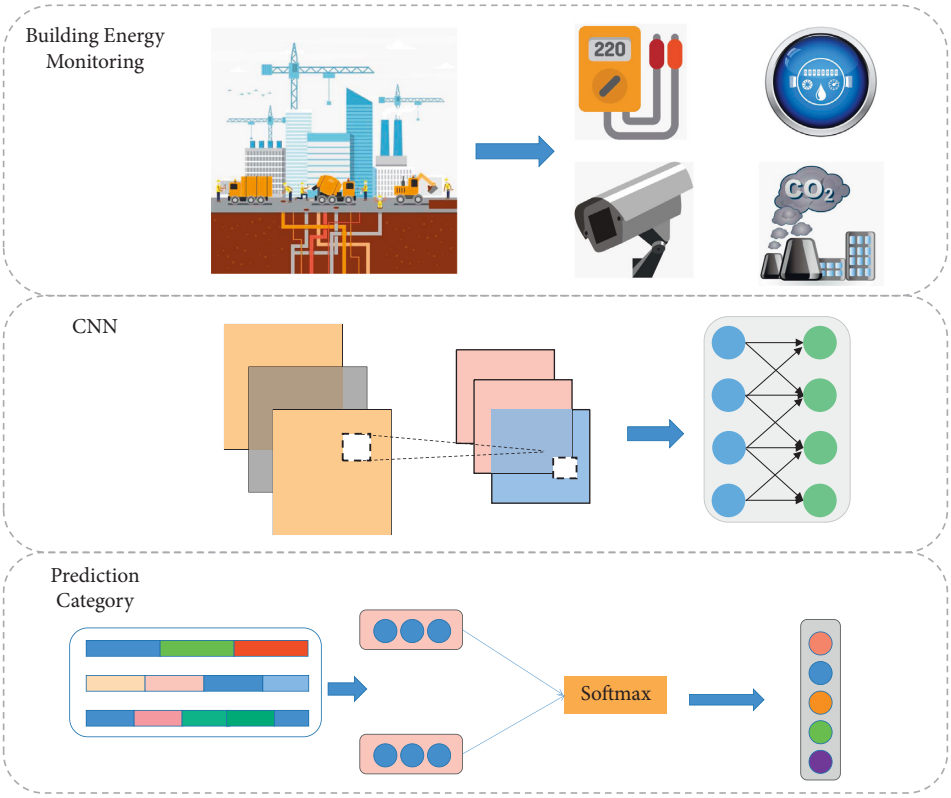

Figure 3: Structure of the proposed model.

coded with the unique thermal coding, it will lead to too large data dimensionality. For this reason, the fusion neural network established in this study introduces an embedding layer, which is used to compute the embedding of discrete classification signals, thus mapping the discrete classification features to a continuous word embedding space enabling the fusion of discrete features with numerical features. At the same time, the word embedding layer reduces the data dimensionality and reduces the training time of the network.

3.4. Convolutional Layer. The convolutional neural network is selected to perform regression on the data. Convolution is a mathematical operation in which the process is to take a tensor, matrix, or vector and pass it through the convolution operation of a convolution kernel to obtain a tensor of smaller dimension containing feature information. Deep convolutional neural networks based on two-dimensional convolutional kernels have made significant breakthroughs in image recognition in recent years. However, the two-dimensional convolution kernel operates on two dimensions of image data, namely, length and width. Considering that the dimension of time-series data is only one-dimensional, this study selects one-dimensional convolution to extract time-series features from the data. The one-dimensional convolution kernel convolves the time-series data on the time series.

By inputting the input of the network into k branches, the input of each cardinal, where R represents the number of branches after split in each cardinal, k represents the k-th cardinal, and U represents the input of each branch after split. The output of each cardinal module, V, represents the output of cardinal with channel weights, $a(c)$ is the weight calculated by SoftMax, and G represents the weight of each split. The final k outputs are stitched after the cardinal module combine the information of the k cardinal outputs and the stitched outputs are element-wise summation with the original inputs to obtain the final output.

$$\begin{aligned}
\hat{U}^k &= \sum_{i=R(k-1)+1}^{Rk} U_i, \\
V_c^k &= \sum_{i=1}^{R} a_i^k(c) U_{R(k-1)+i}, \\
a_i^k(c) &= \begin{cases} \dfrac{\exp\left(G_i^c\left(s^k\right)\right)}{\sum_{j=1}^{R} G_j^c\left(s^k\right)}, R > 1, \\ \dfrac{1}{1+\exp\left(-G_i^c\left(s^k\right)\right)}, R = 1, \end{cases} \\
V &= \mathrm{Concat}\left\{V^1, V^2, \cdots, V^k\right\}.
\end{aligned} \tag{4}$$

3.5. Model Training. As a first step, preprocessing of various types of data involved in building energy consumption is performed. Particularly data dissimilar in scales are pre-processed to avoid computational cost. There are various types of data such as pressure, temperature, voltage, current, and flow. Abnormalities of various forms may occur in the

data due to many reasons, including change in the environment. Therefore, it is needed to normalize data so that it is not affected by various types of magnitudes. In this paper, the maximum-minimum normalization method is used to reduce abnormalities in data.

$$x_{nom} = \frac{x - A_{\min}}{A_{\max} - A_{\min}}. \tag{5}$$

The mean absolute percentage error (MAPE) is used as the evaluation criterion for the outcome error as follows.

$$MAPE = \sum_{i=1}^{N} \left| \frac{\hat{y}_i - y_i}{y_i} \right| \frac{100}{N}, \tag{6}$$

where N is the total number of prediction experiments, y_i is the true value, $\hat{y}_i$ is the predicted value. The smaller the value of MAPE, the smaller the difference between the predicted value and the true value.

4. Experiments and Results

To design a suitable energy consumption management process, it is necessary to integrate requirements of energy consumption, after preprocessing and appropriate analysis of enough volume of data. Therefore, the CNN-based model proposed in this paper is trained by a dataset of 800,000 samples.

4.1. Experimental Setup. The experimental configuration environment is Ubuntu 18.04LTS with 32G RAM, Intel Corei7-7700 CPU and Nvidia GTX-1070Ti GPU, and Keras deep learning framework and TensorFlow as Backend. The data used in this study come from the internal nonpublic data of a Chinese construction company, and the historical data of different buildings in different places for one year are collected. The main information contained in the data include meter (electricity meter, cooling meter, steam meter, and heat meter) readings, building metainformation (e.g., usage, commissioning time, number of floors, building location) and meteorological information (e.g., air temperature, cloud cover, dew point temperature, air pressure, and wind speed). Correspondingly, there are test datasets in the data that have the same structure as the training dataset. For the training data selection, the original data, after the missing value processing, have 11714696 items, containing 27 temporal features and 3 classification features. This study divided the data into training set and test set according to the ratio of 4 : 1; however, in the process of training the model, the author found that the training speed of SVR and LSTM on large datasets was too slow; therefore, for the above two models, this study only selected 800,000 of these samples as the dataset for training the model and also divided the training set and test set according to the ratio of 4 : 1. In this study, the early stopping strategy is used to stop the training to prevent overfitting of the models. Also, k-fold cross-validation is used for all algorithms, and the k-value is set to 6, and the results are averaged over six times. The model parameters were set as shown in Table 1.

Table 1: The model parameters setting.

Predictive models	Parameter name	Parameters
CNN	Number of hidden layer neurons	100
	Dropout	0.2
	Learning rate	0.001
	Optimization algorithm	Adam

The training process performance enhancement and loss convergence are shown in Figures 4 and 5.

4.2. Experimental Results and Analysis. To evaluate the prediction performance of the proposed models, LightGBM, CatBoost, support vector machine regression, and long short-term memory (LSTM) network were selected as the cross-sectional comparison models. LightGBM and CatBoost algorithms are both improvements of the gradient boosted decision tree (GBDT) algorithm. Compared to the GBDT algorithm, which slices features at each level, the LightGBM algorithm slices features directly at the leaf nodes of the tree and introduces histogram optimization without sorting each feature, resulting in a significant speedup compared to the GBDT algorithm. Both the integrated learning algorithms are widely used in the field of data mining. Meanwhile, in order to verify that the one-dimensional convolutional neural network (Conv1D) has the performance of extracting temporal features in temporal order, a long- and short-term memory network is selected for comparison.

From the results in Figures 6, 7, and 8, the model proposed in this study possesses high performance in terms of accuracy and model interpretation, which is only slightly lower than the LightGBM algorithm and better than other integrated learning algorithms and neural networks. The model in this study consumes more time in convergence, which is caused by the search of hyperparameters for more iterations of training. Compared with the LSTM model, the LIGHTGBM model has higher prediction accuracy, and compared with SVR and GA algorithms, TSA has better merit-seeking ability and convergence in optimizing the LSTM model, indicating that the TSA algorithm is suitable for parameter optimization of the LSTM model. Compared with the three single neural network models LSTM, LIGHTGBM, and LSTM, the LIGHTGBM-LSTM model has better prediction accuracy and robustness and has stronger generalization ability. This indicates that the hybrid prediction model proposed makes full use of the advantages of different neural networks and has better prediction performance. As the model meets the practical engineering needs, it provides effective data support for the power system of buildings.

In order to verify the generalization ability of the model, regression prediction is performed for each of the other three measures in the paper, and the LightGBM algorithm is used to compare with the model proposed in this study. In the LightGBM algorithm, the parameters are set in the same way as those for the meter prediction. For the parameters of the model in this study, the parameters of the electricity

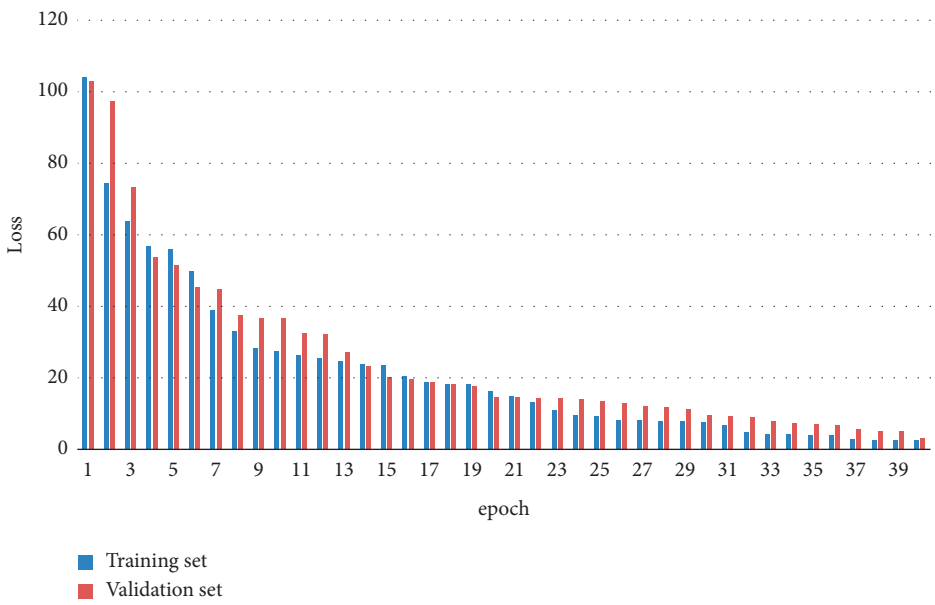

Figure 4: Schematic diagram of training process performance improvement.

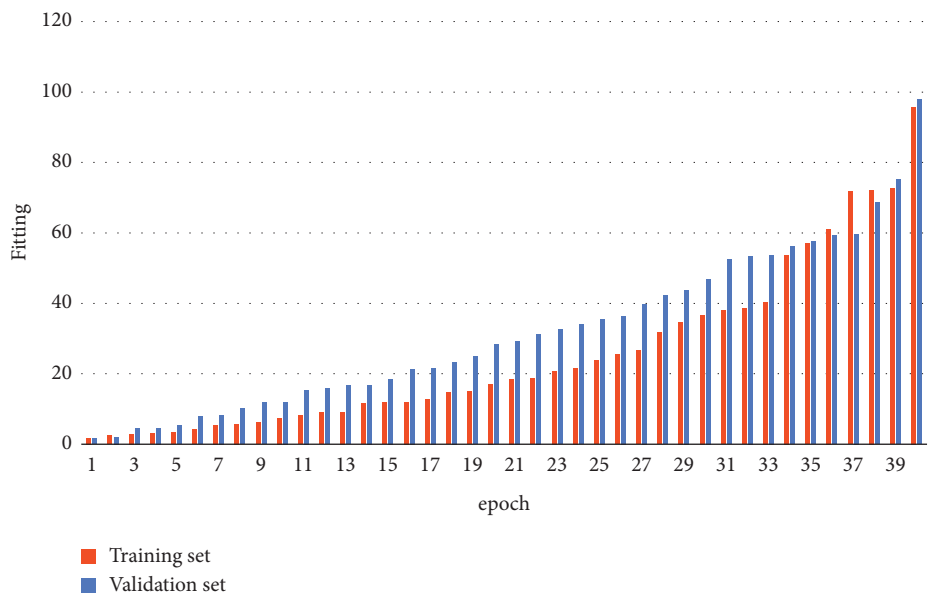

Figure 5: The training process loss convergence schematic.

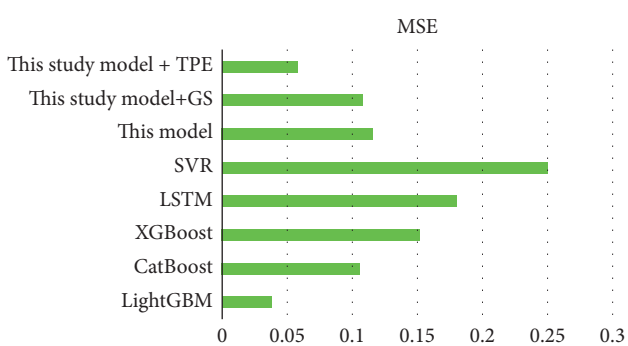

Figure 6: MSE comparison results.

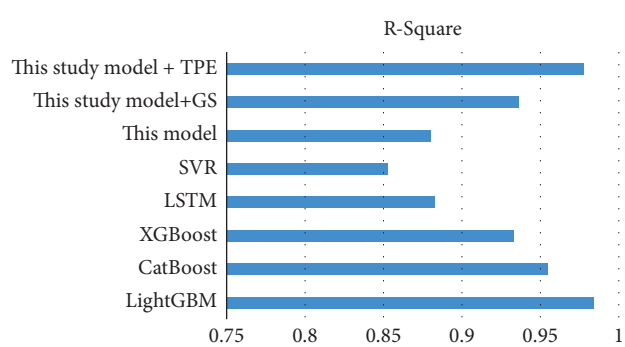

Figure 7: R-square comparison results.

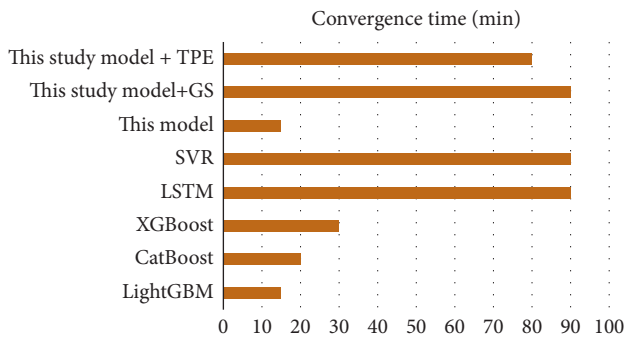

Figure 8: Convergence time comparison results.

Table 2: R-square validation of model generalization capability.

Meters	MSE	
	LightGBM	Proposed model
Cooling meters	0.2467	0.216
Steam meters	0.6171	0.606
Heat meters	0.5800	0.600

Table 3: Model generalization capability MSE validation.

Meters	R-square	
	LightGBM	Proposed model
Cooling meters	0.859	0.878
Steam meters	0.833	0.840
Heat meters	0.828	0.825

consumption prediction model were still used as the basis for parameter setting, and the TPE algorithm was not used for the superparameter search. The experimental results are shown in Tables 2 and 3. As seen in Tables 2 and 3, the performance of the model proposed in this study is close to or even better than that of the LightGBM algorithm.

It can be seen that the model proposed in this study has good generalization ability and is not only suitable for prediction of building electricity consumption but also can get good results when predicting energy consumption such as building cooling and heat.

5. Conclusion

With this research work, the building information system based on convolutional neural network is proposed to analyze building energy consumption of the four cycles-planning, design, construction, and operation-cum-maintenance. The key elements of building construction with the findings observed are summarized. Information integrity, significance, and correlation of the building information system are discussed. In the proposed model, regardless of the quantitative data and correlation rules, features are passed through the comprehensive database of the building information system after digitization and quantification. The building information system can simulate and predict the operation energy consumption in the visualized parameter environment and provide guidance for energy consumption management in the initial operation stage of different buildings. In short, the application of building information system is clearly and intuitively analyzed in terms of the building energy consumption of the whole building cycle and provides a basis for the development of scientific energy consumption management schemes. The efficient generalization ability of the proposed model suits it well in the designing of decision support tools and to improve building energy performance. With the advent of Big Data and Internet of Things, advance sensors and energy meters are required in buildings. In future, the method will be enhanced to support the futuristic sensors and meters so as to meet the requirements of the upcoming data processing systems.

Data Availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Sample Density Clustering Method Considering Unbalanced Data Distribution

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The data distribution of the multidimensional array sensor is unbalanced in data sample collection. To improve the clustering ability of data samples, a data density clustering method of sparse scattered points and multisensor array sensor samples based on the analysis of unbalanced data distribution characteristics is proposed. The sparse scattered multisensor array network's sample data collection structure is created using the Voronoi polygon topology. By analyzing the unbalanced parameters between data classes and reconstructing the characteristic space of data sample sequence, the time series of sample data collected by sparse scattered multisensor array is reorganized, and the statistical characteristic quantity and high-order cumulant of sample data collected by sparsely scattered multisensor array are extracted. Combined with the learning algorithm of unbalanced data distribution sample feature fusion, the fuzzy clustering of sample data information flow collected by sparse scattered multisensor array elements is realized. According to the feature clustering and convergence analysis, the sparse scattered feature detection method is adopted to realize the data density clustering and data structure optimization configuration of sparse scattered multisensor array elements. The test results show that the method in this paper has good convergence, strong spectrum expansion ability, and low error rate of data clustering when collecting samples with sparse scattered points and multisensor arrays.

1. Introduction

The stability of sample data collection and transmission in a multisensor array network is proposed. The accuracy of signal transmission is the key to ensuring the stable operation of multisensor data sampling. The load of sample data collecting and transmission in multi-sensor array networks is too high, and the balance of data clustering and scheduling is constrained and limited due to the load and interference of the transmission channel in sensor networks [1]. Consequently, it is essential to create a powerful clustering model using multisensor array sample data density and sparse scattered points. Based on the resource optimization allocation model of multisensor array network, combined with the big data analysis and statistical characteristics analysis of sample data collected by sparse scattered multisensor array, the self-adaptive distribution and reliability scheduling of sample data collected by sparse scattered multisensor array are carried out [2]. It is of great significance to study the density clustering method of sample data collected by sparse scattered points and multisensor array elements to improve the stability of data detection and transmission.

The data density clustering of sparse scattered multisensor array elements is based on the analysis and reconstruction of unbalanced parameters of data distribution. The key components of the data reconstruction technique are feature selection and resampling methods, including undersampling, oversampling, and mixed sampling methods that combine undersampling and oversampling. Oversampling method balances data distribution by increasing a few kinds of samples in unbalanced data, while undersampling balances data distribution by reducing most kinds of samples in unbalanced data. In large-scale data, the undersampling method can significantly reduce the number of training data and thus improve the training speed. The Random Under Sampling (RUS) method is one of the simplest undersampling methods, as the information carried by the majority of samples is obviously ignored by the RUS

technique, and it is extremely possible that some valuable samples will be eliminated during the subsequent classification procedure.

The improvement of classification idea is also an important strategy to improve the performance of unbalanced data classification. Representative methods include ensemble learning L and cost-sensitive learning [3]. In the existing research, the classification effect of the method combining resampling with the classification idea improvement strategy may be better than that of a single strategy. In reference [4], combining random undersampling and ensemble learning methods, EasyEnsemble and BalanceCascade methods are proposed. EasyEnsemble method randomly selects a number of independent subsets equal to the number of minority samples from the majority of samples, and combines them with minority samples to form a new training set, which independently trains a number of Adaptive Boosting (AdaBoost) classifiers and finally outputs the integrated classifier. The difference between BalanceCascade and EasyEnsemble is that each iteration uses the classification threshold to remove the correctly classified samples from the training set. Compared with RUS, the above two methods reduce the information loss of most kinds of samples but significantly increase the training time. Some researchers proposed RandomUnderSampling Boosting (RUSBoost) method which is based on AdaBoost. In this method, most classes were randomly undersampled in the iterative process, and a few classes formed a temporary training set. Then the weak classifier was trained by using the temporary training set and weights. RUS still uses random undersampling to balance the data distribution [5]. When the imbalance ratio is very high, it may take a lot of iterations. The configuration of sample data collected by multisensor array elements in sparse scattered points is based on the analysis of resourced parameter characteristics and clustering fusion processing. The channel transmission model of a multisensor array network is built by optimizing the distribution of virtual channels and transmission data packets. The channel equalization control is used to achieve the density clustering of sample data collected by multisensor array elements in sparse scattered points. In the traditional methods, the data density clustering methods of sparse scattered multisensor array elements mainly include the data density clustering method of multisensor array network based on neural network, the data density clustering method of sparse scattered multisensor array elements based on PCA, and the dynamic distribution method of data of sparse scattered multisensor array elements based on K-means fusion clustering [4, 6]. In reference [7], a SAC reinforcement learning-based sample data distribution method for sparse scattered point multisensor array is proposed, and a link spectrum data clustering model is established which makes the V2V link to optimize the sample data distribution for sparse scattered point multisensor array after continuous learning. However, the dynamic learning ability of this method for clustering sample data for sparse scattered point multisensor array is not good.

In order to solve the above-given problems, this paper proposes a data density clustering method based on the analysis of unbalanced data distribution sample characteristics. First, the sample data collecting topology of the sparse scattered multisensor array network is established using the Voronoi polygon topology. The sparse scattered feature detection approach is then used in accordance with the feature clustering and convergence analysis. It is done to optimize the data structure and density clustering of the sample data obtained from the sparse scattered multisensor array. Finally, the simulation test analysis shows that this method has superior performance in improving the clustering ability of data density of samples collected by multisensor array elements with sparse scattered points.

2. Topology Model and Data Structure Analysis of Multisensor Network

2.1. Multisensor Element Network Topology Model. Firstly, the model of the topological structure of the multisensor array network is created, and the Voronoi polygon topology is used to produce the topological structure of the sample data collection of the sparsely distributed multisensor array network. It is assumed that the multisensor array network consists of N main networks, and $U = \{u_1, u_2, \ldots, u_n\}$ is used to represent the communication data clustering set of secondary users to be connected, and $C = \{a_1, a_2, \ldots, a_m\}$ represents the channel structure parameters of sample data collection of sparse scattered multisensor array. The network topology of multisensor elements is established by gathering the spectrum parameters of samples collected by sparse scattered points and multisensor elements. These sparse scattered points and multisensor elements are combined with spectrum bandwidth analysis, also the method of dynamic judgment and channel fusibility is adopted to optimize the clustering of samples collected by sparse scattered points and multisensor elements. When the clustering center parameter curve of samples collected by sparse scattered points and multisensor elements is 0/1, the output spectrum bandwidth of samples collected by sparse scattered points and multisensor elements meets the clustering convergence in N-dimensional space, $0 \le w_{kj} \le 1$. According to the service, it should be switched to the reserved spectrum characteristic quantity under the condition that the communication in the sparse scattered point multisensor array acquisition system meets the service quality requirements. The maximum membership $\sum_{j=1\ldots D} w_{kj} = 1 (1 \le k \le K)$ of the sparse scattered point multisensor array acquisition, sample data are obtained by taking the blocking rate as the constraint parameter. The distribution link model of the sparse scattered point multisensor array acquisition sample data are established, as shown in Figure 1.

According to the distribution chain of sample data collected by sparse scattered multisensor array elements shown in Figure 1, let $Cen = [Cen_k]_K$ represent the statistical characteristic quantity of the number of primary users and the number of secondary users in the multi-sensor array element network. In the process of data clustering, incremental scheduling is adopted to obtain the segmented set at the H layer where the requested link sends the synchronization request time series:

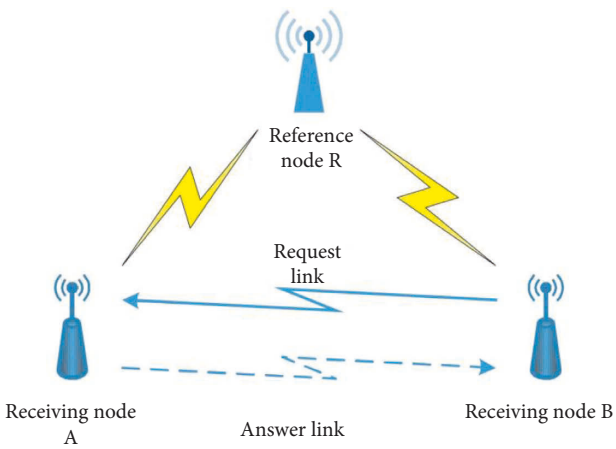

Figure 1: Schematic diagram of sample data distribution link for multisensor array acquisition.

$$\mathrm{Cen}_k = \{\mathrm{Cen}_{k1}, \mathrm{Cen}_{k2}, \cdots, \mathrm{Cen}_{kD}\}. \quad (1)$$

The beacon code is used to record the beacon in each period, and the hierarchical center of kth dispersion of the master node is obtained. Let $U = [u_{ki}]_{K\times N}$ represent the membership matrix of sample data collected by sparse scattered multisensor array elements, where u_{ki} represents the time stamp of sample data collected by sparse scattered multisensor array elements, and $x_i\,(1 \le i \le N)$ belongs to the beacon code of kth. $0 \le u_{ki} \le 1$ at the end of a complete synchronization period. It obtains the offset time series $Q = \{q_1, q_2, \ldots, q_i, \ldots, q_m\}$ and $P = \{p_1, p_2, \ldots, p_j, \ldots, p_n\}$ of sample data collected by sparse scattered multisensor array elements through the forwarding response link, $W = [w_{kj}]_{K\times D}$ is used to represent the joint distribution subspace weight matrix of the sample data collected by sparse scattered multisensor array elements. Therefore, the time series reorganization of the sample data collected by sparse scattered multisensor array elements is realized by analyzing the unbalanced parameters between data classes and reconstructing the characteristic space of the data sample sequence.

2.2. Analysis of Data Structure of Sensor Array Sampling. In the cluster of sample data collected by multisensor elements in sparse scattered points, the interactive parameter synchronization package is constructed first. $S = (U, A, V, f)$ is the statistical distribution set of reference node identification (ID), where U represents the period number, which is collectively referred to as the domain of sample data distribution of sparse scattered points and multisensor elements. A means sending timestamp (ST). The model parameters of a sample data configuration of sparse scattered multisensor array elements are obtained as$V = \cup_{a\in A} V_a$, where V_a is reference node ID and reference node period number information, and the output loss time distribution set is $a \in A$. In the range of $f\colon U \times A \longrightarrow V$, the frequency drift and phase offset of sample data collected by sparse scattered multisensor array elements are adaptively estimated. The data clustering

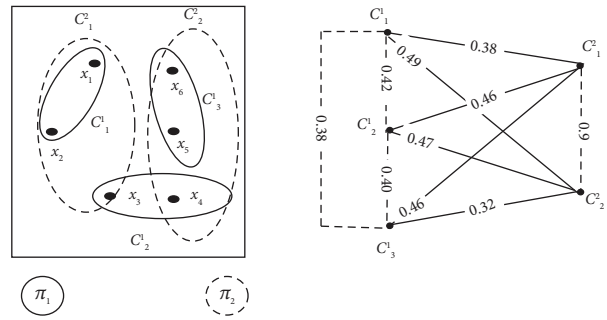

Figure 2: Analysis of data structure model.

sets $\forall u \in U, \forall a \in A$, in the same period of the same reference node are obtained by the method of model parameter estimation, and the output frequency offset is $f(u, a) \in V_a$. The sample data acquisition topology of a sparse scattered multisensor array network is established using the Voronoi polygon topology, and the data structure model is examined. According to the sample data structure analysis of sparse scattered multisensor array, the data distribution imbalance control algorithm is used for optimization control [9] as shown in Figure 2.

According to the data structure distribution in Figure 2, the statistical feature quantity and high order cumulant of the sample data flow collected by sparse scattered points and multisensor array elements are extracted. In the process of resource allocation, the self-sparse structure is constantly adjusted according to the accumulated historical data, and the fuzzy clustering processing of the sample data information flow collected by sparse scattered points and multisensor array elements is realized by combining the learning algorithm of unbalanced data distribution and sample feature fusion [10].

3. Sample Density Clustering Optimization

3.1. Data Clustering Feature Extraction Considering Data Imbalance. Bowyer–Watson algorithm is used to construct the sample data configuration model of sparse scattered point multisensor array. Combining with the topological structure of sparse scattered point multisensor array sampling data clustering, in a limited universe, the obtained channel gain is described as $S = (U, A, V, f)$ in sequence, if $A = C \cup D$, $D = \{d\}$, and $C \cap D = \Phi$, the transmitting power of the transmitter PT of sparse scattered point multisensor array sampling data are C and D in sequence, assuming that the distributed metadata feature quantity of the i-th channel of network M is $S = (U, C \cup D)$. The statistical features of the sample data stream collected by sparse scattered multisensor array elements are extracted by low-frequency wireless spectrum data clustering, and the allocation decision table is obtained. When $a \in A$ is satisfied, the disturbance component of the sample data collected by sparse scattered multisensor array elements in the main link is $\mathrm{IND}(A - \{a\}) = \mathrm{IND}(A)$, the sum of SU disturbances of any network is added, and the frequency division multiplexing method is adopted [11]. Get the linear eigenvalues of the clustering characteristic distribution attribute a of the sparse scattered point multisensor array

acquisition sample data in the closed interval A. The clustering hierarchical function of the sparse scattered point multisensor array acquisition sample data in the backhaul base station is $S = (U, A)$. For$P \subseteq A$, there is $\mathrm{IND}(P) = \mathrm{IND}(A)$. Distribute the superimposed data of the access subframe to the users of the base station and get the statistical characteristic quantity of the sparse scattered point multisensor array acquisition sample data fusion as follows:

$$\min \sum_{p_j \in N_k(p_i)} \left(\left(p_j - \overline{p}\right).t_{\mathrm{comm}}(X)n_i - g\left(u_j, v_j\right)\right)^2, \tag{2}$$

where $t_{\mathrm{comm}}(X)$ is the resource size of the three-level backhaul layer base station of the multisensor array network sample data collection and transmission channel, p_j is the frequency band information of the access subframe, n_i is the interference component of the sparse scattered point multisensor array acquisition sample data output channel, and $g(u_j, v_j)$ is the frequency component of the access sparse scattered point multisensor array acquisition sample set of subset D. Each sample with correct classification is removed as follows:

$$\pi_q = \{C_1^q, C_2^q, \ldots, C_K^q\}, \tag{3}$$

where the statistical feature of the nearest neighbor sample points is $G = \langle V, W^c \rangle$, where K is the reliability clustering parameter of searching the nearest neighbor parameters. Based on the nearest neighbor parameter method and the sequential decision mechanism, the remaining transmissible load π_{b_s} of the V link K is obtained which satisfies $b_s \neq b_t$, and then the joint feature point of the unbalanced data distribution sample is the shared neighbor of $C_{k_q}^{b_t}$, $C_{k_i}^{b_s}$ and $C_{k_j}^{b_s}$. Therefore, the fuzzy statistical characteristic quantity $S = (U, C \cup D)$ of agent K of sparse scattered point multisensor array element collection sample is obtained. For $U = \{u_1, u_2, \ldots, u_n\}$ as the universe, the density peak clustering algorithm is adopted, and the variation attribute of sparse scattered point multisensor array element collection sample is $C = \{a_1, a_2, \ldots, a_m\}$. Under the multiobjective evolutionary constraint, the fuzzy decision attribute of sparse scattered point multisensor array element collection sample is obtained and the control instruction set of data clustering satisfies $C \cap D = \Phi$. Combining with the data distribution imbalance sample feature fusion number, the neural network is trained back to obtain the best data clustering. The information entropy of the sample data collected by sparse scattered multisensor array elements are $\xi_{c_1}^{d_2} = 3/5$, $\xi_{c_2}^{d_2} = 2/5$,$\xi_{c_3}^{d_2} = 2/5$, $\max g_{c_1}(d_2) = 6/5$, $\max g_{c_2}(d_2) = 3/8$, and $\max g_{c_3}(d_2) = 1/10$. Therefore, the method based on multiobjective evolution is adopted to obtain the clustering feature extraction results of sample data collected by sparse scattered points and multisensor array elements. The adaptive configuration of sample data collected by sparse scattered points and multisensor array elements is realized [12].

3.2. Adaptive Adjustment and Output of Data Clustering Center. Feature clustering and convergence analysis suggest that the approach of sparse scattered feature detection be used to modify the dynamic resource allocation [13]. By analyzing the unbalanced parameters between data classes and reconstructing the feature space of data sample sequence, the time series of sample data collected by sparse scattered multisensor array elements is reorganized, and the statistical feature quantity and high-order cumulant of sample data stream collected by sparse scattered multisensor array elements are extracted. The distribution set of sparse points is taken as SDF. The output sample data collected by sparse scattered multisensor array elements is fixed for channel switching mode, and through idle communication spectrum conversion, the optimized model parameter of output sample data are collected by sparse scattered multisensor array elements area $\xi_{c_1}^{d_3} = 1$, $\xi_{c_2}^{d_3} = 1$,$\xi_{c_3}^{d_3} = 1$, $\max g_{c_1}(d_3) = 7/4$, $\max g_{c_2}(d_2) = 3/8$, $\max g_{c_3}(d_2) = 7/4$. Combined with the evaluation results of sample data return efficiency collected by sparse scattered multisensor array elements, the dynamic spectrum allocation strategy is adopted. Considering that the correlation between sample points is not only unbalanced with the data distribution of neighboring points, the frequency division multiplexing mechanism is introduced, and the calculation formula of the cross matrix of neighboring parameter clustering is obtained as follows:

$$\begin{bmatrix} d_1 \\ d_2 \\ d_3 \\ \cdots \\ d_N \end{bmatrix} = \begin{bmatrix} d_{11} & d_{12} & d_{13} & \cdots & d_{1N} \\ d_{21} & d_{22} & d_{23} & \cdots & d_{2N} \\ d_{31} & d_{32} & d_{33} & \cdots & d_{NN} \\ \cdots & & & & \\ d_{N1} & d_{N2} & d_{N3} & \cdots & d_{NN} \end{bmatrix} * \begin{bmatrix} w_{i1} \\ w_{i2} \\ w_{i3} \\ \cdots \\ w_{iN} \end{bmatrix}, \tag{4}$$

where $d_{ij}$is the Euclidean distance of each sample point, and w_{ij} is the information entropy of the sample data collected by the i-th sampling node. Considering that there may be outliers in the data set, these outliers will affect the selection of parameter K. The balanced control parameters of sparse scattered points and multisensor array elements are obtained by using the unbalanced scheduling between classes. At the node I, the characteristic sequence of data collection and clustering is denoted as $(w_{1,j}, w_{2,j}, \ldots, w_{tj})$, where t is the statistical characteristic quantity of detection time. The neighborhood of each sample point is obtained by the parameter K search algorithm, which is denoted as$\Pi = \{\pi_1, \pi_2, \ldots, \pi_B\}$, and a resource optimization allocation model is constructed. The sparse scattered feature detection method is used to realize the data density clustering and data structure optimization configuration of the sample data collected by sparse dispersed points and multisensor array

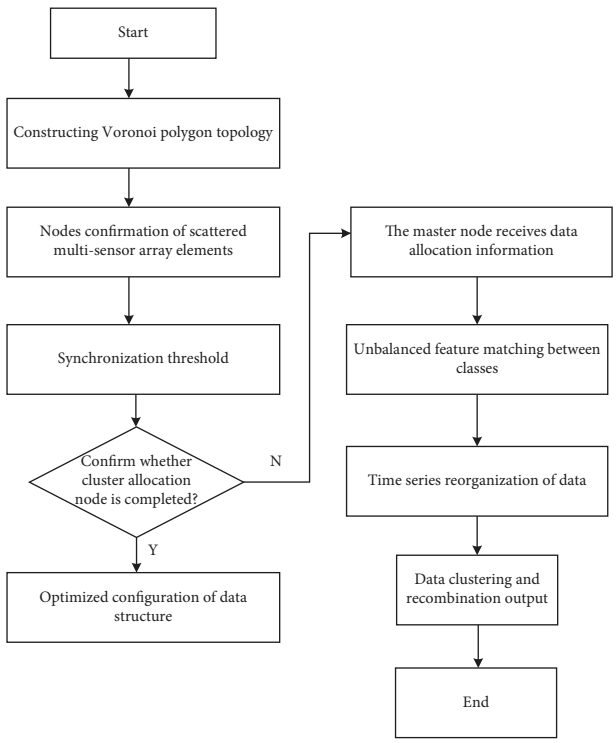

Figure 3: Implementation process of algorithm.

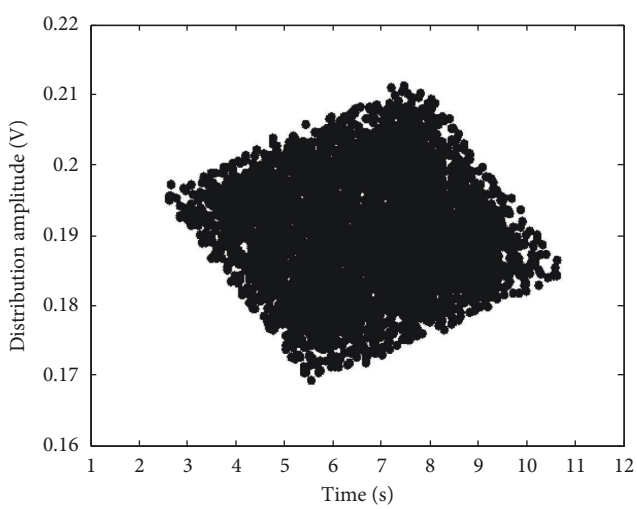

Figure 4: Original time series of sample data collected.

elements based on the clustering and convergence analysis of those samples. The optimized clustering function is as follows:

$$J_{ESSC}(U,V,W,X) = \sum_{k=1}^{K}\sum_{i=1}^{N} u_{ki}^{m} \sum_{j=1}^{D} w_{kj}\left(Cen_{kj} - x_{ij}\right)^{2} + \gamma \sum_{k=1}^{K}\sum_{j=1}^{D} w_{kj}\log w_{kj} - \eta \sum_{k=1}^{K}\left(\sum_{i=1}^{N} u_{ki}^{m}\right)\sum_{j=1}^{D} w_{kj}\left(Cen_{kj} - \overline{Cen}_{j}\right),$$
$$\text{s.t. } 0 \le u_{ki} \le 1, \sum_{k=1}^{K} u_{ki} = 1, 1 \le i \le N; 0 \le w_{kj} \le 1, \sum_{j=1}^{D} w_{kj} = 1, 1 \le k \le K, \tag{5}$$

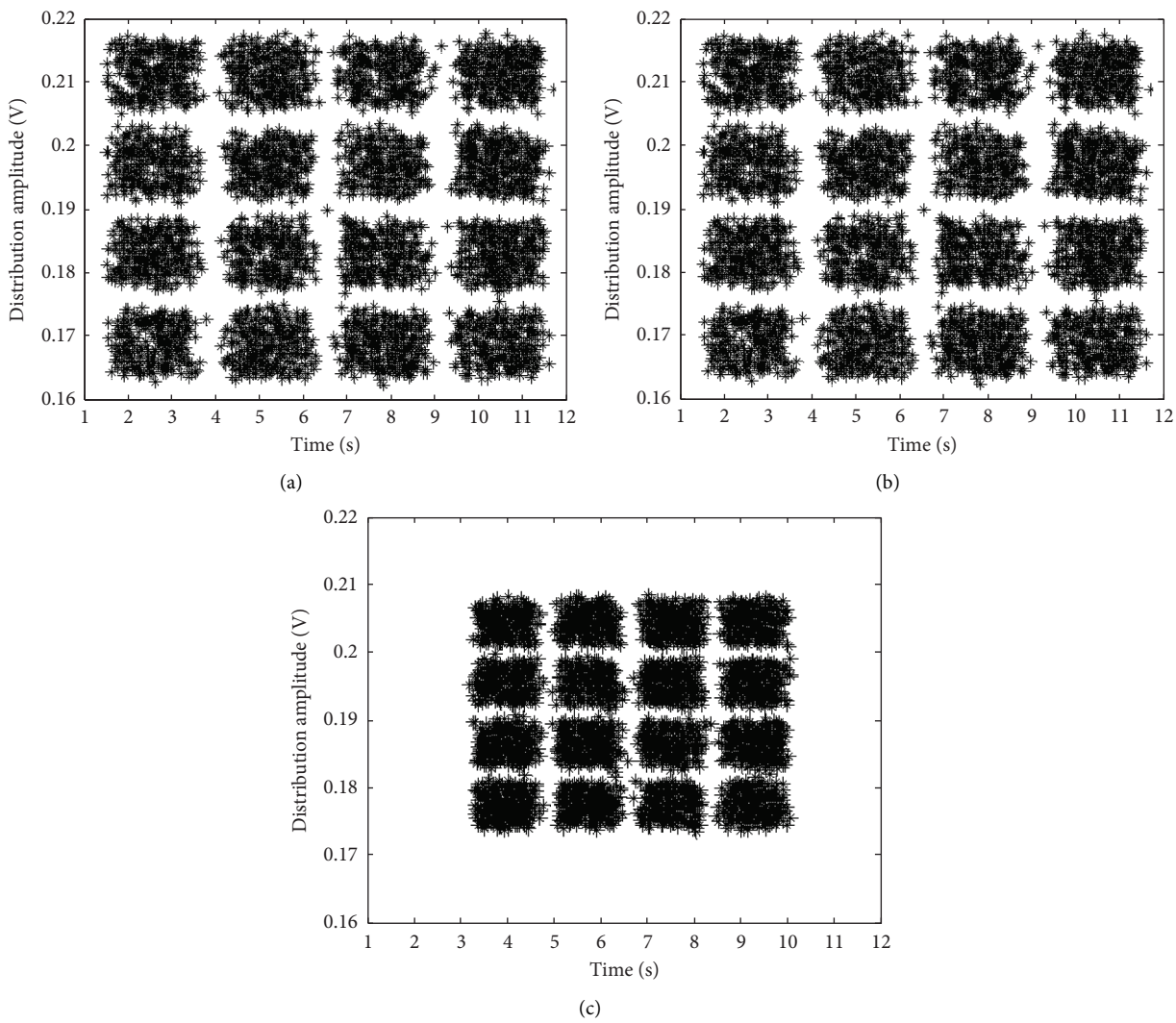

Figure 5: Output result of data clustering. (a) K-means method. (b) FCM method. (c) Methods of this paper.

where $\overline{\text{Cen}}$ is the average value of adjacent order of cluster center of sample data collected by multisensor array elements of each sparse scattered point; E is sample data which collected for sparse scattered multisensor array elements; γ represents the boundary area of most kinds of sample clusters; $\sum_{i=1}^{N} u_{ki}^{m}$ represents the dispersion degree of regional markers; w_{kj} represents the wrong area; N represents the size of resource allocation; K represents the fuzzy weighting coefficient of sample data clusters collected by sparse scattered multisensor array elements. To sum up, according to feature clustering and convergence analysis, sparse scattered feature detection method is adopted [14]. The process of data density clustering and data structure optimization of sparse scattered point multisensor array acquisition samples is realized. The process of data density clustering of sparse scattered point multisensor array acquisition samples is improved as shown in Figure 3.

4. Simulation and Result Analysis

Matlab simulation experiment is used to verify the application performance of this method in data density clustering of sparse scattered multisensor array [15] The parameter are set accordingly. The multisensor array network's K channel number is set to 200, its bandwidth to 40 kHz, its iteration count to 500, and its network benefit to 0.56. According to the above-given parameter settings, the data density clustering simulation of sparse scattered multisensor array is carried out, and the original time series of sparse scattered multisensor array data are given as shown in Figure 4.

Taking the time series of sample data collected by sparse scattered points and multisensor array elements in Figure 4 as the research object, this method is used to realize the density clustering of sample data collected by sparse scattered

Table 1: Error comparison of data clustering.

Iterations	K-means	FCM	This method
10	0.284	0.441	0.199
20	0.277	0.474	0.197
30	0.285	0.416	0.194
40	0.279	0.480	0.183
50	0.258	0.462	0.181
60	0.285	0.473	0.167
70	0.289	0.440	0.116
80	0.274	0.435	0.109
90	0.283	0.412	0.102
100	0.299	0.448	0.096

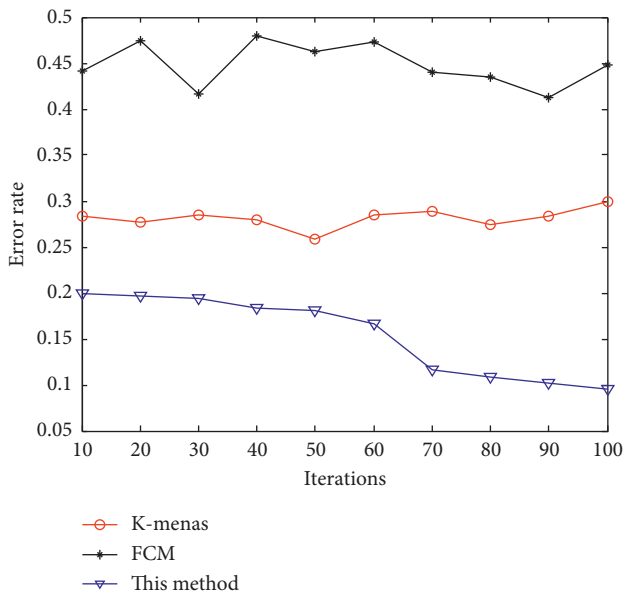

Figure 6: Comparison of BER of data clustering.

Table 2: Experimental data set.

Dataset name	Number of attributes	Number of samples
Brest cancer	9	285
Iris	4	150
Adult	15	356

points and multisensor array elements, and the data clustering results of each frequency band are shown in Figure 5.

It is clear from the analysis of Figure 5 that the distribution convergence of various approaches is evaluated when sparse scattered multisensor array samples are data density clustered by using this method, which has great spectrum adaptability and good interclass equilibrium classification. Taking the bit error rate of data clustering as the test index, the comparison results are shown in Table 1 and Figure 6. From the analysis of Figure 6, it can be seen that the bit error rate by a distance of sparse scattered multisensor array samples in this method is low and the convergence is good.

In order to test the clustering effect of the algorithm in this paper, brest cancer, iris, and adult in the UCI database are selected as the test data sets. The experimental data sets

Table 3: Comparison of different clustering algorithms.

Data set	Clustering algorithm	Convergence time/s
Brest cancer	K-means algorithm	40
	FCM algorithm	35
	Algorithm in this paper	23
Iris	K-means algorithm	70
	FCM algorithm	68
	Algorithm in this paper	45
Adult	K-means algorithm	123
	FCM algorithm	114
	Algorithm in this paper	66

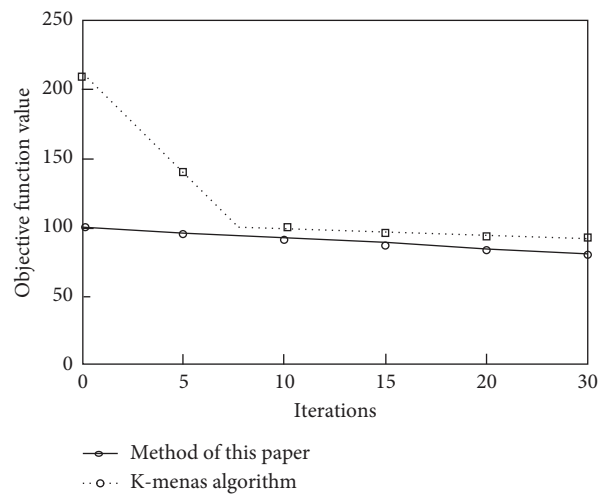

Figure 7: Comparison of the stability of the two algorithms on iris data set.

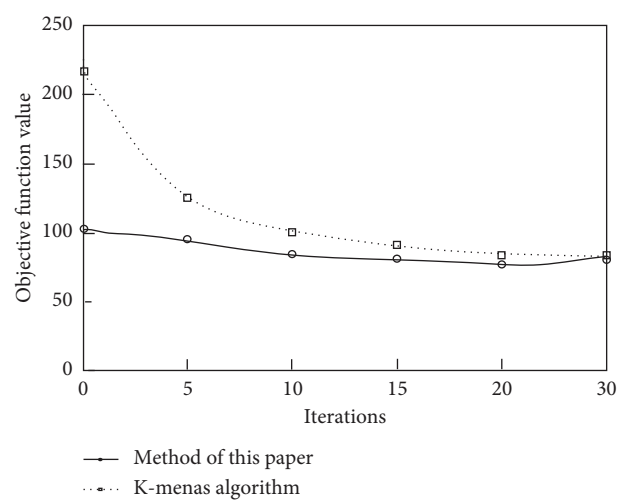

Figure 8: Comparison of the stability of the two algorithms on adult data set.

are shown in Table 2. In this experiment, the parameters are set as follows: the fuzzy index is 2, the maximum number of iterations is 50, and the initial value of iterations is 1.

The breast cancer, iris, and adult datasets in Table 2 were tested for 30 times using the k-means algorithm, FCM algorithm, and the algorithm in this paper, respectively, and

the mean value of convergence time obtained from each experiment was statistically compared. The comparison data are shown in Table 3.

By analyzing the data in Table 3, the k-means algorithm and FCM algorithm have a long convergence time during the experiment, while the convergence time of this algorithm is significantly reduced. Therefore, this algorithm shows a good clustering effect in the experiment. The k-means algorithm is compared with the clustering algorithm in this paper in terms of convergence speed. Iris and adult data sets in the UCI database are used during the experiment. The algorithm in this paper is executed by changing input parameters and 50 experiments are conducted. The results are shown in Figures 7 and 8.

Figures 7 and 8 show that, for two different types of data sets, when using this algorithm and the k-means algorithm to test the stability of the algorithm, the convergence speed of this algorithm is significantly faster than that of the k-means algorithm although the objective function values of this algorithm and k-means algorithm are very close at the end and the number of iterations is less with good stability. Therefore, this algorithm is better than the k-means algorithm in convergence and stability.

5. Conclusions

In this paper, an effective clustering model of sample data density collected by sparse scattered points and multisensor elements is established. The self-adaptive distribution and reliability scheduling of sample data collected by sparse scattered points and multisensor elements are carried out by optimizing the resource allocation model of the multisensor elements network. A data density clustering method based on the characteristic analysis of unbalanced data distribution samples with sparse scattered points and multisensor array elements is proposed. The convergence control of resource allocation is carried out by using the data distribution imbalance sample feature fusion score and the resource optimal allocation model is constructed. According to the feature clustering and convergence analysis, the sparse scattered feature detection method is adopted to realize the data density clustering and data structure optimal allocation of samples collected by sparse scattered multisensor array elements. The simulation results show that this method has good interclass equilibrium classification and high convergence accuracy improving the optimal allocation and scheduling ability of sparse scattered sample data of multisensor array network.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Analyzing the Coupling Degree of Coordinated Development between Ecological Environment and Regional Economy in Underdeveloped Areas

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Accelerating economic development necessitates the rapid consumption of more ecological environmental resources. Excessive consumption of ecological environmental resources will seriously damage the overall coordination between the ecological environment and the local economy. We examine the objective issues of regional economic development and environmental protection in the three eastern provinces. Local governments should prioritize the degree of interdependence between regional economic development and the ecological environment. A healthy development strategy includes managing and improving the regional environment while also ensuring the orderly and stable development of the local economy. The grey correlation analysis model is based on the coupling relationship analysis and uses the underdeveloped Northeast Economic Zone as the study goal. So, this study proposes that the regional economic circle of three northeastern provinces be the main topic of a quantitative analysis of the coupling relationship and influencing factors of the coordinated development of the ecological environment and regional economy from 2013 to 2020. Inferred from the perspective of spatial coupling relationships is the calculation of the coupling degree model based on the grey correlation degree. Specifically, Harbin (0.661), Changchun (0.650), Jixi (0.615), and Liaoyuan (0.629) fall into the antagonistic type and low-level coupling type categories. The degree of coupling between Northeast China's economic development and the natural environment significantly decreased from 2015 to 2018 from the perspective of the time series coupling relationship. The changing trend of coupling degree makes it abundantly clear that the problems with the ecological environment's constraints in the underdeveloped areas of the three northeastern provinces have not been fundamentally resolved. If no action is taken rapidly, the ecological environment will continue to deteriorate because environmental problems do not improve significantly in a short time.

1. Introduction

The country's rapid economic growth has hampered Chinese economic growth, resulting in serious environmental issues. The tourist market has expanded as people's living conditions have improved, rising from 0.49 trillion in 2003 to 5.40 trillion yuan in 2017. The natural atmosphere, which also serves as the primary safeguard for the local economy, greatly influences the excellence of a tourist site [1–3]. The natural atmosphere influences both the travel experience and the tourism expansion rate. Furthermore, changes in the natural environment, particularly those caused by climate change, harm tourism growth. Economic and tourism growth has both positive and negative environmental effects [4, 5]. While guiding or hastening the development of the ecological atmosphere's integrity, tourism and economic development will have a significant negative impact on the environment [6]. A major issue that must be addressed and managed is how to actively develop the local economy and tourism while maintaining a balance with the natural environment.

Traditional urbanization lacks the ability to achieve sustainable growth due to its obsession with large-scale expansion and disregard for quality development. China has

developed a new urbanization strategy based on this that balances quantity and quality. Emerging urbanization has significant implications for the population, geography, economy, society, and new urbanization's intricate relationship with the environment [7, 8]. According to the population urbanization perspective, when non-agricultural residents move to cities and towns, their housing needs and way of life change. This situation puts a strain on resources as well as the environment. The extended development model was the cornerstone of the economic development strategy, and early economic urbanization had a significant negative impact on the environment [9, 10]. Economic urbanization, on the other hand, will lead to more spending on ecological and environmental conservation. As a result of social urbanization, infrastructure and public services have frequently increased, but population growth has placed a strain on the environment. Social urbanization, on the other hand, has grown in importance alongside the concepts of long-term growth and environmental protection. Spatial urbanization might very well cause increased air and sound pollution due to increased traffic, in addition to increasing demand for land resources as cities grow. The negative environmental effects predominated in the early stages of new-type urbanization. However, abundant natural resources and a beautiful environment may provide a solid foundation for increased urbanization [11, 12].

Industrialization is the development of supplementary industries, which dominate economic growth in the late and middle stages. China's economy is now heavily reliant on industries that generate and utilize a significant amount of energy. China's increasing industrialization and urbanization, as well as the promotion of these trends, have had a negative influence on the environment and limited the country's economic growth. Shi et al. analyzed and investigated coordination using geographically and temporally weighted regression (GTWR). In China's 17 tropical and subtropical zones, there is spatiotemporal heterogeneity between economic growth and the natural environment. The biological environment, as well as economic growth, exhibits significant spatiotemporal diversity. More regions were identified as experiencing economic lag. The ecological lag type predominates in developed eastern regions, whereas the economic interval type predominates in central and western regions. Economic growth and the biological environment have agglomeration effects and favorable spatial links. Economic growth and environmental protection are increasingly interacting [13]. Fan et al. examined the coupled, synchronized growth scenario in each of China's 31 major cities. The research results describe the cities as having a privileged ecological environment which is in class 10, while the social economy is in class 5. We also discussed some of the major issues concerning development coordination. The best examples of synchronization can be found in Beijing, Hangzhou, and other cities, which demonstrate how vibrant social economies and reliable environmental protection can coexist. In terms of connected, coordinated growth, Lhasa and Yinchuan rank near the lowest of the cities studied. They must promote social and economic growth that is coordinated and appropriate for the specific ecological environment [14]. Fang et al. properly evaluated the current situation in the urbanized Shandong Peninsula by utilizing data from national statistics from 2008 to 2017. The findings show that raising the CCD level of an urban environment is necessary to ensure sustainable urbanization. Despite progress in coupling and coordination across the board, roughly half of the cities on the Shandong Peninsula remain in transitional or uneven growth phases. This regional growth disparity can be observed using the fundamental geographic pattern, which demonstrates that coastal cities have significantly higher coupling and coordination than inland cities [15]. Excessive resource use and pollution, which are primarily brought on by increased urban development, are also contributing to an increase in environmental stress. Countermeasures for performance improvement in various cities were taken into account. The gradual installation of high-quality infrastructure, enhancing urban appeal, raising resource efficiency, and making the best use of technology for treatment and recycling are a few of these.

All countries' economic development levels have significantly improved as a result of the growth of globalization in the economy, and both the size of the population and the scale of production have significantly increased. However, countries have also demonstrated significant ecological damage during the development process, which hinders social and economic development [16, 17]. The ecological environment is not only a critical foundation for human survival and development but also a powerful force in promoting regional economic development. Therefore, we can only promote sustainable and synchronized growth of both the regional economy and the ecological environment by fully coordinating both [18]. Eastern China's economic development is relatively slow in comparison to other regions due to industrialization. Northeast China's urbanization processes are relatively backward, and local enterprises face numerous development problems and flaws. Inadequate technical and management levels, for example, result in a lack of full coordination between regional economic and environmental development [19]. Therefore, focusing on the research and analysis of the degree of coupling coordination between the regional economy and the ecological environment can effectively predict the region's future economic development.

The innovations of this paper are as follows:

(i) This paper performs an empirical analysis of some cities in Northeast China and compares the dynamic change characteristics of this region using the coupling coordination degree model and the regression analysis model.

(ii) The paper investigates the coordinated development trend index L, develops a fitting equation between the ecological system and the economic system, and conducts a quantitative analysis of the coordinated development degree from 2013 to 2020.

(iii) Using MAPGIS software, the distribution characteristics and spatial differences of the coordinated development level of the ecological environment and economic growth in Northeast China are more intuitively displayed.

(iv) The interaction factors of the two systems are determined using grey correlation analysis. The essential problems of ecological constraints in the underdeveloped areas of the three northeastern provinces are highlighted.

The following is the overall structure of this paper. Section 2 shows the related work. An overview of regional economic development and the ecological environment in underdeveloped areas is described in detail in Section 3. Section 4 consists of constructing a coupling model for the coordinated development of the ecological environment and regional economy. Section 5 provides the results and analysis. Section 6 provides a conclusion of the work.

2. Related Work

The growth limit theory is based on the notion that the environment has a significant impact on economic growth and that a mismatch between the environment and the resources available will severely impede long-term economic advancement. Foreign countries began to study the relationships between the environment and economy since 1950s, the results show that the procedure of economic development will cause a series of environmental problems and even a serious threat to sustainable development. Keynes' economic development concept is also being used in the current research process [20, 21]. In 1966, the idea of a circular economy was first proposed. So, after that, the connection between economic growth and environmental development in 213 countries was researched and examined between 1970 and 2008, leading to the following findings. Environmental pressure and economic growth are strongly connected [22]. This paper investigates and discusses the environmental implications of economic growth. This is accomplished by developing an ecological environment optimization model and conducting a thorough investigation into the issue of ecological environment maintenance. Therefore, the economic environment has a larger optimal maintenance window than the ecological environment [23, 24]. The empirical analysis is used by domestic and international experts and scholars to investigate the beneficial relationships between them in the ecological environment. The study's effects on regional economic development are urbanization and development in China's ecological environment. We discovered that the degree of coupling between the regional economy and the ecological environment is influenced by a variety of factors that vary greatly [25]. Relevant experts and scholars assessed and analyzed the degree of economic development coupling. The environment in five different provinces in Northwest China was evaluated and analyzed, and the relationship between the two was demonstrated [26]. The grey correlation analysis method is used in this paper to select relevant data from Henan Province from 2008 to 2020. In Henan Province, we investigate the key factors influencing the relationship between the regional economy and the ecological environment. Consumers build correlation and coupling degree models of the regional economy and ecological environment, as well as their roles. We examine the relationship between the regional economy and the ecological environment in Henan Province from various perspectives, primarily from time and space [27].

3. An Overview of Regional Economic Development and the Ecological Environment in Underdeveloped Areas

3.1. An Overview of the Study Area. Northeast China refers to the region comprised of three northeast provinces, Liaoning Province, Jilin Province, and Heilongjiang Province, as depicted in Figure 1. It also includes the five eastern league cities of the Inner Mongolia Autonomous Region: Chifeng City, Xing'an League, Tong Liao City, Xilin Gol League, and Hulunbuir City [28]. The three northeastern provinces chosen for this study are in the heart of Northeast Asia. They not only are important agricultural bases in China but also have relatively strong industrial development. As a result, the study of these three provinces is extremely representative.

During the process of analyzing Northeast China's economic development, the issues and flaws in its economy are condensed and summarized in the following aspects. First, even though Northeast China's national economy is expanding more rapidly than the rest of China, its rate of development is still comparatively slow. Second, the ecological environment of Northeast China is under greater stress due to the region's economic development, which is heavily dependent on local environmental resources [29].

3.2. Analysis of Economic Development in Underdeveloped Areas (Three Northeastern Provinces). The economy of Northeast China has shown the momentum of rapid development after China's improvement and opening up. The change in GDP in Northeast China is shown in Figure 2. The GDP in Northeast China changed the most from 2013 to 2020, with a total GDP of 5091.932 billion yuan. In 2020, the economic development of Liaoning was the most prominent in the three northeastern provinces, with a GDP of 2490.95 billion yuan, followed by Heilongjiang and Jilin.

As a result of the industrial structure's adjustment, the tertiary industry has grown to play a significant role in Northeast China's economic structure. While the primary industry accounts for the smallest portion of the economic structure, the secondary industry is second only to the tertiary industry in terms of economic contribution. Figure 3 shows that the proportion of the three major industries in the three northeast Chinese provinces remains consistent in 2020. It is primarily due to the consistency of the three northeast Chinese provinces' cultural backgrounds and resource distribution [30]. In

Figure 1: Study area map of Northeast China.

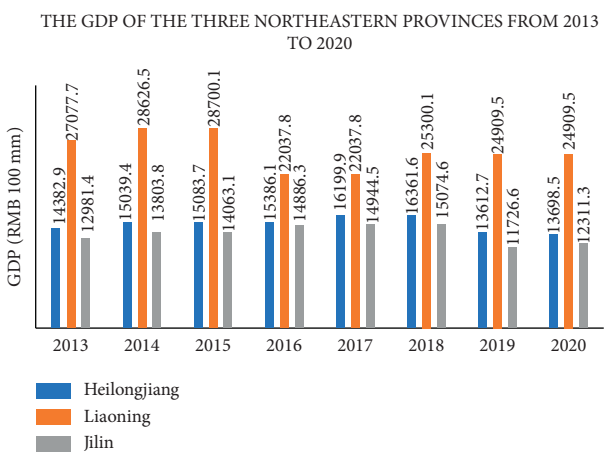

Figure 2: Statistics of regional gross national product of the three northeastern provinces.

comparison to Heilongjiang Province, the proportion of secondary industry in Liaoning Province and Jilin Province is relatively high, indicating that these two provinces have a higher level of industrialization.

3.3. Analysis of Ecological Environment in Underdeveloped Areas (Three Northeastern Provinces). In the procedure of economic development, Northeast China has experienced many years of large-scale development, which has had a negative influence on the ecological environment. Therefore, the ecological environment problems in Northeast China are becoming more and more serious [31]. Figure 4 depicts an investigation into industrial SO_2 and smoke emissions in Northeast China. The air quality problem in Northeast China in 2020 is severe, and industrial SO_2 and industrial smoke emissions are rising. Industrial waste proportions are relatively high, particularly in terms of industrial SO_2 and manufacturing smoke emissions. They account for a relatively high proportion and are the primary causes of the destruction of the regional ecological environment.

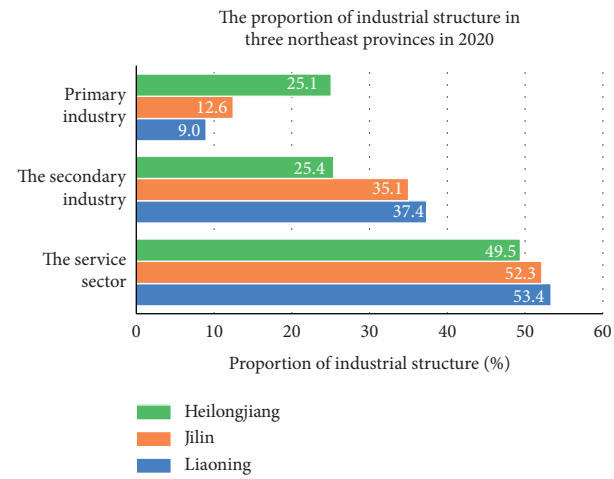

Figure 3: Industrial structure of provinces in Northeast China.

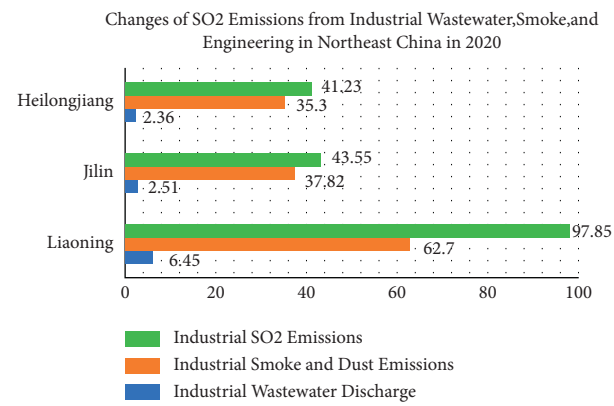

Figure 4: Changes in industrial wastewater, soot, and SO_2 emissions from projects in Northeast China.

According to an analysis of industrial SO_2, industrial soot, and industrial wastewater emissions in the aforementioned provinces, Liaoning Province is the most affected. In Heilongjiang and Jilin provinces, industrial SO_2, industrial soot, and industrial waste emissions are relatively low. Because Liaoning Province's iron and steel industries are so advanced, pollution, waste gases, and wastewater emissions are high. There is currently no effective treatment for toxic gases discharged by the iron and steel industry, which is also the primary cause of Liaoning Province's significant over-standard emissions of industrial SO_2, industrial dust, and industrial wastewater. If this industrial pollution is not effectively treated, it will endanger Northeast China's ecological environment [32].

4. Constructing a Coupling Model for the Coordinated Development of the Ecological Environment and Regional Economy

4.1. Construction of System Coupling Model Based on Grey Correlation. Grey correlation analysis is also referred to as grey correlation degree. This quantitative method of analyzing influencing system factors is primarily based on the

similarity and development trend of two system factors [33, 34]. Regression analysis, correlation analysis, quantitative description, and grey correlation analysis of all influencing factors in the system can more accurately replicate the system's differences and complete the identification of main factors [35]. The model's basic steps are as follows.

Step 1. Determine analysis sequence.

The two sets of analysis sequences in this paper are the economic development sequence group and the ecological environment sequence group, which are X_i and Y_i, respectively.

Step 2. Dimensionless sequence variables.

In the analysis of grey correlation degree, it is generally necessary to deal with the dimensionless data. This paper adopts the averaging method:

$$\begin{aligned} X' &= \left(X_i - X_{min}()\left(X_{max\,x} - X_{min}()\right)\right), \\ Y' &= \left(Y_j - Y_{min}()\left(Y_{max\,x} - Y_{min}()\right)\right). \end{aligned} \tag{1}$$

Step 3. Calculate the correlation coefficient.

Whether the coupling degree and correlation degree can be calculated usually depends on the solution result of the correlation coefficient. The two behavior sequences in the system have the correlation characteristics shown in the following formula (grey correlation theory), which can be described as

$$\xi_{ij}(t) = \frac{\min_i \min_j \left|X_i'(t) - Y_j'(t)\right| + \rho \max_i \max_j \left|X_i'(t) - Y_j'(t)\right|}{\left|X_i'(t) - Y_j'(t)\right| + \rho \max_i \max_j \left|X_i'(t) - Y_j'(t)\right|}, \tag{2}$$

where $\xi_{ij}(t)$ represents the correlation coefficient at time t, $X_i'(t))$ and $Y_j'(t)$ are the standardized values of the ith economic development and the jth ecological environment indicators of cities in Northeast China at time t, respectively, and ρ represents the resolution coefficient $\rho = 0.5$.

Step 4. Calculate the degree of correlation and coupling.

Calculate the correlation coefficient's average value based on the sample size of k. In other words, it is possible to obtain a correlation matrix (index sequence) and the level of interaction between the ecological environments. The resulting matrix can show the complexity of the coupling between the two factors and economic development.

$$r_{ij} = \frac{1}{k}\sum_{j=1}^{k} \xi_{ij}(t), \tag{3}$$

where k represents the number of samples, and the ecological environment and economic development coefficient of the sample area studied in the paper are also represented by k. In the coupling process of ecological environment and economic development, various factors that have no obvious influence can be reflected by comparing the r_{ij} value of different parameters and the sequence of data values.

Step 5. Coupling model based on correlation degree.

Based on the correlation matrix, the average value is calculated by row or column, respectively, and the correlation model of system coupling can be obtained:

$$\begin{aligned} d_i &= \frac{1}{l}\sum_{j=1}^{1} r_{ij}\,(i = 1, 2 \ldots m, j = 1, 2, \ldots, l), \\ d_j &= \frac{1}{m}\sum_{j=1}^{m} r_{ij}\,(i = 1, 2 \ldots m, j = 1, 2, \ldots, l). \end{aligned} \tag{4}$$

The number of eco-environmental system indicators is l in formulas (3) and (4). The number of indicators of the economic development scheme is m. The average value of the correlation degree of the ith index between the eco-environmental system and the economic development system is d_i, which reflects the size of the coupling of the eco-environmental system affected by it. The regular degree of the correlation degree of the jth index of the economic development scheme and ecological environment system is d_j, which reflects the size of the coupling of the economic development system affected by it.

Using space and time as entry points and based on the relevant degree of coupling, this paper provides quantitative analysis and judgment on the coordination of environmental schemes and economic development. An overall assessment of the coupling strength of the two systems in Northeast China's economic development and ecological environment is required. The following is the specific solution equation:

$$C(t) = \frac{1}{m \times l}\sum_{i=1}^{m}\sum_{j=1}^{I} \xi_{ij}(t), \tag{5}$$

where $C(t)$ is the coupling degree and m and l represent the index number of economic development and ecological environment system, respectively.

4.2. Description of Evaluation Index. The regional economic system and ecological environmental system are relatively complex. So, it is necessary to select reasonable and effective evaluation indicators in the process of studying the impact relationship between these two systems. Table 1 depicts the evaluation index system developed in this paper.

The data selected in this paper are mainly from the statistical yearbook of China from 2013 to 2020 in the three northeastern provinces.

5. Results and Analysis

5.1. Analysis Results of Main Factors. It is based on original data, a distinctive sequence, a grey correlation analysis method, and a variety of economic development parameters. The research unit disregards the original cities as provincial boundaries in the three eastern provinces. Table 2 shows the results of calculating the correlation matrix of the coupling impact of the ecological environment and economic development for the three eastern provinces in 2020.

The most visible indicators of economic development are an increase in GDP per capita and an improvement in the overall state of the economy. The characteristics of the country's industrial structure are visible due to the sample area's historical status as China's industrial core. The main indicator of regional economic growth in the industrial sector is an increase in the value of industrial output. The coupling of the ecological environment leads to economic development. The ecological environment and economic level subsystems have the strongest correlations, with a correlation coefficient between them of up to 0.695.

The ecological environment will have a significant impact on economic development. The correlation coefficient of 0.706 between the economic development system (X) and the ecological environment pressure subsystem results in the first position (Y2). That is, the factors that have the greatest impact on the sample area's economic development are the use of water and soil resources, the discharge of pollutants, and so on. The economic development system and sulfur dioxide emissions (y4) have a coupling degree of 0.705. The economic development system and industrial smoke emissions (y5) have a coupling degree of 0.697. The degree of coupling between the economic development system and industrial wastewater emissions (y6) is 0.715, which is quite high.

5.2. Spatiotemporal Analysis of the Coupling Relationship between Regional Economy and Ecological Environment

5.2.1. Result Analysis of Spatial Coupling Relationship. For starters, regionality refers to both spatial and temporal development patterns. Second, the interaction of their elements is based on the ecological environment and economic development's coupling degree values, as well as the classification conclusion of the coupling mechanism in the sample area. From high to low, the coupling stages can be classified into four types: high-level coordination, running in type, antagonistic in type, and low-level coupling type. Using nine representative cities from the three eastern provinces as the specific analysis object, the system's reference parameter is determined as urban GDP. The coupling and coordination relationships between various regions are then described, with specific data shown in Table 3.

(1)Coordinated Type. Dalian is a coastal city with a superior geographical location. It is the external window of Liaoning, which is even the sample area. It is in the first group of economic development in the three northeast provinces, with a coupling degree of 0.676. In 2020, the GDP of Dalian reached 703.04 billion yuan.

(2) Running in Type. Shenyang, the capital city of Liaoning Province, is a running city in a coupling area. In 2020, the coupling degree of Shenyang's ecological environment and economic development was 0.621. The population pressure was large, which restricted the city's environmental coordination and economic development to a certain extent.

(3) Antagonistic Type. The economic development level of such areas has diversified characteristics, and many reasons have led to the formation of the most obvious degree of coupling between environmental and economic development in this area. In terms of talent and labor attraction, Harbin (0.661), the capital of Heilongjiang Province, and Changchun (0.650), the capital of Jilin Province, have relatively prominent regional advantages and faster economic development. However, due to excessive population and the occupation of too many environmental resources, environmental dependence does not decrease but increases. This gradually highlights the ecological environment's negative feedback impact on economic development and the urbanization process. Compared with the two, it has the highest coupling degree.

(4) Low-Level Coupling Type. Jixi's ecological environment and economic development were 0.615 and 0.629 in 2020, respectively, because of the lack of leading industries and a low level of regional environment and economic development. The environmental impact is significantly less than the pressure it can withstand, and the issue of environmental protection has not even been considered, so there is no obvious degree of coupling.

5.2.2. Result Analysis of Time Series Coupling Relationship. Time series analysis can reflect the periodic fluctuation characteristics of the degree of coupling between the ecological environment and economic development in nine cities in the sample area. The "m" time series analysis of the coupling degree from 2013 to 2020 is shown in Figure 5. The figure depicts the fluctuation characteristics of the degree of coupling between the ecological environment and economic development in this region.

The analysis and calculation results show that 0.659 and 0.711 are the value ranges of the sample area's coupling degree from 2013 to 2020, and the fluctuation range is large, indicating two problems. First, in the sample area, there is a

Table 1: Regional economic ecological environment evaluation indicators.

System layer	Element layer	Index layer
Regional economic system	Economic level	GDP (x_1) Per capita GDP (x_2) Per capita gross non-agricultural output value (x_3)
	Economic structure	The proportion of primary industry in GDP (x_4) GDP percentage for tertiary industry (x_5) The value of total industrial output as a percentage of the combined value of industrial and agricultural output (x_6)
Eco-environmental benefits	Ecological environment level	Greening coverage rate of built-up area (y_1) Area of cultivated land per capita (y_2) Per capita public green space area (y_3)
	Ecological environment pressure	Industrial SO_2 emission (y_4) Industrial smoke emission (y_5) Industrial wastewater discharge (y_6)
	Ecological environment protection	Centralized sewage treatment rate (y_7) Rate of total utilization of industrial solid waste (y_8) Removal of industrial smoke (dust) (y_9)

Table 2: Coupling correlation data statistics on regional economic development and the ecologic environment.

System	Index	Economic level			Economic structure			Mean value	
		x_1	x_2	x_3	x_4	x_5	x_6		
Ecological environment level (Y_1)	y_1	0.551	0.566	0.538	0.721	0.747	0.730	0.642	
	y_2	0.701	0.685	0.698	0.845	0.589	0.516	0.672	**0.657**
	y_3	0.520	0.836	0.778	0.732	0.601	0.501	0.657	
Ecological environment pressure (Y_2)	y_4	0.767	0.763	0.771	0.651	0.690	0.588	0.705	
	y_5	0.753	0.792	0.754	0.684	0.641	0.555	0.697	**0.706**
	y_6	0.856	0.833	0.858	0.691	0.562	0.488	0.715	
Ecological environment protection (Y_3)	y_7	0.595	0.618	0.599	0.555	0.670	0.732	0.628	
	y_8	0.561	0.545	0.550	0.613	0.645	0.668	0.597	**0.638**
	y_9	0.730	0.801	0.746	0.655	0.649	0.573	0.692	
Mean value		0.670	0.715	0.699	0.683	0.644	0.595	0.667	
			0.695				**0.640**		

Table 3: Statistics of coupling degree types of some cities in Northeast China (2020).

Area		Coupling degree	Urban GDP (100 million yuan)	Classification of types
Liaoning Province	Shenyang	0.621	6571.6	Running in type
	Dalian	0.676	7030.4	Coordination type
	Anshan	0.642	1738.8	Running in type
Jilin Province	Changchun	0.650	6638.0	Antagonistic type
	Jilin	0.663	1452.6	Antagonistic type
	Liaoyuan	0.629	429.9	Low-level coupling type
Heilongjiang Province	Harbin	0.661	5183.8	Antagonistic type
	Qiqihar	0.656	1200.4	Antagonistic type
	Jixi	0.615	572.4	Low-level coupling type

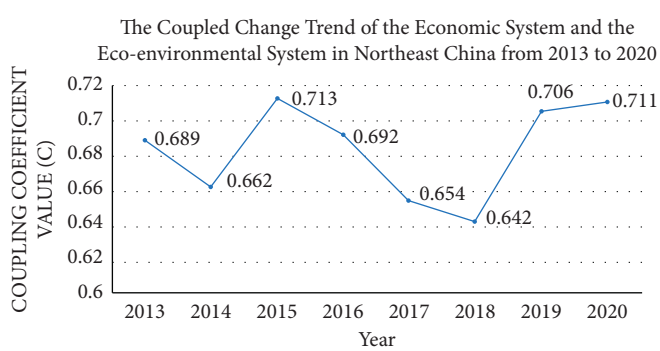

Figure 5: From 2013 to 2020, the coupling change trend of the economic system and the ecological environmental system in Northeast China.

strong coupling between the ecological environment system and the economic development system, which are closely related. Second, the degree of action, focus, and intensity of the coupling between the local ecological environment and economic development are dynamic rather than static.

6. Conclusions

The coupling degree of the ecological environment and economic development in the sample area in 2020 is 0.711, indicating a medium correlation degree. According to the grey correlation analysis method, the main constraints on economic development are the emission of three wastes and the restriction of water and soil resources. The overall level of the economy and people's living standards in Northeast China reflect the stress of economic development on the ecological environment. The spatial distribution is determined by economic development and environmental interaction, and Northeast China is primarily antagonistic and low-level in terms of spatial coupling relationships. The main representative cities are Shenyang (0.621), Anshan (0.642), Liaoyuan (0.629), and Jixi (0.615), and comparative analysis reveals that the overall coupling degree of cities in Liaoning Province is higher. Compared to the other two provinces, Jilin and Heilongjiang have a significantly higher percentage of cities with a high coupling degree. A time series analysis shows that the coupling degree curve has changed from 0.713 in 2015 to 0.642 in 2018, indicating that this is the second stage. The degree of coupling between economic development and the environmental state fluctuated significantly after declining in 2018 and beginning to rise in that year. The changing characteristics of the coupling degree curve are expected to drive the next five years. In this region, the degree of coupling between economic development and the ecological environment will increase and will be antagonistic in the short term. At the same time, the ecological environment will have a significant constraining effect on economic development.

Data Availability

The data used to support the findings of this study are available on reasonable request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Application of Art in Computer Graphic Design

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Studying painting, drawing, sculpting, and graphic design are all included in an art and design degree. Basic design ideas, colour theory, critical analysis, and creative approaches are taught to students majoring in art and design. One of the key elements that determine the calibre of art and design is colour matching. Modern art design makes extensive use of computer technology. To create high-quality art pieces, designers must thoroughly research computer colour matching. This paper is based on a knowledge of the colour matching of the art design. This paper uses computer technology to successfully select the hue and colour quantity rate of a mathematical framework. At the same time, it should select the style of colour matching style, background hue, and colour quantity. It is proposed to employ cyan, magenta, yellow, key (CMYK), hue-saturation-brightness (HSB), red, green, and blue (RGB), and other modes to get the approximate hue sum, which can serve as a useful benchmark for the modernization of art design. The experimental results demonstrate that the two groups of colour matching selected for this paper have high colour difference accuracy, but the formula accuracy provided by the weight factor for colour difference is superior to that provided by other weight factors whether it is the formula accuracy provided by computer colour matching or the accuracy of actual art images.

1. Introduction

Design is an art form, a way for people to express themselves that adheres to a set of carefully established rules in order to give things, performances, and experiences meaning. The design has the ability to solve issues, just like all other kinds of art, but there is no assurance that it will [1]. A degree in art and design covers a variety of visual arts, including graphic design, painting, and drawing. Students majoring in art and design study fundamental design concepts, colour theory, critical thinking, and artistic methods. One of the key elements that influence the calibre of art and design works is colour matching, which is intimately tied to people's daily lives. Computer technology has progressively filtered into art design with the advancement of science and technology and societal development, but most designers do not precisely and methodically study colour matching expertise, and it is challenging to create artworks with impact [2].

Hue refers to the texture and appearance of a colour. In the process of colour matching and colour selection of computer art design, it is necessary to determine the hue and create an accurate range split between cool and warm colours to be used in the colour matching of future art design efforts [3]. The colour with the largest area is known as the primary colour in art design, and its hue can be crucial in most colour matching contexts while performing a prominent role in total colour matching. Red, yellow, orange, green, blue, purple, and magenta are the primary divisions of hue, and they can be broadly split into seven colours that also signify several exclusive purposes. Therefore, distinguishing between cold and warm colours in the colour phase can draw attention to the meaning and implications of artworks and help how colours are correctly combined in the artwork. In addition, it is necessary to select the hue of the basic colour [4]. Determining the hue type is required when choosing the hue of the contrast colour in order to choose the right hue for the primary colour to serve as the contrast colour. Hue is the general tendency of the image colour in a design, in which a stronger colour impact is created. This effect is seen in things of various colours that exhibit a distinct hue, making objects of various colours has a similar colour tendency. Solid colour, brilliant colour, dark colour, turbid colour, light colour, light turbid colour, black colour, and white colour are the eight general categories into which

colours can be loosely separated. To successfully choose the performance hue in the aforementioned colours, it is needed to first consider the true meaning of the art design works as well as the designer's subjective perception. In order to properly create the design works with acceptable structure, clear colours, and powerful themes, it is necessary to pick the primary colour of the colour matching that occupies a considerable area and the corresponding auxiliary colours [5]. It is important to separate the primary colour from the contrast colour when combining and matching two or more tones. To create art design pieces using image colours, it is necessary to concentrate on the primary colour and emphasise the supporting function of the contrast colour [6].

A chromaticity rate refers to the scale of colour strength, formed by the comprehensive tone and colour shading, which has a certain impact on people's visual perception and psychological dynamics. People will experience discontent if the chromaticity rate is improperly chosen [7]. Therefore, to precisely determine if the colour intensity needs to be altered while creating computer-aided art, it is required to use the design system. When colour amounts are correctly reduced and when colour matching and hues are consistent, viewers will have a strong feeling of elegance and will recognize the "advanced grey" stage in the image [8]. It will provide people with a powerful visual effect and display a lively image performance if the colour quantity is correctly increased. In light of this, it is necessary to colour and alter the design work. In order to present creative beauty in its truest form, it is important to make full use of computers to change colours that are apparent and disorganised [9].

One of the fundamental techniques for computer colour matching is full spectrum colour matching. It traditionally matches each wavelength point equally. In fact, there are clear disparities in the colour perception changes brought on by the identical size changes of the object at various wavelengths [10]. At certain wavelengths, there exist changes, but the colour cannot change in line with them, demonstrating strong inertia. At other wavelengths, the changes are small, but there are large colour perception differences, demonstrating a strong sensitivity. Therefore, different weights should be matched with various wavelengths. Give more weight to sensitive wavelengths for key matching, and give less weight to insensitive wavelengths. Even though there are already two different types of weight factors, they are unable to capture the variations in colour perception at different wavelengths [11].

According to the design of the colour sensitivity function model and the investigation of its laws, this paper provides colour difference weight factors for full spectrum colour matching [12]. This research effectively chooses the hue and colour amount rate of a mathematical framework using computer technology. It should choose the background colour and amount at the same time as the style of colour matching. To get the approximate hue sum, which can act as a helpful benchmark for the modernization of art design, it is recommended to utilize CMYK, HSB, RGB, and other modes. The experiment results show that the two colour matching groups chosen for this study have high colour difference accuracy, but the weight factor for colour difference provides formula accuracy that is superior to that of other weight factors, whether it is formula accuracy from computer colour matching or formula accuracy from actual art images.

The remainder of the paper is organized as follows: Section 2 is composed of the related work. Section 3 discusses the colour matching style selection for computer graphics creation based on mathematics. Section 4 discusses the computer art design colour matching method based on mathematics. Section 5 discusses the experimental results, and finally, the paper is concluded in Section 6.

2. Related Work

The core principle of computer colour matching is the absorption and scattering theory of light in fully opaque material, known as the Kubelka–Munk theory [13]. In theory, the Kubelka–Munk function has a linear connection with concentration, but in actuality, it has a nonlinear relationship. This is mostly because the Kubelka–Munk theory was founded on the following three assumptions:

(1) The colour layer has an unlimited thickness.

(2) Light is adequately dispersed in the pigment layer and is totally diffused. In fact, light is not necessarily fully diffused in the medium.

(3) The medium has two light pathways, one upward and one downward, and they are perpendicular to the interface.

In practice, the Kubelka–Munk function has a nonlinear relationship with concentration due to theoretical flaws and other factors [14]. In order to reconcile theory and experience, the surface reflection factor is frequently utilised to address theoretical flaws in practice. Etters et al. believe that the substrate determines the surface reflection factor. The surface reflection factor is the reflectivity at the maximum absorption wavelength when printing and dyeing with strong absorbing colours. After careful consideration, this strategy has certain drawbacks. Even if no surface reflection exists, the reflectance at the maximum absorption wavelength is not always zero [15]. Zeng Hua et al. proposed the surface reflection factor that is determined mathematically in order to create a linear dye database for the colour difference weight factor, which makes the Kubelka–Munk function and concentration tend to be linear in practice [16].

3. Colour Matching Style Selection for Computer Graphic Creation Based on Mathematics

This section is further divided into the following subsections.

3.1. Colour Matching Style. The majority of the time, contrast type, scattered type, and central type are combined to create colour matching styles. Use the contrast type to divide the color matching board into useful parts and useless parts, so that the color matching board can convey a strong sense of contrast [17]. For example, colour contrast, such as warm

and cold tone contrast, will often be separated into left and right or up and down halves. The term "scattered type" refers to an open configuration that is unconstrained and unrestricted, avoiding the centralised appearance of a single hue in the design but yet successfully dispersing it with a specific meaning to create an air of comfort and freedom. Placing the design topic in the middle of the image is referred to as the central configuration. This technique can successfully convey the design's substantive meaning and inspire confidence and peace of mind [18]. It is important to highlight that this layout is more conventional and conservative than modern, making it unsuitable for demonstrating strong practical qualities.

3.2. Background Tone. Effective background tone selection is essential in the computer art design process if the design subject is to be highlighted. The three categories of dark colour, light colour, and white colour are typically used to categorise it. Dark backgrounds, such as black, brown, and dark blue, have high visual tension and evoke a feeling of mystery, which is the basic foundation for the dark type [19]. Because of this, it could emphasise the design's primary elements and show their solid coherence and vibrant qualities. A light background differs slightly from a white background. The latter can express the primary hue while at the same time reducing the sharp contrast, giving the sense of being clean, basic, and organised. The former displays a more graceful and gentle sensation based on colour.

3.3. Colour Quantity. Effective colour selection and colour quantity management are essential throughout the computer-aided design and colour matching process in order to prevent the phenomenon of colour confusion in design works caused by excessive colour selection, which would negatively affect the outcome [20]. The division of colour schemes dictates that a painting should generally employ not more than three colours. It is of the kind with a few colours that might make people feel simple and at ease. In light of this, it is imperative to closely regulate the colour type matching when using polychromatic number types in accordance with the design theme and content when the number of colours is unrestricted. This allows for the display of a lively, upbeat, and colourful feeling [21].

4. Computer Art Design Colour Matching Method Based on Mathematics

This section is composed of the following subsections.

4.1. Establishment of a Linear Dye Database. The basic theory of computer colour matching is the Kubelka–Munk function theory, and its basic expression is

$$\frac{K}{S} = \frac{(1-R)^2}{2R}, \tag{1}$$

where k is the absorption coefficient of light in opaque medium, s is the scattering coefficient of light in opaque medium, k/s is the Kubelka–Munk function, which can be written as $f(R)$, and R is the reflectivity of opaque medium [22]. Theoretically, the Kubelka–Munk function is linear with concentration, and its expression is

$$f(R) = \phi C + [f(R)]^{(t)}, \tag{2}$$

where $[f(R)]^{(t)}$ is the Kubelka–Munk function of the substrate, ϕ is the Kubelka–Munk function value of the unit concentration of the beam material, C is the concentration, and $f(R)$ is the Kubelka–Munk function value after printing and dyeing on the substrate. ϕ is known as the process of establishing a dye database.

The Kubelka–Munk function expression after using the surface reflection factor Ro is

$$f(R) = \frac{[1-(R-R_0)]^2}{2(R-R_0)}. \tag{3}$$

The computer colour matching theory deviates from a linear relationship for a number of reasons; to get the surface correction factor, start by reversing this departure. To extract the spectrum information of colours, dyes with various concentration levels are utilised. Accordingly, after modification using formula (3) the spectral data of the dye and the matrix are:

$$[f(R)]_\lambda^{(i)} = \frac{\left[1-\left(R_\lambda^{(i)}-R_0\right)\right]^2}{2\left(R_\lambda^{(i)}-R_0\right)}, \tag{4}$$

$$[f(R)]_\lambda^{(t)} = \frac{\left[1-\left(R_\lambda^{(t)}-R_0\right)\right]^2}{2\left(R_\lambda^{(t)}-R_0\right)}, \tag{5}$$

where $[f(R)]_\lambda^{(i)}$ and $R_\lambda^{(i)}$ are the Kubelka–Munk function value and reflectivity at the λ wavelength at the ith concentration while printing and dyeing, while T represents the substrate. Therefore, substituting (4) and (5) into (2), the Kubelka–Munk function of unit concentration of each dye can be written as

$$\phi_\lambda^{(i)} = \frac{\left[1-\left(R_\lambda^{(i)}-R_0\right)\right]^2/2\left(R_\lambda^{(i)}-R_0\right)-\left[1-\left(R_\lambda^{(t)}-R_0\right)\right]^2/2\left(R_\lambda^{(t)}-R_0\right)}{Ci}. \tag{6}$$

In (6), C_i represents the concentration value of the ith concentration when printing and dyeing. In addition, (6) shows that the difference in the unit Kubelka–Munk function between various concentrations should tend to be the least if the Kubelka–Munk function and concentration also tend to be linear.

$$\sum_{i \neq j} \left[\phi_\lambda^{(i)} - \phi_\lambda^{(j)}\right]^2 \longrightarrow \min. \tag{7}$$

Equation (7) can be rewritten as follows since it is valid for all wavelengths:

$$\int_{\lambda_1}^{\lambda_2} \sum_{i \neq j} \left[\phi_\lambda^{(i)} - \phi_\lambda^{(j)}\right]^2 \mathrm{d}\lambda \longrightarrow \min. \tag{8}$$

When there are k different types of dyes, equation (8) can be rewritten because the surface reflection factor is dependent on the substrate and is unrelated to the kind of dyes.

$$\sum_{1}^{k} \int_{\lambda_1}^{\lambda_2} \sum_{i \neq j} \left[\phi_\lambda^{(i)} - \phi_\lambda^{(j)}\right]^2 d\lambda \longrightarrow \min. \tag{9}$$

Find the minimal value of (9), replace formula (6) with it, and then R_0 will be obtained.

The cotton polyester combination T65/C35 serves as the foundation, and three dispersion dyes—red dye 3B, yellow dye RGFL, and blue dye 2BLN—were employed to dye the substrate with eight different concentration values. The surface reflection factor $r0 = 0.06020$ is derived on the basis of cotton polyester combination T65/C35 using the above-described approach.

4.2. Use the CMYK Mode to Realize Approximate. CMYK mode can be used to reconcile gradient colours and approximation colours in the process of computer-based art design colour matching based on mathematics. Cyan, magenta, and yellow (CMY) often have three representational values. In order to achieve the light and shade changes of design works, it is important in actual reconciliation to restrict value changes to a specific range. In addition, minor adjustments to CMY can alter the colour, while the K value remains the same. Take the pink water cup as an example. To emphasise the material qualities of the water cup and to boost the authenticity and stereoscopic quality, it is first necessary to choose the proper colour to fill the water cup. Then, by region selection, we modify the edge and middle colour difference appropriately. Since the edge's dark section contains two colours, the CMY value is essentially unchanged. To obtain the darker pink edge region, we increase the K value to the brightness level. Additionally, it is important to make sure that the colour K value of the middle brightest region does not change. Because it progressively moves towards the yellow area and if accompanying C magenta and Y yellow are overlaid to generate orange, there will be a transition from pink to orange tone when the y value of CMY grows sufficiently. Orange's high brightness makes it ideal for use as the water cup's focal point because it effectively draws attention to the product's three-dimensional design and authenticity. It also strengthens the impact of approximation in colour and draws attention to the practicality of computer-aided design colour matching.

4.3. Use the HSB Mode to Realize Approximate. HSB mode is similar to the approximate hue and method of the CMYK mode. The variation of the H value and the B value must be kept within a reasonable range while performing the gradual hue sum of the HSB mode on a computer. The two often alter just slightly, whereas the s value varies considerably. Based on this, it is possible to achieve the progressive blending of the same hue saturation property. Additionally, the B value can be completely utilised based on minor adjustments to H and S values, and then by properly modifying and altering it, the same tone lightness characteristic can be changed. According to the experience summary, the HSB mode is the simplest and fastest technique to contrast hue and sum. Typically, the blending process is divided into two steps: first, we use the colour ring to identify the contrast colour and then use the HSB mode to adjust the lightness and saturation in accordance with the colour's specific values and colour coefficients. By doing this, it can effectively improve the harmony of the contrast colour matching by encouraging close correspondence between the specific values and colour coefficients of the contrast colour. As a result, the designer's awareness of the nature of colours and ability to match colours will be improved. At the same time, it could also encourage the successful integration of art design works.

4.4. Use the RGB Mode to Realize Approximate. RGB mode refers to the three primary colours of optics. The letters R, G, and B represent red, green, and blue, respectively. In nature, any colour that can be seen by the naked eye is formed by the mixing and superposition of these three colours, called additive mode. To provide a smooth transition between comparable tones while utilising the RGB mode for the gradual tone sum, it is necessary to maintain the appropriate colour system value in line with subjective perception. This can be performed by adjusting the other two values to make them complementary.

For example, when designing a website, it is necessary to use the RGB mode for colour gradients using the canvas drawing function and circular statements. Such as the circular statements used to fill colours are "cxt.fillstyle = RGB" ('+ (30×i) +', '+ (255–30×i+', 255). This could be used to examine how the B value in the statement is always kept at 255 but increases by 30 each time the loop is run based on the preceding loop. As a result, the value of G will be 255 less than the value of R, causing it to take on a specific complementary connection with the same quantity of state. It successfully demonstrates the transformative impact from blue tone to blue-purple tone after six cycles, illuminating the RGB mode's genuine adjusting effectiveness.

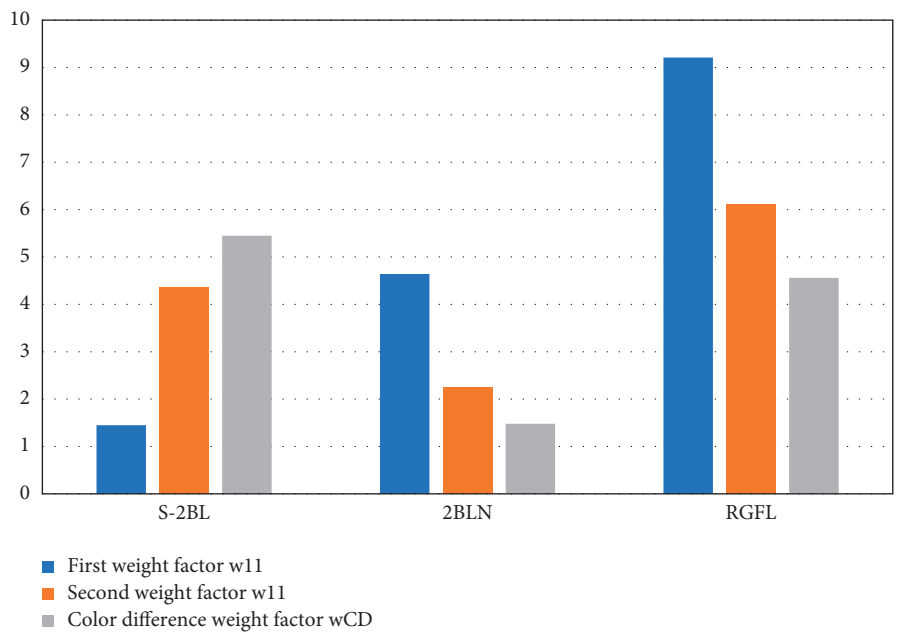

Figure 1: The recipe for matching blackish-green samples.

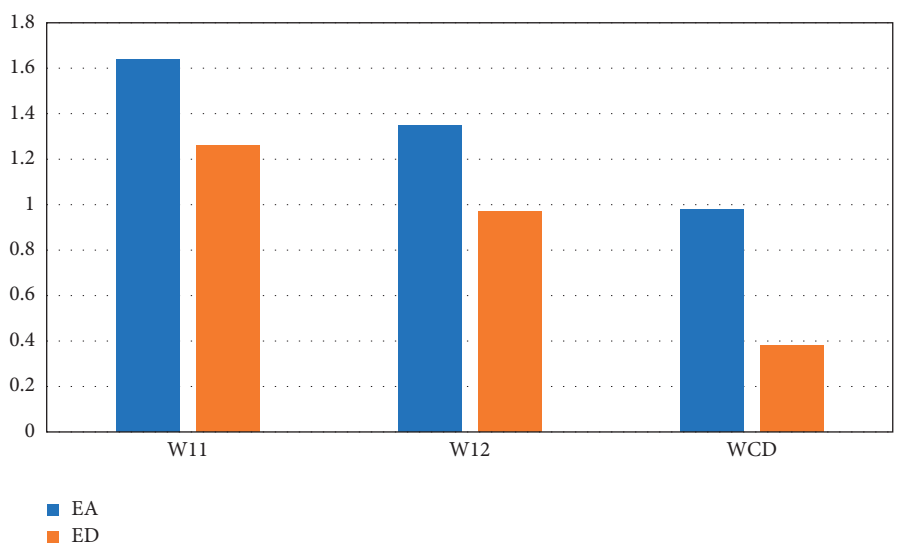

Figure 2: The colour difference of the matching blue sample.

5. Experimental Results

The cotton polyester mixture T65/C35 is utilised as the foundation in order to evaluate the colour matching impact of the colour difference weight factor. Five dispersed dyes, including scatter red dye 3b, dispersion yellow dye RGFL, dispersed blue dye 2BLN, dispersed dark blue HGL, and dispersed black S-2BL, are used to create a tiny dye colour sample database. The lighting source was the Commission Internationale de l'Eclairage (CIE) standard light source D65, and the weight factors w11 and II are calculated using equations (7) and (8), respectively, in order to match the traditional colors dark green and blue and the corresponding color difference weight factors. By using the international lighting commission's ciel976 (L×a×b) colour space difference calculation, the colour matching impact is quantified. Figure 1 and Figure 2 display the corresponding equation (unit: g/L) and colour difference.

In these tables, EA stands for the colour difference produced when a light source is illuminated, and ED stands for the colour difference produced when a D65 light source is illuminated. According to the data in Figures 1 to 4, when matching dark green or blue, the colour difference for weight factors 1 and 2 is relatively large, whereas the colour difference for computer colour matching using the colour difference weight factor is relatively small, better meeting the needs of computer colour matching. Despite the great degree of colour difference accuracy in the two colour matching

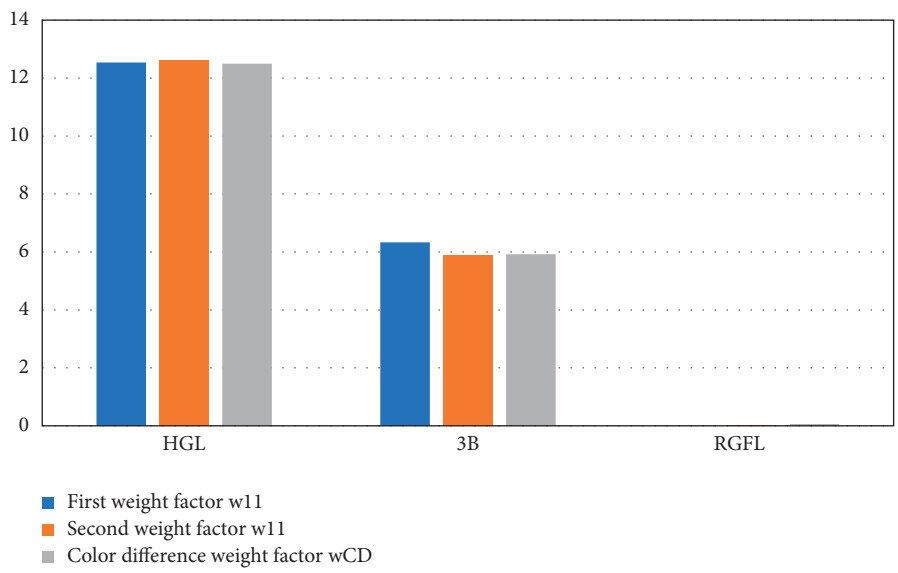

Figure 3: The recipe for the matching blue sample.

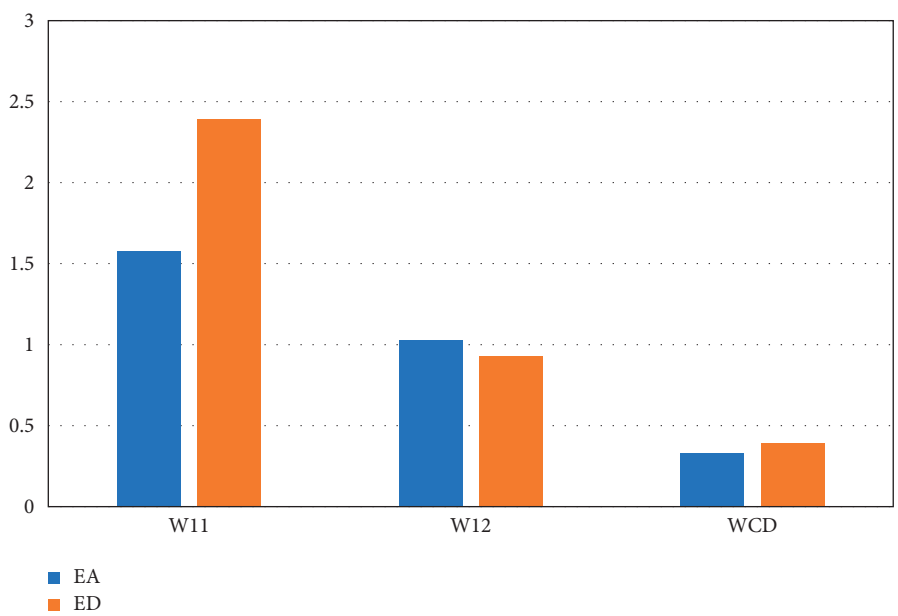

Figure 4: The colour difference of the matching blackish-green sample.

groups selected for this study, the formula accuracy provided by the weight factor for colour difference is superior to that provided by computer colour matching and genuine art pictures.

6. Conclusions

An art and design degree includes instruction in graphic design, sculpture, painting, and drawing. Students majoring in art and design are taught fundamental design concepts, colour theory, critical analysis, and creative techniques. Colour matching is one of the most important factors in determining the quality of art and design. In the framework of mathematical operation, the use of computers for successful colour matching in art design is to satisfy the inescapable demands of the growth of modern society and is a crucial approach to creating wonderful artworks. Its colour matching technique not only has a high degree of universality but can also significantly increase the designer's design skills and completely exhibit the observability of the design works, therefore fostering a positive creative environment.

The object colour sensitivity function is expanded for computer colour matching based on the linear database, and a colour difference weight factor is developed. The results of the colour matching demonstrate that this approach has pretty excellent outcomes and can more effectively satisfy the needs of computer colour matching. The weight factor

accurately reflects the variation in colour perception brought on by the shift at each wavelength, which is the main source of its perfect effect.

Data Availability

The datasets used and analyzed during the current study can be obtained from the corresponding author upon reasonable request.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Optimization Simulation of Balanced Distribution of Multimedia Network Modular Teaching Resources

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The balanced distribution of multimedia wireless network modular teaching resources is improved by optimizing and adjusting the balanced distribution of multimedia wireless network modular teaching resources. Based on block grid balanced scheduling and resource spectrum fusion, a balanced distribution method of multimedia wireless network modular teaching resources is proposed. A blockchain Internet of Things accesses control network architecture system for the balanced allocation of multimedia wireless network modular teaching resources established using the priority business scheduling method. Modular resource allocation of multimedia wireless networks and adaptive forwarding are adjusted to control the data packets. The bandwidth guarantee mechanism is used for the equitable allocation of multimedia wireless network modular teaching resources information flow. Multi-service hierarchical management of multimedia wireless network modular teaching resources spectrum is controlled by block grid balanced scheduling and resource spectrum fusion. The high-energy physical computing system structure is used to allocate the resource spectrum balance of the modular teaching resources of the multimedia wireless networks, ensuring the bandwidth requirements of various services. The classified management and balanced allocation of the multimedia wireless networks' teaching storage, system, and teaching spectrum resources are made possible. The results of the tests show that this method effectively reduces the delay in the allocation of modular multimedia wireless network teaching resources, improves the utilization rate of modular multimedia wireless network teaching resources, and significantly improves their reading and writing performance.

1. Introduction

Higher standards are being put forth for the reliable distribution of multimedia wireless network modular teaching resources as a result of the put forward development of Internet technology [1]. Multimedia teaching has been studied and used in foreign countries earlier. The first generation of computer-assisted instruction systems was introduced by IBM in the United States in 1946, more than ten years after the development of the first computer [2–4]. Because the system was large and inconvenient at the time, it was not widely popularized or used. Developed countries, such as the United States, make extensive use of basic resources. The computerization and networking of education, as well as control over communication channels, have long been realized. The conventional mode of transmission is the teaching method used in the American education system. The process of teaching with multimedia equipment and courseware is known as multimedia mode, and network-based teaching is recognized as network mode. Virtual reality mode refers to the teaching process that is based on computer simulation and other technologies [5]. In fact, in the actual teaching process, many kinds of teaching modes are often mixed in it giving full play to their combined advantages.

Modular teaching resource allocation is an important component of the multimedia wireless network. The multimedia wireless network is important in the transmission of network data information and the structure of network networking [6], to ensure that multimedia wireless network modular teaching resource transmission is of high quality and efficiency. To reduce the packet loss rate and jitter of multimedia wireless network data transmission, it is necessary to combine data transmission delay control and bandwidth reliability allocation and improve the bandwidth

allocation capability of multimedia wireless network modular teaching resource transmission. The key to ensuring the efficient operation of multimedia wireless networks is to adjust the balanced distribution of multimedia wireless network modular teaching resources [7, 8]. It is the adjustment of the link bandwidth in conjunction with the allocation of multimedia wireless network modular teaching resources. It is possible to realize a balanced allocation of multimedia wireless network modular teaching resources. The current method highly depends on the balanced allocation method for multimedia wireless network modular teaching resources. The balanced allocation method of multimedia wireless network modular teaching resources is based, among other things, on link balance and diversity. It constructs a balanced diversity interval parameter adjustment model for the balanced allocation of multimedia wireless network modular teaching resources. It adopts the most cost-effective server coverage strategy and develops the application services quality of service (QoS) protocol. It also reduces transmission delay and bit error rate while improving the ability of multimedia wireless network modular teaching resources to be allocated in a balanced manner. A joint allocation method of multimedia wireless network modular teaching resources is proposed in a big data environment. The dynamic transformation of a multimedia wireless network in a big data environment is investigated in this paper [9]. To address these issues, researchers have recently focused on the balanced distribution of multimedia network modular teaching resources.

In some kinds of significant network information advancement, the methodology of learning has also revolutionized. The digital educational environment enhances the development of educational effectiveness and strongly affects students' achievement, according to several teaching theories and study findings. Guo et al. proposed a blockchain-based digital rights management system to address these challenges. This system includes a brand-new architecture for communicating and being able to manage multimedia resources for online learning predicated on the combination of both public and private blockchain systems, and also three different reference implementation schemes for the accomplishment of multimedia digital rights documentation, protection of information, and undifferentiated verifying of certificates. The recommended blockchain-enabled DRM solution is a strong contender for resolving the problem of blockchain-based multimedia data security in an online learning environment [10]. Kumala et al. established a multimedia portal including videos and educational modules. MDLC employs a variety of tactics, including concept, design, material acquisition, assembly, validation, and marketing. A diagramming system and a learning video storyboard were used to create multimedia with MDLC. The results demonstrated that the MDLC approaches created multimedia. Based on the findings of the alpha and beta testing, it was determined that the developed e-learning multimedia is practical and appropriate for use by primary school students. The developed multimedia includes a range of educational features to help students understand and engage with the presentation [11]. Ren et al. show that the performance vectors of virtual machines and servers can be used to create a matching model between virtual and actual resources, and resource demand can be calculated using linear prediction. The balanced allocation approach for sports-distant education resources was developed to reduce the number of servers, increase resource use, and balance the use of various resources. The Pareto optimal solution set is the result of balanced allocation. Its average resource performance matching distance, calculated using the BF and RR approaches for 1000 virtual machines, is 284 and 465, respectively, less than 765 for the same machines. Hua investigates the responsibilities and rights of each hierarchy entity, how each hierarchy entity generates and distributes resources, and proposes an online service department–based hierarchy method for transferring educational knowledge assets. The author describes in detail the integrated design framework for personalized learning materials at the cloud service center. For resource sharing, the approach of resource financial viewpoint, system factors, and resource acceptance disparities are discussed. The dynamic assessment model of the quality of teaching-learning materials is presented and described for resource exchange behaviors in resource sharing [12].

The allocation band of multimedia wireless network modular teaching resources is determined based on the distinction of services. The resource allocation is divided into two parts when combined with the optimization scheme: heavy load and light load, and the bandwidth requirement description is combined to realize automatic bandwidth allocation. However, this method cannot fully utilize the benefits of SDN centralized control, and the bandwidth service guarantee performance is not good. We designed the modular teaching resources of multimedia wireless network, and the case level data management and transmission system of high energy physics. Realize the balanced distribution of multimedia wireless network modular teaching resources through HTTP technology and local cache [11]. This method, which is intended to address the shortcomings of traditional methods, has a high computational cost and poor adaptability to multi-process scheduling. This paper proposes a balanced allocation method of multimedia wireless network modular teaching resources based on block grid balanced scheduling and resource spectrum fusion.

The main contribution of the paper is the following:

(i) First, we complete the network architecture, and then give the balanced allocation algorithm of multimedia wireless network modules according to the network architecture.

(ii) Secondly, the network bandwidth is automatically adjusted through resource matching and optimal allocation.

(iii) Finally, the simulation test demonstrates that this model outperformed others with regard to increasing the ability of balanced allocation of multimedia wireless network modular teaching resources.

The rest of the paper is organized logically as follows: Section 2 shows related work; Section 3 shows network

architecture and multi-service hierarchical network management; Section 4 shows the optimization of balanced allocation of multimedia wireless network modular teaching resources; Section 5 shows experimental work and simulation. Finally, the work of the paper is concluded in Section 6.

2. Related Work

This research is divided into two sections. The primary focus of the paper is the distinctions between college music instruction and other social subjects. Brain computing, which aims to study objects by replicating the composition and information interpretation of biological neural networks and the feasibility of multimedia technologies, aims to study objects by replicating the composition and information interpretation of biological neural networks. To track and assess the efficacy of music instruction, the intelligent learning properties of a deep learning algorithm are proposed. The author has discussed the design and creation of network interactive multimedia, which aids in conceptualization and references for the use of multimedia technology in Chinese college musical education [13]. This study's author proposes a recurrent neural network (RNN) based on resource construction, approach, and applications. The analysis of the user's role requirements of teachers, students, and system administrators involved in teaching and learning looks at the needs of music students. Researchers are working on a mobile teaching platform that is compatible with music instruction characteristics. The experimental results show that as more iterations are added, the system becomes more effective. Given the robust system stability and an average accuracy of 72 percent, precision fluctuation is to be expected [12]. The author recommends using an intelligent optimization-based information fusion technique to establish grassroots teaching organizations. It has been demonstrated that information fusion has three levels: data, characteristics, and outcomes. The foundational elements of well-known educational organizations were investigated. The information fusion of teaching grassroots unit development is accomplished using the threshold value of teacher construction and grassroots unit work, and the optimization of the particle swarms' approach is used to determine the greatest value of the work entropy of teaching grassroots units [14]. The main topic covered by the study's author was how efficient multimedia networks can support business English majors in technical colleges in enhancing their work experiences and substantially enhancing their practical English proficiency, computer skills, communication skills, and cooperation skills. It investigated ways to help business English majors at technical institutions get job experience and enhance their practical English, computer, communication, and teamwork abilities via the use of multimedia networks. A task-based teaching strategy and the constructive learning theory were used to develop an experimental teaching program. The statistical results show that multimedia networks can aid students in enhancing their total competency, especially in earning job experience and using English abilities. Statistics show that multimedia networks may aid students in developing their entire competency, notably in earning job experience and using English abilities [15].

3. Network Architecture and Multi-Service Hierarchical Management of the Network

3.1. Network Architecture. To achieve a balanced distribution of multimedia wireless network modular teaching resources, block grid balanced scheduling and resource spectrum fusion are used. It established an SDN (Software Defined Network) architecture model for the balanced distribution of multimedia wireless network modular teaching resources. Combined with SDN network architecture protocol, self-defined configuration and programmable network resource spectrum parameter control are carried out [16]. Dynamic interaction is carried out in the data layer of multimedia wireless network modular teaching resources distribution, and in various network application interface protocols, multiple services are divided and scheduled in parallel above the data center. The hierarchical formal description method is adopted to establish the hierarchical structure of multimedia wireless network modular teaching resources spectrum distribution, as shown in Figure 1.

In the hierarchical structure configuration of multimedia wireless network modular teaching resources spectrum allocation in Figure, based on the overall link bandwidth allocation method, the cluster computing system is adapted to allocate data spectrum resources, and the spectrum resources of the network are distributed as a seven-tuple $G = (T, X, Y, \Omega, Q, \delta, \lambda)$, where:

T: Dénotes the time transmission sequence of the multimedia network modular teaching resource scheduling time coordinate of the file-level data management transformation. If T is an integer, this indicates that case-level data management is discrete; if T is a real number, this indicates that network bandwidth allocation is a continuous sequence [17].

X: Select the event set that communicates with the nearest multimedia wireless network modular teaching resource server site.

Y: Event set of multimedia network modular teaching resource job processing process.

Ω: Input segment set, a subset of $X \times T$, describes the input characteristic quantity of multimedia wireless network modular teaching resource file cross-domain transmission [18].

Q: Case screening, reading multimedia wireless network modular teaching resources, and processing the internal state set of multimedia wireless network modular teaching resources in parallel.

δ: $Q \times \{*\} \longrightarrow Q$: Transfer function for the server to pull files, where $*$ represents internal events.

λ: $Q \times \{*\} \longrightarrow Y$: Case-level data management function for spectrum allocation of multimedia network modular teaching resources.

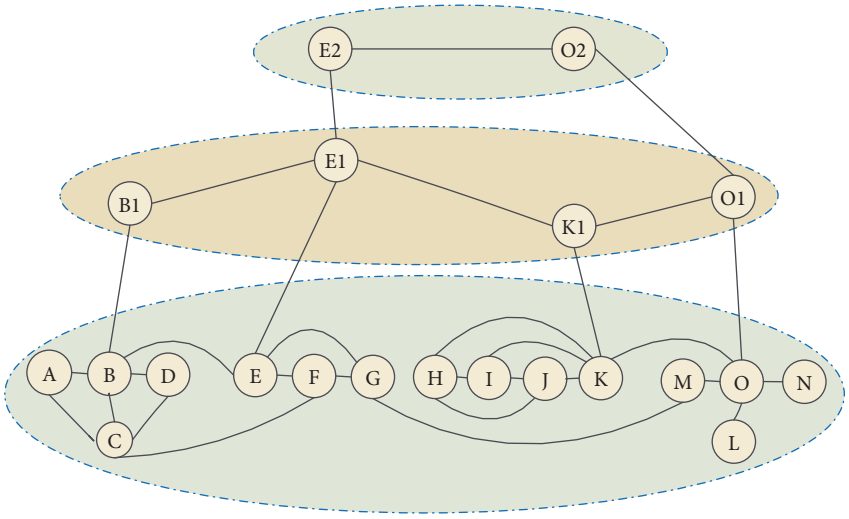

Figure 1: Hierarchical structure of spectrum allocation of multimedia wireless network modular teaching resources.

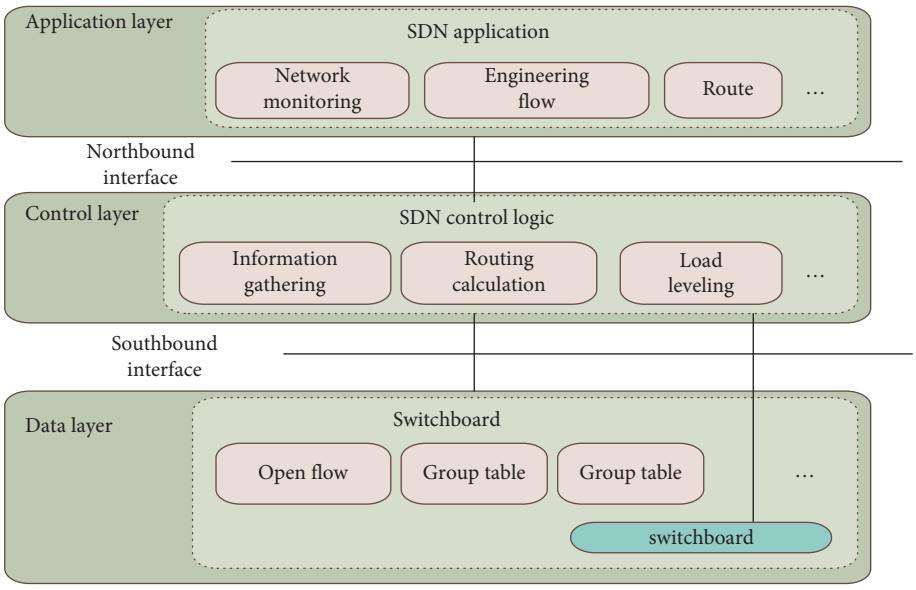

Figure 2: The architecture of balanced distribution of multimedia wireless network modular teaching resources.

Definition 1. Describe the modular module combination of multimedia wireless network modular teaching resources balanced distribution node. $M = (\Sigma, \Gamma, S, S_0, \delta, \omega)$, wherein

Σ: Input N Data nodes of multimedia wireless network modular teaching resource cluster.

Γ: Enter the label of the node in the Over group of multimedia wireless network modular teaching resources.

S: Nonempty finite set in the balanced state of multimedia network modular teaching resource system.

S_0: Disk space distribution state set of multimedia network modular teaching resource cluster nodes.

δ: Maximum dispersion difference: $\delta : S \times \Sigma \longrightarrow S$

ω: Output multimedia wireless network modular teaching resource scheduling function $\omega : S \longrightarrow \Gamma$

According to the above definition, the network architecture of a balanced distribution of multimedia wireless network modular teaching resources is divided into three layers: the application layer, control layer, and data layer [19–21]. As shown in Figure 2, the application layer realizes network interaction and flow control, the control layer carries out information collection and load balancing scheduling, and the data layer realizes information exchange.

According to Figure 2, the balanced allocation model of multimedia wireless network modular teaching resources consists of three layers. Specifically, the application layer, control layer, and data layer have relative independence. The application layer is primarily responsible for specific business logic processing, while the control layer is responsible for providing reusable services and the data layer is responsible for data storage and access. When using a multimedia wireless network to allocate teaching resources, the

application layer and the control layer are generally deployed together, while the data layer is deployed separately [22]. In the application layer, this includes application service file transfer protocols and domain name systems, and it completes network teaching data retrieval by sending an HTTP request. It provides the service of searching IP addresses by domain name or reversely searching domain names from IP addresses through the domain name resolution system. To provide a reliable byte stream service, the control layer divides the data, sends HTTP request messages, and forwards them to the data layer after marking the serial number and port number of each message. At the same time, the data of considerable teaching resources is divided into data packets with message segments as units for management and control. It provides perfect services for the balanced distribution of modular teaching resources in multimedia wireless networks. The data layer mainly stores nonoriginal data, that is, databases or text files that complete data retrieval. Applications are in the form of storing data and providing data services for the application layer and the control layer [23].

3.2. Multi-Service Hierarchical Management. The blockchain Internet of Things accesses a control network architecture system with a balanced distribution of multimedia wireless network modular teaching resources established according to the priority business scheduling method described above. The corresponding network equipment is remodified by allocating multimedia wireless network modular resources and adjusting data packet forwarding adaptively. In the directed graph, the spectrum weighted distribution parameters Σ_V and Σ_E of multimedia wireless network modular teaching resources are obtained, as are the tag sets of nodes and edges. Using the correlation queue scheduling algorithm, a six-tuple multi-service hierarchical area representing multimedia wireless network modular teaching resources is obtained, where V is the service distribution node set above the data center, and E is the low-priority data flow, where $G = (V, E, s, t, \ell, \pi)$ represents the number of video services and FTP services, and $|V| = n$. A server is deployed on the host h3 to obtain the data request service flow X of the network and some intermediate layers [24]. These two functions are the starting node and the target node of the multimedia wireless network modular teaching resources pointing to the edge. $i: K \longrightarrow L$ is a tuple $r = (L \supseteq K \subseteq R)$ that consumes the cost of virtual machines, the total consumption of multimedia wireless network modular teaching resources, and the distribution of suppliers, where L, K, and R are graphs, $r = (L, i, K, j, R)$ and L_r, K_r, R_r are the best solutions found by the whole group at present, and the distribution rules of multimedia wireless network modular teaching resources spectrum [25]. The multimedia wireless network modular teaching resource spectrum is managed in a multiservice hierarchical manner. The multimedia wireless network modular teaching resource rule K_r is given using the block grid balanced scheduling and resource spectrum fusion methods, and the corresponding graph is named $r = (L \supseteq K \subseteq R)$. The right picture of network bandwidth and the interface picture of multimedia wireless network modular teaching resource is the left picture of multimedia wireless network modular teaching resource bandwidth occupied by R.

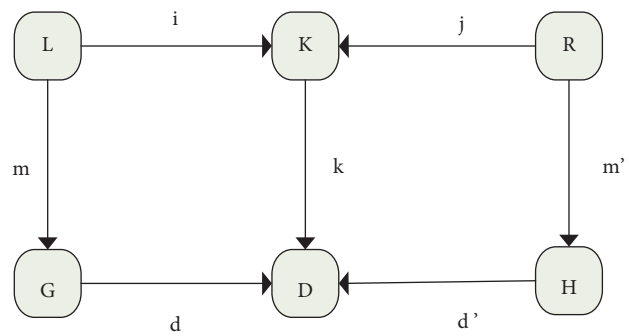

Figure 3: Management diagram of balanced distribution of multimedia wireless network modular teaching resources.

Therefore, the multi-service hierarchical management of multimedia wireless network modular teaching resources is constructed. A topological graph $m: L \longrightarrow G$, $d: G \longrightarrow D$, $k: K \longrightarrow D$, $m': R \longrightarrow H$, $d': H \longrightarrow D$, and a rule are obtained, such as the mapping $r = (L, i, K, j, R)$ reflecting the current state of nodes. According to the disk space usage of the cluster, the link set G for bandwidth allocation of multimedia wireless network modular teaching resources is obtained, which is recorded as $G \Rightarrow_r H$.

If R is a rule set, G and H are two graphs, and $G \Rightarrow_R H$ represents CPU utilization and disk I/O utilization, which means that $r \in R$ exist to make $G \Rightarrow_r H$. The management diagram of modular teaching resources balanced distribution of multimedia wireless networks is constructed, as shown in Figure 3.

4. Optimization of Balanced Allocation of Multimedia Wireless Network Modular Teaching Resources

4.1. Resource Spectrum Allocation. To ensure the bandwidth requirements of various services, the high-energy physical computing system structure is adopted to allocate the resource spectrum balance of multimedia wireless network modular teaching resources [26]. The transformation rule $r = (L, i, K, j, R)$ is applied to derive graph H from graph G of multimedia wireless network modular teaching resources, so as to obtain the busy degree reflecting the current node bandwidth, which is realized by the following steps:

Step 1: Select the L graph in the graph model G that represents the current busy multimedia wireless network modular teaching resource node, and the L graph is the interception parameter K in G. When the bandwidth is balanced, it is necessary to achieve a suitable relationship between L and G to meet the spectrum allocation mapping of multimedia wireless network modular teaching resources.

Step 2: If the disk utilization dispersion meets the threshold, go to step 3, otherwise, exit $m: L \longrightarrow G$.

Step 3: Delete the generated context map D from the multimedia wireless network modular teaching resource matching distribution map G to define the disk dispersion degree and cluster state feature mapping $d: G \longrightarrow D, k: K \longrightarrow D$, so that $\langle i: L \longrightarrow K, k: K \longrightarrow D, m: L \longrightarrow G, d: G \longrightarrow D\rangle$ meets the convergence.

Step 4: Combine the weights D and R of the two influencing factors and calculate the K diagram of the spectrum allocation of multimedia wireless network modular teaching resources, and allocate the proportion of the current system state $\langle k: K \longrightarrow D, j: K \longrightarrow R\rangle$ [27].

Calculate the deviation of the disk utilization rate of nodes in the multimedia wireless network modular teaching resource cluster. For nodes SN_B and $B = (X, Y, E)$, they are a single module in the above figure. Open the terminal in Ubuntu virtual machine to obtain two node sets X and Y for modular teaching resource allocation of multimedia wireless network, and edit them. Use the floodlight controller to obtain directed edges SD, $L \supseteq K \subseteq R$, and $G \supseteq D \subseteq H$, and the protocol function of external user connection convergence exchange is expressed as i, j, d, d'.

The defined streaming media service graph model of multimedia wireless network modular teaching resources is $B = (\mathrm{NN}_B, \mathrm{SN}_B, C_B)$, which is the lower node set of each host node, NN_B is the upper node set of multimedia wireless network, and $e = (s, n) \in C_B$ is the edge set. Under the restriction of transmission rate, each node has a unique node and edge. Therefore, a resource matching optimal allocation model for the balanced allocation of multimedia wireless network modular teaching resources is established.

4.2. Balanced Allocation of Wireless Modular Teaching Resources. A high-energy physical computing system structure is used for the resource spectrum balance allocation of multimedia wireless network modular teaching resources. It is possible to realize the classified management and balanced allocation of multimedia wireless network modular teaching storage resources, system resources, and modular teaching spectrum resources [28]. The storage resource allocation scheme of a multimedia wireless network is given as $f_B: B \longrightarrow B1$. The bandwidth of the corresponding multimedia wireless network modular teaching resources physical link is defined as $\sim_{\text{upper}} \subset V_A \times V_B$, $\sim_{lower} \subset V_{\mathrm{A1}} \times V_{\mathrm{B1}}$. The allocation quadruple of the bandwidth of the physical link of the multimedia wireless network modular teaching resources is interchangeable. If the transmission rate threshold is set to $\langle f_A, f_B, \sim_{\text{upper}}, \sim_{\text{lower}}\rangle$, $a \in V_{\mathrm{A1}}$, and if there is a relationship $a \sim_{\text{upper}} b$, one of the following conditions holds:

$$\begin{aligned} &a \notin \operatorname{dom}(f_A) \text{an d} b \notin \operatorname{dom}(f_B) \\ &a \in \operatorname{dom}(f_A), b \in \operatorname{dom}(f_B) \text{an d} f_A(a) \sim_{\text{lower}} f_B(b) \end{aligned}. \quad (1)$$

In the Ubuntu virtual machine, turn on the multimedia wireless network modular teaching resource allocation terminal. Adjust the bandwidth balance of the multimedia wireless network based on the HTTP protocol using the L and R diagrams. The output f_A corresponds to K and L, which corresponds to the external user connection aggregation switch and the external user connection aggregation sequence. Where $\rho = \{H_{i-1} \Rightarrow^{Ri} H_i\} i \in \{1, \ldots, n\}$ is the $\sim_{\text{lower}}$ transformation, to realize the automatic balance adjustment of the multimedia wireless network. The schematic diagram of realizing the balance allocation of multimedia wireless network modular teaching resources is shown in Figure 4.

5. Experimental Work and Simulation

System testing is an important part of software engineering. The purpose of system testing is to verify whether the developed system has reached the required functions and performance indicators and whether it can be applied to the actual use environment. The test environment of the system simulates the real running environment of the system, and a cloud computing service platform is built in the central computer room of the school to provide services such as dynamic resource scheduling and dynamic load balancing. In the test environment, the network bandwidth is Gigabit, and the network connection devices are Huawei switches, routers, etc. A teacher's computer and ten simulated students' computers are set in the client. During the testing process, test cases are constructed according to the system design scheme. After running the test cases based on the test environment, the theoretical output and the actual results are compared and the test results are analyzed. The external users of the experimental multimedia wireless network are connected to the floodlight controller; Mininet is installed in Ubuntu and the topology of a multimedia wireless network is built. The information data service subsystem mainly publishes all kinds of data in this system in the form of Web services, including the billing strategy selected by users, the related data of users' teaching-on-demand payment resources, etc. Meanwhile, the full-duplex Web service mode is used to realize the operation of other external management information systems. The initial IP of multimedia wireless network modular teaching resources allocation IP = 192.168.21.166. In the experiment, the network performance is tested by reading 124 GB files through the multimedia wireless network, and the network delay from 1 ms to 100 ms is tested. The read-write block size of multimedia wireless network modular teaching resources is set to 14 MB, and 100 groups of sequence samples are taken as test sets. First, the optimal delay parameters for the balanced distribution adjustment of multimedia wireless network modular teaching resources are calculated, as shown in Figure 5.

In Figure 5, when $k = 50$, the ratio is the smallest, and it represents the lowest bit error rate. Taking this as the bandwidth allocation delay parameter, the phase φ_{10}, φ_{11} and spectrum bandwidth θ_{10}, θ_{11} of modular teaching resource allocation in the multimedia wireless networks are obtained. The calculation results are shown in Table 1.

According to the parameter analysis results in Table 1, the spectrum of multimedia wireless network modular teaching resources is allocated. An important function of the online resource player is to buffer the resource media stream

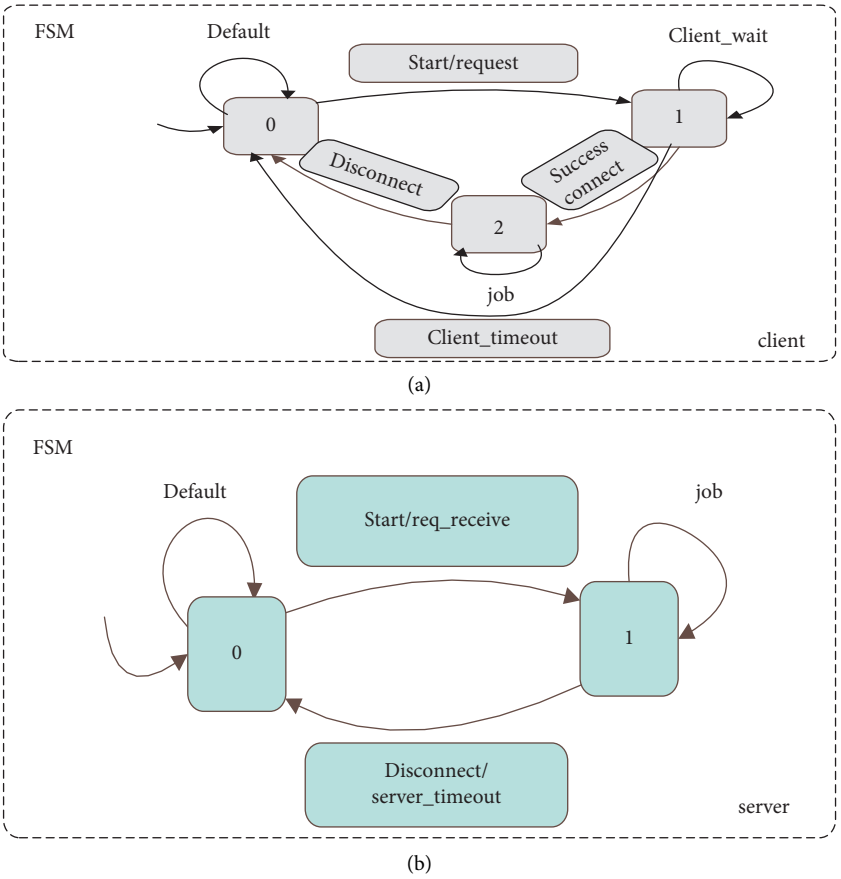

Figure 4: Schematic diagram of modular teaching resource allocation in multimedia wireless network. (a) Client. (b) Switch side.

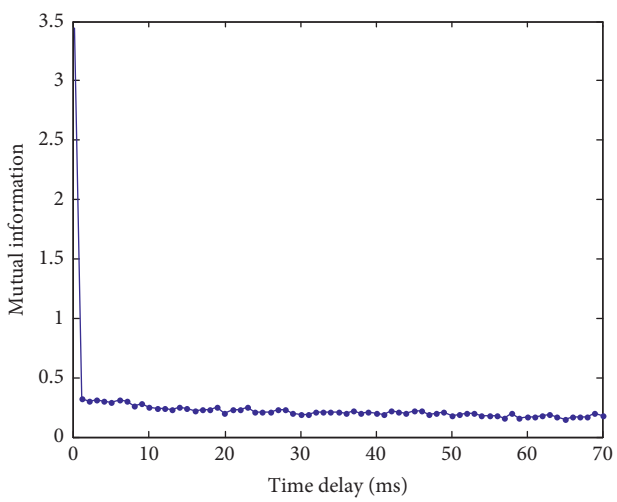

Figure 5: Optimal delay parameters of automatic equalization and distribution adjustment in multimedia wireless network.

data and show it to users on the interface. Media Element control itself has the function of buffering while playing, and it also provides the event notification function of the current state of buffered data. The Canvas container is used as the host window for the outline structure design of the progress bar, and a rectangle control is added as the cursor of the progress control. When a streaming media data source is connected to the media element control, the buffering time property of the control can control the data buffering time, and the settings of its parameters affect the smoothness of streaming media playback. After the data are buffered for some time, the buffer progress changed event will be triggered, which is used to inform the external current buffering progress. The background will respond to the event and update the user interface. We can obtain the results of the modular teaching resource allocation of the multimedia wireless network, as shown in Figure 6.

Table 1: Analysis results of spectrum-related parameters of network resources.

Model	Parameter			
	φ_{10}	φ_{11}	θ_{10}	θ_{11}
ARMA	0.858	0.867	0.819	0.321
STARMA	0.476	0.375	0.772	0.598

According to the analysis of Figure 6, before the improvement, the balance of resource allocation was not good, and the distribution was random. After the improvement, the method described in this paper was used to evenly distribute the spectrum of a multimedia wireless network modular teaching resource. The accuracy points of the spectrum distribution of teaching resources increased by 42

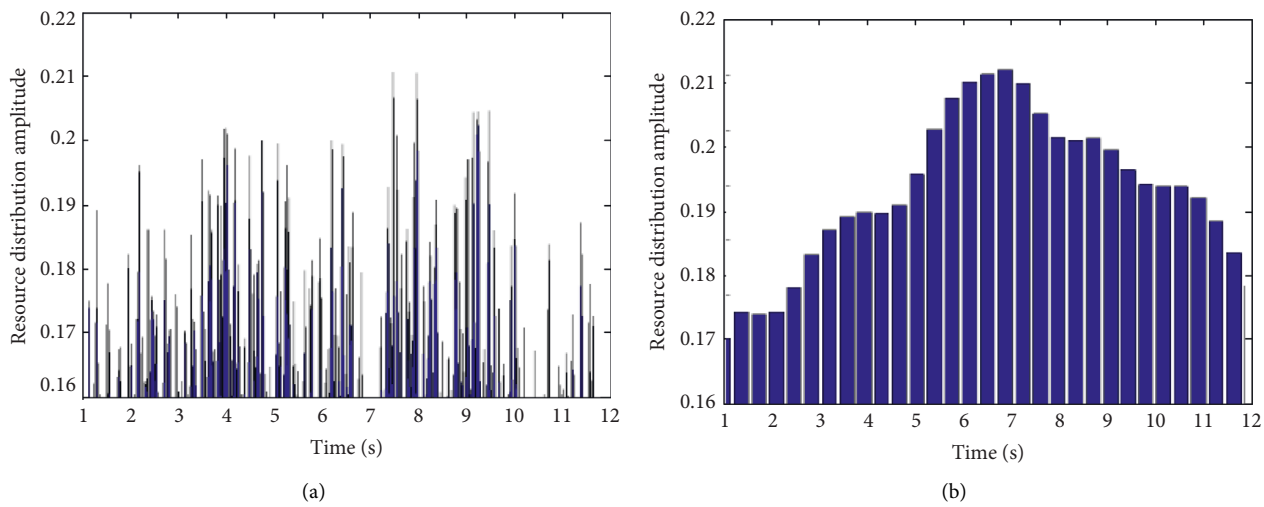

Figure 6: Results of balanced allocation of resources. (a) Before improvement. (b) After improvement.

Table 2: Delay error of multimedia wireless network modular teaching resources.

Spatial position	Root-mean-square error		
	This method	ARMA	STARM
1	0.221355	0.244033	0.302818
2	0.222521	0.253248	0.308463
3	0.221074	0.241868	0.301496
4	0.220116	0.256496	0.310455
5	0.220529	0.237529	0.298843
6	0.220802	0.239694	0.300165
7	0.219769	0.231570	0.295190
8	0.220322	0.235901	0.297843

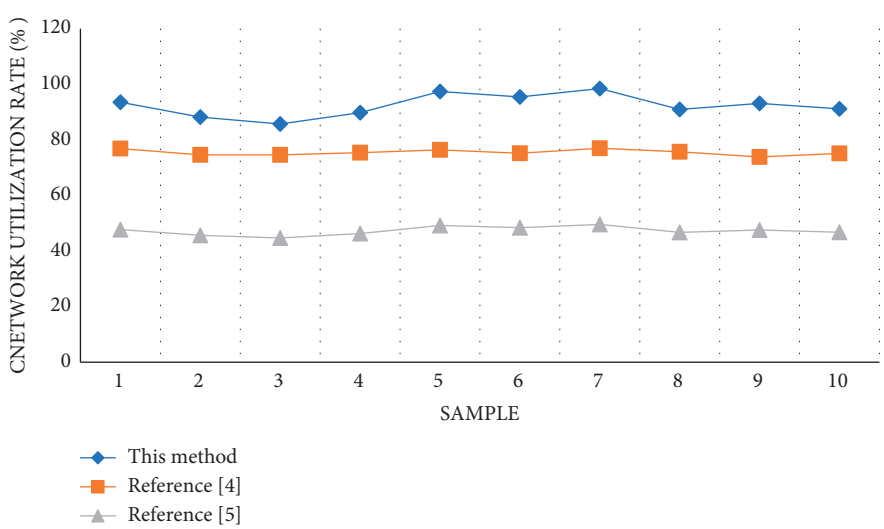

Figure 7: Comparison of network bandwidth utilization.

points, effectively improving the reading and writing performance of multimedia wireless network modular teaching resources, thus improving the bandwidth automatic balanced distribution of multimedia wireless network modular teaching resources. We tested the delay error of the modular teaching resource distribution of multimedia wireless network, as shown in Table 2.

Figure 7 displays the comparison outcomes from a test of the multimedia wireless networks' bandwidth usage. According to the analysis in Figure 7, with an average utilization rate of 0.9521, which is significantly higher than the conventional methods of 0.9433 and 0.8471, this method can adaptively allocate the bandwidth of the optical fiber network and improve utilization rates.

6. Conclusions

Due to the limited construction budget of campus network resource servers and a large number of campus network users, there is also a high demand for multimedia teaching. It is critical to understand how to schedule various resources reasonably and scientifically to improve system performance. A dynamic scheduling strategy of resource load based on prediction is proposed to meet this demand. This strategy uses virtualization technology to divide the computing power in multimedia teaching clusters into multiple virtual central processing units. Then, it builds a resource request prediction model to predict the demand for teaching on demand in the future according to the current multimedia teaching situation. Data such as the frequency with which resource content is ordered and the number of times it has received praise are used to build the prediction model. This strategy logically distributes resources based on the actual multimedia teaching needs by utilizing the dynamic adjustment functionality of virtual hardware resources. This achieves the goal of completely utilizing resources under load balance situations. The optimized allocation algorithm is achieved through the optimized allocation of multimedia wireless network modular teaching resources. Increase the resource support for the multimedia teaching content in the issue, and provide flexible services to multimedia teaching technology users. Modular teaching resources are reliably allotted bandwidth by managing the multimedia wireless networks' transmission delays. It is possible to lower the multimedia wireless network transmission's packet loss rate and jitter. It is possible to increase the consistency of the multimedia wireless network's capacity for resource allocation. This paper proposes a balanced resource allocation method for multimedia wireless networks based on block grid balanced scheduling and resource spectrum fusion. The cluster computing system is used to distribute data spectrum resources under the overall link bandwidth allocation method. The resource spectrum of multimedia wireless network modular teaching resources is distributed using a high-energy physical computing system structure. Thus, the multimedia wireless network's automatic balanced allocation adjustment is realized. According to the research, the method presented in this paper can be modified for use in the deployment of multimedia wireless networks. Furthermore, it increases the use of wireless network multimedia teaching resources.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Research Article

Decision Modeling and Evaluation of Enterprise Digital Transformation Using Data Mining

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The paper discusses the commercial opportunities for digitalization, as well as the changes that occur when digital technology is adopted throughout all business areas. A survey of digital firms found that maturing digital organisations are concentrating on integrating digital technologies to revolutionise how businesses operate. A digital strategy supported by management who nurture a culture of change and innovation is a primary predictor of a company's ability to digitally remake itself. Companies that integrate big data, cloud, mobile, and social technologies into their infrastructure are more lucrative, have larger sales, and have a better market valuation than competitors with a weak vision. This paper aims to conduct an in-depth study on the evaluation and decision-making model of the effectiveness of enterprise transforming to digitalization based on data mining in order to address the shortcomings of self-evaluation, promote and improve the process and promote enterprise transforming to digitalization. First, it determines the evaluation index and uses triangular fuzzy numbers to clarify the index weight. It also gathers the opinions of various experts in the decision-making process. Afterward, the decision tree evaluation model is generated through the information gain and ROC curve. Based on enterprises' relevant transforming to digitalization data, the decision tree model is used as the evaluation decision model, and the research on the evaluation model of the point of enterprise transforming to digitalization is completed. Experiments show that the method proposed in this paper has high accuracy, fast algorithm operation efficiency, and robust data mining ability. It can effectively improve and promote the progress of enterprise transforming to digitalization.

1. Introduction

China's economy has changed from speedy growth to quality development. Implementing new development concepts and building a modern economic system is a need of the hour. There is also a need to reform the enterprise structure, promote the deep integration of advanced technology, improve supply quality, promote optimization, and upgrade China's traditional industries. Some enterprises in China are large-scale and have relatively complete systems. However, there are also problems of being large but not strong. Under the gradual weakening of low-cost advantages of Chinese enterprises, their independent innovation ability becomes poor, and production management efficiency becomes low. Transforming to digitalization is a critical way to improve overall competitiveness. Therefore, it is imperative to speed up the transforming to the digitalization of enterprises.

The weak foundation of transforming to the digitalization of Chinese enterprises and the poor application ability of digital technology are the main reasons for the enormous gaps in the digital capabilities of enterprises. After breaking down barriers between individuals and companies, organisations in the sector are confronting the challenge of adapting to digitalization. They will be able to build innovative services and efficient business practises if these limits are lifted. These changes are occurring in organisations of all sizes. They have one trait: the ability to revolutionise processes and business models, increase worker productivity and creativity, and personalise customer/citizen experiences. To do this, businesses will require an outcome-driven,

technology-enabled Digital Business Platform. The use of technology to the creation of new business models, processes, software, and systems results in improved revenue, a stronger competitive advantage, and increased efficiency. Enterprises acknowledge their own needs for transforming to digitalization and choose the most appropriate entry point. Transforming to digitalization is not a single technology application but a proposition of strategy and management. Most enterprises in China do not have an information foundation and talent, so they do not know how to carry out transforming to digitalization or combine their actual situation and needs. They blindly carry out transforming to digitalization. As a result, the digital equipment and software of many enterprises do not meet the needs of enterprises, and transforming to digitalization does not achieve the effect. This paper aims to evaluate the effectiveness of enterprise transforming to digitalization.

The innovations of this paper are as follows: first, it determines the evaluation index of the effectiveness of enterprise transforming to digitalization, uses triangular fuzzy numbers and closeness to clarify the index weight, and gathers various expert opinions in the decision-making process. Then, through the information gain and ROC curve, the decision tree evaluation model is generated. Based on enterprises' relevant transforming to digitalization data, the decision tree model is used as the evaluation decision model of the effectiveness of enterprise transforming to digitalization. Secondly, it compares the other enterprise transforming to digitalization effectiveness and evaluation models. It shows that the proposed method has high accuracy, faster algorithm operation efficiency, strong data mining ability, and can effectively promote enterprise transforming to digitalization progress.

The structure of this research paper is as follows: Section 2 explains the related work done in this study. Section 3 sheds light on the construction of evaluation indicators for the effectiveness of enterprise transforming to digitalization. Similarly, Sections 4 and 5 describe the evaluation and analysis of enterprise transformation effectiveness based on data mining and experimental result. Finally, the concluding remarks are mentioned in Section 6.

2. Related Work

The transformation of an enterprise aims to better adapt to the current environment. With the support of the national government, there is a need to change the business model of the enterprise through existing resources and explore new ways that are most suitable for the survival and development of the enterprise. By taking digital technology as a fusion agent of the digital and experimental economy, the research results show that the speed of enterprise transformation is relatively slow. It is not combined with the current situation of enterprise development. It results in an overall low level of enterprise transforming to digitalization [1]. Digital technology has gradually become a technology that has led the way. In the rapidly changing digital pattern, the transforming to the digitalization of enterprises has aroused widespread concern in society. In the digitalization process, it is essential to scientifically analyze their digitalization level to find a more suitable path for enterprise development and realize the transformation and upgradation of enterprises.

Therefore, based on the detailed analysis of the connotation and essence of digitalization and enterprise digitalization transformation, enterprises must refine specific evaluation indicators and critical process areas using literature research and expert evaluation method and develop a digitalization transformation effectiveness model. The model has five key process areas with 19 first-class and more than 60 second-class indicators. Compared with the current relevant evaluation models at home and abroad, this model can reflect the changes in the enterprise operation mode and digital technology's integration and system application. It also provides researchers with insights into emerging digital phenomena and is conducive to formulating strategic objectives and implementing relevant plans for enterprises [2]. Transforming to digitalization has become the trend of enterprise operation in the era of the digital economy. Traditional enterprises have become data-driven operating enterprises in the process of transforming to digitalization. Against this background, data protection and application are the main aspects of enterprise data resource operation. By establishing an enterprise transforming to digitalization effectiveness evaluation model, focusing on the protection of enterprise data, taking impact evaluation as a guide, referring to the transformation effectiveness theory, and combining with enterprise data management, an enterprise transforming to digitalization effectiveness model includes more than 30 first-class indicators and more than ten second-class indicators can be established. This model is applied to two specific industries in China that provide a basis for the transforming to the digitalization of enterprises; however, no particular method is proposed [3]. The framework structure of the mathematical model is established based on the choice of enterprise transforming to digitalization based on the RCSP model of life cycle theory.

Under this framework, for enterprises with different life cycles, the model transforms the problem of enterprise transforming to digitalization into a decision-making process. It is decomposed into many interrelated and mutually constrained stages. The Delphi technology is used to obtain the evaluation score of the inspection expert group, give the weight calculation method, introduce Bayesian criteria, and clarify the posterior probability from the starting point to the endpoint to obtain the probability matrix. The detailed analysis of the stable distribution of the Markov chain is used to obtain the probability matrix in the case of balance. It also enriches the selection method of evaluation and decision-making but does not put forward specific improvement countermeasures [4].

3. Construction of Evaluation Indicators for the Effectiveness of Enterprise Transforming to Digitalization

In this section of the paper, we will study the establishment of candidate indicators for evaluating the effectiveness of

enterprise transforming to digitalization and determination of index weight of enterprise transformation effectiveness evaluation based on the fuzzy analytic hierarchy process. It will help us understand the construction of evaluation indicators for the effectiveness of enterprise transforming to digitalization. The details are as follows.

3.1. Establishment of Candidate Indicators for Evaluating the Effectiveness of Enterprise Transforming to Digitalization. Quantitative indicators shall be selected to evaluate the effectiveness of enterprise transforming to digitalization. Quantitative data can be used to obtain them [5, 6]. The commonly used indicators for evaluating the effectiveness of enterprise transforming to digitalization are obtained through a detailed analysis of more than 70 domestic and foreign documents related to the evaluation of enterprise transforming to digitalization, combined with the characteristics of the evaluation indicators. The specific indicators are shown in Table 1.

Select 12 experts in the field of enterprise transforming to digitalization, send the questionnaire to the experts, and the experts will score the transformation evaluation indicators. When the evaluation index $AV \geq 80\% \times 5 = 4$, it is considered that the expert evaluation results can be adopted; otherwise, it means that this index is eliminated [7, 8]. According to the final score of the candidate indicators, the level of office automation and the proportion of online equipment will be eliminated because of the bandwidth of the backbone network and Internet interface, the application rate of scientific and technological achievements transformation, and the proportion of highly educated talents. The final score of the candidate indicators is shown in Table 2.

After the screening of experts, starting from the three first-class indicators of technological changeability (X), organizational changeability (Y), and management changeability (Z), a total of 26 detailed evaluation indicators are used to establish an enterprise transforming to digitalization effectiveness evaluation model in seven aspects. It includes digital infrastructure, R & amp; D, and digital investment. The specific indicators are shown in Table 3 [9, 10].

3.2. Determination of Index Weight of Enterprise Transformation Effectiveness Evaluation Based on Fuzzy Analytic Hierarchy Process. The weight of the enterprise transforming to digitalization effectiveness evaluation index is measured using the method of fuzzy mathematical theory along with the analytic hierarchy process. It reflects the impact of information fuzziness on the evaluation results [11, 12].

3.2.1. Definition of Triangular Fuzzy Numbers. Note that, $F(R)$ is the fuzzy set of all on R. Suppose $M \in F(R)$, if M membership function is $A(X)$, $R \longrightarrow [0,1]$ is expressed as follows:

$$M(X) = \begin{bmatrix} \dfrac{x-l}{m-l}, & X \in [l,m] \\ \dfrac{x-u}{m-u}, & X \in [m,u] \\ 0, & other \end{bmatrix} \tag{1}$$

In formula (1), $l \leq m \leq n$, l represents the upper bound of the membership function support, u represents the lower bound of the membership function support, and the triangular fuzzy number M is (l, m, u). In the evaluation index model, l represents the most pessimistic evaluation of experts on this index, m represents the most likely evaluation, and u represents the most optimistic evaluation. The function image is shown in Figure 1.

3.2.2. Application of Fuzzy Closeness. Their closeness can measure the degree of closeness between two fuzzy subsets. If an expert's fuzzy average is close, it means that the expert's evaluation structure is closer to the group evaluation results, and the reliability is relatively high. Therefore, the weight is larger [13, 14].

Assuming that A and B are two fuzzy subsets of R, the closeness $\sigma(A, B)$ between them is defined as follows:

$$\sigma(A,B) = \frac{\sum_{x \in U} (A(x) \wedge B(x)}{\sum_{x \in U} (A(x) \vee B(x)} \tag{2}$$

Experts evaluate various indicators according to the evaluation indicators of the effectiveness of enterprise transforming to digitalization. It is assumed that the set of evaluation experts is $D = (D_1, \cdots, D_k, \cdots, D_l)$ Suppose that the evaluation result of each index of k experts D_k is $M = (M_{k1}, \cdots, M_{ki}, \cdots, M_{kn})$, for the ith index, experts make the language evaluation D_k, and the corresponding triangular fuzzy number is M_{ki}. Therefore, the fuzzy closeness between the triangular fuzzy numbers M_{ki} and M_{mi} of experts D_k and D_m is

$$\sigma(M_{ki}, M_{mi}) = \frac{\sum_{x \in U} (M_{ki}(x) \wedge M_{mi}(x)}{\sum_{x \in U} (M_{ki}(x) \vee M_{mi}(x)} \tag{3}$$

Construct the expert evaluation proximity matrix N, in which, for the expert's evaluation results, the proximity is 1.

$$N = \begin{bmatrix} 1 & \sigma(\overline{M}_1, \overline{M}_2) & \cdots & \sigma(\overline{M}_l, \overline{M}_l) \\ \sigma(\overline{M}_1, \overline{M}_2) & 1 & \cdots & \sigma(\overline{M}_2, \overline{M}_l) \\ \vdots & \vdots & \ddots & \vdots \\ \sigma(\overline{M}_1, \overline{M}_l) & \sigma(\overline{M}_2, \overline{M}_l) & \cdots & 1 \end{bmatrix} \tag{4}$$

The closeness of the average expert D_k is defined as the k-th row of the matrix N divided by $\sigma(\overline{M}_k, \overline{M}_k) = 1$, the average value of other elements is

$$\sigma_{D_k} = \frac{1}{l-1} \sum_{j=1, j \neq k}^{l} \sigma\left(\overline{M}_j, \overline{M}_k\right) \tag{5}$$

Table 1: Evaluation indicators for the effectiveness of enterprise transforming to digitalization.

Secondary indicators	Tertiary indicators	Secondary indicators	Tertiary indicators
Digital infrastructure construction capacity	Intranet access rate	Organizational structure transformation ability	Digital sector leadership
	Internet access rate		Number of enterprise management levels
Digital R & D capability	Backbone and internet interface bandwidth	Digital talent construction ability power	Proportion of digital talents
	Application rate of data security measures		Digital skilled employee coverage
	Output rate of new products		Expenditure ratio of digital skilled talents training
	Transformation and application rate of scientific and technological achievements		Proportion of highly educated talents
Digital input capacity	R&d input intensity	Business digital management capability	E-commerce application ratio
	Number of patents application success rate		Office automation level
	Proportion of digital investment		Service response time ratio
	Proportion of digital equipment investment		Order on time delivery rate
	Proportion of digital operation and maintenance		Data visualization rate
Financial digital management ability	Proportion of data security investment	Production digital management capability	Proportion of online equipment
	ERP system coverage		Automation rate of production equipment
	Capital turnover rate		Proportion of digital equipment directly connected to production software
	Inventory capital turnover rate		Product defect detection rate
			Comprehensive utilization rate of equipment

Table 2: Final scores of candidate indicators.

Tertiary indicators	Final score	Tertiary indicators	Final score
Intranet access rate	4.18	Digital sector leadership	4.43
Intranet access rate	4.08	Number of enterprise management levels	4.38
Backbone and internet interface bandwidth	3.65	Proportion of digital talents	4.58
Application rate of data security measures	4.23	Digital skilled employee coverage	4.25
Output rate of new products	5.00	Expenditure ratio of digital skilled talents training	4.42
Transformation and application rate of scientific and technological achievements	3.45	Proportion of highly educated talents	3.38
R&D input intensity	4.54	E-commerce application ratio	5.00
Number of patents application success rate	4.65	Office automation level	2.93
Proportion of digital investment	5.00	Service response time ratio	4.68
Proportion of digital equipment investment	4.58	Order on time delivery rate	5.00
Proportion of digital operation and maintenance	4.38	Data visualization rate	4.46
Proportion of data security investment	4.62	Proportion of online equipment	2.50
ERP system coverage	4.88	Automation rate of production equipment	4.53
Capital turnover rate	4.38	Proportion of digital equipment directly connected to production software	4.43
Inventory capital turnover rate	4.28	Product defect detection rate	5.00
		Comprehensive utilization rate of equipment	4.48

Table 3: Enterprise transforming to digitalization effectiveness evaluation index system.

Secondary indicators	Tertiary indicators	Secondary indicators	Tertiary indicators
Digital infrastructure construction capacity x1	Intranet access rate $x11$	Organizational structure transformation capability $Y1$	Digital sector leadership $Y11$
	Intranet access rate $x12$		Number of enterprise management levels $Y12$
	Application rate of data security measures $x12$	Digital talent construction capability $Y2$	Proportion of digital talents $Y21$
Digital R & D capability x2	Output rate of new products $x21$		Digital skilled employee coverage $Y22$
	Transformation and application rate of scientific and technological achievements $x22$		Expenditure ratio of digital skilled talents training $Y23$
	R&d input intensity $x23$	Business digital management capability $Z1$	E-commerce application ratio $Z11$
Digital input capacity x3	Number of patents application success rate x31		Service response time $Z12$
	Proportion of digital investment x32		Order on time delivery rate $Z13$
	Proportion of digital operation and maintenance $x33$		Data visualization rate
	Proportion of data security investment $x34$	Production digital management capability $Z2$	Automation rate of production equipment $Z21$
Financial digital management ability $Z3$	ERP system coverage $Z31$		Proportion of digital equipment directly connected to production software $Z22$
	Capital turnover rate $Z32$		Product defect detection rate $Z23$
	Inventory capital turnover rate $Z33$		Comprehensive utilization rate of equipment $Z24$

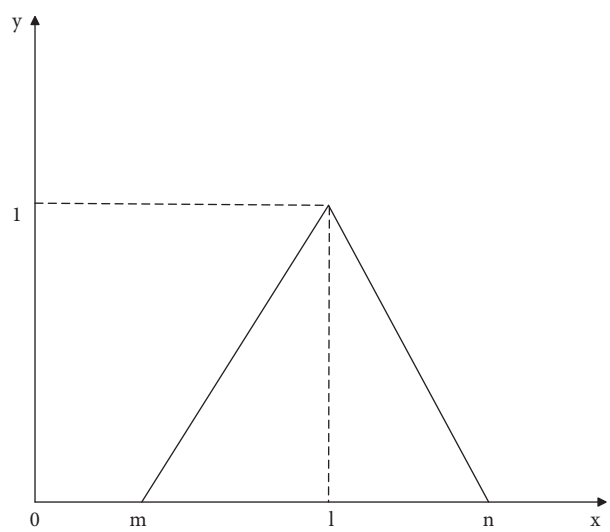

Figure 1: Membership function diagram of triangular fuzzy numbers.

Figure 2 shows the calculation process of index weight based on the triangular fuzzy number analytic hierarchy process.

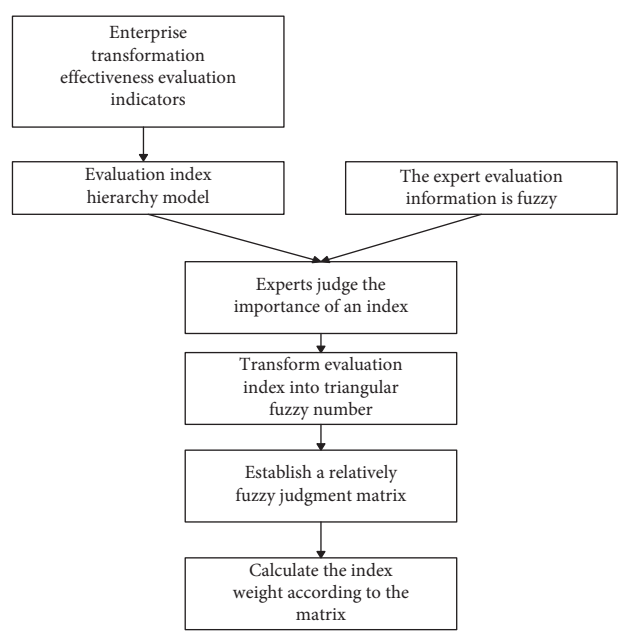

Figure 2: The calculation process of index weight based on triangular fuzzy number analytic hierarchy process.

4. Evaluation and Analysis of Enterprise Transformation Effectiveness Based on Data Mining

This section explains the information gains, evaluation of the decision tree model, ROC curve, and decision tree model. These elements will help evaluate and analyze enterprise transformation effectiveness based on data mining. The explanation is as follows.

4.1. Information Gain. Information entropy represents the information gain of uncertainty. It can measure the impact of a feature on the classification results of enterprise transformation effectiveness [15, 16].

Information entropy is expressed as follows:

$$Info(D) = -\sum_{i=1}^{c} p_i \log(p_i) Info(D) \tag{6}$$

Formula (6), D represents the training data set, c represents the number of categories of enterprise transforming to digitalization data, and p_i represents the proportion of the number of category i samples to the total number of samples.

For the corresponding data set D, when the feature A is selected as the judgment node of the decision tree, the information entropy after the action of the feature A is $Info(D)$, and the calculation is expressed as follows:

$$Info_A(D) = -\sum_{i=1}^{k} p_i \frac{|D_j|}{|D|} \times Info(D_j) \tag{7}$$

Formula (7), k represents the value of information entropy reduction of enterprise transformation data sample D after the action of feature A, which can be expressed as follows:

$$Gain(A) = Info(D) - Info_A(D_j) \tag{8}$$

Compared with the feature selection suitable for the decision tree nodes, it is the feature with the largest $Gain(A)$ value.

4.2. Evaluation of Decision Tree Model. Create a decision tree model and test it with a check set. Classification accuracy, recall rate, false alarm rate, and accuracy are among the evaluation indicators. These are computed using the confusion matrix [17, 18].

This paper primarily studies the significance of the effects of enterprise transforming to digitalization. The confusion matrix mainly evaluates the accuracy of the supervised learning model. Each column of the matrix represents the prediction of a category example. Therefore, the class with a significant impact on enterprise transforming to digitalization is regarded as 1, and the class without significant effect is 0. These are presented in Table 4.

In Table 4, P signifies the number of positive cases of enterprise transformation effectiveness, N denotes the number of negative cases of enterprise transformation effectiveness, TP signifies the number of positive cases correctly predicted, EP represents the number of negative cases indicated into positive cases, FN represents the number of positive cases predicted into negative points, and TP and TN characterize the number of negative cases correctly projected.

Various indicators obtained from Table 4 are as follows.

The classification accuracy probability is expressed as follows:

$$Accuracy = \frac{TP + TN}{P + N} \tag{9}$$

The recall rate is expressed as follows:

$$Recall = \frac{TP}{P} \tag{10}$$

The false alarm rate is expressed as follows:

$$Fprate = \frac{FP}{N} \tag{11}$$

The accuracy is expressed as follows:

$$\text{Pr}ecision = \frac{TP}{TP + FP} \tag{12}$$

The positive example coverage is expressed as follows:

$$Sensitivity = \frac{TP}{TP + FN} \tag{13}$$

Negative case coverage is expressed as follows:

$$Specifcity = \frac{TN}{TN + FP} \tag{14}$$

4.3. ROC Curve. The ROC curve is drawn by using two index values. Among them, the X axis represents specificity, which is the negative case misjudgment rate, and the Y axis represents sensitivity, which is the positive case coverage rate. It is shown in Figure 3.

4.4. Decision Tree Model. It can be seen from Figure 3 that the area AUC under the ROC curve is 0.87, which exceeds 0.8. It is considered that the effect of model fitting is suitable, and the decision tree is visually displayed [19-20]. By pre-pruning the decision tree, the node splitting of the decision tree is based on the gain principle of maximum information entropy. In each node, if the information entropy is greater, the purity of the sample distribution in the node will be lower, and the amount of information that can be provided will be less. The generated decision tree is shown in Figure 4.

The data construction and application ability in Figure 4 is an important indicator to evaluate the effectiveness of enterprise transforming to digitalization. Therefore, through variables as the root node, build a decision tree to classify the enterprises and draw the characteristics of different enterprises. The above-given process completes the research on the evaluation model of the effectiveness of enterprise transforming to digitalization based on data mining.

5. Experimental Result

Take the accuracy of enterprise transformation data classification, data mining ability, and algorithm operation efficiency as verification indicators. To validate the effectiveness of the enterprise transforming to a digitalization evaluation and decision-making model, simulation experiments are carried out. Figure 5 shows the comparison of data classification accuracy between the decision tree

Table 4: Confusion matrix.

Actual class	Remarkable achievements in transforming to digitalization = 1	Remarkable achievements in transforming to digitalization = 0
Remarkable achievements in transforming to digitalization = 1	TP	FN
Remarkable achievements in transforming to digitalization = 0	FP	TN
	P	N

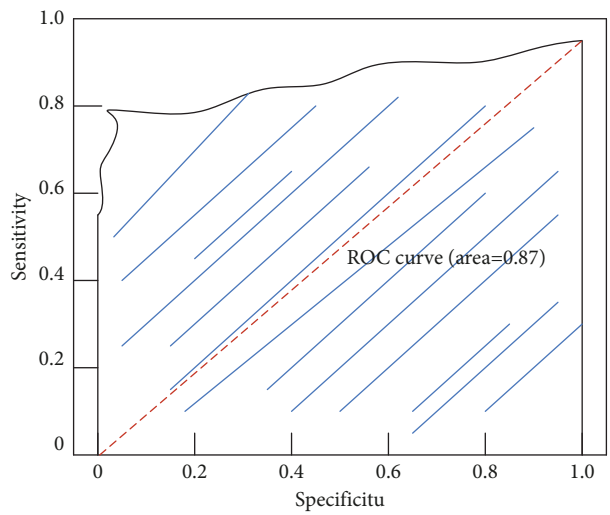

Figure 3: ROC curve of decision tree.

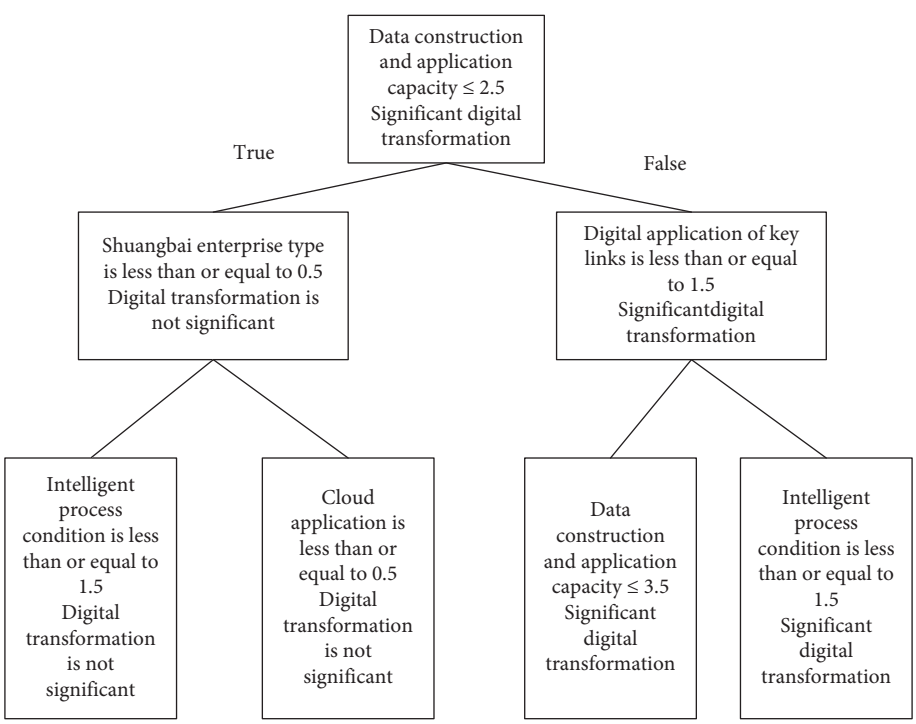

Figure 4: Visualization of decision tree.

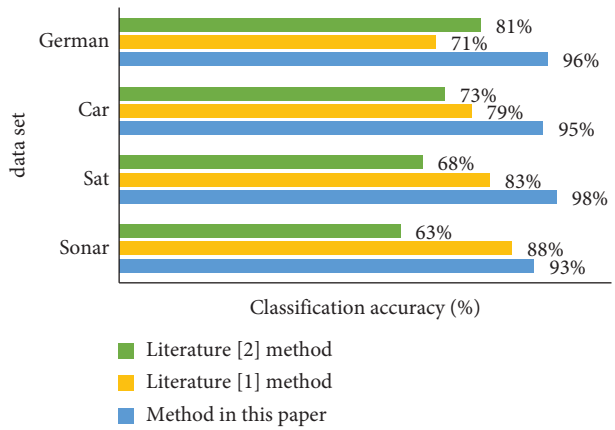

Figure 5: Comparison of data classification accuracy of different methods on different data sets.

analysis method proposed in this paper and the methods presented in the literature [1, 2].

By analyzing Figure 5, we can see differences in the classification accuracy of enterprise transforming to digitalization data using different methods on data sets. The highest accuracy of data classification using the method proposed in the literature [1] on each data set is the sonar data set, with a classification accuracy of 88%. The data set with higher accuracy of data classification using the method proposed in the literature [2] is the German data set, with a classification accuracy of 81%, The classification accuracy of the proposed method on each data set is more than 90%, and the highest data set is sat, with the classification accuracy upto 98%. Table 5 compares the operational efficiency of the approach described in this work to the literature [1, 2]. It illustrates that the technology suggested in this study can categorise corporate transforming to digitalization data properly and increase transformation impact.

Figures 6 and 7 show the comparison of enterprise data mining capabilities using the methods proposed in this paper and traditional techniques. It demonstrates that the strategy described in this study has a good operational effect and may effectively increase data mining efficiency in corporate transforming to digitalization. It can be seen from Table 5 that, compared with the methods presented in the literature [1, 2], the operation efficiency of this method is the highest. At the same time, as the number of enterprise data samples increases gradually, the operation efficiency of the process proposed in this paper shows a slow upward trend, whereas as the number of enterprise data samples increases gradually, the efficiency of algorithm operation also gradually declines, with no upward trend.

Figures 6 and 7 in this paper show the proposed method's data mining ability. Figure 6 shows that the ability to mine enterprise data using the proposed method in this paper is relatively strong. The accuracy of data mining using the method proposed in this paper is relatively high from the start of the experiment. The accuracy of data mining has not changed much with the gradual increase in data volume, and the fluctuation is minor. As shown in Figure 7, the accuracy of data mining has been maintained at more than 85%; the

Table 5: Comparison of operation efficiency of different algorithms.

Number of data samples(Piece)	Method in this paper (%)	Literature [1] Method/5	Literature [2] method (%)
300	72	68	61
600	75	67	58
900	76	68	56
1200	78	62	52
1500	79	60	50

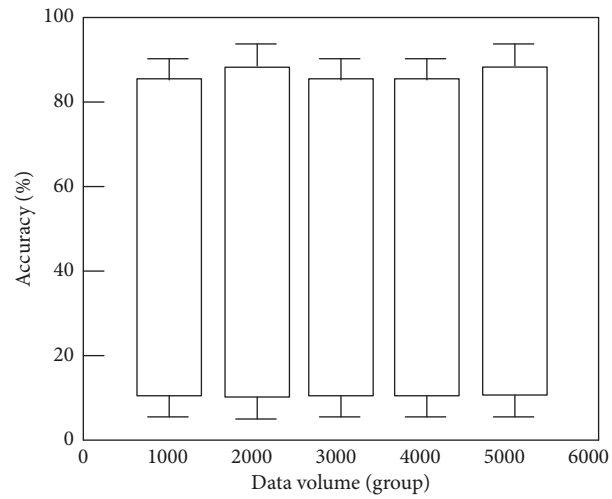

Figure 6: Data mining capability of the method proposed in this paper.

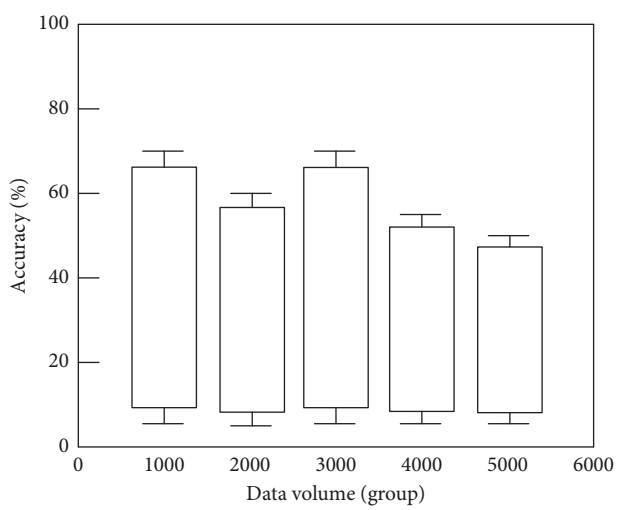

Figure 7: Data mining ability of traditional methods.

ability of data mining using traditional approaches is inadequate. From the start of the trial, data mining accuracy is lower than the approach provided in this work. As the amount of data rises progressively, the accuracy of data mining swings drastically. When the amount of data reaches

5000, the accuracy of data mining is at its lowest. It demonstrates that the method proposed in this paper can effectively mine data with an increasing amount of information to improve the effect of enterprise transforming to digitalization.

6. Conclusion

Today's businesses desire a favourable business climate that does not impede their potential to innovate. In today's global business environment, a company's ability to quickly and effectively adapt to changes is a vital success factor. The basic determination of transforming to digitalization is to enable organisations to adapt to rapidly changing business environments. Its implementation requires a well-defined strategy and prioritisation, as well as financial resources, leadership, and active participation from all personnel inside the organisation. The flow speed is determined by the sector. The present tendency is for fast growth of global connection. Cloud computing, big data and analytics, mobility and Internet access, e-commerce, social media, intelligent sensors, and the Internet of Things are all transforming the global economy. Four converging forces are producing critical technologies that will have a substantial influence on the corporate industry in the next years: social networks, mobile devices, cloud computing, and data analytics. In and of itself, these forces are unique and innovative, but when combined, they radically transform business and society, breaking old business models and ushering in new leaders. These factors together opened the door for transforming to digitalization platforms. As a result, this article investigates the success of business transforming to digitalization in depth. To analyze transforming to digitalization assessment indicators, the decision tree technique is utilised. Experiments have shown that the suggested strategy in this research may successfully enhance corporate transforming to digitalization and increase the efficacy of transforming to digitalization.

Data Availability

The data used to support the study are available on reasonable request from the corresponding author.

Conflicts of Interest

The author declares there are no conflicts of interest in publishing this paper.

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Retraction

Retracted: Evaluation of the Modern Value of Imperial Examination Culture in the Context of Cultural Confidence Based on Deep Learning Models

Mobile Information Systems

Received 25 July 2023; Accepted 25 July 2023; Published 26 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] X. Zhao, "Evaluation of the Modern Value of Imperial Examination Culture in the Context of Cultural Confidence Based on Deep Learning Models," *Mobile Information Systems*, vol. 2022, Article ID 9748146, 11 pages, 2022.

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Research Article

Evaluation of the Modern Value of Imperial Examination Culture in the Context of Cultural Confidence Based on Deep Learning Models

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National prosperity, national spiritual independence, and cultural security greatly impact the cultural self-confidence. It is also a new era issue that must be answered in building a socialist cultural power. In this paper, we scientifically define the core concepts of the imperial examination system, imperial examination culture, and imperial examination cultural heritage. We systematically discuss the connotation and extension of the imperial examination cultural heritage, analyze the positive energy and negative effects of the imperial examination culture, propose the construction of a new type of examination culture system, and innovate the content and form of the examination. We conduct an in-depth study on the modern value of the imperial examination culture in the context of cultural confidence and then construct appropriate evaluation indicators to use the deep learning model to evaluate the value. The technical principle and performance optimization method of DBN neural network are introduced and then the modern value evaluation system of imperial examination culture is constructed. The parameters of the DBN model are optimally selected through experiments. After the optimal model is trained, the sample data are input to obtain the results. The results are compared with the evaluation results of human experts to judge the performance of the model. In many cases, the results are very close to, or the same as the expert results, in some of the experiments, the accuracy of our model varied from the expert results by a small margin of up to 0.4%.

1. Introduction

The rise and fall of national prosperity, cultural security, and national spiritual independence all have a significant impact on cultural self-confidence. It is also a new era issue that must be answered in building a socialist cultural power [1]. The imperial examination system was first developed in the Sui and Tang Dynasties, perfected in the Song and Yuan Dynasties, and flourished in the Ming and Qing Dynasties. It lasted for 1,300 years in Chinese history. It had a major impact on the politics, economy, education, psychology, behavior, and culture of ancient China and the world, and it was a major institutional creation that shaped the cultural self-confidence of China, the Chinese people, and the Chinese nation. It is known as one of the most distinctive features of Chinese civilization, and it constituted a strong institution. The system was originally developed to recruit officials for the imperial government and consisted of two systems, the imperial civil service examination system, and the imperial military examination system. The imperial examination system is not only a political system but also an educational examination system, which is closely related to education [2, 3]. Cultural self-confidence is a more fundamental, larger, and longer lasting kind of self-assurance as well as a core soft power. The examination system represented by the imperial examination system is a grand event for the country to select talents. It is the traditional Chinese examination culture that has been nurtured in the process of civilization development for more than 5,000 years. The innermost spiritual aspirations of the Chinese people have been gathered by the cultural genes of the examination, which include self-advancement via investment, selection of

academics from the brilliant texts, and seeking talents for the nation. It represents the most unique examination concept logo in China, reflects the most basic psychological and behavioral characteristics of the Chinese people, and is an important part of strengthening the cultural self-confidence of the Chinese people [4–7]. The imperial examination culture and modern examination culture have played a huge role in promoting economic development and social progress. Only by deeply understanding this logical starting point and its modern value can we better realize the creative inheritance of imperial examination culture and the innovative transformation of examination culture and continuously contribute Chinese examination wisdom and Chinese examination strength to the progress of human examination civilization. The new examination culture system is the critical inheritance, creative transformation, and innovative development of the excellent part of the imperial examination culture [8]. The imperial examination system is the cultural soft power of ancient China, and the college entrance examination is the cultural soft power of modern China. The socialist examination culture system with Chinese characteristics built on it is formed and developed under the leadership of the party. In the unremitting struggle of socialist selection of builders and successors for the comprehensive development of morality, intelligence, physique, beauty, and labor, they have taken root in the vast land of China, absorbed the examination and cultural nutrients accumulated by the Chinese nation's long struggle, and learned from human civilization about talent selection. The outstanding achievements of the college, especially the college entrance examination system and culture, are in line with China's national conditions and have a profound practical foundation and broad development prospects [9]. The imperial examination system is a major event in Chinese history, and the imperial examination culture has become one of the basic components and core elements of Chinese traditional culture, so it is worthy of continuous exploration from a single-disciplinary, multidisciplinary, or interdisciplinary perspective [10]. Imperial examination culture is the source of the discipline culture of imperial examinations, which is a specialized research field or specialty that studies the imperial examination system and its operation history that existed in the history of China and other East Asian countries. It is also an applied interdisciplinary subject. The research method is to study the emerging borderline interdisciplinary subjects based on the characters, events, and the operation law of the elements of the imperial examinations. The formation of the disciplinary culture of imperial examinations is closely related to the construction of imperial examinations. The imperial examination culture is the theoretical source of the cultural construction of the examination discipline, and it is also the most basic part of the thinking, knowledge, framework, and methods of the examination discipline [11]. Examination subject culture belongs to subculture in the examination culture system, and its formation is a sign of the maturity of imperial examinations subjects. According to the principle of academic general agreement, subject culture can promote the high-quality development of the dominant subject areas of examinations and also influence the development trend of examination subjects and the evolution of the frontiers of examination subjects [12]. Imperial examination culture is the internal motivation for its research field to develop into subdisciplines, related disciplines, and mutual integration to form interdisciplinary and borderline disciplines. It is an important aspect that should be strengthened in the construction of its discipline culture and ultimately promote the scientific, standardized, and institutionalized disciplines of imperial examinations and examinations through the power of discipline culture [13, 14]. As a great institutional invention of our nation, the imperial examination system is highly praised by foreigners and contains extremely rich institutional cultural resources and treasures of wisdom. For example, the spirit of openness, fairness, and justice manifested by the perfect examination management system and strict punishment legislation. This undoubtedly has universal enlightenment and reference significance for fair and reasonable system construction in various fields today. In addition, the imperial examination system, as an important examination system for selecting officials in ancient times, also has a mirror value for today's examination reform. Modern examinations, especially large-scale educational examinations, also undertake complex and heavy social functions, and their waste has the characteristics of affecting the whole body [15].

We should earnestly learn from experience and lessons from the abolition of the imperial examination system, and we should consider the examination reform carefully and proceed with caution. This paper conducts in-depth research on the modern value of imperial examination culture in the context of cultural confidence and then constructs appropriate evaluation indicators to use deep learning models for value evaluation. The main contributions of the paper are the following.

We define the core concepts of the imperial examination system, imperial examination culture, and imperial examination cultural heritage and systematically discuss various aspects of imperial examination culture that include connotation and extension of the imperial examination cultural heritage, the positive energy and negative effects of the imperial examination culture, and the modern value of the imperial examination culture. We introduce the research progress of imperial examination culture and then propose the construction of a new type of examination culture system, consolidate the cultural foundation of the examination subject, and innovate the content and form of the examination. The study introduces the technical principle and performance optimization method of DBN neural network and then constructs the modern value evaluation system of imperial examination culture. The parameters of the DBN model are optimally selected through experiments. After the optimal model is trained, the sample data are input to obtain the results. A comparison of the achieved results with the expert's evaluation results shows that the error rate of our model is very low and the results are close, or the same as those of the expert's evaluation.

2. Related Work

Since the 1980s, there has been an upsurge of cultural discussions in the ideological and cultural fields of our country for more than ten years. The research on the imperial examination system has ushered in a spring of blooming flowers and entered a period of continuous upsurge. Not only are monographs published every year, but the number of published papers has doubled, and graduate students have chosen imperial examinations as their thesis topics [16]. Due to the emancipation of the mind and the relaxation of the academic environment, the research on the imperial examination system was unprecedentedly active. Reference [17] pointed out that the imperial examination system was a consistent system in 1300. As an examination system, it is unique in the world because of its early implementation, long duration, and great influence. Due to the factors of the imperial examination system itself, he had tenacious vitality in the feudal society. The historical role of the imperial examination system in its emergence, completion, and prosperity should be affirmed. Reference [18] argues that the historical role and status of the imperial examination system should be reunderstood, and the functions and specific contents of the imperial examination system should not be confused. As far as the system itself is concerned, the imperial examination system is worthy of being a masterpiece of Chinese traditional culture and has played an extremely important role in Chinese history. Like other essences of traditional culture, the positive parts of the imperial examination system are worthy of our inheritance and development. Reference [19] argues that the imperial examination integrates various functions such as cultural inheritance, educational supervision, value orientation, resource allocation, and social regulation, but the most far-reaching influence is the educational value orientation. The supervising function of the national selection examination in the realization of its training objectives in education cannot be eradicated as a malady. After the 1990s, while continuing to strengthen the examination and interpretation of the system, many scholars began to pay attention to the theoretical study of the imperial examination system. Reference [20] made an in-depth and original discussion on the Qing Dynasty champion from a new perspective. The author uses the method of Madhyamika historiography to study a period of the imperial examination system and a group of relevant figures and draws many valuable and convincing conclusions.

In the 21st century, the research on the imperial examination system has continued to heat up, and the research on the imperial examination system has entered the disciplinary stage of "Imperial Examination Science" [21]. Taking the imperial examination system and its operation history existing in China and other East Asian countries as the research object, and around this research object, research has been carried out at multiple levels in the research field, forming a relatively stable research scope and content. There are those who conduct overall research on the imperial examination system, and some who conduct research on the imperial examination system in different generations [22]. More importantly, the research on the imperial examination system has shown a multidisciplinary research trend, and there has been a multidisciplinary research on the imperial examination system in political science, sociology, cultural studies, education, and literature [23]. In recent years, the diversification and integration of research methods of the imperial examination system have been outstanding. In addition to comprehensively using the methods of comparison, connection, analysis, induction, and verification, many studies also generally use statistical and quantitative analysis methods to study the geographical distribution, geographical movement, social mobility, and the scale of examinations at all levels and their acceptance rate and other issues [24]. Reference [25] published a large number of important papers on the imperial examination system and successively undertaken several national-level projects related to the imperial examination system, which greatly enhanced the academic awareness of the imperial examination system research and the academic value of scientific research results. There is an inseparable relationship between the imperial examination system and literature, and its influence on literature is also multifaceted. From the perspective of research content, scholars' research mainly focuses on examination-style research, literature research, and Baguwen research [26]. With the deepening of the research on the imperial examination system, the cultural research of the imperial examination system has gradually attracted the attention of the world. Reference [27, 28] expounds the origin of the imperial examination system, its relationship with Chinese culture in its historical evolution, and its influence on the scholar community. On the basis of fully absorbing the research results of predecessors, it digs deep into historical materials and uses a combination of vertical and horizontal methods. The research method longitudinally examines the course of the reform of the imperial examination system and horizontally explores the cultural factors of the decline and fall of the imperial examination system. Reference [29] is a comprehensive perspective of the imperial examination system from the perspective of "big culture," which opens up new horizons. People tried to integrate the "Imperial Examination System" and "Culture" together to form a new research field of "Imperial Examination Culture." Reference [30] pointed out that the imperial examination culture as a whole culture, in a broad sense, refers to the concepts, systems, and material forms of culture related to the selection of talents by subject examinations. It is guided by the political concept of "uniformity," and the values of learning is the best way to serve as an official, with fair competition and equal selection of the best as its fundamental principles. In the practice of imperial examinations in 1300, it has cultural phenomena such as art, history, and folklore that are integrated, and a wealth of imperial examination documents and other related material cultural relics have been accumulated.

3. Method

Our proposed approach is based on deep belief networks (DBN), which can be seen as a stacked combination of many RBMs. The feature learning of the model occurs in the pretraining stage, while its weights and biases are adjusted

under the guidance of a trainer in the fine-tuning stage. This section discusses DBN-based model, its training process, and the parameter determination in detail.

3.1. DBN-Based Short-Term Traffic Flow Prediction Model

3.1.1. Restricted Boltzmann Machines. DBN can be regarded as a stack of restricted Boltzmann machines (RBM) in structure. RBM is a two-layer undirected graph consisting of the underlying visible layer and the upper hidden layer. Its structure is shown in Figure 1. Slightly different from the classic Boltzmann machine (BM), RBM only has connections between layers, and no connections between neurons within a layer. This reduces the size of the neural network and simplifies the training process, which is beneficial for practical applications. RBM is faster than BM due to restrictions in terms of connections between nodes. It is expressive to encode any distribution, computationally efficient and improved performance [31, 32].

Where v denotes the set of neurons in the visible layer in RBM, the set of neurons in the hidden layer is denoted by h, while v_i and h_j are the neurons in the visible layer and the hidden layer, respectively. m and n are the number of neurons in the visible layer and the hidden layer, respectively. It is assumed that each neuron in the RBM satisfies the binomial distribution, that is, $v_i \in \{0, 1\}$ and $h_j \in \{0, 1\}$. Each neuron has an activation function $\sigma(x)$, usually the sigmoid function is selected as the activation function, and its mathematical form is

$$\sigma(x) = \frac{1}{1 + e^{-x}}. \tag{1}$$

When a neuron state is set to 1, the neuron is activated. RBM is an energy model whose energy function can be expressed as

$$E(v, h) = -\sum_{i=1}^{m} a_i v_i - \sum_{j=1}^{n} b_j h_j - \sum_{i=1}^{m}\sum_{j=1}^{n} w_{ij} v_i h_j, \tag{2}$$

where w_{ij} is the weight between the ith neuron in the display layer and the jth neuron in the hidden layer, a_i is the bias of the ith neuron in the display layer, and b_j is the bias of the jth neuron in the hidden layer. w_{ij}, a_i, and b_j are the parameters that RBM needs to learn, and these three parameters are represented as θ, that is, $\theta = \{w_{ij}, a_i, b_j\}$.

According to the principles of statistical mechanics, the neuron state (v, h) has the following joint probability distribution function:

$$P(v, h) = \frac{e^{-E(v,h)}}{\sum_{v,h} e^{-E(v,h)}}, \tag{3}$$

where $\sum_{v,h} e^{-E(v,h)}$ is a normalization factor, also known as the partition function.

Similarly, other joint probability and conditional probability distribution functions can also be expressed in this way:

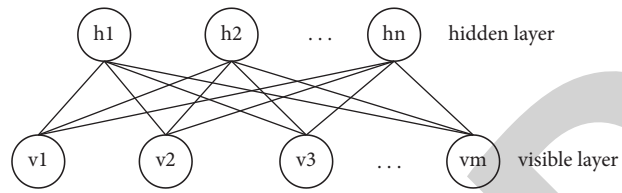

Figure 1: RBM basic structure.

$$P(v) = \frac{\sum_{h} e^{-E(v,h)}}{\sum_{v,h} e^{-E(v,h)}},$$
$$P(h \mid v) = \frac{e^{-E(v,h)}}{\sum_{h} e^{-E(v,h)}}, \tag{4}$$
$$P(v \mid h) = \frac{e^{-E(v,h)}}{\sum_{v} e^{-E(v,h)}}.$$

The joint probability distribution is represented by the energy equation of RBM, and then its conditional probability distribution function is obtained, which lays the foundation for the description of the training algorithm of RBM.

3.1.2. RBM Training Process. The training goal of RBM is to make its structural parameters best fit the training data, and this process is accomplished by adjusting the parameter θ of the RBM. In practical applications, for the determination of parameters, the method of maximum likelihood estimation is usually used, which is realized by finding the maximum value of the likelihood function. The constructed likelihood function is as follows:

$$lnL(\theta) = \ln \prod_{s=1}^{S} P(V_s) = \sum_{s=1}^{S} \ln P(V_s), \tag{5}$$

where S is the number of training samples in the training data set and V_s is the state of the neurons in the display layer corresponding to the sth training sample, that is, the state of the neurons in the display layer when the sth training sample is input.

The partial derivative of the likelihood function with respect to the parameters can be obtained as its gradient value:

$$\frac{\partial lnL(\theta)}{\partial \theta} = \sum_{s=1}^{S} \frac{\partial \ln P(V_s)}{\partial \theta}. \tag{6}$$

Then the gradient update process of the tth step can be expressed as

$$\theta(t) = \theta(t-1) + \lambda_p \frac{\partial lnL(\theta)}{\partial \theta}, \tag{7}$$

where λ_p is the learning rate.

Generally, in order to prevent the training process from falling into a local minimum and to solve the contradiction between the training speed and the convergence of the training process, the momentum method is usually used in the training process, that is, a momentum factor is added when updating the gradient. Therefore, (6) can be transformed into the following form:

$$\theta(t) = m_p\theta(t-1) + \lambda_p \frac{\partial lnL(\theta)}{\partial \theta}, \tag{8}$$

where m_p is the momentum factor.

The above is the basic process of RBM training. However, when calculating the gradient, it is found that the second item in parentheses is difficult to calculate directly. In the iterative process, each calculation of this item needs to traverse all the states of the explicit layer and the hidden layer, which is undoubtedly catastrophic for the calculation process. For functions that are difficult to calculate directly, we can use the sampled value approximation instead, which uses the Gibbs sampling method. The sampled value is obtained by sampling the objective function, and the sampled value is used instead of the expected value. If the standard Gibbs sampling method is used to sample the objective function, after each sample sequence is obtained, the preheating part in the sequence needs to be removed. That is to say, before the Markov chain reaches the steady-state distribution, it will take some time to prepare, which will affect the system efficiency in practical applications. To solve this problem, a k-step contrastive divergence (CD-k) algorithm can be used. The CD-k algorithm can be regarded as an improvement to the Gibbs sampling method. In the Gibbs sampling algorithm, the initial value is set randomly, so that for the Markov chain, a finite number of state transitions are required to reach the steady-state distribution. In the CD-k algorithm, the input sample value is directly used as the initial value. Since the initial value obeys the target distribution, the Markov chain converges at the beginning, that is, the stable distribution is achieved, which saves a lot of time. After that, the desired sample value can be obtained after only k steps of sampling. Through the sampling process, the expected value is replaced, so that the parameter value of the RBM can be updated.

The training process of RBM can be regarded as the process of reconstructing and fitting the input data by the explicit layer. The effect of RBM training can be evaluated by the reconstruction error. The reconstruction error can be described as follows:

$$Re = \frac{1}{S}\sum_{s=1}^{S}\sum_{k=1}^{K'}\left(v_{sk}^{In} - v_{sk}^{Re}\right)^2, \tag{9}$$

where S is the number of input samples and K' is the number of neurons in the display layer, that is, the dimension of the input data. v_{sk}^{In} is the input value of the kth neuron in the display layer corresponding to the sth input sample and v_{sk}^{Re} represents its reconstructed value.

3.1.3. Deep Belief Network and Training Process. The DBN is a typical nonconvolutional network that may be seen as a stacked combination of many RBMs. There are r RBMs that make up the DBN, which are numbered RBM1 to RBMr. Alternatively, the DBN may be thought of as having an input layer and a hidden r-layer. Hidden layers derive data characteristics from input sample data, while the input layer accepts data samples. In comparison to a shallow network, DBN is superior at identifying and extracting data characteristics. From the bottom to the top, the DBN extracts data characteristics. In order to get the most representative data features, the lower RBM's output is sent into the higher RBM and the features it extracts are fed back into the lower RBM. The depth of DBN determines its feature extraction ability, but the number of layers of RBM depends on the specific situation. For data sets with a small amount of data, too many layers may cause overfitting [33–36].

During the DBN training process, there are two stages: the pretraining stage and the fine-tuning stage, respectively. Pretraining is to train the RBM layer by layer from bottom to top, so that each layer of RBM converges to a local minimum during training. All network weights are fine-tuned at this step, so that the model's training process may converge to its global minimum. BP method is employed for this purpose. Pretraining and fine-tuning are performed independently, and the fine-tuning stage needs to use the results of the pretraining stage. For deep neural networks, the training method of pretraining and fine-tuning can achieve a good training effect, and pretraining can solve the problems of gradient disappearance and local minima to a certain extent.

(1) Pretraining stage: The pretraining stage is an important stage in the whole training process, and feature learning mainly occurs in this stage. The goal of the pretraining phase is to tune the model parameters to complete the reconstruction of the data. The pretraining process can be decomposed into training the RBM. When the training of RBM1 is completed, its output value is used as the input value of RBM2 to complete the initialization of RBM2. After that, the output value of RBM2 is used as the input value of RBM3 after the training is completed. And so on until the RBMr training is complete. Pretraining is an unsupervised training method that does not need to add labels when constructing training samples.

(2) Fine-tuning stage: During the fine-tuning step, the model's weights and biases are adjusted under the guidance of a trainer in order to get parameters that are as close as possible to the global optimal. The BP method is employed extensively in the fine-tuning step, and an output layer generates the output result. The model structure consists of $r+2$ layers of neurons, including an input layer, an r hidden layer and an output layer.

The data set in the fine-tuning stage is denoted as $\overline{X}_s$, $s = 1, 2, \ldots, S$, then the error function is in the form:

$$E = \frac{1}{2S}\sum_{s=1}^{S}\sum_{k=1}^{K^{r+2}}\left(y_{sk} - \hat{y}_{sk}\right)^2, \tag{10}$$

where K^{r+2} is the number of neurons in the output layer L^{r+2}, and y_{sk} and $\hat{y}_{sk}$ are the real value and output value of the kth neuron corresponding to the sth sample, respectively.

According to the gradient descent algorithm, the weights and biases are updated according to the following process:

$$\begin{aligned} w_{ij}^{u}(t) &= m_f w_{ij}^{u}(t-1) - \lambda_f \frac{\partial E}{\partial w_{ij}^{u}} \\ &= m_f w_{ij}^{u}(t-1) + \frac{\lambda_f}{S}\sum_{s=1}^{S}\delta_{sj}^{u} O_{si}^{u-1}, \\ c_j^{u}(t) &= m_f c_j^{u}(t-1) - \lambda_f \frac{\partial E}{\partial c_j^{u}} \\ &= m_f c_j^{u}(t-1) + \frac{\lambda_f}{S}\sum_{s=1}^{S}\delta_{sj}^{u}, \end{aligned} \tag{11}$$

where $w_{ij}^{u}(t)$ is the weight of the jth neuron in the L^{u} layer and the ith neuron in the L^{u-1} layer at the t step, where $2 \le u \le r+2$. $c_j^{u}(t)$ is the bias of the jth neuron in the L^{u} layer at step t. m_f and λ_f are the momentum factor and learning rate of the fine-tuning stage, respectively. O_{si}^{u-1} is the output value of the ith neuron in the L^{u-1} layer corresponding to the sample $\overline{X}_s$.

3.2. Model Parameter Determination and Performance Optimization

3.2.1. Parameter Determination. The quality of the training data and the accuracy of the predictions are directly linked to the prediction model's parameter selections during training. The training parameters include the number of hidden layers, the number of input layer neurons, and the number of hidden layer neurons in each layer, as well as the CD-k algorithm and the BP algorithm, which are used in conjunction with each other. In both the pretraining and fine-tuning stages, parameters, such as the learning rate, momentum factor, and so on, must be established. For the adjustment of model parameters, there is currently a lack of theoretical guidance. In practice, the trial-and-error method is usually used in combination with the experience of the parameter adjusters, that is, first set an initial value for all parameters according to experience, and then adjust each parameter one by one. When adjusting a certain parameter, other parameters should be fixed. When using the trial and error method to adjust parameters, attention should be paid to the order of parameter adjustment, and the parameters related to the model structure can be adjusted first.

3.2.2. Performance Optimization

(1) Local minima problem: deep networks often encounter local minima problems when performing gradient descent. The training process may oscillate at the local minima, increasing training time and even affecting convergence. For the local minimum problem, the additional momentum method is generally used to solve it, which has been mentioned in the previous description. In this paper, the momentum method is added to the training process of DBN. Adding the gradient update amount of the previous time point in the weight update process can effectively avoid the training process from falling into a local minimum.

(2) Gradient disappearance problem: when using the BP algorithm to train a deep network, in the process of error back propagation, the gradient value of the bottom layer of the network is relatively small, and the update speed of weights and biases is slower than that of the upper layer, resulting in insufficient training of the bottom layer, this phenomenon is called gradient vanishing. In the process of gradient descent, using the sigmoid function as the activation function is prone to the problem of gradient disappearance. When the network performs gradient update, the derivative needs to be multiplied continuously. Therefore, the gradient value of the network from top to bottom will become smaller and smaller, resulting in the problem of gradient disappearance. The training mode of pretraining and fine-tuning can alleviate the gradient vanishing problem to a certain extent. But to fundamentally solve it, the ReLU function needs to be used. It can be seen from the expression of the ReLU function that when the value of the independent variable is positive, its derivative value is always 1. Therefore, if the ReLU function is used instead of the sigmoid function as the activation function, the problem of gradient disappearance can be fundamentally solved. In the training process of DBN, the ReLU function is used as the activation function in this paper.

(3) Overfitting problem: the solutions to the overfitting problem include regularization, dropout, data set augmentation, etc. Through comparative analysis, this paper chooses the dropout method to eliminate the overfitting phenomenon. The specific experimental results are given in Chapter 4.

3.3. The Evaluation Index of the Modern Value of Imperial Examination Culture. The basic principle of modern value evaluation of imperial examination culture is a unique creative activity. Therefore, the evaluation of such innovative behaviors with highly overlapping knowledge and information must be carefully discriminated and determined based on scientific and reasonable principles to ensure that the imagination and creativity of the imperial examination culture are not damaged by the negative effects of evaluation.

(1) The principle of value neutrality: the most frequently used evaluation methods for cross-science or interdisciplinary research in the world are peer review and bibliometric methods, which are also two evaluation models with relatively neutral value. Due

to factors such as the ability and subjectivity of reviewing experts, competition brought about by the integration of production, education and research, and scoring and voting to win more, peer review may also damage the fairness and effectiveness of the review, forming a "Matthew effect" or a network of acquaintances, and the more senior experts are, the more likely they are to disagree on emerging cross-cutting or interdisciplinary research. Bibliometrics has its own limitations, such as the incomparability of different disciplines, the imbalance of scientific research capabilities in different countries, and the limitations of emerging or small disciplines and their researchers. Therefore, its objectivity is relative. In order to maintain value neutrality, the quantitative methods of mature disciplines cannot be used to evaluate unpopular disciplines such as imperial examination culture.

(2) The principle of efficacy delay: academic research, like talent training, has a periodic and lag effect. Evaluating the quality or effectiveness of a research paradigm or a research methodology should not be limited to whether it is ancient or modern, Chinese or foreign, classic or new. Instead, it should be seen whether it is suitable for the research object, and whether its application effectively promotes the deepening or expansion of the academic circle's understanding of the research object. This principle is also applicable to the effect judgment of the interdisciplinary research methodology applied to the modern value of imperial examination culture. For the evaluation of the modern value of the imperial examination culture, various direct or indirect ways can be considered to improve the effectiveness of the evaluation standards.

(3) Sustainable dialectical principle: just like the evolution of natural and social phenomena, the modern value of imperial examination culture also has an evolutionary process. The study of the modern value of imperial examination culture is not a static structure, but a dynamic extension, a continuous existence that may be unpredictable and non-repetitive. Its development is a living, life-rich creative and evolutionary process, which is not only stably connected with the history of imperial examinations but also organically connected with modern examinations. It is a continuous evolution and comprehensive integration of many elements. Therefore, we should evaluate the modern value of imperial examination culture from a developmental and dialectical perspective. Based on the above principles, this paper constructs an evaluation index system for the modern value of imperial examination culture, as shown in Table 1.

Table 1: The evaluation index of the modern value of imperial examination culture.

Index	Label
The value of modern talent selection	K1
The value of reconstructing the modern examination system	K2
The value of classical literary studies	K3
The value of classical historiography	K4
The research value of modern social customs	K5
The research value of related cultural relics	K6
The research value of related arts	K7
The research value of modern science and technology development	K8
The value of inheritance and innovation of traditional culture	K9
The value of promoting relevant academic research	K10
The value for paradigm change in social science research	K11
The value of national cultural identity and cultural confidence	K12

4. Experiments and Analysis

4.1. Data Samples. We constructed a data set based on the modern value evaluation index system of imperial examination culture in Section 3. The data set includes 1600 sets of data, of which 1440 sets are used as training sets and the rest are used as test sets.

4.2. Performance Optimization Test. In order to solve the overfitting problem, this paper chooses the dropout method to eliminate the overfitting phenomenon. Figure 2 is a comparison chart of the training effect of the DBN model before and after adding dropout. In this paper, the dropout ratio is set to 0.1, that is, 10% of neurons are randomly dropped in each layer of the network. Before adding dropout, after about 300 iterations, the model overfitted and the training error were smaller than the test error. After adding dropout, the training error is about the same as the test error after about 200 iterations. It can be seen that the dropout method can effectively solve the problem of overfitting, so as to obtain a model with stronger generalization ability.

4.3. Model Parameter Determination. The determination of model parameters currently lacks the guidance of systematic theory, and the combination of empirical method and trial-and-error method is generally adopted. First set the initial value of the model according to experience, then fix other parameters unchanged, manually adjust a parameter, and so on, until all parameters are adjusted, so that the training process converges smoothly. The number of neurons in the output layer of the DBN model is set to 1, which is the evaluation value of the modern value of the imperial examination culture. The results obtained are shown in Figure 3. It can be seen that when the number of neurons in the hidden layer is 8, the MSE is the smallest. Therefore, the number of neurons in the hidden layer is chosen to be 8.

The learning rate includes the learning rate λ_p in the pretraining stage and the learning rate λ_f in the fine-tuning stage, which are adjusted separately. In the pretraining stage, a λ_p is shared for all RBMs, and its parameter adjustment range is [0.2, 1.0]. The parameter adjustment range of λ_f is

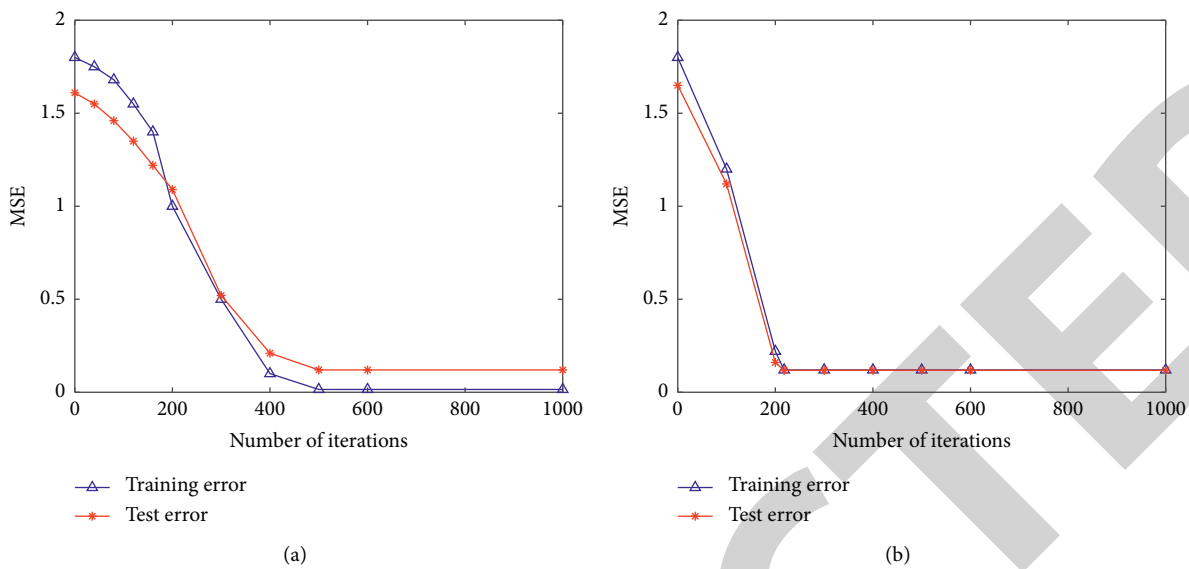

Figure 2: The fitting effect of the model before and after adding dropout.

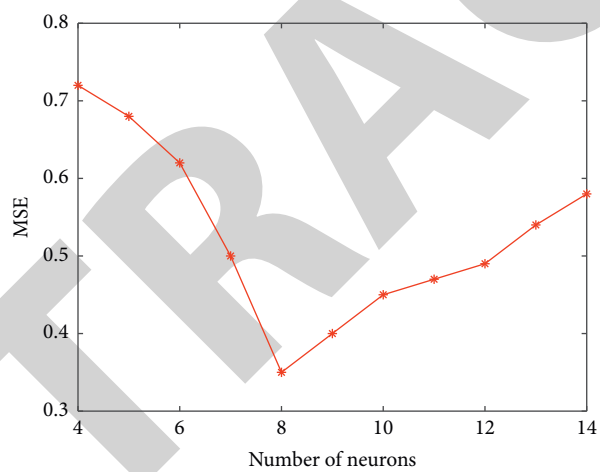

Figure 3: Influences of the number of neurons in the hidden layer of a DBN on the MSE.

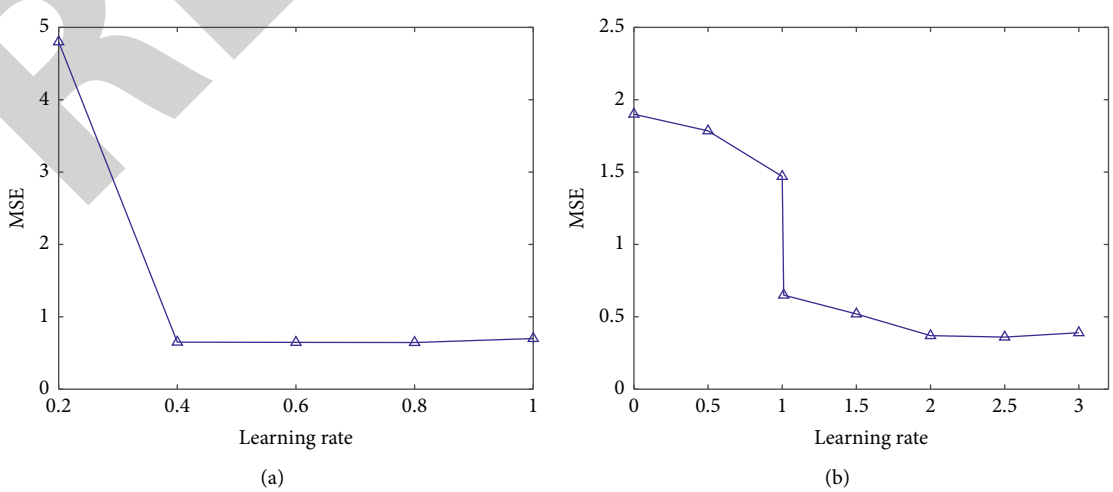

Figure 4: The effect of learning rate on error during pretraining and fine-tuning phase. (a) During pretraining. (b) During fine-tuning.

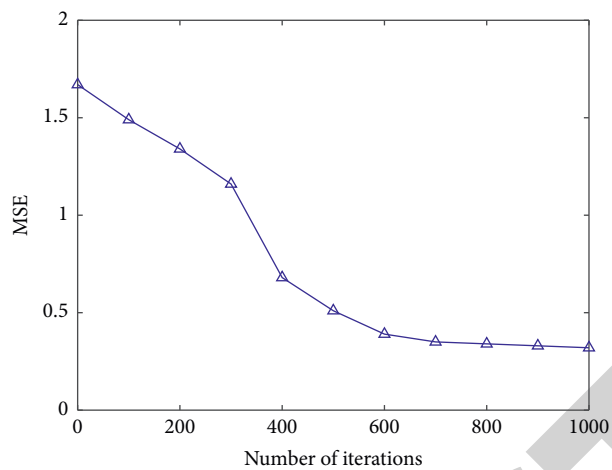

Figure 5: Influences of epochs on the errors in the fine-tuning phase of a DBN.

Table 2: Comparison of model output and expert evaluation results.

Experiments	1	2	3	4	5	6	7	8
Model output	0.788	0.614	0.832	0.901	0.915	0.857	0.785	0.663
Expert result	0.785	0.618	0.833	0.899	0.915	0.858	0.782	0.662

[0.2, 3], and the adjustment step size of both is 0.1. The effect of the learning rate on the error is shown in Figure 4. As λ_p increases, the error gradually decreases. When λ_p is greater than 0.8, the error increases slightly, so λ_p is set to 0.8. The variation trend of the error with the value of λ_f is similar to that of λ_p, and the final value of λ_f is set to 2.5. The adjustment process of the momentum factor is similar.

The number of iterations should be set not only to satisfy the conditions of stable convergence of the system but also to make the number of iterations as small as possible to reduce the training time. The effect of the number of iterations in the fine-tuning stage on the error is shown in Figure 5. The error gradually decreases as the number of iterations increases, and the final number of iterations is set to 1000. The same method can be used for the pretraining stage, where the number of iterations is finally set to 200.

4.4. Comparison of Model Evaluation Results. In order to prove the accuracy of the DBN model proposed in this paper on the evaluation of the modern value of imperial examination culture, this paper compares the output results of the model with the evaluation results of experts, as shown in Table 2. It can be seen that the output of the model is very close to the evaluation results of experts. In many of our experiments, the results are the same as those obtained from the expert evaluation, or very close to them. In a few experiments, we noticed a small difference of up to 0.4%. The error is small, and the model has superior performance in evaluating the modern value of imperial examination culture.

5. Conclusion

The history of time is surging, and the fair selection of talents will last forever. The culture of "harmony" for more than 2,000 years and the culture of the imperial examination system for more than a thousand years have made the examination culture a Chinese gene. China's existing examination system is not only the most equitable student selection and educational resource allocation system at this stage but also has an extremely profound and extensive cultural foundation for imperial examinations. Imperial examination culture and examination culture are the soul of talent selection systems such as ancient and modern Chinese and foreign examinations. Cultural treasures representing Chinese tradition must be safeguarded and managed, while study into and use of these resources must be strengthened. This paper conducts an in-depth study on the modern value of the imperial examination culture in the context of cultural confidence and then constructs appropriate evaluation indicators to use the deep learning model to evaluate the value. We introduce the research progress of imperial examination culture interdisciplinary and modern utilization value of imperial examination culture and introduce the technical principle and performance optimization method of DBN neural network. We construct the modern value evaluation system of imperial examination culture and optimally select the parameters of the DBN model through experiments. Compared with the evaluation results of experts, the DBN model proposed in this paper has superior performance in the evaluation of the modern value of imperial examination culture and the error rate is low. The data set we used is small scale, and a large-scale data set will give more insights about the performance of the model. We intend to extend our work by using a large-scale data set, big data analytics tools and different other deep learning algorithms to be able to handle large volumes of data.

Data Availability

The data sets used during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: A Classification Technique for English Teaching Resources and Merging Using Swarm Intelligence Algorithm

Mobile Information Systems

Received 25 July 2023; Accepted 25 July 2023; Published 26 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Y. Yang and H. Huang, "A Classification Technique for English Teaching Resources and Merging Using Swarm Intelligence Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 2735412, 11 pages, 2022.

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Research Article

A Classification Technique for English Teaching Resources and Merging Using Swarm Intelligence Algorithm

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The evolution of social education has necessitated the optimization of various teaching approaches, and the classification of English teaching resources is one of the crucial factors. With the development of electronic computers and Big Data technologies, the classification of teaching resources that could not be realized before has become possible now. However, the traditional classification methods cannot meet the requirements of modern computing due to the limitations of implementation. The emergence of swarm intelligence algorithms makes the classification of teaching resources possible. Swarm intelligence algorithm is a swarm-based multipoint random search algorithm, which includes evolutionary algorithm, immune algorithm, particle swarm procedure (PSO), ant colony process, artificial fish swarm mechanism, and other typical intelligent techniques. The swarm intelligence algorithm has strong robustness and strong global and local search capabilities, as well as, implicit parallelism. Furthermore, it has no special requirements for objective functions and constraint functions. It has the function of "black box" and can overcome problems where traditional optimization methods are insufficient. The swarm intelligence algorithm has a large space for development and rich forms of expression, and there is an essential connection between them, so that they can be well integrated. The key goal of this study is to implement the swarm intelligence algorithm to the task of classifying English teaching resources and to provide a reference for optimizing the English teaching model. The experimental findings demonstrate that the suggested classification model for English teaching resources has excellent performance, is favorable to enhancing the utilization rate of teaching resources, and is applicable to other disciplines.

1. Introduction

In today's educational system, it is frequently necessary for teachers and students to share interactive teaching tools. The organic integration of teaching resources in the development of informatization and computer networks makes it appear digital and networked. Owing to the construction of the educational system informatization platform, the integration of massive teaching resources is the main task of English teaching in colleges and universities. Among them, English teaching resources usually include English textbooks, cases, PPT courseware, and all other learning materials and auxiliary facilities that are conducive to cultivating students' English literacy. According to their mode of operation, educational resources can be broken down into two categories: hardware resources and software resources. The term "hardware resources" is most commonly used to refer to physical hardware facilities like school conditions and multimedia equipment. On the contrary, the term "software resources" is most commonly used to refer to a variety of paper materials and software materials that support teaching.

The integration of English teaching resources helps to build a rich and flexible English teaching classroom. In today's English teaching classrooms, due to the long writing and updating cycle of English teaching materials, the teaching content is outdated and boring, and the audio and video resources supporting the teaching materials can only

be used for listening and reading exercises, and there is a lack of interactive exercises between teaching and learning. Therefore, instructors should integrate teaching resources based on the content of textbooks and the actual situation of their students, enrich teaching content, deepen students' understanding of knowledge, utilize multimedia resources in a flexible manner, continually change teaching methods and methods, stimulate students' interest in learning, and improve classroom learning efficiency. Enhance the level of excellence in English education and instruction. In addition, the integration of English teaching resources helps to cultivate innovative and confident English learning groups. Students who have grown up in the age of holding mobile devices and looking at computers have a more individualized approach to learning English and their learning needs. They are good at using the power of the Internet to find information and learn more knowledge; they like cooperative learning and demonstrate the value of thinking with collective power; they insist on hands-on operation, experience interactive learning tasks and are highly efficient. Through the integration and utilization of teaching resources, teachers allow students to acquire knowledge, solve problems, develop abilities, and cultivate innovative consciousness through exploration and experience, laying a solid foundation for cultivating students' comprehensive language and language ability. The integration of English teaching resources also helps to create professional and open English literacy teachers. By browsing and reading a large number of English teaching resources, teachers can not only update teachers' subject professional knowledge, broaden teachers' cultural horizons, increase the openness of teachers' ideas but also optimize their teaching methods and enrich their teaching activities, thereby improving their English education and teaching level.

As mentioned earlier, although the development of Internet technology along with the evolution of Big Data and machine learning has made all kinds of educational resources rich and huge, network resources also face huge challenges. A large number of educational resources are still growing exponentially with complex types. There is neither an efficient organization nor good management in place. Text-based resources have the most quantity out of all the many kinds of resources that are available, which include video, audio, photos, and text. In this scenario, the question of how to properly categorize educational resources is an essential one that requires prompt resolution. In years gone by, sorting was typically done by hand, and the task was delegated to trained specialists. This categorization approach yields very accurate results when the available resources are limited. However, because there are more resources now than there were before, there is an issue with the classification accuracy and the low efficiency of manual classification. This problem gets more prominent as the amount of time spent on work increases.

In the discipline of data mining, data classification is an important activity because it can be used to mine models of significant data classes and forecast future patterns in data. The process of data classification may essentially be broken down into two stages: the first is the building of a classification learning model, and the second is the application of a classification model. The classification modeling algorithm, which constructs a classification function or model derived from the data set for each category; and then uses the established classification model to classify and predict the data of unknown categories; is the essential component of the phase in which the model is being constructed. This algorithm is at the heart of the model building phase. Data classification modeling is a function or mapping that can separate data classes through training and learning. The mapping is generally represented by classification rules or mathematical formulas. Overly complex rules will cause difficulties for people to judge, and mining a more understandable classification model is one of the goals of classification modeling algorithms. Evaluation of the generated model's accuracy and validity in making classification predictions is required before the model can be used for classification purposes. The model established by the classification modeling algorithm from the massive data must be accurate and effective, that is, the accuracy of the classification prediction is high, and classification modeling algorithms must be able to mine classification models and extract relatively accurate classification information in a suitable time. Algorithms with exponential time complexity are useless in classification modeling.

This paper investigates the theory and methodology of English teaching resource classification with the goal of finding solutions to the challenges outlined earlier. It conducts in-depth research on the swarm intelligence classification modeling technique in order to increase the precision and accuracy of the data classification process. The fundamental principle of the particle swarm classification algorithm is dissected first, followed by the improvement of the particle swarm classification algorithm based on the Gaussian mutation mechanism of fireworks algorithm and the new elimination mechanism of coyote algorithm, and finally, the proposal of an English teaching resource classification model based on improved swarm intelligence. Experiments have shown that the proposed categorization model has superior characteristics and a greater level of efficiency. This demonstrates that the model has been successful in achieving its intended purpose. The key contributions of our research can be summarized as follows: (a) apply swarm intelligence algorithm to the task of classifying English teaching resources and provide a reference for optimizing the English teaching model; (b) conduct an in-depth research on the swarm intelligence classification modeling technique in order to increase the precision and accuracy of the data classification process; and (c) investigate the theory and methodology of English teaching resource classification with the goal of finding solutions to various related challenges.

The left behind portions of this paper are systematized as follows: Section 2 offers a review of the related works and techniques for classification. Section 3 provides an explanation of swarm intelligence algorithms; Section 4 outlines the model that has been proposed for the classification of English teaching resources; Section 5 details the experimental work; and Section 6 provides a summary of this paper.

2. Related Work

At present, several widely used data classification algorithms include decision tree induction, Bayesian learning, support vector machines (SVMs), etc. [1–6]. However, when these algorithms solve problems such as classification, prediction, and function discovery, there are still many problems in the comprehensibility, classification accuracy, and generalization ability of the built learning models [7–12]. Therefore, traditional classification modeling algorithms face huge challenges in terms of prediction accuracy, scalability, and efficiency. Data classification is widely used in the fields of bioinformatics [13], weather forecasting [14], network technology [15], finance [16], and text classification. The classification of texts automatically enables efficient management and organization of textual material. The text that needs to be categorized follows a set of guidelines that are determined by the classification model that is being used. Calculations are performed to determine the degree to which it is associated with each category, and the results are then automatically sorted into the appropriate categories. This technology is used in the process of retrieving information, screening incoming mail, and creating digital libraries.

The technique for automatically classifying texts reduces expenses associated with labor while also achieving high classification speeds and levels of precision. As a result, it is considered to be the primary technique of classifying various educational resources. Before the 1990s, the predominant methods relied on the information provided by specialists to manually establish rules and construct classifiers. This is an effective classification method for use with corpus data. Having said that, this technique has its limitations when applied to large-scale data sets, after the 1990s, with the growth of Big Data technology for machine learning. Similarly, Hong et al. [17] started their efforts to apply it for text classification in an effort to improve the accuracy of their results. This method of classification classifies classified texts in an automated fashion by learning and obtaining classified texts based on a set of preclassified texts. This approach does not call for the participation of any experts. It classifies items more quickly and has a higher degree of accuracy. Furthermore, Meng et al. [18] provided a comprehensive description of each text classification implementation in addition to its architecture. After some time had passed, this essay came to be considered as a classic in the field of text classification. Li et al. [19] presented an approach called the SVM, which is grounded on statistical philosophy. The primary objective and key goal here is to identify the hyperplane of best fit for high-dimensional classification data. The strategy could involve gaining knowledge from relatively few examples. In the same vein, the robustness and classification impact are both satisfactory, which, in fact, has engrossed a prodigious deal of focus from a variety of specialists.

Nature has its inherent evolutionary laws, and biological behaviors also have their own intelligence. These laws and intelligent behaviors have been successfully modeled by researchers and used to solve many complex practical problems. Many new modeling methods inspired by nature and biological behavior have been validated through simulation experiments because nature can solve many complex problems for humans through its own genetic evolution. Individuals in biological groups are very simple, but their collective behavior is particularly complex. By studying the group behavior of organisms, many swarm intelligence models have been constructed. Simple individuals in the model can show very complex emergent behaviors through cooperation between groups. These behaviors have been effectively modeled by a huge number of researchers, and those models have been used to solve a significant number of complicated practical issues. In modern ages, some swarm intelligence procedures, for instance, the particle swarm optimization (PSO) algorithm [20], firework algorithm (FA) [21], grey wolf optimization (GWO) algorithm [22], coyote optimization algorithm (COA) [23], genetic algorithm (GA) [24], whale optimization algorithm (WOA) [25], ant colony optimization (ACO) [26], and gravity search algorithm (GSA) [27], etc., which solve problems by simulating a natural phenomenon or biological evolution process and have a high degree of self-organization, self-adaptation, and self-learning. In the disciplines of artificial intelligence, machine learning, and data mining, characteristics like parallelism and parallelism have demonstrated tremendous vitality and potential for further growth. These characteristics include: There are a great deal of algorithms of this type. These methods are used to find solutions to difficult issues involving computational optimization. On the contrary, swarm intelligence algorithms typically have drawbacks such as a low level of optimization accuracy and the ease with which they might fall into a local optimum. Researchers from both the United States, and other countries are focusing a lot of their attention on finding solutions to these issues [28].

At present, the research on swarm intelligence optimization algorithm mainly focuses on the theory of the algorithm, the improvement of the algorithm and the application of the algorithm. The theory of the algorithm is usually developed in the analysis of the convergence, stability, and time complexity of the algorithm. Many improved algorithms have achieved good results in practical applications, but they lack theoretical support. Therefore, it is very important to theoretically analyze the swarm intelligence optimization algorithm. In terms of algorithm improvement, the improvement methods adopted by researchers mainly focus on population initialization, algorithm parameters, hybrid algorithms [29, 30], and learning strategies. Although many methods are proposed every year to improve swarm intelligence algorithms, the algorithm converges. The problems of slow speed and low accuracy still exist, and no algorithm can solve any optimization problem well, which means that new and improved algorithms need to be proposed continuously in this field. In terms of the application of algorithms, it has not only been used to solve optimization problems, but also applied to medical data analysis [31], robot path planning [32], energy saving and emission reduction [33], and other fields, which have broad application prospects and research value [34]. However, all the aforementioned traditional classification methods cannot meet

the requirements of modern computing due to the limitations of implementation. Therefore, we use the swarm intelligence to overcome these limitations.

3. Particle Swarm Algorithm in Swarm Intelligence

An example of this type of algorithm is the swarm-based multipoint random search algorithm that is used by the swarm intelligence algorithm. Swarm refers to a collection of multiple similar individuals, such as biological groups such as birds, ants, and fish groups, and nonbiological groups such as quantum groups. The swarm intelligence algorithm simulates certain movement processes of various groups (such as the evolution process of biological groups, the biological foraging process, the quantum state change process, etc.) or some movement processes of constructing groups. In accordance with the manner in which they are constructed, algorithms for swarm intelligence can be classified as belonging to one of the following groups:

(1) Bio-inspired: Bio-inspired computing refers to a series of heuristic intelligent computing methods that are inspired by various natural phenomena or processes in the biological world. Include, in particular, the evolutionary algorithm, the artificial immune algorithm, DNA computing, membrane computing, and a lot of other similar things.

(2) Cluster intelligence: The swarm intelligence algorithm is a bionic algorithm that simulates the complex and orderly group behavior of a social biological group as it reacts to a particular internal law. This behavior is modeled after the behavior of bee hives. Include, for the most part, the particle swarm algorithm, the ant colony algorithm, the artificial fish swarm algorithm, the bee colony algorithm, and so on.

(3) Social and cultural inspiration: Social and cultural heuristics are behaviors that simulate human societies. It mainly includes cultural algorithms (simulating the evolution process of human society), population migration algorithms (simulating population flow and population migration), etc.

(4) Mixed way: The hybrid method refers to the hybrid application of multiple optimization methods. Most of the currently used swarm algorithms are hybrid algorithms to make up for the deficiencies of a single algorithm in some aspects. Mainly include: immune evolutionary algorithm, bee colony genetic algorithm, annealing genetic algorithm, tabu genetic algorithm, quantum genetic algorithm, etc.

An example of particle swarm optimization is a population that is made up of N particles in a search space that has D dimensions. A D-dimensional variable is associated with each individual particle. The value of the objective function is the fitness of the particle, which is used as a standard to measure the quality of the solution, and the position of the particle is continuously updated while the iteration process is taking place. The position of every particle characterizes an answer that is feasible, and the value of $X_i = (X_{i1}, X_{i2}, \cdots, X_{i\,D})$ expresses the position of the ith particle. The velocity, $V_i = (V_{i1}, V_{i2}, \ldots, V_{i\,D})$, is the value that represents the ith particle [35]. The next iteration particle will perform a fitness comparison with the optimal position of the individual's history, set the current individual optimal position of the ith particle as $p_{i\,d}$, and the current global optimal position as $p_{g\,d}$, and then perform an update using the following formulas for the velocity and position of the particle at the kth iteration:

$$V_{id}^{k+1} = \omega V_{id}^{k} + c_1 \xi \left(p_{id}^{k} - x_{id}^{k}\right) + c_2 \eta \left(p_{gd}^{k} - x_{id}^{k}\right), \quad (1)$$

$$x_{id}^{k+1} = x_{id}^{k} + V_{id}^{k+1}. \quad (2)$$

Among them, ω is the inertia weight factor, c_1 and c_2 are the learning factors, and ξ and η are random numbers between (0, 1). Figure 1 depicts the method known as the particle swarm in the form of a flowchart. The primary procedures and steps involved in the particle swarm algorithm are given in Algorithm 1:

4. The Proposed Classification Model for English Teaching Resources Founded on Improved Swarm Intelligence Algorithm

4.1. Improved Swarm Intelligence Algorithm. In the study of swarm intelligence algorithms, it was discovered that the update mechanism of the fireworks algorithm has good optimization performance. In addition, the coyote algorithm is a newly proposed swarm intelligence algorithm in recent years, and its elimination mechanism can enhance the global search ability. Both of these findings were discovered through the study of swarm intelligence algorithms. On the foundation of the first particle swarm procedure, as illustrated in Algorithm 1, this paper presents the Gaussian mutation mechanism of the fireworks algorithm as well as the new elimination mechanism of the coyote algorithm. In addition, this paper recommends an enhanced version of the particle swarm technique, that is, also known as GEM-PSO. The research for this paper was thorough [36]. An enhanced form of the particle swarm technique is described in more depth down below.

In the iterative process of the original PSO procedure, the local search aptitude of the procedure in the later phase of the iteration is weak, and it is frequently informal to collapse or struck into the local optimum point. This makes it more likely that the algorithm will produce a solution that is suboptimal overall. Therefore, in order to discover an appropriate solution to this issue, the authors of this research make use of the fireworks method's Gaussian mutation mechanism to carry out position mutations everywhere around the global optimal point during each iteration of the process. The decision of whether or not to update the position of the global optimal point is made by comparing the fitness of the position of the Gaussian mutation to the fitness

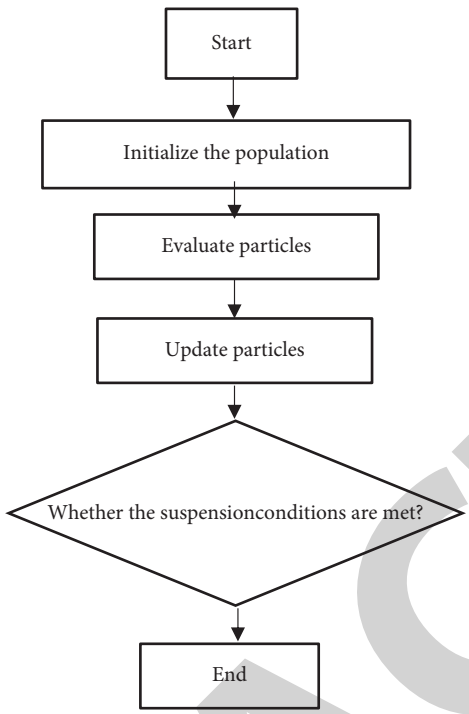

Figure 1: Particle swarm algorithm flow chart.

Step 1: Perform an initialization of the particle swarm's parameters, including the determination of the population size N, the weight coefficient ω, and the maximum number of repetitions T.
Step 2: Determine the individual extreme value as well as the global extreme value after computing the fitness value of each particle in turn according to the position of the particle.
Step 3: Calculate updated values for the velocity and position of each particle grounded on equations (1) and (2).
Step 4: Determine if the determined numeral of iterations has been touched. If the determined numeral of iterations has been grasped, then yield the optimal solution. If the determined numeral and figure of iterations has not been gotten, then skip Step 2 and carry on the current ongoing iteration.

Algorithm 1: The PSO technique.

of the position of the global optimal point [37]. In this way, "premature" convergence can be avoided to a large extent, while still the local search ability can be significantly enhanced.

After the global optimal particle x_{gd} of each iteration is updated in the ith iteration, the Gaussian mutation process is performed. First, the number of mutations in the D dimensions of the particle is calculated, and z dimensions are randomly selected from the dimensions of $x_{g\,d}$. The index list sort of the dimensions of the variation is, then, obtained. Note that the diffusion formula for z and $x_{g\,d}$ is given by equations (3) to (6), respectively.

$$z = D * \mathrm{rand}(0, 1), \tag{3}$$

$$g = \frac{1}{\sqrt{2\pi}}^{e^{-x^2/2}}, \tag{4}$$

$$\mathrm{gaussian} = x_{g\,d}[\mathrm{sort}] * g, \tag{5}$$

$$\begin{cases} x_{g\,d} = x_{g\,d}, \text{if fit}\left(x_{g\,d}\right) < \text{fit}(\text{guassion}), \\ x_{g\,d} = \text{gaussion}, \text{if fit}(\text{gaussion}) < \text{fit}\left(x_{g\,d}\right). \end{cases} \quad 6)$$

In the aforementioned equations, g is the Gaussian function value whose mean and standard deviation are both 1, and gaussian is the particle position array after mutation, such as formula (3). Taking the minimum value as an example, compare the fitness values of each mutation point in the gaussian array and $x_{g\,d}$. If the fitness value of the point in the gaussian is smaller, replace the global optimal point with the Gaussian mutation particle, and then proceed to the next iteration. The findings of the experiments indicate that by combining the particle swarm with the Gaussian variation mechanism of fireworks, it is possible to successfully leap out of the local optimal state and increase the correctness of the algorithm.

The novel elimination mechanism from the coyote algorithm is amalgamated into the particle swarm algorithm in order to improve the particle swarm algorithm's ability to

conduct a global search and to raise the likelihood of locating a solution that is optimal on a global scale. Following the completion of each iteration's update of the particle's individual extreme value and global extreme value, a subset of particles from the population are chosen at random, new particles are generated using the coyote regeneration mechanism, and the newly generated particles are used to replace the particles in the population that have the lowest fitness. Following the completion of each iteration of the update to the position and velocity of the particle swarm, a random selection of $2a$ particles from the total number of particles is made, and these particles are then merged in pairs to produce new particles [38]. The formula for determining the position of the ith new particle is given by equation (4) below:

$$\mathrm{pup}_i = p_1 \cdot x_m + p_2 \cdot x_n + n(lb + \mathrm{rand}(1, D) \cdot (ub - lb)), \tag{7}$$

where x_{m_i} and $x_n\,(m, n \in (1, 2, \ldots, 2a))$ are one of the $2a$ particles, ub and lb are abbreviations that stand for the upper and lower limits of the spatial extent, respectively. Furthermore, D represents the dimension of the space, p_1 and p_2 are two D-dimensional arrays with array values 0 or 1. The generated a particles are sorted from poor to excellent according to the fitness of the objective function. In the next phase, the fitness function is compared with the a particles with the worst population fitness in the current iteration. Note that the good new particles are always replaced by the poor ones, and enter the next iteration. Figure 2 presents the flow chart for the proposed GEM-PSO algorithm [39]. This should be noted that the seven steps, as shown in Algorithm 2, is a rundown of the primary phases involved in enhancing the traditional particle swarm algorithm.

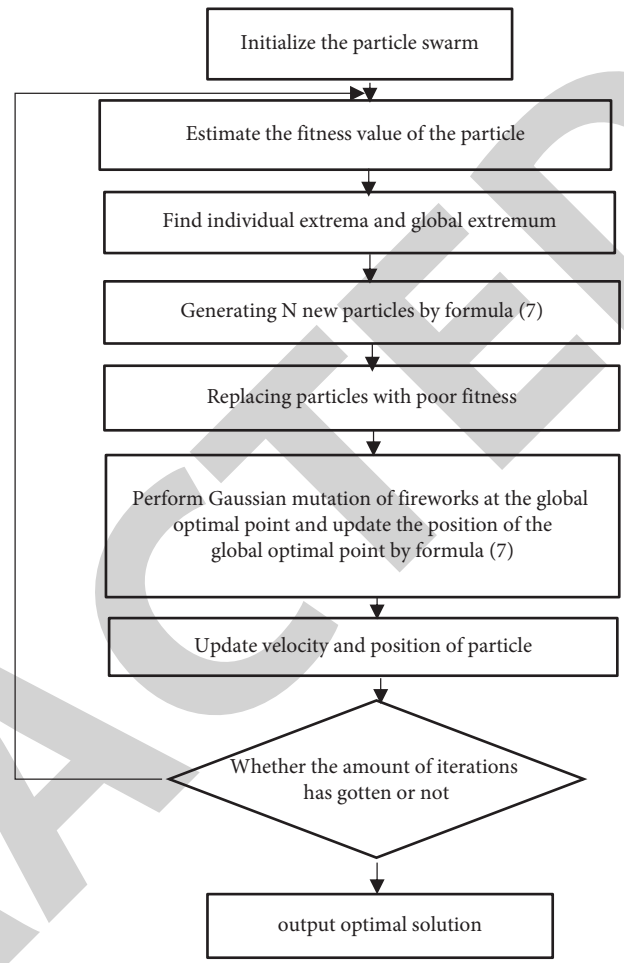

Figure 2: Improved particle swarm algorithm flowchart.

4.2. Classification Model of English Teaching Resources Based on Improved Swarm Intelligence Algorithm. In the field of machine learning, SVM is an established classification technique. In solving machine learning tasks for instance classification, regression, and density estimation, it has numerous distinct advantages [40].

As shown in Figure 3, the circle point and the triangle point in the figure represent two types of things, respectively. This should be noted that H symbolizes the classification line in two-dimensional space, whereas in three-dimensional space, it is represented as a curved surface. Furthermore, $L1$ and $L2$ represent the classification lines that pass through the training samples closest to H in the two classes of algorithms and are parallel to H, respectively. The interval between $L1$ and $L2$ is the classification interval. The choice of kernel function and the settings for the kernel function have a momentous influence on the performance of the SVM. The RBF kernel function, which takes in g and C as its parameters, is the kernel function that is utilized the most frequently. When using a classification model such as the SVM, the suitability of parameter selection has a significant influence on the outcomes of the classification. The parameters of the current SVM are currently adjusted with swarm intelligence algorithms to improve performance [41].

In this paper, the digital resources are represented as high-dimensional vectors, the GEM-PSO-SVM classification model is recognized and suggested. Furthermore, the improved swarm intelligence procedure is used to iteratively discover the parameters of the optimal RBF kernel function to advance the classification precision of the SVM technique, and then the trained SVM is used. Finally, the paper makes use of the SVM that was previously trained. The classification model classifies other test set samples to achieve the purpose of accurately classifying resources. The advantage of the proposed classification model is that the calculation is simple and fast, and its block diagram is shown in Figure 4.

5. Experimental Design and Results

5.1. Experimental Design

5.1.1. Data Sets. Assuming that there are 200 digital English teaching resources, they can be divided into four categories by identifying them in a third-party way. Through the proposed English teaching resource classification model based on swarm intelligence algorithm, 200 resources are classified.

Step 1: Determine the population number N, the weight coefficient ω, the Gaussian variance, the number of new particles, and the maximum number of iterations T before you begin to initialize the parameters of the particle swarm.
Step 2: Calculate the fitness value of each individual particle in turn in accordance with the position of the particle, and after that, acquire the individual extreme value in addition to the global extreme value.
Step 3: Calculate the position of the new particle as well as its fitness value, then compare the fitness of the new particle to the fitness of the particle with the lowest fitness in the population. Keep the particles with higher fitness and get rid of the ones with lower fitness.
Step 4: When compared to the fitness value of the global extreme value in the current iteration, it is preferable to keep the point that has the highest fitness as the global extreme value. This is accomplished by performing the Gaussian mutation of the fireworks algorithm at the global extreme point, finding new position points around the global extreme point, and calculating their fitness.
Step 5: Maintain the velocity and location of the particles.
Step 6: Check to see if the algorithm has achieved the convergence criterion; if it has not, go back to Step 2 and try again.
Step 7: At the end of the algorithm, the position with the most individual is output, that is, the optimal solution of the objective function.

Algorithm 2: The enhanced PSO algorithm.

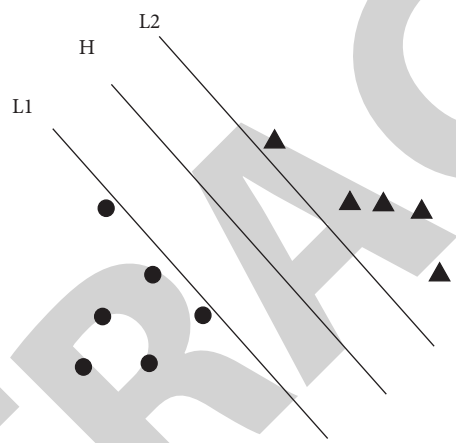

Figure 3: Schematic diagram of support vector machine classification.

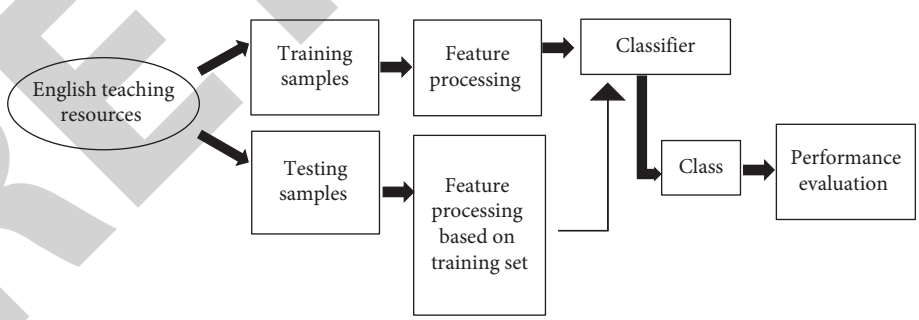

Figure 4: Schematic diagram of classification model of English teaching resources based on swarm intelligence algorithm.

5.1.2. Data Enhancement. In English texts, the verb tense changes and the irregular plural changes of nouns cause words to appear in various forms. Therefore, during vocabulary processing, different forms of the same word will be processed as different words, resulting in complex feature items and an increase in the number. Affects feature vector extraction and reduces the accuracy of automatic resource classification. In this regard, the root can be restored using the Python version root reduction technology.

In English digital teaching resources, the vocabulary is large, so feature extraction is required, that is, the keyword set that can represent the content is automatically selected from the resources. This module's purpose is to filter out words that provide little to no information and to make use of the dimension of vector space in order to simplify the calculation process, avoid overfitting, and ultimately accomplish the goal of improving classification accuracy while also reducing the complexity of calculations. At present,

there are various ways of lexical feature extraction. In this paper, the information gain method is selected to extract lexical feature items.

5.1.3. Performance Evaluation. The precision rate, the recall rate, and the $F1$ value are the three metrics that are typically used in practice to evaluate the classification performance of an algorithm [42]. According to the possible outcomes of classification prediction, if we define TP as the number of texts predicted to be positive but actually positive, FP as the number of texts predicted to be positive but actually negative, and FN as the number of texts predicted to be positive but actually positive, and TN as the number of texts that are predicted to be negative classes and are in fact negative classes, then the calculation formulas for precision, recall, and $F1$ value are as follows: TP is the number of texts predicted to be positive but actually positive:

(1) Accuracy:

The accuracy rate is calculated by dividing the total number of texts by the number of texts for which accurate predictions were made. The accuracy rate can be defined and estimated using the following (5):

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}, \tag{8}$$

where TP denotes the true positive, TN stands for true negative, and FP characterizes false positive. Furthermore, FN symbolizes false negative.

(2) Recall rate:

The number of texts that are accurately anticipated as belonging to a positive class and a proportion of the total number of texts that are predicted to belong to a positive class is referred to as the recall rate. Another name for the recall rate is the remembers rate. It is possible to describe it as given by equation (6):

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FP}}. \tag{9}$$

(3) The $F1$ value:

The $F1$ value is a type of assessment index that considers both the precision rate and the recall rate in a comprehensive manner. The larger the $F1$ value, the better is the predictive approach and vice versa. The $F1$ value can be defined as given by equation (7).

$$F1 = \frac{(2 * \text{Accuracy}) * \text{Recall}}{\text{Accuracy} + \text{Recall}}. \tag{10}$$

For classification accuracy, recall, and $F1$ value, we specifically evaluate the performance of the proposed classification model using these evaluation metrics for each class.

5.1.4. Compared Methods. We compare the proposed GEM-PSO-SVM classification model with four other state-of-the-art techniques as discussed below.

(A) SVM classification model based on particle swarm algorithm PSO-SVM.

(B) SVM Classification Model Based on Coyote Algorithm COA-SVM.

(C) SVM classification model based on fireworks algorithm FA-SVM.

(D) SVM classification model of improved particle swarm algorithm based on hierarchical autonomous learning HCPSO-SVM.

5.2. Experimental Results. We use the proposed GEM-PSO-SVM classification model and other classifiers in the classification of English teaching resources. We take the average precision, recall, and $F1$ value from 10 distinct experiments and use that information to evaluate the classification performance of the algorithm. This allows us to check the classification performance of the improved SVM. The use of 10-fold cross-validation is recommended as a method for separating the training sets from the test sets.

Figure 5 demonstrates that the classification of English digital teaching resources results in an average accurate rate that is as high as 99.25%. Furthermore, as can be seen by examining the data presented in this figure, our proposed model is superior that other ones. For other models, the average correct rates were observed 92.5%, 93%, 93%, and 94.25%, respectively. In this comparison, the proposed classification model has higher accuracy.

On the $F1$ value classification index results, as shown in Figure 6, the classification performance of the proposed GEM-PSO-SVM model is better than other classification models. Similarly, the classification performance shows a balanced trend among the four types of samples.

Figure 7 shows that the five classification models have relatively good classification results in the four categories of samples, but the performance of the PSO-SVM classification model is relatively weak, and the proposed GEM-PSO-SVM model has the best results. Classification performance, the average classification recall value is 96%.

The comprehensive results of the aforementioned three evaluation classification models show that the proposed GEM-PSO-SVM model has superior performance on the English teaching resource classification task.

5.2.1. Classification Efficiency. PSO-SVM, COA-SVM, FA-SVM, HCPSO-SVM, and GEM-PSO-SVM were all ran on the test set for 50 times and iterated 500 times in order to further validate the classification efficiency of GEM-PSO-SVM. HCPSO-SVM was also performed on the test set. As can be seen in Table 1, the typical amount of time spent running is as follows:

Table 1 shows that the HCPSO-SVM classification model has the highest classification efficiency, while the GEM-PSO-SVM classification model has the second-highest classification efficiency.

Based on the aforementioned comparative classification models and the evaluation results of the proposed classification model in terms of classification performance and

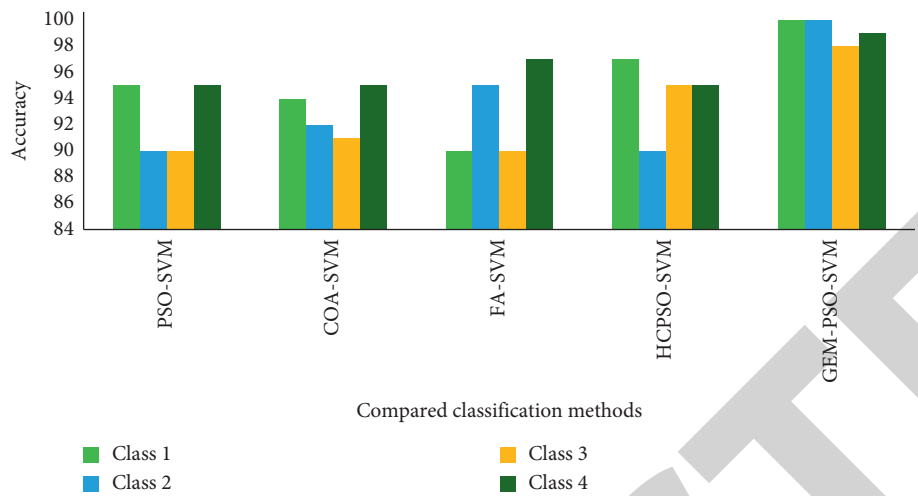

Figure 5: Comparison of classification accuracy of each class of samples under different classification methods.

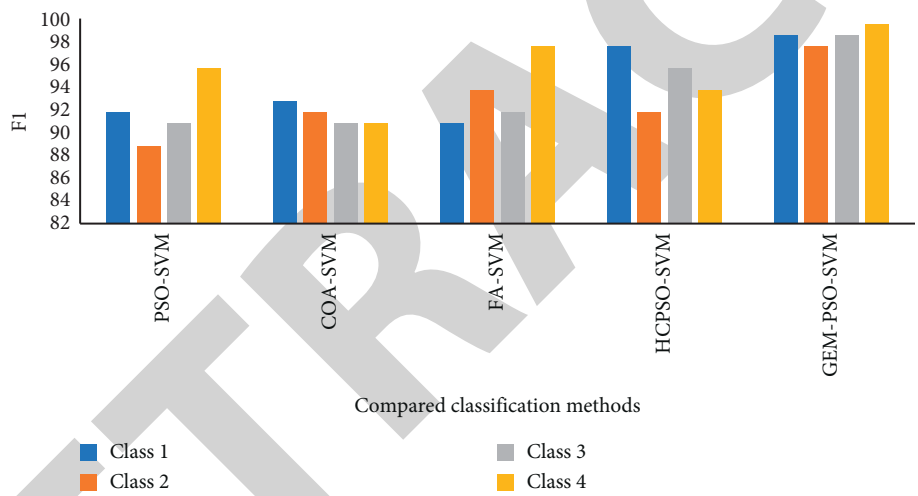

Figure 6: Comparison of classification $F1$ values of each class of samples under different classification methods.

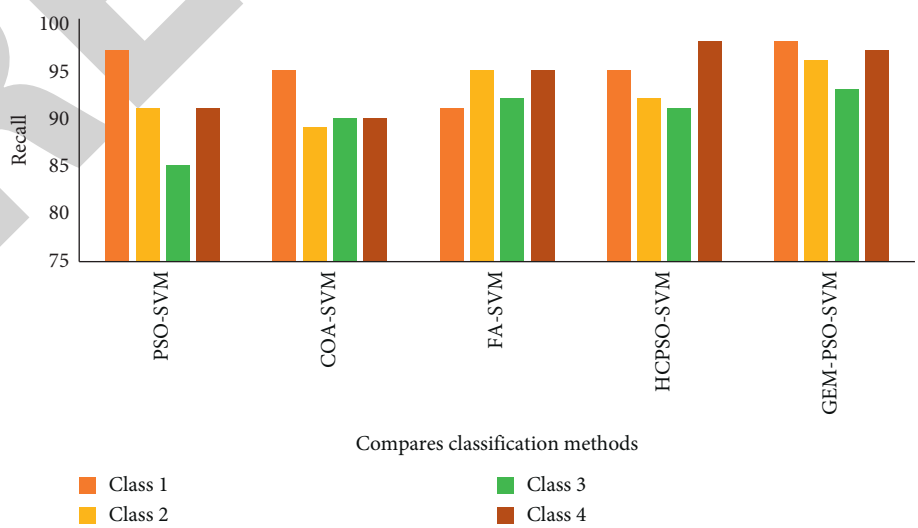

Figure 7: Comparison of classification recall values of each class of samples under different classification methods.

Table 1: The classification efficiency of each classification model in the task of classifying English teaching resources.

Compared classification methods	Time (second)
PSO-SVM	2.1
COA-SVM	3.2
FA-SVM	2.5
HCPSO-SVM	1.6
GEM-PSO-SVM	2.0

classification efficiency, GEM-PSO-SVM is one of the more superior classification models.

6. Conclusion and Future Work

In this paper, we proposed an updated particle swarm optimization technique to categorize English teacher resources. Driven by the computer networks, the resources and forms of digital English teaching are becoming more and more diversified, which not only arouses the enthusiasm and interest of students in learning but also realizes the real-time transformation of the traditional learning mode. However, when teachers and students share resources, it is difficult to query. As a result, the purpose of this research is to provide a categorization model of English teaching resources that is based on an algorithm for swarm intelligence. The proposed classification method ensures improved classification accuracy and classification efficiency. This classification model is not only conducive to changing the traditional English teaching mode and expanding the learning methods but also conducive to improving the efficiency and quality of learning. It is worth popularizing and applying to other disciplines.

In the future, we will consider improving the proposed PSO technique while introducing parameters adaptation in which the inertia weight, $c1$, and $c2$ can be dynamically computed. Furthermore, we will integrate the well-known concept of Markov jumping to control the movements of the particle and to avoid early or immature convergence. Also, we will work on increasing the number of states which we believe may lead to significant improvements. As a final recommendation, we will consider improving the execution time of the proposed method. In fact, Big Data technologies such as cloud and edge computing model can be used to further improve the convergence speed and execution time of the proposed algorithm.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest to disclose.

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Research Article

A Personalized Recommendation System for English Teaching Resources Based on Learning Behavior Detection

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When confronted with a plethora of resources, many students struggle to quickly filter out the content that is relevant to them. Because there are many English teaching resources and it is difficult to accurately recommend suitable teaching resources for students. Therefore, in this paper we suggest a personalized recommendation system for English teaching resources, which is founded on learning behavior detection. To begin with, a spatiotemporal convolutional network is introduced to effectively identify students' online classroom behavior, and a global attention module is added to increase the model's ability to learn global feature information. Furthermore, the identified characteristics of student behavior are incorporated into the recommendation module. Similarly, the differential evolution (DE) algorithm is implemented to the smoothing factor and kernel function center of a generalized regression neural network (CRNN) for resource recommendation mode, while taking into account the strong dependence of the GRNN training effect on the smoothing factor and the kernel function center. The smoothing factor and offset factor are optimized and solved, and the optimized smoothing factor and offset factor are used to recommend GRNN resources. Experiments show that the approach described in this work first has a high precision (i.e., 90.98%) in behavior recognition, and second, the recommendation performance is superior to both of the comparison algorithms (i.e., 85.23% and 78.33%), resulting in better resource recommendation accuracy. The fundamental goal of this work is to deliver several important guidelines for the informatization and intelligence of the English educational resources and services.

1. Introduction

Alterations will be made to the manner in which education and learning are carried out, as well as the background of the Internet and education, which will be investigated during the transformation of English teaching in schools and institutions of higher education. The proliferation of technology in schools has led to the development of a novel instructional approach known as blended learning. Mobile devices are reshaping both the teaching and learning process, as well as the relationship between instructors and students. Students are able to gain exposure to a variety of cultural perspectives when the audio-visual English instruction is integrated into a blended learning environment. This allows students to rethink the traditional approach to education that centers on the role of the teacher [1, 2]. This is particularly true when it originates to education in the actual world. For the reason that of the diminishing role of teachers and instructors, students are incapable to build their own understanding networks or pick out the most suitable learning approaches and methodologies [3], even though there are massive amounts of resources available to them. This leads to an excessive amount of information. I am unable to independently build upon and actively acquire new knowledge. According to this analysis, in order for teachers to help students integrate learning resources and improve their learning efficiency, they need to explore personalized teaching modes within the context of AI adaptation, understand their students' current learning status and needs, and rely on intelligent teaching systems [4, 5].

It is possible, particularly, for schools to improve the quality of their teaching if they have a better understanding of how engaged students are in their own educational institutions. When evaluating the educational program at a particular university, the most important metric to look at is the degree to which students participate in the process of

their own education [6]. As an essential component of students' active participation in their own education, researchers have spent a significant amount of time analyzing the conduct of students in the classroom. The traditional method of evaluating students' behavior in the classroom is to do so manually, which is a time-consuming process. Because of the rapid progress that has been made in AI in recent years, we are now in a position to turn this disadvantage into a strength by utilizing AI technology [7, 8]. It has become a major issue in the development of education, which will lead to the development of an intelligent, efficient, and comprehensive education analysis system. Recognize how students learn in a classroom setting.

Because of the explosive growth of the Internet, human behavior recognition has found widespread use in a variety of contexts, including video surveillance and video comprehension, to name just two examples [9, 10]. The most important aspect of human action recognition is learning how to extract rich and discriminative features for the purpose of fully describing the spatial and temporal information of human actions. By comparison, the RGB video-based methods of behavior recognition are currently receiving less attention than skeleton-based ones. This is, in fact, due to the latter's poor adaptability to dynamic environments and certain complex backgrounds. By contrast, the skeleton-based methods of behavior recognition are currently receiving more attention.

This should be noted that learners will find it increasingly difficult to locate helpful learning resources on the Internet as the amount of data that is stored on the Internet, which is still continues to grow very rapidly. The process of extracting useful data from the network will require users to devote a greater amount of their time to it. As a consequence of this, server-side records, statistics, and calculations are utilized in the process of implementing personalized resource recommendation for users. As a result, users are able to rapidly obtain valuable data from the massive amounts of data [11–13]. In fact, users currently prefer cloud-based online learning, but the difficulty of pushing resources is increased due to the large amount of resources in the online environment, the diversification of resource forms, and the limitation of available platforms for resources. However, cloud-based online learning is currently the preferred option for majority of the users. In order to provide accurate resource recommendations, it is necessary to perform an in-depth analysis on both the user and the resource, as well as education on their respective characteristic attributes. After that, you should look for a resource that corresponds to that user's smallest distinguishing feature as closely as possible and then, potentially, recommend using that resource [14, 15].

At this very moment, a great number of research projects on intelligent recommendation are being carried out. A number of academic institutions manage large amounts of data and make recommendations for resources using the Hadoop platform. A number of researchers make use of the Spark platform in an effort to improve the effectiveness of the resource recommendation process [13]. They are based on massive resource recommendation research carried out in an environment utilizing cloud computing, and their primary focus is on developing a cloud computing data push platform rather than conducting in-depth research into microresources and the methods used by them. The collaborative filtering algorithm and the multiclass support vector machine algorithm can be used to construct an intelligent recommendation system. Although there has been an increase in the recommendation's accuracy, it is still unable to accurately reflect the specifics of the microresources in question [15, 16].

In this paper, both global attention mechanisms and GCN are discussed with the goal of improving the detection of student actions. Deep learning, also known as DL, is a technology that has been making significant contributions to AI in recent years. Some researchers claim that they are able to more accurately identify and classify resource attributes that contain multiple features by using DNN as a recommendation algorithm for educational resources. As a consequence of this, the paper uses the generalized regression neural network (GRNN) algorithm in DL to make recommendations regarding online educational resources. In order to make the GRNN algorithm better suited for resource recommendation, additional optimizations have been made to increase the accuracy of the resource recommendations it generates. The following points discuss the fundamental contributions of our research.

(i) This paper suggests a personalized recommendation system for English teaching possessions founded on learning behavior detection.

(ii) A spatiotemporal convolutional network is introduced to effectively identify students' online classroom behavior, and a comprehensive attention component is added in order to increase the model's ability to acquire global feature knowledge.

(iii) The identified characteristics of student behavior are then incorporated into the recommendation module. Finally, the differential evolution (DE) procedure and set of rules are implemented to the smoothing factor and kernel function center of a generalized regression neural network (CRNN) for resource recommendation model.

The remaining portion of the manuscript is prepared as follows. In Section 2, we make available a comprehensive summary and review of the state-of-the-art literature. The methodology of the suggested research work is deliberated in Section 3. Furthermore, a mathematical model of the suggested recommendation procedure is also discussed in this section. Experiments, simulations, and empirical outcomes are deliberated in Section 4. In the last, Section 5 recapitulates this research and provides some guidelines for the future work.

2. Related Work

Students who are participating in a blended learning scenario can benefit from having access to a learning environment that is interactive and immersive thanks to the

utilization of various modes of presentation, including text, images, audio, and video. The idea of learning that continues throughout one's life can be supported by participating in a wide range of educational pursuits, such as giving speeches, reading, and writing [1, 2].

Several researchers have investigated blended learning in relation to the recently developed audio-visual instructional strategy for the English language. Several researchers have presented ideas for models of digital education that are based on campus settings [3, 4]. Blended learning can be successfully implemented if the focus is placed on the following six measures: teacher grouping, venue separation, and time dispersion; classification of resources; a wide variety of learning approaches; and time dispersion and dispersion of time, respectively. Some academics believe that students can actively acquire and share educational resources using their familiar mobile devices in BYOD learning, and they provide an example of a student-centered foreign language teaching model based on the WeChat system. BYOD learning refers to the practice of students bringing their own devices to class in order to participate in the learning process. Some academics have attempted to combat the problem of "dumb English," and as a result, a new classroom model has been developed that includes students in addition to teachers and students. This model was developed as a result of the efforts of these academics. Using news English audio-visual content as an example, a number of researchers have developed a flipped classroom that is based on virtual reality and carried out empirical research [5–9].

On the other hand, rather than focusing on how to better create an immersive learning environment using electronic devices, the majority of attention is centered around the development of platforms and software as well as the integration and development of learning resources. There has not been nearly enough focus placed on conducting in-depth research into the operation of course services. In light of students' restricted capacity for independent learning, AI-based adaptive education mechanisms are an immediate necessity for the purpose of complementing the work of educators and delivering individualized support to pupils.

On the basis of their level of complexity, human behavior can be broken down into four different categories: posture, individual action, interactive action, and group activity. Gesture can be defined as the movement of the human skeleton [10, 17], which is the most fundamental part of the body. A sequence of well-coordinated movements will eventually result in a single action. Examples of interactions include those between humans, as well as those between humans and objects. This term, when applied to the context of group activities, refers to pursuits that involve a number of people and a number of different things [18, 19]. The actions of students in classroom scenes are not limited to those that are simply related to posture. This category includes not only individuals but also things and activities, such as writing on paper or playing with mobile phones, for example [20].

Visual behavior recognition, in the vast majority of instances, requires both the characterization of behavior and the detection of targets. The data obtained from using pose estimation to determine the position and motion of each joint in the human body can then be used to characterize human behavior. Pose estimation is used to obtain this information. Key is in two dimensions for a number of different players [21]. There are two different kinds of point detection algorithms: top-down and bottom-up. These names refer to the direction in which key points and the human body are detected first. The most traditional bottom-up method available in OpenPose is used to determine the joint points of body parts. This method measures the body parts' maximum thermal value. After that, it will be possible to construct a human posture skeleton and rapidly connect the different joint points with one another. The OpenPose algorithm can still produce high-quality results and has a high degree of robustness, even if there are more people in an image. This is because the algorithm is able to scale well.

The RNN, CNN, and GCN action recognition methods are the three primary varieties of skeleton-based action recognition methods [11, 14]. The most well-known ST-GCN model encodes skeleton sequences by first constructing a spatiotemporal graph, then stacking a series of spatiotemporal graphs, utilizing convolutional extract features, and finally performing predictive recognition utilizing a model constructed with GCN. This model was developed by Google Brain. Based on GCN, a number of researchers have proposed an attention-enhanced graph convolution LSTM network, which is abbreviated as AGC-LSTM, for the recognition of human skeleton behavior. It is possible to learn high-level semantic spatial and temporal features. Researchers have proposed a structure known as the 2s-AGCN, which learns the structure of the skeleton graph in an adaptive manner. This enables a greater degree of model flexibility and represents a departure from the conventional manual setting. An operator method has been proposed by a number of researchers, and it is capable of extracting multiscale structural features and modeling long-term context dependencies from graph convolutions [5, 7, 9, 18, 19].

When teaching English in the context of information technology, it is imperative to take into account the learning habits of students and the individual differences of those students. This will allow educational resources to be distributed more efficiently and will also allow educational services to become more intelligent. Scholars have conducted research in this field, and some of them have proposed a personalized recommendation model of learning content that is based on user interest, learning preference [12, 13], and knowledge model in order to answer the issue of massive resources and personalization. A number of researchers have developed a framework for the recommendation of personalized learning resources based on the learner model. The framework makes use of a hybrid recommendation system that generates an electronic schoolbag learning database. Researchers have found that taking into account user cognition and the rules of neighboring user groups are the best way to generate an optimal personalized learning path for each individual student.

The hidden Markov model is a tool that is utilized by some academics in order to model the emotional states of learning that students are experiencing, comprehend the

changes that students are experiencing in their emotional cognition, and adapt teaching strategies to fit the overall cognitive state of learners (HMM) [15, 16, 22–26]. Personal recommendation and learning system adaptability research are currently in the early stages of weak artificial intelligence [27, 28]. This is not ideal for the personalized learning needs of English audio-visual courses because of the limitations of weak artificial intelligence [29, 30].

3. The Proposed Method

3.1. Learning Behavior Recognition. First of all, this paper proposes a method for identifying learning behaviors in school English classrooms. This paper divides learning behaviors into listening, speaking, reading, and writing. After effectively identifying student behaviors, English teaching resources for corresponding behaviors are recommended to students through a personalized recommendation system [31].

This information can be obtained by using pose estimation algorithms like OpenPose in conjunction with depth cameras like the Kinect. A frame's skeletal information is represented by vectors, and the 2D or 3D coordinates of each human joint are represented by corresponding vectors. Vectors are used to represent skeletal information in frames. The natural human body connections that are shown in Figure 1 of this article are used in order to connect the various joints to one another [32].

The ST-GCN first obtains the skeleton sequence data, which is composed of coordinates, in order to model the structural information that is present between these joints. Joints that exist in one frame are regarded as possessing the same spatial dimension, whereas joints that exist in another frame are regarded as possessing a time dimension that is distinct from the former. A residual mechanism is added in between each ST-GCN, and there are a total of nine ST-GCN units, each of which is composed of the GCN and TCN [33]. These layers make up the TCN module and are referred to as the ReLU layer, dropout layer, 1-D convolution layer, and the batch normalization layer [34]. The following is how the spatial graph convolution for each node in the graph representing the human skeleton is calculated using the following equation:

$$f_o(x_i) = \sum \frac{x_j}{\sum x_j} f_i(x_j) w(I_i(x_j)), \tag{1}$$

where $f_o(x_i)$ and $f_i(x_i)$ are output and input feature maps, respectively. Furthermore, the $w(I_i(x_j))$ is the weight function, and $I_i(x_j)$ is the mapping function.

The calculation method, which is based on the adjacency matrix A_i, is as follows:

$$f_o = \sum w_i f_i\left(B_i^{-0.5} A_{ii}^{-0.5}\right). \tag{2}$$

This should be noted that the weight of the attention approach is calculated using (3) as follows:

$$W_{att} = \alpha(g(AP(f_i)) \oplus MP(f_i)), \tag{3}$$

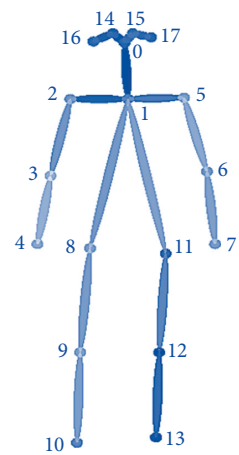

Figure 1: Structure of human skeleton.

where $AP(f_i)$ is the average pool operation, $MP(f_i)$ is the max pool operation, g is convolution operation, and α is the ReLU function.

The data that have been preprocessed are delivered to the action recognition model by the first branch stream after it has been received. The first thing that this network does is a process the data that have received. After that, it determines which joints are activated via the CAM, and then modifies the joint that corresponds to that activation in the mask matrix. The value of the updated mask matrix is passed through to the second stream, where it is then saved in the variable. The output for the second stream network is created by giving it as input the data that have been preprocessed as well as the mask matrix.

In a similar manner, the input of the third stream network is multiplied by the mask matrix from the second stream, and the results are aggregated. This ensures that the input of the second and third streams is only composed of joints that were not activated by the streams that came before them, which in turn enables the action recognition model to investigate additional feature information that differentiates each joint. The loss function of the network is computed using the following equation:

$$L = y \ln \hat{y} - \sum y_j \ln \hat{y}_j. \tag{4}$$

Locating the target detection module at the coordinates of the hand, intercepting the hand in the original image, and inputting the information into the small classification network are the steps that need to be taken in order to extract features from the partial picture of the hand. It is important that the model's attention be drawn to the position of the hand. The next step is to incorporate information about the student's posture into the context of the classroom instruction in order to further constrain the behavior that was detected and to improve the accuracy of the four actions (listening, speaking, reading, and writing).

3.2. Recommendation Module. The main organization of the GRNN model is presented in Figure 2. The model comprises an input layer and an output layer. In addition, there is a

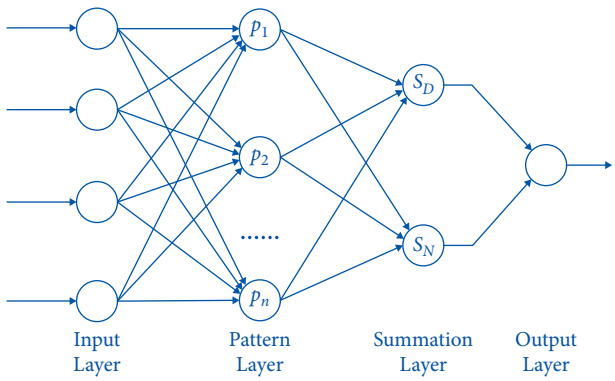

Figure 2: The basic structure of the GRNN model.

pattern and a summation layers that help to optimize the learning procedure.

The input of the model is identified by the X matrix as is given in the following equation:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}. \tag{5}$$

The output is defined in the following equation:

$$Y = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{l1} & x_{l2} & \cdots & x_{\mathrm{ln}} \end{bmatrix}. \tag{6}$$

The output of the Pattern Layer p_i is given by the following equation:

$$p_i = \exp\left(\left|\frac{-(x_i - x_j)^T (x_i - x_j)}{2\beta}\right|\right), \tag{7}$$

where β is the plain language factor.

In the next module, we introduce the offset factor χ, and then, we have definition as given in the following equation:

$$p_j = \exp\left(\left|\frac{-(x_i - \chi x_j)^T (x_i - \chi x_j)}{2\beta}\right|\right). \tag{8}$$

The output of the Summation Layer is given by the following equation:

$$S_i = \sum w_{ij} p_j. \tag{9}$$

Lastly, we introduce the DE mechanism to optimize β and χ.

The collaborative recommendations of English audio-visual resources can be of assistance in this process as the English educational resource service moves closer to informatization and intelligence. The first thing that needs to be done is to construct a template for the generation of recommendations. According to the findings of a recent study, the intelligent recommendation system has the potential to assist users in broadening their cognitive horizons by analyzing the behavior of user groups. The students' scores and cognitive abilities are analyzed using mobile devices, which also collect the students' scores. Matrix decomposition technology is used to create a feature vector, which is then used to generate an automatic recommendation list for each individual learner as well as resource. The correlation between these two variables is used to make predictions regarding the scores. Through the application of the recommendation model to the process of dynamically personalizing educational content for students, a learning effect of sufficient quality has been accomplished.

By integrating information technology and relying on an intelligent teaching system to design an appropriate learning plan for each learner's level of proficiency, collaborative recommendation mechanisms can be used to help teachers optimize their teaching. This can be accomplished by using collaborative recommendation mechanisms. We develop the students' capacity for self-directed learning. The specific process and flow of the information of the recommended module are shown in Figure 3.

4. Results and Discussion

The data collection for the online classroom focuses on the four behaviors of listening, speaking, reading, and writing that students frequently demonstrate in English classes. These influencing factors, which include the location of computers and students' sitting postures, are included in the data gathering in order to create and mark the research on students' online classroom behavior recognition more realistic. This was done in order to progress the correctness and precision of the results. We use the accuracy and the recall ratio to gauge the precision of the prediction process as given by (10), and (11), respectively.

$$\mathrm{Acc} = \frac{\mathrm{TP} + \mathrm{TN}}{\mathrm{TP} + \mathrm{TN} + \mathrm{FP} + \mathrm{FN}}, \tag{10}$$

$$\mathrm{Rec} = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}}, \tag{11}$$

while TN stands for true negative and TP stands for the true false. False positive and false negative are both characterized by FP and FN, respectively. In order to quantify the outcomes of predictions, these indicators are frequently used in artificial intelligence and machine learning research. In addition to these metrics, researchers have employed the RMSE (root mean square error) and MAPE (mean absolute percentage error) indicators to show the value and precision of the prediction outcomes.

Researchers can use AI to not only increase the number of ways they can collect data on student behavior but also the efficiency with which they can do so. Using the recorded classroom videos that were intercepted, the OpenPose human body pose estimation algorithm is applied to obtain each student's human body. These videos were taken inside the classroom. The major landmarks on the skeleton are identified and analyzed in this process. Abscissa and

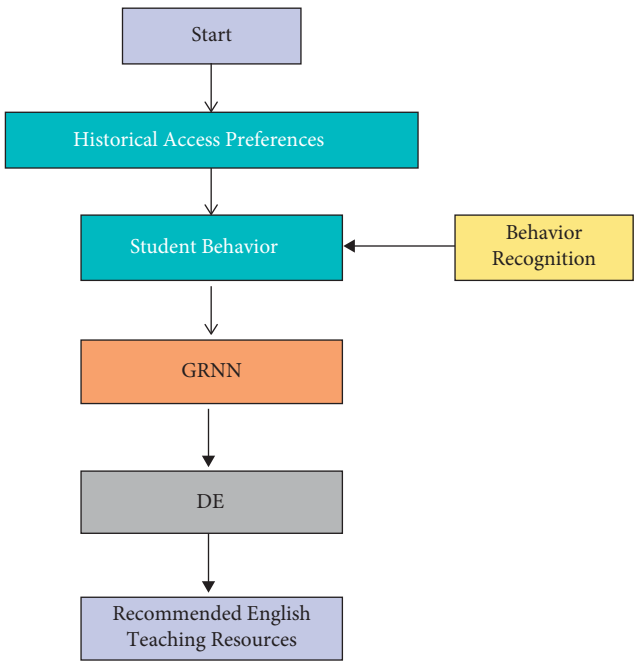

Figure 3: The structure of our suggested DE-based method.

ordinate are sorted, key points in the human body of one student are analyzed, and the maximum and minimum abscissa and ordinate values of the ordinate are calculated. It is expanded so that the body area of a single student is proportional to the total scene image's human body area and can be intercepted so that a single student can be found, located, and studied within the video frame. This allows for the detection, location, and study of a single student within the video frame.

The participants in this study consisted of one hundred different college students. An online classroom simulation was used to collect data from one hundred students who participated in the four activities that were presented earlier in this paragraph. One behavior must be completed by each student in two separate groups for there to be sufficient assurance that at least one group of data has been gathered taking into account the influence factors such as sitting posture. A total of two hundred video files are produced as a result of recording each behavior in the form of a series of video files. The video data file is cropped so that there is always only one student visible in each video. This is done so that the recognition effect of each behavior can be maintained. During the experiment, the skeleton data from the online classroom behavior were scrambled. As a result, only about 80 percent of the students were chosen to be trained on, and only about 20 percent were used for testing.

First, we compared the recognition accuracy of our method and ST-GCN, GCN, and CNN under different iterations. Comparison of accuracy of OUR, ST-GCN, GCN, and CNN is shown in Figure 4.

The comparison of loss rates is made known in Figure 5.

This could be easily perceived that the accuracy of the approach suggested in this paper is significantly better than the other three methods, and can achieve higher accuracy and lower loss with fewer iterations.

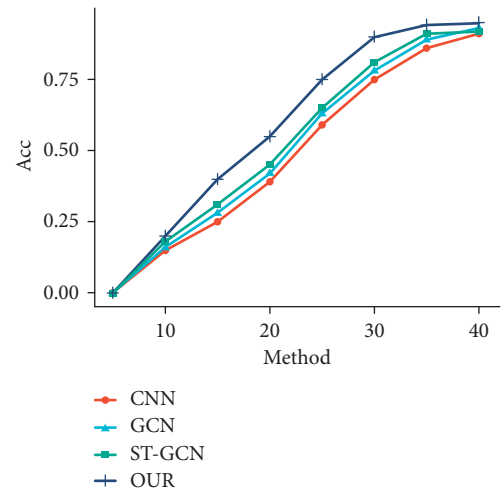

Figure 4: Comparison of accuracy of OUR, ST-GCN, GCN, and CNN.

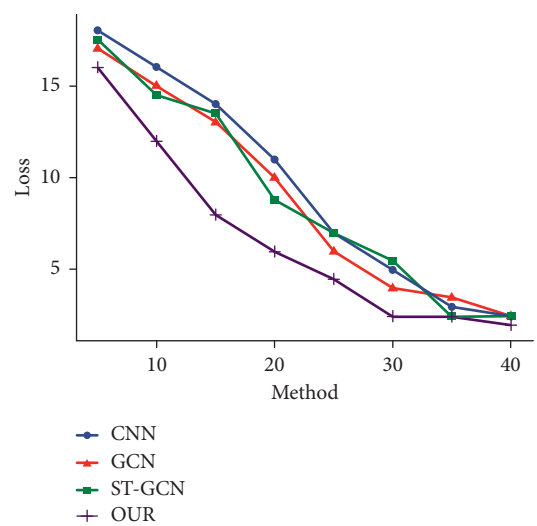

Figure 5: Comparison of loss of OUR, ST-GCN, GCN, and CNN.

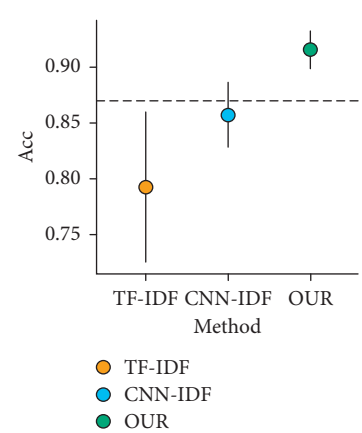

Figure 6: Comparison of Acc of TF-IDF, CNN-IDF, and OUR.

In order to prove and authenticate the recommendation effect of the approach, as suggested in this paper, TF-IDF and CNN-IDF are selected as comparison algorithms, and

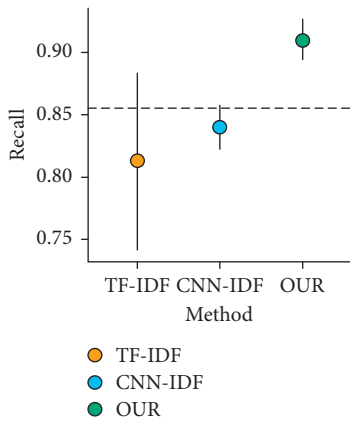

Figure 7: Comparison of Recall of TF-IDF, CNN-IDF, and OUR.

Acc and Recall are selected as evaluation indicators. On the resource dataset collected in this paper and multiple public datasets, we compare the recommendation effects of different methods, as shown in Figure 6 and 7.

As can be seen from Figure 6 and 7, for multiple sample sets, the resource recommendation correctness of the approach, as suggested in this paper, is the highest, with an average value higher than 0.92, followed by CNN-IDF, Acc, and Recall both converge to above 0.85, and TF-IDF performs poorly.

5. Conclusions and Future Work

The fundamental goal of this paper is to propose a personalized recommendation system for English teaching resources that is based on the detection of learning behaviors. To begin, a spatiotemporal convolutional network is presented, and then, a global attention module is incorporated into the model in order to enhance its capability of acquiring information regarding global features. In addition to this, the recommendation module takes into consideration the observed patterns of behavior exhibited by the students. It is shown in this paper that the differential evolution (DE) algorithm that is built into a generalized regression neural network (CRNN) for resource recommendation mode has an effect on the smoothing factor and kernel function center of the GRNN. The recommendations that GRNN makes regarding resources are arrived at by combining an optimized smoothing factor with an optimized offset factor. Experiments show that the approach described in this work has superior correctness and precision for recognizing behaviors, as well as superior performance when it comes to making recommendations, in comparison with the algorithm that was used in the comparison. The determination of the research work conducted in this study is to shed some light on the informatization and intelligence of English educational resource services. The focus of this study is on English educational resource services.

In the future, we will attempt to implement and put forward new deep learning techniques. Besides this, we will further investigate how different activation functions, as well as the number of layers and hidden layers of the network model, will affect the outcomes of our study. As evidence by the literature review in the earlier sections, graph convolutional networks (GCNs) along with the attention mechanism have the capability to accurately predict the images, and we will implement the GCN model and compare it with our approach. Another interesting direction for the future work is to consider a diversity of the learning mechanism for the recommendation system, that is, different datasets, to study and generalize the outcomes. This work is limited to only a single dataset, and in the future, we will investigate other datasets. Different datasets will have more number of items, and their classification should be investigated. Finally, we will continue to study the execution time, in terms of training and prediction durations, of the proposed model.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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Hindawi
Mobile Information Systems
Volume 2023, Article ID 9807809, 1 page
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Retraction

Retracted: Application Analysis of Artificial Intelligence Algorithm in Accounting Field under the Background of Innovation Economy

Mobile Information Systems

Received 25 July 2023; Accepted 25 July 2023; Published 26 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] J. Chen, "Application Analysis of Artificial Intelligence Algorithm in Accounting Field under the Background of Innovation Economy," *Mobile Information Systems*, vol. 2022, Article ID 7970237, 9 pages, 2022.

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Research Article

Application Analysis of Artificial Intelligence Algorithm in Accounting Field under the Background of Innovation Economy

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At present, economic business activities occur to the accounting element confirmation link of the accounting information system (AIS), which still occupies a large amount of manpower and material resources of the enterprise to generate information. This has been restricting the development of modern AIS. Based on this, first, this paper studies the influence of the knowledge economy on accounting innovation and in the innovation economy. The process of confirmation for accounting elements in economic business, under the traditional AIS, is analyzed. Then, the model of the accounting element confirmation, i.e., BPNN, is constructed by combining the backpropagation (BP) neural network (NN) theory with the artificial intelligence (AI) algorithm. Finally, we simulate the confirmation process of accounting elements based on the economic business data of specific online stores. The experimental outcomes illustrate that under the proposed BPNN model, the output value of the accounting entry is also increasing and has been in the interval [0, 0.14] with the continuous increase in the input value of economic business activities. Moreover, the overall simulation error of economic business activity data does not exceed 0.3% in the simulation test of the proposed accounting business data confirmation model based on the BPNN algorithm. The empirical outcomes indicate that the model has high accuracy and reliability. The purpose is to realize the identification of business events by machines and complete the automatic confirmation of accounting elements in the back-end economic business of online stores. This paper provides new ideas for realizing the overall intelligence of the AIS.

1. Introduction

At present, most scholars focus on the study of accounting measurement and reports, and there are few studies on accounting confirmation. It was not until around 1830 that the term "confirmation" was first used. Subsequently, the meaning of "confirmation" was proposed in the "accounting outline" [1]. In the 1970s, the specific meaning of "confirmation" was mentioned, but its concept was not formally proposed [2]. In the 1980s, an authoritative concept and definition of accounting identification were proposed. Once an economic business activity occurred, "confirmation" was the process of recording the events in this economic activity with the names of elements such as assets, liabilities, income, and expenses, and finally reflecting them on the financial statements to be output [3]. Basic issues such as the meaning, function, process, premise, standard, and foundation of accounting identification were discussed starting from the definition of accounting identification. At this time, the research on accounting identification was standardized [4]. Later, the theory of accounting confirmation and measurement in the accounting theoretical system was expounded from the research perspective of the accounting theoretical system.

The theoretical issues related to identification and measurement were also pointed out for further research [5]. From the perspective of cognitive theory, judgments were made through the accounting facts reflected in an event. Scholars believed that this process consisted of three stages. Each stage differently impacted the quality of accounting information, which determined the reliability and relevance of the quality of accounting information [6]. Subsequently, accounting identification in the information environment was emphasized. Scholars proposed that accounting confirmation should be further strengthened to adapt to the characteristics of rapid

changes and large business volume under the background of e-commerce. This would be a decisive factor in solving current accounting problems [7].

The artificial neural network (ANN) has experienced a long period of development and gradually formed a relatively complete discipline system. Scholars have combined the ANN theory with many disciplinary theories and successfully applied it to other disciplines. This should be noted that the first neural model was proposed in the 1940s, which prompted many scholars to study ANN [8]. In the early 1950s, Hebb's law was proposed. This law stated that the strength of the connection between neurons and synapses was not fixed in a neural network. This nonfixation established neuron-to-neuron connections, and information was stored in connection weights. This law laid the foundation for establishing the learning function of neural networks [9]. In the mid-1950s, an inference engine for simulating the behavior and conditional firing was proposed. This kind of inference engine was composed of signal processing units. It was applied to adaptive pattern identification. This model could reflect the actual working principle of the neural network [10]. In the late 1960s, the research results of the neural network were questioned with the upsurge of ANN research. Scholars believed that the current ANN could only solve simple linear problems, but they could not effectively solve multilayer network problems. Since then, scholars' research on the ANN had entered a period of low ebb [11].

In 1982, the Hopfield network model theory was pointed out. Scholars had proved that the ANN model could reach a stable state under certain conditions. Under the influence of this theory, many research scholars had rejoined the upsurge of studying ANN. The research on the neural network theory had gradually stepped out of the low ebb and toward the renaissance period [12]. In the 1980s, the research on ANN in various countries in the world gradually recovered. Chinese scholars had also joined the research upsurge of ANN. In the 1990s, the first academic conference on neural networks in China was held, which was a new beginning of research on ANN and neural computers in China [13]. Since the 1990s, scholars at home and abroad have continued to develop and improve the field of neural network research. They especially focus on the research of neural networks in the field of nonlinear control and have made substantial progress [14]. After several decades of development, the ANN has now achieved fruitful results in the fields of automatic control, pattern identification, assisted decision-making, signal processing, and artificial intelligence (AI). At present, the ANN is mainly used in printed and handwritten character identification, speech identification, signature identification, fingerprint identification, face identification, and image processing.

It is found that the application of ANN in the field of accounting has been vigorously developed under the background of the innovation economy through the collection of literature. However, there are still problems such as the large consumption of manpower and material resources from the occurrence of economic business activities to the confirmation of accounting elements in the accounting information system (AIS). Based on this, this paper uses the ANN technology in the AI algorithms to construct a confirmation model for various economic business data in accounting. The innovation is that it adopts the backpropagation (BP) ANN theory to explore the accounting field and applies the pattern identification function of AI to the accounting element confirmation process, realizing the cross-application of different theories. This paper aims to help the accounting field to develop further by realizing a model that consumes less accounting business data. The main points of our research can be shortened as follows: (i) this paper studies the influence of the knowledge economy on accounting innovation and in the innovation economy; (ii) the process of confirming accounting elements in economic business under the traditional AIS is analyzed; and (iii) the model of the accounting element confirmation is constructed through combining the backpropagation (BP) and neural network (NN) theory with the artificial intelligence (AI) algorithm.

The remaining part of this article is structured in the following way. In Section 2, we discuss various methods along with knowledge economy and accounting innovation. Applications of the AI and BP neural networks are also discussed. In Section 3, an automatic accounting confirmation model based on the BPNN model is proposed. The experimental setup and obtained results are analyzed in Section 4. Finally, Section 5 summarizes the paper while shedding lights on the future research.

2. Background and Methods

2.1. Knowledge Economy and Accounting Innovation

2.1.1. Characteristics of the Knowledge Economy. The knowledge economy is founded on knowledge and considers the present technology of science and learning as the fundamental components. In fact, it is an economy built on the construction, packing, practice, and depletion of required knowledge, details, and statistics. The social economy is classified by industrial structure, and it can be divided into the agricultural economy, industrial economy, and knowledge economy. The agricultural economy invests in land and labor. The industrial economy invests in capital and equipment, while the knowledge economy invests in knowledge and information [15]. The specific content of the characteristics of the knowledge economy is shown in Figure 1.

2.1.2. The Influence of the Economy of Knowledge over Innovation in Accounting. According to various characteristics and features related to the knowledge economy, the influence of the economy of knowledge over the accounting innovation is manifested in five aspects, as shown in Figure 2. This includes the innovation of the accounting means, theory, content, financial reporting, and essential accounting education.

2.2. Application of AI Algorithms in the Accounting Field

2.2.1. The BP ANN Model

(1). The BP Neural Network (BPNN) Structure. From the topological organization point of view, the BP neural network is a typical and forward hierarchical network, which is

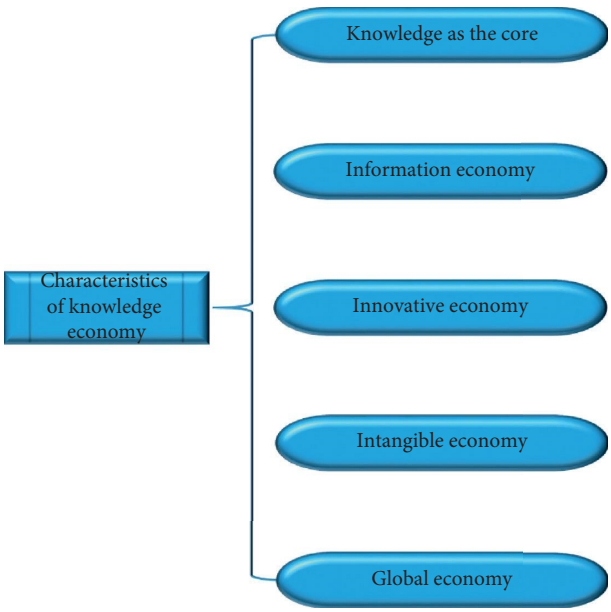

Figure 1: Characteristics of the knowledge economy.

distributed into three different layers, i.e., the input layer, the output layer, and the hidden layer. Neuron nodes are not connected in the same layer of the network, and the hidden layer of a BP network can have one or more layers [16]. Figure 3 shows the three-layer BP ANN structure and classical prototype.

In Figure 3, point i is the input layer neuron of the network. Moreover, node j is the hidden layer neuron and the number of hidden layers may vary subject to the depth of the network. Similarly, node k is the output layer neuron. After the input layer of the ANN is stimulated by the external environment (such as economic business data that need to be processed), each input layer transmits the stimulation signal to the subsequent hidden layer. As the internal information processing center, the hidden layer is extremely important in the pattern identification function of the BPNN model. There is an existing input pattern X_{pi}, and each input of the hidden layer can be expressed as given by the following equation:

$$I_{pi} = \sum_{i} W_{ji} O_{pi}, \tag{1}$$

where W_{ji} is the weight coefficient of the hidden layer node j and the input layer node i, and O_{pi} is the output vector value of the node i. If the threshold of node j is θj, the excitation function is sigmoid, and $A = I_{pj} - \theta j$; then, the output value of node j is computed using the following equation:

$$O_{pj} = \frac{1}{1 + e^{-A}}. \tag{2}$$

The output of the ANN produces the final output vector, and the input value of the node k of the output layer is given by the following equation:

$$O_{pk} = \frac{1}{1 + e^{-A}}. \tag{3}$$

If the threshold of the output layer node k is θ_k, the transfer function between the hidden layer and the output layer is sigmoid, and $B = I_{pk} - \theta_k$; then, the output vector value of node k is given by the following equation:

$$O_{pk} = \frac{1}{1 + e^{-B}}, \tag{4}$$

where O_{pk} is the final output vector produced by the output layer, and e represents the constant.

(2). The BP Algorithm Training Process. The BPNN algorithm can be divided into forward propagation and BP techniques. The forward propagation of the network model means that the input samples are transmitted from the input layer to the hidden layer units and finally to the output layer. In the process of signal transmission and processing, the output of neurons in the upper layer only affects the neurons in the lower layer. When the resulting value is output, the neural network will compare the actual output value with the expected output value. If there is an error between the actual result and the expected output value, then the network model enters the process of feedback adjustment. The error signal value is transmitted in the reverse direction according to the forward propagation path, and the connection weight coefficient between neurons is corrected. The error signal between the final actual output and the expected output reaches the expected setting [17].

The ANN algorithm used in the accounting element classification process is mainly divided into sample training and pattern identification. The first step is to select appropriate training samples. The training samples refer to the economic feature attributes in the economic business activity data that distinguish their categories, so the machine can distinguish different economic business activities. Many ANN models are trained according to the actual collected economic and business data. Existing research shows that the quality and quantity of training samples greatly affect the effects and impacts of the ANN as a classifier, and the selection of sample category feature vector impacts the classification results. The second step is pattern identification. The economic features that distinguish economic business activity categories are used as input vectors. The accounting entries of the business process are obtained as the output vector value by looking up the relevant accounting standards. Figure 4 shows the information dissemination route of the neural network. One is the work signal represented by the solid line, which is the forward propagation from economic business data to accounting entries. The other is the error signal represented by the dotted line, which is the feedback propagation of the error signal in the accounting entry. The accounting entries under the corresponding economic business activities and accounting standards are obtained through the continuous feedback training of the neural network [18, 19].

(3). The BP Algorithm Calculation Steps. The learning steps of the BP ANN are shown in Figure 5.

The first step is to input training samples (Xk, $Y*k$) and $k = 1, 2, \ldots, N$. The second step is to build the network model

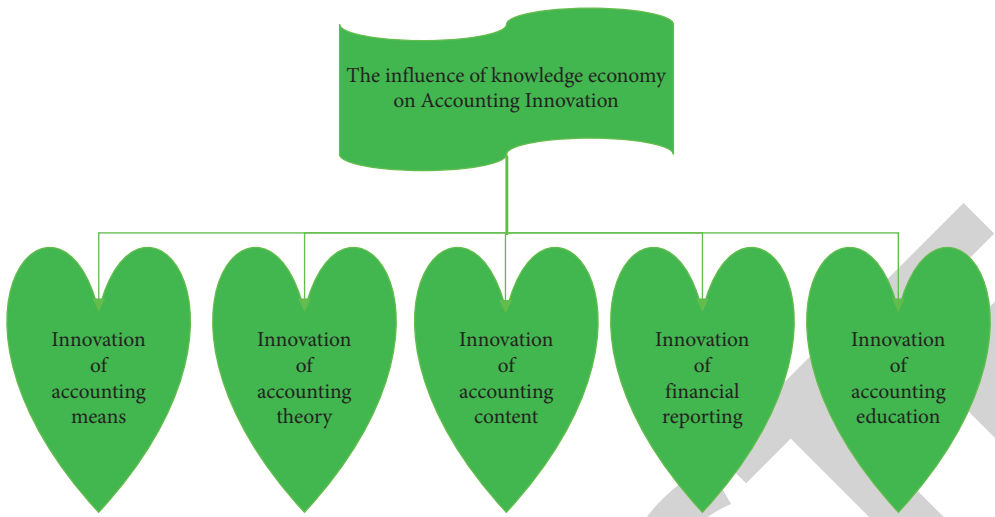

Figure 2: The specific performance of the knowledge economy affecting accounting innovation.

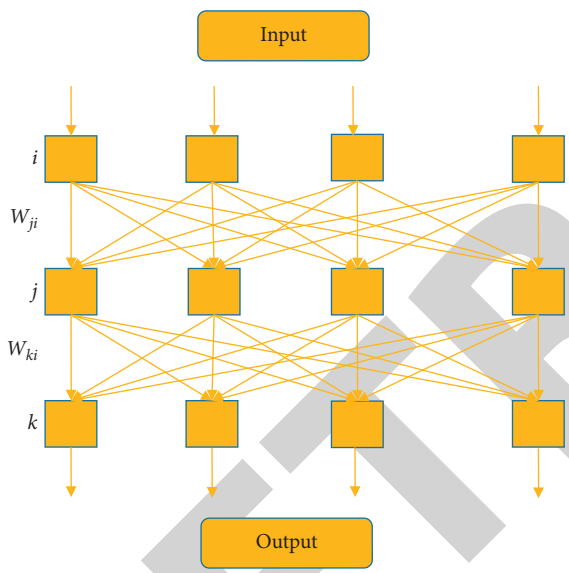

Figure 3: Schematic diagram of the three-layer BP ANN structure.

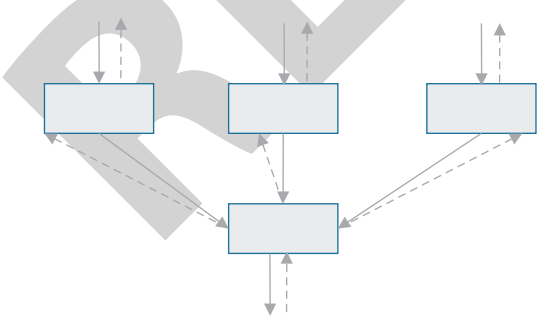

Figure 4: Information dissemination route of the neural network.

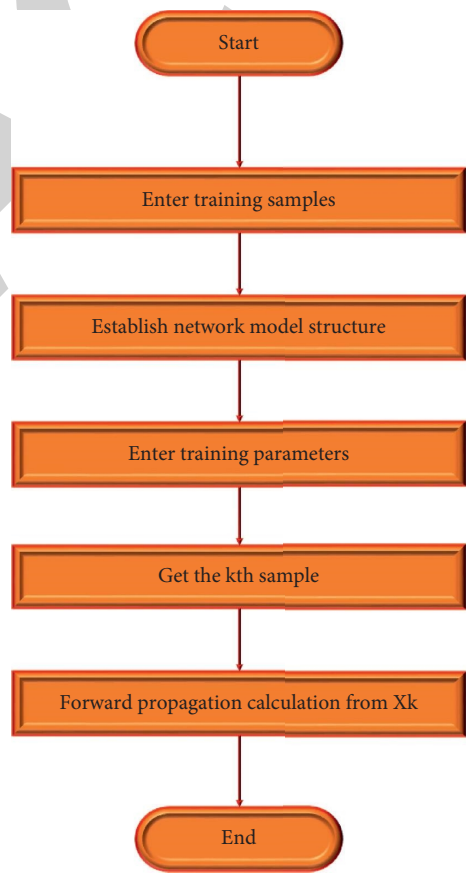

Figure 5: Learning process of BP ANN.

structure. This should be noted that the input vector of the training samples decides the amount of nodes in the input layer of the proposed network model. Similarly, the vector that defines the training sample output determines the total amount of nodes in the output layer of the network. The third step is to input network model parameters, for instance, the learning rate η and the allowable error ε. The serial number of the training sample is $k = 1$, and the number of initialization iterations of the model is $t = 1$. The fourth step is to obtain the kth training sample $(Xk, Y*k)$, $Xk = (x_{1k}, x_{2k}, \ldots, x_{nk})$, and $Y*k = (y*_{1k}, y*_{2k}, \ldots, y*_{mk})$. The fifth step is to start the forward propagation calculation from X_k, and

the output of each node of the input layer is calculated as given by the following equation:

$$O_{ik}^{(l)} = f\left(x_{jk}\right), \quad j = 1, 2, \ldots, n. \tag{5}$$

The sixth step is to calculate the input and output of each node of each layer using the following equations, respectively.

$$I_{jk}^{(l)} = \sum_{i=1}^{n(l-!)} w_{ij}^{(l-1)} O_{ik}^{(l-1)}, \tag{6}$$

$$O_{jk}^{(l)} = f\left(I_{jk}^{(l)}\right). \tag{7}$$

In equations (6) and (7), $l = 2, \ldots, L$ and $j = 1, 2, \ldots, m$. The seventh step is that if any sample K in the training sample has an error value $E_{jk} \leq \varepsilon$ and $j = 1, 2, \ldots, m$, the learning process is terminated. On the contrary, the model performs error backpropagation and weight correction adjustment between neurons. The final step is to calculate the backpropagation error [20].

(4). The Working Process of the BPNN Classification. When the BP ANN is applied to the construction of the automatic accounting element confirmation mechanism, its working principle can be divided into the following: (i) the preparation stage, (ii) the learning stage, and (iii) the classification stage [21, 22]. The three stages and specific steps within each stage are as follows:

(1) *Preparation*. The first is the preparation stage. The tasks of the preparation stage are the selection of training samples and the determination of the initial weights and parameters of the network model. The training samples are generally the typical economic feature vector values of each category on the economic business activities to be classified. The determination of the network structure means that when the classification of accounting elements is applied, the amount of nodes, which as specified in the input layer, is generally selected as the amount of economic feature vectors of business activities. In the output layer, the total amount of nodes is identical to the category of accounting entries to be distinguished. Moreover, the selection of nodes and their amount within the hidden layer can be based on experience. There is no specific and accurate theory to guide [17]. The determination of the initial weights and control parameters of the network means that the random function of the computer can generate the initial weight matrix of the ANN. The classification of the network model requires control parameters such as accuracy, the maximum number of cycles, or learning factors, which can also be selected based on experience [23].

(2) *Learning*. The second is the learning stage. At this stage, the training samples are fed as responses into the proposed network model for training, and the network weight function is updated according to the selected training samples. The training sample input means that the economic business feature vector value passes through each hidden layer. Moreover, in each layer it obtains the actual output value and error value in the output layer [24]. Updating the network weight function means that if the actual output error value meets the parameter requirements, the model stops training [25, 26]. Otherwise, the model will return to the first step until the output meets the requirements. If the number of cycles exceeds the initial maximum number of cycles, the training is not as expected. The neural network stops training and repeats the first step of training by setting new model parameters.

(3) *Classification*. The last is the classification stage. This stage is the automatic classification process of confirming the accounting elements of economic business activities with the help of the results of the BP network model. The characteristic attribute values of the new economic business activities are calculated in turn according to the model weight coefficients accumulated in the training process. In addition, each accounting entry output by the economic business event is classified into the category with the smallest error according to the comparison among the real output value and the anticipated output result. This should be noted that the BP network has some defects, for instance, easy to fall into the local minima, very difficult to determine the network structure, and more importantly slow convergence speed. In the actual accounting confirmation process, many repetitions are often required to obtain satisfactory classification results [27].

2.2.2. Analysis and Design of Accounting Confirmation Mechanism Based on BP Network

(1). Automatic Accounting Confirmation Process Based on BPNN. After the data of internet economic business activities are standardized, the AIS automatically collects the original vouchers or agreements of related businesses and stores them in the system's event voucher database. The computer automatic accounting confirmation processing platform converts these standardized data into accounting information according to relevant information [28, 29]. Figure 6 demonstrates the confirmation process of the accounting elements based on the proposed BP ANN model.

(2). Input and Output Vector Analysis of Automatic Accounting Confirmation Based on BPNN. In the internet environment, economic business activities mainly include internal business and external business. The economic entities involved in enterprise procurement and sales include suppliers, buyers, logistics companies, and banks. From the specific online store transaction process, the accounting entries involved in the commodity procurement business

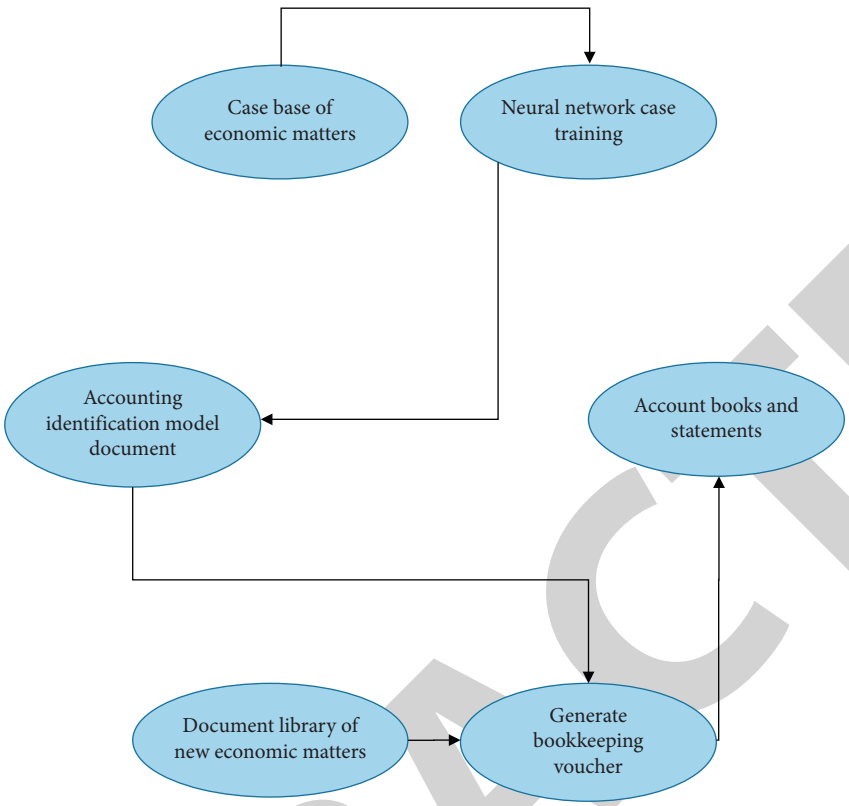

Figure 6: Schematic diagram of the accounting element confirmation process.

mainly include the automatically generated trigger mechanism or agreement for the commodity purchase invoice and the payment slip. According to the above information, an automatic accounting confirmation model based on BP ANN is constructed. The input vector analysis in the purchase payment business link is revealed in Table 1.

From the analysis of the business process, the input vectors in the commodity procurement process include commodity name, commodity code, invoice type, supplier, department name, and salesperson. The input vector of the commodity purchase payment link consists of the supplier, department name, salesperson, settlement number, settlement method, currency, exchange rate, and amount.

In addition, a total of 62 input vectors in the economic business can be obtained using the same method to analyze sales collection business, fixed asset purchase payment business, and other types of businesses.

After the economic and business activities occur, the accounting process is performed according to the obtained original voucher information to generate accounting entries, which are used as the expected output of the neural network model, as shown in Table 2.

(3). Input and Output Design. Outputs are results produced by the system or accounting information provided to users. The purpose of output design is to reflect the output information of the system accurately and timely. Information can meet the needs of users, which is directly related to the use effect of the system and the success of system development. The appropriate input form or vector is determined according to the characteristics of different economic and business activities. The purpose of the input design is to determine the ANN input value. According to the inherent characteristics of the network model, an intelligent accounting information processing platform with a stable structure and pattern identification is trained. In the experiment, the data related to the economic and business characteristics of the online shopping transaction activity are captured as the input vector of the network model according to the actual transaction. Furthermore, different accounting entries are used as expected output values to conduct model training according to the results of different business accounting processing.

3. Automatic Accounting Confirmation Model Based on BPNN

3.1. The BP Network Structure Design. This paper adopts the basic three-layer BP ANN model. It is finally determined that 62 economic features are selected as input vectors by analyzing the business process, so the number of nodes in the input layer is 62. The number of nodes in the output layer is equal to the number of different accounting entry types to be divided into results. There are 13 types of accounting entries in this study, so the number of nodes in the output layer is 13. For the selection of the number of hidden layer nodes, the number of hidden layer nodes is set under the condition of comprehensively considering the error accuracy and the complexity of the network structure. Usually, the global error tends to be the smallest or smaller than the predetermined allowable error, which will be used as an

Table 1: The purchase-to-pay business input vector.

Eigenvalues of the input vector	1	2	3	4	5	6	7	8	9	10	11
Name of the input vector	Commodity name	Commodity code	Invoice type	Supplier	Unit name	Salesperson	Statement number	Payment method	Currency	Exchange rate	Amount

Table 2: The output vector for business link.

Output vector number	1	2	3	4	5	6	7	8	9
Output vector name	Goods purchase settlement business	Purchase of fixed assets	Provision for impairment of fixed assets	Collection of goods sold	Capital increase business	Profit division business	Employee payroll preparation business	Utility bill payment business	Housing rental business
Expected output value	1	2	3	4	5	6	7	8	9

indicator for the selection of the number of hidden layer nodes. The last step is to determine the excitation function. The excitation function of the neural network chosen here is the logarithmic function of the sigmoid. The sigmoid function is the first derivative and is continuously differentiable. For the three-layer BPNN, the region divided by the sigmoid excitation function is composed of a nonlinear hyperplane, rather than a linear division. This excitation function has a smooth and soft arbitrary interface, so its classification is more reasonable and accurate than the linear excitation function. Moreover, the model has good fault-tolerant characteristics.

3.2. The BP Network Learning Design. For the design of the BP network learning, the first is the selection of the initial weight a of the model. The settings of the initial weights of the network model are generally randomly generated within a fixed range according to a uniform distribution. This fixed range is between zero and one. The size of the initial weights influences the convergence speed of the model and the prevention of local minima. Therefore, the initial value will be set according to the specific network mode and different training samples in the actual situation. The second is the determination of the learning rate factor η. This paper selects a small learning rate factor η to ensure the convergence of the training results. The selection of the initial value of η is the same as that of the normal algorithm, and just defines a positive number between zero and one. The last step is the selection of the global error E. In this paper, the error threshold is predetermined according to the actual situation in the training process of the suggested BP network prototype. In fact, when the error threshold is set small, the training effect is good. However, the speed of the network convergence decreases, but the number of training times increases. If E is large, the opposite is true.

3.3. Simulation Experiment Design. In this paper, the MATLAB software was used to build a BPNN model with given parameters as described, i.e., (62 nodes in the input layer while 13 nodes in the output layer, and we assume 1 hidden layer only). The parametric value for initial weight takes $a = 0.1$, the learning speed takes $\eta = 0.1$, and the given network global error takes $E = 0.000001$.

4. Results and Analysis

4.1. The Training Results of the BP Network Model. The BP network model constructed here is trained through the MATLAB platform, and the results acquired are shown in Figure 7.

From Figure 7, in the BP ANN constructed here, different input values of economic business activities correspond to different output values of accounting entries. There are twists and turns in the curve, but the input value continues to increase with the business activity. The accounting entry output value is also increasing and has been in the interval [0, 0.14].

4.2. The Effect of the Automatic Accounting Confirmation Model Based on the BPNN. Figure 8 reveals the simulation test error results obtained through the MATLAB platform for the accounting confirmation of economic and business activity data.

In Figure 8, when the model is simulated and tested, the simulation errors of different economic and business activity data are 0.21%, 0.01%, 0.23%, 0.01%, 0, 0.01%, 0.13%, 0.01%, 0.01%, 0.02%, 0.01%, 0.01%, and 0, respectively. The overall error does not exceed 0.3%. The above data show that the model has high accuracy and reliability.

5. Conclusions and Future Work

At present, there are some problems in the confirmation link of accounting elements from the occurrence of economic business activities to the AIS. Therefore, this paper integrates the BPNN technology into the accounting field. In addition, an automatic accounting confirmation model is constructed

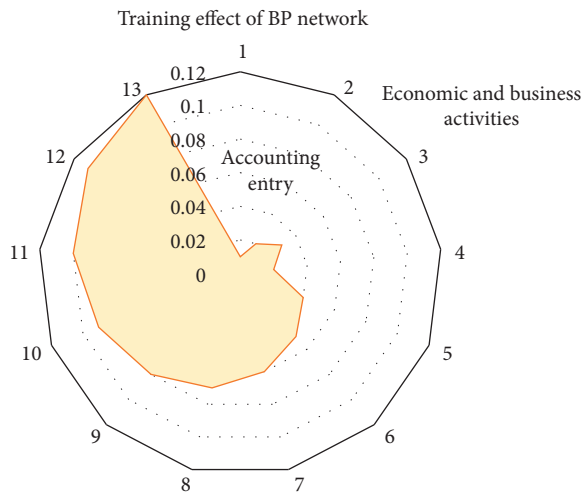

Figure 7: The effect of the BP network training process.

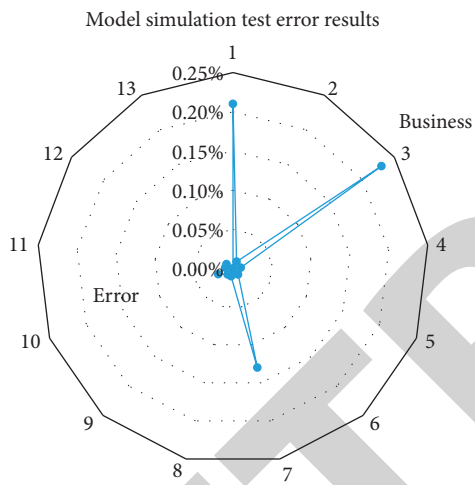

Figure 8: Model simulation test error results.

combined with the economic business scope of accounting. The simulation analysis of the model shows that the BP ANN established here has a good training effect, and the overall test error is less than 0.23% when the automatic accounting confirmation model based on the BPNN is used to simulate the data. It indicates that the model has high accuracy, reliability, and applicability. The shortcoming is that the business covered is not wide enough, and the accounting entries in the basic accounting theory cannot be discussed one-to-one when the business links are analyzed. Furthermore, the content of the case is not rich enough and needs to be supplemented.

This paper will carry out extended research and discussion on the above problems in the future. The determination of this research is to establish a spontaneous identification mechanism for data input and accounting information output in economic business activities to efficiently process business data generated in e-commerce activities and provide a choice for the real-time accounting information output. In the future, we will compare other deep learning techniques over a large amount of data. The impact of activation functions of the obtained results should also be investigated. Finally, this study was conducted over a dataset that consists of several attributes and records. In the future, larger datasets should be used to generalize the outcomes obtained in this work.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Research Article

Design of Teaching Effect Evaluation Algorithm of Flipped Classroom Based on Fuzzy Comprehensive Evaluation

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The flipped classroom model has become an essential path of teaching improvement in the colleges and institutions of higher education across the Republic of China as a direct result of the extensive assimilation of information technology and education courses that have taken place in this era of mobile Internet. Simultaneously, in order to react to the desire for the construction of new liberal arts and the training of talents serving society, a fuzzy comprehensive evaluation (FCE) algorithm is proposed to assess the teaching effect of flipped classrooms. This is done with the intention of meeting the requirements of both the construction of new liberal arts and the training of talents who can serve society. We divided the people who were going to be the subjects of this teaching into two groups: (i) one to serve as the experimental group; and (ii) the other to serve as the control group. We then supplemented the lessons for each group using either flipped classroom teaching or traditional teaching methods, depending on which group they were in. After that, the results based on the fuzzy comprehensive assessment reveal that the teaching method of the flipped classroom can successfully raise students' ability for autonomous learning as well as cultural creativity and practice. Furthermore, it can also increase the quality of teaching in the classroom. The learning effect is superior to that of the conventional instructional approach, and as such, it is deserving of further promotion. The evaluation can successfully grade the teaching effect of the classroom, which provides growth for a novel notion for the evaluation of the teaching influence of the flipped classroom.

1. Introduction

The flipped classroom teaching model [1–3] is a new teaching approach that was tested out and promoted at Woodland Park High School in Colorado, United States of America. It has gained significant attention from educators both in the United States and in other countries of the world. In fact, students use their own time outside of class to view instructional videos and other materials that have been provided by their teachers in advance [4]. The name is given to the more in-depth examination of the material being taught in the classroom, which may take the form of exercises, group discussions, or other types of activities [5]. Because academics in both the United States and other countries have conflicting opinions regarding the flipped classroom method of instruction, numerous academics in the field of education have participated in in-depth investigations into the topic's efficacy [6]. According to a number of study papers, the instructional influence of the flipped classroom teaching style in college physics classes is noticeably superior to that of the traditional teaching mode [7–9]. A controlled experiment on the teaching effect of undergraduate physics courses is one of the most influential pieces of research that has been done on the teaching effect of flipping the classroom in this nation. The findings indicate that, after two flipped courses, the experimental group's students made considerably more progress than the control group's students did. This was the case even though both groups were taught the same material and the teaching objectives were the same.

The capacity of the teacher using the flipped classroom to instruct is a direct factor in determining the teaching effect [10–13]. According to the findings of the research, the teaching video, the learning task package, and the classroom

activity organization are the direct features that disturb the teaching influence of the flipped classroom. These findings are consistent with the research conclusions reached by other domestic scholars. The implementation of nontraditional instructional techniques poses the problem of rethinking course curricula for teaching professionals. The preparation of instructional materials has taken a significant amount of time and effort on the part of teachers. The results of certain questionnaires indicate that students are pleased with the preclass preparation and teaching mode used by the teachers. This finding suggests that the concepts behind the flipped classroom teaching style can significantly boost students' concentration in learning and improve their ability to learn on their own. As a result, hastening the cultivation of flipped classroom teaching ability among teachers is an imperative assurance for boosting the efficiency of flipped classroom teaching. Moreover, the use of the flipped classroom methodology as a teaching strategy is an important component that encourages independent student learning and has an impact on the effectiveness of instruction.

The teaching effects of flipped classrooms can be significantly improved by directing students to assume responsibility for their own education; encouraging students to use their creativity to acquire knowledge; and developing students' capacity for self-directed study. According to the results of the study, neither the awareness nor the capabilities of today's pupils have considerably increased, and the current state of affairs regarding autonomous learning is not favorable. The students face a number of challenges, the most significant of which is that the time they have available for flipped learning before class is severely limited due to the fact that the new teaching approach is incompatible with it [13]. Because of the significant amount of work that is expected from them academically, some students have voiced their opinion that it is not advisable to implement the flipped classroom teaching mode on a more regular basis. The flipped classroom should place an emphasis on teaching students according to their aptitude and concentration, as well as helping pupils who have a poorer ability to learn on their own independently [14].

Establishing the evaluation index system [15, 16] is a challenging task. Each of these indicators needs to be completed in order to guarantee impartiality, fairness, independence, and integrity, and the process is fairly convoluted. In the course of the construction process, the evaluation standards of numerous practice indicators for instructors as evaluation standards can better satisfy the demands of teachers and can easily be changed into standard practice for teachers. However, this pure form of individual teachers is influenced by the teachers themselves, but it is difficult to obtain sufficient effective samples at the same time, considering that there may be difficulties and deviations in the effective teaching behaviors described by teachers in classroom teaching. In fact, this makes it a tedious and challenging task to take a broad view of the effectiveness of singular teachers. The term assessment refers to all of the methods by which academic staff members make judgements regarding a student's progress throughout the whole learning process and within a specific unit of study.

Assessment is an essential component of both learning and teaching. Evaluations are carried out with the intention of providing a continuous process of planning, measuring, analyzing the outcomes, and employing the findings to arrive at well-informed decisions, which should ideally lead to some sort of advancement. Evaluation of the learning experience as well as the instructor's own performance is a component of any course or teaching evaluation. In other words, it can be broken down into two components. It is the job of teachers to evaluate their students' progress in learning and to assign reasonable grades. The department of staff management at a university is the one responsible for conducting teaching evaluations. The department can evaluate the quality and efficacy of teaching in order to monitor the teaching process and acquire data from specific aspects. This will enable the department to provide feedback to instructors in the future that will help them improve their own teaching. The major contributions of the research presented in this work are as follows: (1) A fuzzy comprehensive evaluation (FCE) algorithm is proposed in order to respond to the requirements of the construction of new liberal arts and the training of talents for societal service, as well as to evaluate the teaching effect of flipped classrooms. (2) A single-layer fuzzy evaluation model along with a multilayer fuzzy evaluation model is suggested.

The left behind part of the paper is arranged as follows. In Section 2, we deliberate the state-of-the-art methods and rivals in the related works. In Section 3, the research design and the methodology are presented. Furthermore, the two models are also demonstrated in this section. Simulation experiments and the attained outcomes are discussed in subsequent Section 4. Lastly, in Section 5, we provide a summary of our research and discuss some future research directions.

2. Related Work

Evaluating the informatization teaching ability of teachers in a way that is objective and accurate [17, 18], is one of the key tasks that must be completed in order to stimulate the growth of informatization teaching in the Republic of China, and the research on this topic has significant practical significance [19]. Numerous investigations into this topic have been carried out by academics in the past. Some researchers have developed an evaluation method for teachers' ability to teach informatization based on smart classrooms [20, 21], and they have provided some plausible proposals for the evaluation of teachers' capacity to teach informatization in higher vocational institutions. Some academics have undertaken studies on the standard of instructors' ability to teach informatization, and this provides a certain theoretical basis for additional research that may be conducted. The informatization teaching skills of teachers have been evaluated using a set of evaluation indexes that have been established by a few researchers and are rather comprehensive. After conducting research on the comprehensive

evaluation method for teaching informatization in colleges and universities, a number of academics came to the conclusion that the evaluation results obtained using the radar map comprehensive analysis method are not only objective and accurate but also offer a number of distinct benefits. Some researchers use the TPACK theoretical model to conduct research with examples and evaluate the informatization teaching capacity of educators based on their findings [22, 23]. They are of the opinion that the present crop of preservice teachers has a poor level of technical ability, and they believe that there are still gaps in the integration of technology and content instruction. Some researchers have constructed a three-dimensional foreign language teaching evaluation system in accordance with the informatization teaching mode. They have also clarified the evaluation objectives of the evaluation system, and they are of the opinion that the system possesses the benefits of being comprehensive, objective, scientific, and accurate. Researchers have examined the efficacy of teaching information technology in vocational institutions, as well as the standards for evaluating it and the techniques for putting it into practice effectively.

Evaluating a teacher's performance is one of the most efficient ways to boost the overall quality of instruction, and it also plays a significant part in making administration in educational institutions of higher learning more robust. A large number of researchers have done work linked to teaching assessment in their studies. One use of data mining that sees use is in the evaluation of the effectiveness of classroom instruction [24]. Some academics utilize decision trees to assess the level of instruction provided by colleges and universities, with the ultimate goal of raising the overall standard of instructor training. To achieve more accurate results from the evaluation, some academics employ support vector machines using both the default settings and chosen parameters. Rough sets are a method that some academics use to acquire information about the employment situation and the quality of teaching in colleges and institutions of higher education. An evaluation model is established, and the applicable rules are reviewed. This helps to ensure that the evaluation level is improved as much as possible.

The FCE technique is a mathematical method that uses the thinking and methods of fuzzy mathematics to thoroughly evaluate items that are difficult to properly identify in the real world [25–27]. It should be noted that this particular method was initially developed by the University of California, Berkeley. The application of certain scholars in the teaching of a comprehensive assessment of fuzzy evaluation. A novel teaching performance evaluation framework that is based on the fuzzy AHP and FCE approaches has been presented by several academics. The novel evaluation technique first finds the evaluation index system's components and subfactors and then employs the degree analysis fuzzy AHP method to calculate the weights of the factors and subfactors that were determined in the previous step. The proposed teaching performance evaluation framework that is based on the fuzzy AHP and FCE methodologies is illustrated by a case application by some academics.

The field of study known as fuzzy mathematics is one that makes use of associated mathematical procedures in order to deal with and address a variety of hazy things and occurrences. In both our professional and personal lives, there are some challenges that can be challenging to accurately convey using numerical terms. It is possible that using a vague number to describe it will be more socially acceptable. It is possible to interpret it in a number of different ways. Since Moorel proposed the concept of interval numbers in the 1960s, scholars have always paid attention to the application and research of interval numbers. This is due to the fact that the selection of attribute weights needs to make the lower limit of the widespread attribute cost of every structure the smallest possible, and the upper limit of the complete attribute significance of every system needs to be maximized. A planning model is established by using the weighting method, and the attribute weights are determined by the attribute weighting method. Some academics employ the Hausdorff distance in order to ascertain the attribute value of the interval number as well as the degree of closeness of the ideal interval number. Additionally, the Hausdorff distance formula is utilized in order to ascertain the relative importance of the related attributes. According to the research of a few academics, the multiattribute decision-making issue of the intermission quantity can be solved by describing the positive and negative superlative interval numbers of the interval number and employing the relative closeness as a factor in determining how much weight to give each interval attribute. The operation can be made more straightforward by converting the attribute weights into numerical values. The multiattribute decision-making problem with scheme preference was explored by some academics, and one of them offered a way to compute attribute weights based on the interval number separation degree formula.

In order for colleges and institutions of higher education to effectively implement the national education policies and procedures, consolidate the fundamental task of building morality and cultivating people, and simultaneously further progress and increase the level of teaching work, a comprehensive assessment of their teaching conditions is required. This assessment must be carried out in order for schools and institutions of higher education to effectively implement the national education policies and procedures. It is necessary, at this time, to evaluate the teaching quality of each college according to the scores that were given by the experts because the scores that were given by the experts were frequently fuzzy numbers (such as interval numbers) as a result of the various uncertainties that were present in the actual situation. There is currently no standardized approach to the teaching of evaluation anywhere in the world, including in the United States. Methods such as AHP, PCA, utility function, FCE, and so on are examples of the most frequently used mathematical analysis techniques [28, 29]. Every approach comes with its own set of perks. The extent of its use as well as any restrictions it may have. The AHP contains significant amounts of subjectivity, and the ranking is fairly arbitrary.

The principal component analysis method does not provide a clear explanation of what it means. The utility function method and the FCE method both rely on subjectivity when deciding how much weight to give to each factor [30]. As a result of the unpredictability of the comprehensive evaluation of teaching, a mathematical model that is based on the dispersion maximization method has been established in order to determine the weight vector group of attributes [31]. This model seeks to eliminate, to the greatest extent possible, the subjectivity associated with determining the weight vector and possesses some degree of objectivity. This method uses interval numbers as an example. A teaching evaluation model in a fuzzy environment is provided, and a decision method based on an interval number weight vector group is proposed. This provides a new evaluation method for teaching the evaluation model in a fuzzy environment. Take interval numbers as an example. Providing [32, 33].

3. Research Design

3.1. Data Sources. Figure 1 displays the flow chart that corresponds to the algorithm. The comparison of the final exams and questionnaires that were administered at the end of the course by a school in Shanghai provides the source for our data. The test set consists of eighty percent of the total data, while the training set consists of twenty percent of the total data [29]. Our evaluation model of the flipped classroom teaching effect, which is based on the model for comprehensive evaluation, is created in this manner.

3.2. Analysis Based on the AHP-FCE Method. Utilizing the membership degree theory found in fuzzy mathematics, one can quantitatively evaluate those complex multifactor schemes that are difficult to define using precise mathematical relationships. This is what is meant by FCE. To a large extent, the quality of the FCE is determined by the extent to which the calculation of the index weight is objective and scientific. This occurs during the process of determining the membership degree of each factor in the process of calculating the membership degree of each factor. When compared to the method of subjective qualitative determination of weights, AHP, which is a qualitative and quantitative multifactor decision-making method, is capable of making the calculation of index weights of fuzzy factors more objective and scientific. This is in contrast to the method of subjective qualitative determination of weights.

3.2.1. Single-Layer Fuzzy Evaluation Model. The following is a detailed description of the process that constitutes the single-layer fuzzy evaluation model:

(i) Step 1: obtain the factor set $S = \{s_1, s_2, ..., s_n\}$ associated with classroom instruction.

(ii) Step 2: the next step is to build up the $P = \{p_1, p_2, ..., p_m\}$ judgment set.

(iii) Step 3: evaluation of a single factor. The result of the ith evaluation of a single component is that the fuzzy relationship between S and P is $(g_{i1}, g_{i2}, ..., g_{im})$, and the evaluation matrix for all n factors looks like this as given in

$$G = \left(g_{ij}\right)_{n\times m}. \tag{1}$$

(iv) Step 4: carry out an exhaustive analysis and have the weight set $W = (w_1, w_2, ..., w_n)$, whereas the w_i indicates the relative importance of each factor i, which is illustrated using

$$\sum_{i=1}^{n} w_i = 1\left(w_i \geq 0\right)w_i. \tag{2}$$

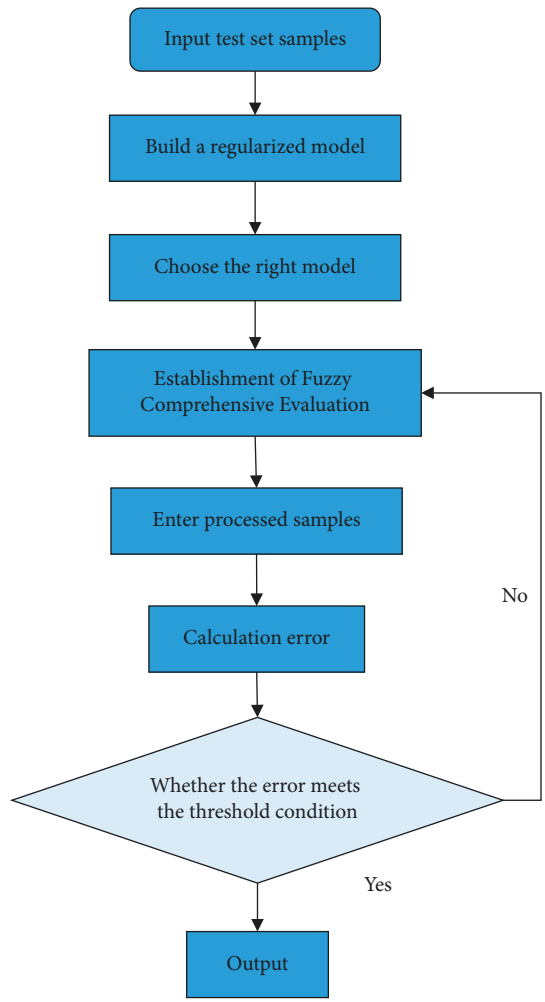

Figure 1: The algorithm flowchart.

The following formula, as demonstrated using equation (3), is a list of the results from the comprehensive evaluation:

$$A = W \cdot G = \left(w_1, w_2, \ldots w_n\right) \cdot \left(g_{ij}\right)_{n\times m} = \left(a_1, a_2, \ldots a_n\right). \tag{3}$$

Among the above equation (3), the generalized fuzzy synthesis operator is denoted by the letter "·" and is illustrated using

$$a_j = \sum_{i=1}^{n} w_i g_{ij} \, (j = 1, 2, \ldots, m). \tag{4}$$

3.2.2. Multilevel Fuzzy Evaluation Model. Following the design of the evaluation index system for the teaching impact of the mathematics network live broadcast, the teaching effect of the live broadcast classroom is evaluated with the assistance of the multilevel fuzzy evaluation model.

The following is a rundown of the particular steps involved in the multilevel fuzzy evaluation model:

Step 1: perform the calculations and collect the final result of the full evaluation. A_{ij} of the lower subtarget in accordance with the model of evaluation with a single layer I is the number of the criterion layer, and j is the number of the evaluation index that is contained within the same criterion layer.

Step 2: the second step is to reestablish the fuzzy matrix G_i. The formula for this step is as follows using

$$G_i = \begin{bmatrix} A_{i1} \\ A_{i2} \\ \cdots \\ A_{ik} \end{bmatrix} = \begin{bmatrix} a_{i_1 1} & a_{i_1 2} & \cdots & a_{i_1 m} \\ a_{i_2 1} & a_{i_2 2} & \cdots & a_{i_2 m} \\ \cdots & \cdots & \cdots & \\ a_{i_k 1} & a_{i_1 m} & \cdots & a_{i_1 m} \end{bmatrix}, \tag{5}$$

where k is the number of assessment indications that can be potentially found in layer i of them all.

Step 3: comprehensive assessment of a single layer, assuming that the weight set of the i-layer evaluation index is denoted by the symbol $W_i = (w_{i1}, w_{i2}, \ldots w_{ik})$, the following formula, as shown in equation (6), is an example of the comprehensive evaluation result for this layer:

$$A_i = W_i \cdot G_i = (w_{i1}, w_{i2}, \ldots w_{ik}) \cdot \begin{bmatrix} a_{i_1 1} & a_{i_1 2} & \cdots & a_{i_1 m} \\ a_{i_2 1} & a_{i_2 2} & \cdots & a_{i_2 m} \\ \cdots & \cdots & \cdots & \\ a_{i_k 1} & a_{i_1 m} & \cdots & a_{i_1 m} \end{bmatrix} = (b_{i1}, b_{i2}, \ldots b_{im}). \tag{6}$$

Step 4: conduct an all-encompassing analysis of the overall objective, beginning with the most fundamental component and working your way up through the layers. The following formula, which is illustrated in equation (7), is a list of the outcomes of the comprehensive examination of the overall goal:

$$A_i = (b_{01}, b_{02}, \ldots b_{0m}). \tag{7}$$

3.3. Evaluation Indicators. As metrics for determining the accuracy of the model, we make use of the accuracy, precision, recall, and $F1$ metrics. These indicators are widely used in artificial intelligence and machine learning research to quantify the prediction outcomes. The following equation (8) is the formula for determining the accuracy rate:

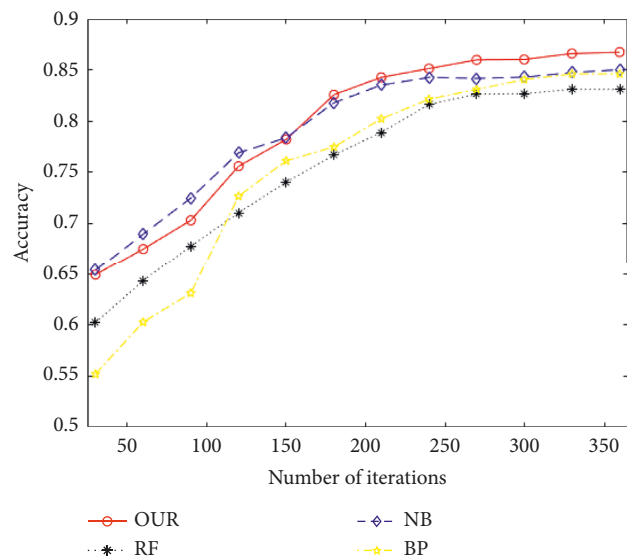

Figure 2: Accuracy of various approaches at different iterations.

$$Acc = \frac{TP + TN}{TP + TN + FP + FN}, \tag{8}$$

where TP denotes the true false and TN stands for true negative. Similarly, FP and FN characterize false positive and false negative, respectively. The following equation is the formula for determining the precision rate:

$$Pre = \frac{TP}{TP + FP}. \tag{9}$$

The following equation is the formula for determining the recall rate:

$$Rec = \frac{TP}{TP + FN}. \tag{10}$$

The following equation is the formula for determining the $F1$:

$$F1 = \frac{2 \times Pre \times Rec}{Pre + Rec}. \tag{11}$$

Besides these metrics, researchers have also used the MAPE (mean absolute percentage error) and RMSE (root mean square error) indicators to demonstrate the usefulness and accuracy of the prediction outcomes [23].

4. Experiments and Results

We will refer to the fuzzy algorithm as "OUR algorithm" for the sake of making the comparison between the following algorithms as simple as possible. We will also compare the random forest algorithm (RF), the Naïve Bayes algorithm (NB), and the BP neural network algorithm (BP) with the proposed approach.

As can be seen in Figure 2, we obtained varying degrees of success. When compared to the other five classification

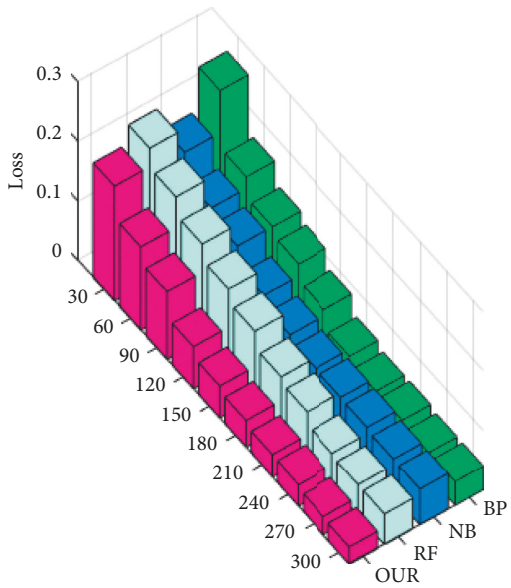

Figure 3: The loss for various approaches at different iterations.

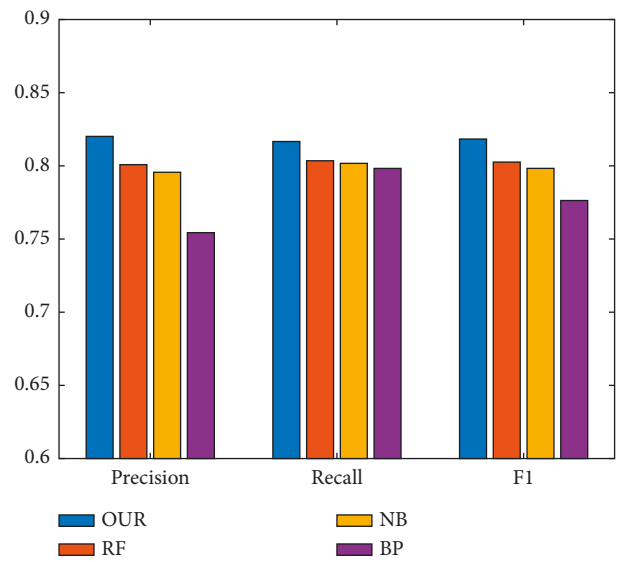

Figure 4: The precision, recall, and $F1$ metric values under dissimilar algorithms.

prediction algorithms that were tested, it is clear that the accuracy of the OUR method is superior to that of the others. This demonstrates that the OUR methodology is still quite successful in determining the impact that flipped classroom instruction has had on student learning. The efficacy of various assessment methods allows for the impact of interventions to be determined. It is during the iterative process that the correctness degree of the BP mechanism improves at the fastest possible rate. However, after the number of iterations hits 250, the growth rate begins to gradually slow down. During the iterative process, the accuracy of the RF algorithm continuously improves until it reaches its peak, at which point it is ranked last. When it was all said and done, the accuracy of the NB algorithm came in second.

Figure 3 depicts the loss that occurred while the procedure was being iterated. During the iterative process, we are able to observe that the algorithm loss of the OUR algorithm is always reducing, and as a result, it is currently the lowest value among the four different loss values. In contrast to the BP method, the initial loss is the one that is the highest, but as the iterative process continues, the parameter fitting gets better and better, which results in the model loss growing smaller and smaller, and the final loss is the one that is the second highest. As the number of repetitions grows, there is a gradual reduction in the amount of data lost by both the NB method and the RF algorithm. However, the end outcome is not as excellent as the data lost by the OUR algorithm. The precision, recall, and $F1$ metric values under diverse algorithms are shown in Figure 4.

We compared the OUR method with the RF algorithm, the NB algorithm, and the BP algorithm with regard to precision, recall, and $F1$ metric value, as is illustrated in Figure 4. Because the OUR method has the highest precision rate, recall rate, and $F1$ metric value, it is clear that there are no issues with the algorithm's stability. This can be noticed by looking at the figure. It is able to provide an accurate analysis of the flipped classroom's instructional effectiveness.

When it comes to conventional methods of education, the teachers themselves are frequently portrayed as the main characters in the classroom. Students are mostly responsible for listening and taking notes in the classroom, while professors are primarily responsible for delivering lectures. There is very little participation from students overall. The drawbacks of this form of instruction are readily apparent, despite the fact that it is helpful in fostering the development of teaching practices. An interest in learning, imperfect comprehension, generally unchangeable thought patterns, and so on. Students are given the opportunity to acquire knowledge that is relevant to their classes in advance by watching videos at home before coming to class. It should be noted that the majority of the time spent in class is devoted to the memorization, application, and exploration of material. The primary modes of instruction are exploratory and expanding activities, role-based debates, group discussions, and so on.

Communication between students as well as communication with students and the implementation of the flipped classroom teaching style in classroom instruction is beneficial for teachers because it targets students' knowledge blind spots as well as their needs and interests, and it guides students to engage in self-directed learning in a manner that is more scientific and rational. Students can be given greater initiative through the use of layered teaching, which can also inspire students' excitement for learning, actualize the creation of high-level thinking, encourage the integration of knowledge, and eventually enhance knowledge integration. The teaching impact evaluation model of flipped classrooms, which is based on fuzzy comprehensive assessment, can assist educators in devoting more of their consideration to the refinement of students' elementary literacy and the training of students in fundamental abilities.

5. Conclusions, Limitations, and Future Work

To summarize the findings, the flipped classroom teaching style, which is grounded in FCE, has achieved good implementation results in classroom teaching, and it has effectively stimulated students' learning interests and learning abilities. In fact, this was accomplished through the implementation of a comprehensive assessment. This teaching approach, which is focused on solving real-world problems, places an emphasis on the integration of a wide range of academic fields, and makes extensive use of the newest and latest generations of information technology, is able to successfully implement the student-centered teaching method, provide students with a greater variety of learning resources and opportunities, encourage students to engage in self-directed learning, and result in improved academic performance. We have confidence that the recommended approach is a novel approach to flipped classroom education that should be considered for use in institutions of higher learning.

There are a few issues associated with the methods of evaluating humans. For instance, the findings of the evaluation of the teaching quality are extremely subjective and unscientific, and the accuracy of the evaluation is very poor. As a result, the results of the evaluation cannot effectively reflect the actual teaching level of teachers. With the rise of the Internet and other forms of information technology, the question of how to employ information technology in a manner that is both scientifically and precisely correct in assessing the quality of instruction has been brought to the forefront. In an effort to find solutions to these issues, we have been making an effort to implement the fuzzy comprehensive assessment approach into the practical teaching evaluation of computer majors. Several datasets were gathered while classes were being taught, sparing university administration the additional labor that would have been required. After that, the data from the index are entered into the fuzzy comprehensive model in order to produce the outcomes of the scientific research. We are able to properly evaluate the teaching effect of the classroom by utilizing an evaluation algorithm that is based on FCE. This allows us to assist schools in objectively evaluating the classroom in which teachers are positioned. In the future, we will address these issues while proposing evaluation algorithms that are based on FCE.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Data Classification of Mental Health and Personality Evaluation Based on Network Deep Learning

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In real life, people are at a risk of encountering various negative emotions all the time, and in the case of long-term negative emotions, it is easy to fall into a state of depression. However, in the current mental health system, the diagnosis of the depressive state of a client usually requires a doctor or a consultant to conduct face-to-face or video consultation with the client, which is time consuming and labor intensive. Therefore, it is necessary to adopt IT for mental health monitoring and personality data analysis. In order to achieve better results in identifying the students' mental health problems, this paper attempts to use multiple data sources, proposes an algorithm for identifying mental health problems based on multiple data sources, and uses the data on students' mental states provided in psychology as labels to improve the shortcomings brought about by the questionnaire approach. To further optimise the model identification results, this paper proposes a mental health problem identification algorithm based on the DeepPsy model. A 2D-CNN was used to extract the online pattern of a day, an LSTM network was used to capture the temporal dependency between days, and a deep learning network was designed to combine the underlying features with the online trajectory pattern. Experiments showed an accuracy of 0.71, a recall of 0.75, and an F1-Measure of 0.72, and were able to identify 75% of students with mental health problems.

1. Introduction

In traditional mental health diagnosis, it is usually necessary to diagnose whether the client has psychological problems through assessment, interview, etc. This method is more labor intensive and not conducive to the discovery and intervention of early psychological problems. However, many previous studies have shown that people's various habits and traces in their lives project psychological states. Although at present, the accuracy of traditional mental health diagnosis is better than diagnosis through multi-dimensional machine learning, diagnosis through machine learning also has its own advantages. The intelligent system constructed by big data can diagnose and analyze a large number of users at the same time, saving time and labor costs, and can monitor the psychological state of users 24 hours a day, which is conducive to the discovery and prevention of early bad psychological states. These are things that traditional mental health diagnostic methods cannot do. Therefore, traditional mental health diagnosis and big data mental health diagnosis can complement each other. Since the diagnosis accuracy of big data system is not as good as that of traditional health diagnosis, in practical application, the model can be optimised by methods to achieve lenient entry and strict exit. That is, users who are suspected of psychological well-being (PWB) problems are discovered, reminded, and recalled through the big data system, and then further diagnosis and intervention are carried out through traditional mental health diagnosis methods.

Mental health and personality evaluation are becoming more and more important, and Day C develops specific parenting interventions for some special parents. These

parents generally have severe personality disorders and mental health problems, because parents' psychological problems are likely to be infected by their children. The aim of devising a pragmatic mixed methods design is to develop and pilot specialized parenting interventions [1]. Family education greatly affects the mental health of adolescents. Chen analyzed the impact of family cumulative risk on the growth and development of adolescents from different perspectives, and put forward corresponding family education methods on this basis, mainly to provide certain guidelines for children's mental health education and personality issues [2]. Mamsharifi et al. investigated social support and personality traits to predict mental health problems and performed regression analysis on the data [3]. The relationship between racial discrimination and negative mental health outcomes has been questioned, and Mekawi et al. used bivariate relationships and hierarchical regression analysis methods to determine whether racial discrimination contributes to depression, anxiety, and post-traumatic stress symptoms that affect the role of personality [4]. Shirazi and Omidvar studied the role of critical thinking and dynamic personality in predicting job self-efficacy and performed regression analysis on the data [5]. In general, the diagnosis of depression in the traditional PWB diagnosis system mainly relies on psychiatric interviews, which is time consuming and labor intensive, and will lead to more serious conditions, which is not conducive to the prevention and treatment of depression.

How to extract emotional information from big data becomes extremely important. Gong Y's research found that different personalities, emotional states, and external stimuli will have different effects on emotional semantic analysis. The process characteristics describing emotional evolution were more comprehensively predicted starting from the description and calculation of emotional dynamic characteristics [6]. Adamopoulos et al. investigated whether the underlying personality traits of online users affect the effectiveness of the platform, using machine learning methods combined with econometric techniques [7]. Ammannato and Chiesi studied and investigated information on game players' behavior and reaction patterns to assess the likelihood of personality traits. It was found that in five of the six personality dimensions, the probability of correctly identifying a player's trait level is higher than chance by using deep learning for training deep neural networks [8]. To address mental stress health in the framework of smart medical care, Rachakonda et al. proposed a novel deep learning-based system that can monitor a person's stress level through body temperature, movement speed, and sweat during physical activity [9]. Psychological research models how people learn features and categories, but deep neural networks learn representations of real-world stimuli through the network that might be used to capture the mental representations. Peterson et al. had found that simple transformations that correct for these differences can be obtained by convex optimization, extending the scope of psychological experiments and computational modeling [10]. Although there is a strong relationship between behavior and PWB problems in the above studies, the obtained labels may be inaccurate by using questionnaires to obtain and the relationship between behavioral single data source and PWB cannot accurately assess the PWB status.

2. PWB and Personality Evaluation of Deep Learning

2.1. Application of Artificial Intelligence Technology in PWB State Prediction. Advances in intelligent technology merge into the psychological realm. For example, there are artificial intelligence assistants that can chat with users, evaluate the user's PWB, and recommend suitable solutions to users [11]. There are also related technology companies that have developed devices using AR and VR technologies. Users can wear these devices and watch VR and AR video images for psychotherapy.

The development of the Internet, big data, and artificial intelligence technology provides new methods and opportunities for the study of psychology. Through social media content, sensors (including various wearable devices and cameras) and smartphones, a large amount of data can be obtained from people's daily lives. The PWB big data is summarized and classified as shown in Figure 1.

As shown in Figure 1, the big data at the PWB level is divided into emotional, cognitive, behavioral, social, and biological levels. These big data at the PWB level will project people's PWB status. For example, at the level of social big data, when people feel sad or happy, they will let their relatives and friends know their current emotions by sending a circle of friends [12]. At the level of biological big data, people's sleep quality will be affected by mental health conditions, so collecting people's sleep data through wearable devices such as sleep bracelets can also conduct research on mental health conditions. In short, people's emotions and PWB status can be known by analyzing these PWB big data. The character classification is shown in Figure 2.

As shown in Figure 2, personality theory refers to the description of a person's personality mainly covered by five traits, including openness, conscientiousness, extraversion, agreeableness, and neuroticism [13].

Although the current level of artificial intelligence technology has not reached the point where it can truly replace human psychological counselors, the development of artificial intelligence technology has brought a huge impact on traditional psychological counseling work. Some high-cost and low-efficiency psychological counseling will be replaced by artificial intelligence, and artificial intelligence technology will play a role in promoting and advancing the entire PWB industry [14].

2.2. Network Deep Learning to Evaluate PWB

2.2.1. Decision Tree Algorithm. The most critical technique in the construction of a decision tree is the selection of split attributes, and the dataset often contains many attributes. For some high-dimensional datasets, there may even be thousands of attributes. How to choose the best attribute is the focus of decision tree research, that is, among several

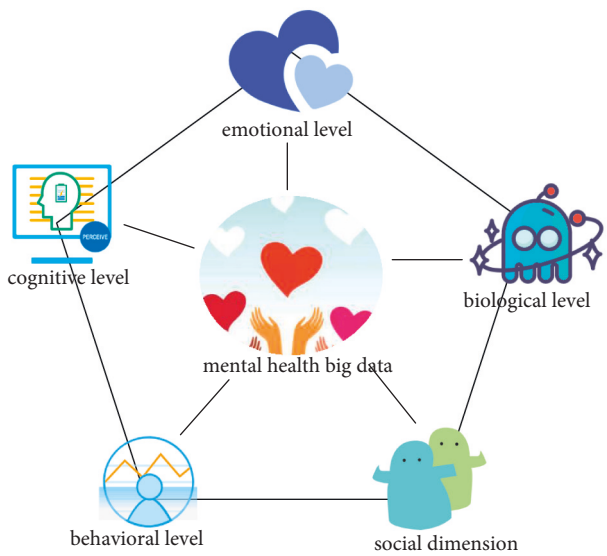

Figure 1: PWB big data.

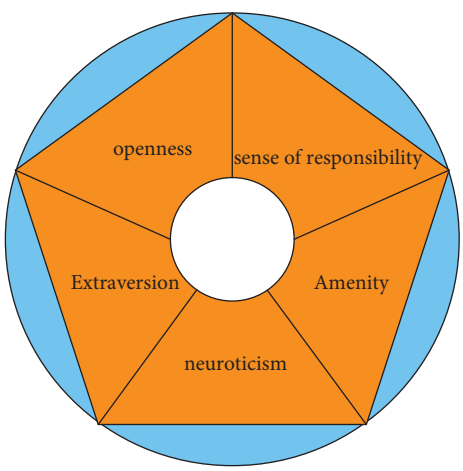

Figure 2: Character classification.

attributes, which attribute is preferentially selected for splitting [15]. The calculation of information entropy is shown in Formula (1):

$$\text{Entropy}(E) = -\sum_{m=1}^{i} f_i \log_2 f_i. \tag{1}$$

Among them, i represents the number of categories in the dataset E, and the smaller the Entropy (E) value, the higher the purity of E. The information gain of the sample set E is shown in Formula (2):

$$Gain(E,b) = Entropy(E) - \sum_{n=1}^{N} \frac{|D^n|}{|D|} Entropy(D^n). \tag{2}$$

The attribute selection has the highest gain, and the C4.5 algorithm is shown in Formula (3):

$$\text{Gini\_ratio}(E,b) = \frac{\text{Gini}(E,b)}{IS(b)}. \tag{3}$$

Among them:

$$IS(b) = -\sum \log_2 \frac{|D^n|}{|D|}. \tag{4}$$

The CART algorithm outperforms the former in speed. The calculation is shown in Formula (5):

$$\text{Gini}(E) = 1 - \sum_{n=1}^{i} f_n^2. \tag{5}$$

Decision tree algorithms are not data sensitive. Both nominal data and numerical data can be processed, and features without correlation can also be processed [16].

2.2.2. Gradient Boosting Tree. The base classifier of the Gradient Boosting Decision Tree (GBDT) algorithm is also a decision tree, and it is a CART decision tree, like random forests [17]. It is difficult to achieve both accuracy and diversity by using only one decision tree classifier, and a single decision tree classifier is prone to overfitting and unstable classification results in classification problems. The gradient boosting tree algorithm solves these shortcomings of decision trees [18]. The basic idea of gradient boosted trees is to reduce the loss by accumulating weak classifiers. The initialized base classifier is shown in Formula (6):

$$f_0(y) = \text{argmin}_\lambda \sum_{n=1}^{N} L(x_n, \lambda). \tag{6}$$

Each base classifier needs to do:

The negative gradient calculation result is used as the residual value, and the process is shown in Formula (7).

$$\phi_{nm} = -\left[\frac{\partial L(x_n, f(y_n))}{\partial, f(y_n)}\right]. \tag{7}$$

For fitting a regression tree, for leaf nodes, the calculation is shown in Formula (8):

$$a_{mj} = \text{argmin}_a \sum_{y_{n\in R_{mj}}} L(x_n, f_{m-1}(y_n) + a). \tag{8}$$

The output gradient boosting tree is shown in Formula (9):

$$\hat{f}(n) = f_M(n). \tag{9}$$

The difference between a gradient boosted tree and a random forest is that each tree in a random forest is built independently of other trees, while a gradient boosted tree is built based on the results of the previous trees. The latter can ensure the continuity of features, and there are many nonlinear transformations, which are helpful for feature transformation and high-dimensional feature generation [19]. In addition, gradient boosting trees, like random forests, overcome the problem that decision trees are prone to overfitting and are not sensitive to outliers.

2.2.3. Neural Network. A classifier with the lowest current error rate was selected as the first base classifier, and the accuracy of the classifier was calculated as shown in Formula (10):

$$u_l(a_z) = \begin{cases} 1, & b_z = f_l^z, \\ -1, & b_z \neq f_l^z. \end{cases} \tag{10}$$

Among them f_l^z represents the actual output class of the first base classifier relative to input a_z. Calculate the error of the base classifier on distribution d_l as shown in Formula (11):

$$r_l = \sum_{z=1}^{Z} d_l(z) u_l(a_z). \tag{11}$$

The weight of the base classifier in the final classifier is calculated as shown in Formula (12):

$$r_l = pIn\left(\frac{1 + r_l}{1 - r_l}\right), p \in [0, 1]. \tag{12}$$

The weight distribution of the updated training samples is shown in Formula (13):

$$d_{l+1}(z) = \frac{d_l(z)\exp(-\gamma_l u_l(a_z))}{\sum_{z=1}^{Z} d_l(z)\exp(-\gamma_l u_l(a_z))}. \tag{13}$$

Then, return to the second step until the classification effect reaches the preset accuracy or the pre-given base classifier has been used up.

$$H(A) = argmax_o \sum_{l=1}^{M} \gamma_l H_l^o(A). \tag{14}$$

Among them, $H_l^o(A)$ represents the direct output of the first base classifier.

2.3. Identification Algorithm of Students' PWB Based on Multisource Data. The overall framework of the multisource data-based student PWB problem identification algorithm is shown in Figure 3.

As shown in Figure 3, the accuracy rate (Precision) was higher than the recall rate (Recall), and the highest recall rate (Recall) can only reach 0.58, indicating that there are relatively few samples that can be correctly identified. Secondly, the comprehensive performance of the decision tree was the best, especially the recall rate (Recall) was improved more. Therefore, the decision tree was selected as the classifier of the PWB identification algorithm based on multisource data. The results of five classification algorithms in identifying students with PWB are shown in Table 1.

The experimental results are as follows, as stated in Table 1: Precision is 0.68, Recall is 0.56, and F1-Measure is 0.67. The algorithm using multisource data was able to identify 56% of pupils with PWB difficulties, as per the experimental findings of the test set.

2.4. Identification Algorithm of Students' Mental Health Problems Based on DeepPsy. In this recognition algorithm, the algorithm uses data such as student consumption, access control, network, and grades to analyze students' behavior in school, and can identify students with mental health problems to a certain extent. But through in-depth analysis, it is found that the algorithm has shortcomings.

2.4.1. Weaknesses of Algorithms. For the identification algorithm of students' mental health problems based on multisource data, students with mental health problems can be identified to a certain extent, but the results of the experiment are not ideal. Through further analysis of the whole method framework, it is found that there are two deficiencies. First, due to the large difference in the length of the online behavior sequences, there are a large number of vacancies. For a shorter sequence, it may not be possible to extract the students' online patterns. Secondly, the online mode has been trained twice, and each training will generate a certain loss. The process of extracting surfing patterns using a one-dimensional convolutional neural network (ID-CNN) incurs one loss, and another loss when training with a classification algorithm [20, 21].

To this end, an online trajectory matrix is constructed, and a network is designed to obtain an improved identification algorithm for students' mental health problems.

2.4.2. Construction of Students' Online Trajectory Matrix. The time granularity of the data in the network log is accurate to the second. The length of the sequence obtained by directly establishing the behavior sequence according to the order of time varies. Usually, students' online behavior is time-periodic, and even the purpose of Internet access in different periods is generally different. For example, more web pages related to the study are browsed during the day, and more web pages related to entertainment and shopping are browsed at night [22]. If the categories of web pages accessed by students are calculated by time period, then the purpose of the students' Internet access in each time period can be known. It was divided each day into 24 time periods, that is, each period is 1 hour. In this way, students' daily surfing trajectory can be transformed into a two-dimensional matrix $C * H$ of time and behavior (web browsing category). Among them, C represents the number of types of web pages, H represents the number of time periods, and the value in the matrix is the number of visits to the web page. If there is no access record within the time period, it is filled with 0. For feature extraction of a two-dimensional matrix, the commonly used method is to use two-dimensional convolutional neural network (2D-CNN). The frame is shown in Figure 4.

As shown in Figure 4, the model is mainly divided into two modules. The first module designs a joint model of 2D-CNN and LSTM with the input of the student's online trajectory matrix, which is responsible for extracting the hidden patterns of the students' online behavior trajectory. The second module uses the basic features (including abnormal scores) extracted from the four data sources as input to establish a fully connected neural network, which is responsible for building the impact of students' basic features on the identification of mental health problems. Then, the outputs of the two modules are connected, and finally a fully connected layer neural network is used. All parameters in

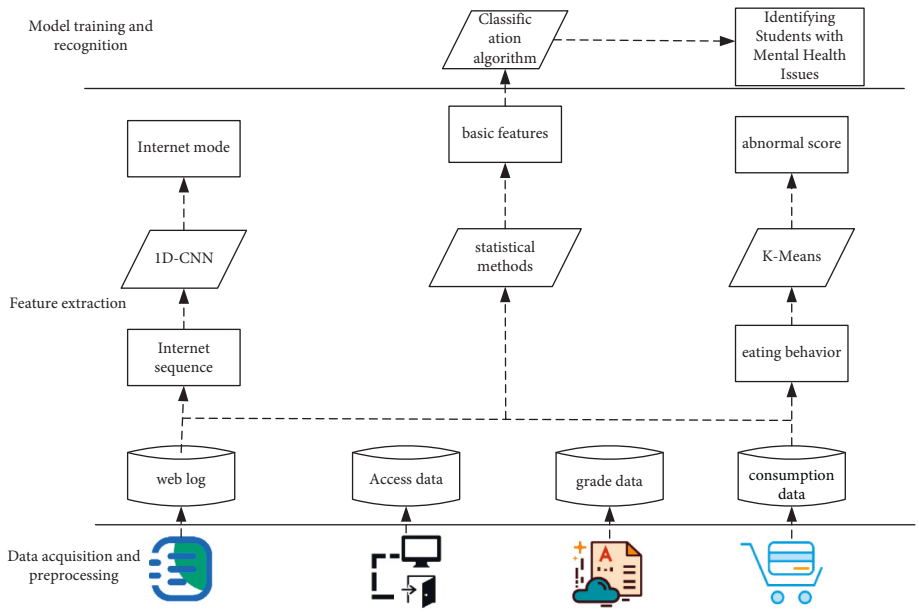

Figure 3: Algorithm framework for student PWB problem identification based on multisource data.

Table 1: Results of five classification algorithms for identifying students with PWB.

Classification algorithm	Precision	Recall	F1-Measure
RT	0.68	0.53	0.65
GBDT	0.66	0.52	0.62
NB	0.62	0.50	0.60
NN	0.65	0.50	0.63
DT	0.68	0.58	0.69

this model are connected. When training the model, the back-propagated loss is applied to both the first module and the second module. At the same time, the online behavior trajectory module will make corresponding adjustments according to the feedback of the students' basic feature module, and the students' basic feature module will also be affected by the characteristics of the students' online behavior trajectory [23].

2.4.3. Network Architecture Design. A total of eight neural network layers are built in the 2D-CNN part of the online behavior trajectory module. The first and fourth layers of the neural network layer are convolutional layers, and the same convolution is used at the same time, that is, the edge of the matrix is filled with 0, so that the dimension of the matrix will not change after the convolution operation.

$$x_n^i = f\left(\sum_{m\in N_m} x_n^{i-1} * k_{mn}^i + b_n^i\right). \tag{15}$$

The second and fifth layers of the neural network layer use a batch normalization layer. What it does is batch normalize the output of the previous convolutional layer. Its operation is shown in (16).

$$\hat{x}_n^i = f\left(W_m^i\right) down\left(x_n^i\right) + b_n^i. \tag{16}$$

To combine the features output by the convolutional and pooling layers, the extracted feature matrix is first flattened into a vector before the fully connected layer. The function of the Dropout network layer is to randomly hide some neuron nodes, which can prevent overfitting during training and improve the generalization ability of the model. Therefore, the eighth layer uses a Dropout network layer. For each student, the output for each day is a vector feature for a total of T vectors.

After the 2D-CNN part, the daily surfing behavior characteristics of each student are extracted. In the ninth hidden layer to obtain the time dependence, the calculation is as Formulas (17) and (18).

$$O_k = \delta\left(W^{(9)} * \left(h_{k-1}, x_k\right) + b^9\right), \tag{17}$$

$$h_k = O_k * \tanh\left(C_k\right). \tag{18}$$

A long short-term memory network has an output at each moment. Only output the value of the last moment, and then input this value into the tenth layer fully connected neural network, and the result obtained is the output of the online behavior trajectory module, as shown in Formula (19).

$$s^{tra} = f\left(W^{(10)} + h^T + b^{(10)}\right). \tag{19}$$

The basic feature module uses a fully connected neural network, and then the outputs of the two modules are connected together as the input of the next layer of fully connected neural network, and the connection operation is shown in Formula (20).

$$s^{concat} = f\left(W^{(11)} conxat\left(s^{tra}, s^{base}\right) + b^{(11)}\right). \tag{20}$$

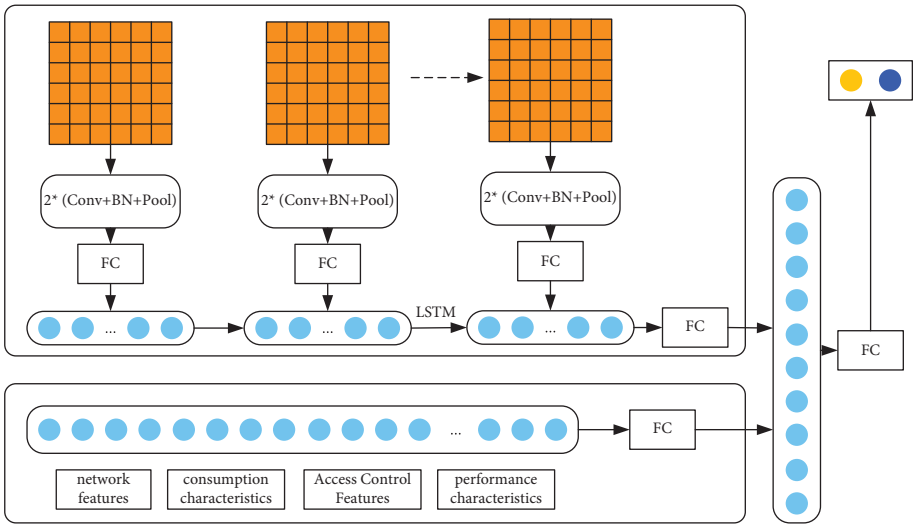

Figure 4: Mental health problem identification framework based on DeepPsy model.

In this study, the target is a binary classification problem, using the sigmoid function to convert the output into a number between 0 and 1, which represents the probability that the sample belongs to "1," and then output the class result.

3. PWB and Personality Data Experiments

3.1. Personality Evaluation and Prediction Based on Social Network. Through repeated training of the SVM algorithm, that is, the classic SVM-REF algorithm, the features corresponding to the optimal model are screened out, and 5 personality prediction models are constructed using these features. The experiment still used the scikit-learn library to improve the feature selection process. While calling its RFE interface, grid search is used to determine the optimal hyperparameters of the linear SVM during each round of training, and tenfold cross-validation is used in the training process. In the personality classification task of this experiment, there are a total of 42 image features. That is to say, a total of 42 models were constructed in the first round of the algorithm, and one feature would be removed at the end of one round of training. These 42 models are trained under the basic settings of grid search optimal hyperparameters and tenfold cross-validation. This allows the algorithm to obtain the optimal model under the current feature set for each round of execution. Finally, after the iteration of the SVM-RFE algorithm, an optimal model will be obtained, and the corresponding features of the model are the features after the feature selection operation. Next, the extracted features are applied to the experimental process, and there are only differences in the feature extraction stage, and other settings remain unchanged.

3.1.1. Experimental Results of Openness and Extraversion. It is worth noting that 18 of the 20 image style features extracted by the deep convolutional neural network appear in the above 30 features. It showed that the stylistic features of the avatar are more important to the openness model than the facial features of the avatar. When experimenting separately on face features and style features, the model built with style features is stronger than the model built with face features in both accuracy and F1 score. A comparison of the predictive effects of openness and extraversion is shown in Figure 5.

As shown in Figure 5, after the improvement, the average accuracy of the four open prediction models increased from 66.0% to 70.6%, and the average F1 increased from 66.2% to 68.1%. After the improvement, the average accuracy of the four extraversion prediction models increased from 56.3% to 59.6%, and the F1 average increased from 56.8% to 59.0%, and the overall model performance continued to improve. The accuracy and F1 value of the naive Bayesian and k-nearest neighbor classification models have improved significantly, the SVM classification model with Gaussian kernel has a small improvement in accuracy, while the accuracy of CART has hardly changed, and the F1 value has even declined. By using SVM-RFE to improve the feature selection method, the classification algorithm's prediction of openness personality reached the highest accuracy rate of 78.4% and the highest F1 value of 77.8%. It is proved that the proposed method of using avatar style and facial features to predict user's openness personality is effective. The experimental results of the openness prediction of multiple images published by users daily are analyzed. The openness experimental results are shown in Table 2.

As shown in Table 2, the overall performance of the classification model improved when inferring openness using multiple images posted daily by users, and when inferring user personality based on multiple images posted daily by users. The average accuracy of the four open prediction models increased from 70.6% to 78.0%, and the F1 average increased from 68.1% to 74.5%. Only the F1 value of the CART classification model decreased, by only 0.05. Among them, the accuracy and F1 value of the k-nearest neighbor algorithm was as high as 83.3% and 82.9%, which are the optimal performance indicators under the open

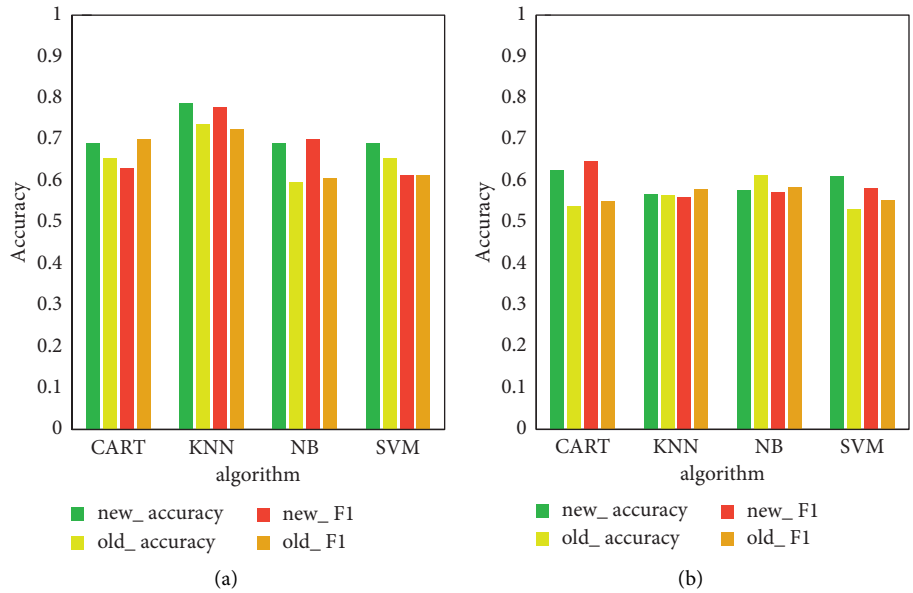

Figure 5: Comparison of predictive effects of openness and extraversion. (a). Comparison of predictive effects of openness. (b). Comparison of predictive effects of extraversion.

Table 2: Open experiment results.

Classification algorithm	Based on user avatar		Based on daily multiple images	
	Accuracy	F1	Accuracy	F1
RBF SVM	0.693	0.613	0.826	0.789
Naive bayes	0.692	0.702	0.750	0.733
k-NN	0.784	0.778	0.833	0.829
CART	0.654	0.632	0.712	0.627

Table 3: Extraversion test results.

Classification algorithm	Based on user avatar		Based on daily multiple images	
	Accuracy	F1	Accuracy	F1
RBF SVM	0.611	0.582	0.713	0.756
Naive bayes	0.577	0.572	0.721	0.709
k-NN	0.569	0.56	0.715	0.703
CART	0.627	0.647	0.700	0.670

prediction task. The performance improvement of Gaussian kernel SVM was the most obvious, the accuracy rate was increased by 0.133, and the F1 value was increased by 0.176. This not only proved the feasibility and effectiveness of using users' daily posted images to predict users' openness characteristics, but also further confirmed that when multiple images are used to predict users' openness, the performance of the model will be enhanced. The results of the extraversion experiment are shown in Table 3.

As shown in Table 3, the average value of F1 increased from 59.0% to 71.0%, and the overall model performance kept improving. The accuracy of all classification models exceeded 70.0%, the highest was 72.1% obtained by the Naive Bayes classification model, and the highest F1 value was 75.6% obtained by the Gaussian kernel SVM. Among them, the F1 value of the Gaussian kernel SVM increased by 0.174 before and after, and the accuracy of the k-nearest neighbor model increased by 0.146 before and after, and the improvement effect is the most obvious in the two evaluation standards.

3.1.2. Conscientiousness Test Results. When experimenting on conscientiousness through SVM-RFE, a total of 19 image features were screened out, and the comparison of the conscientiousness prediction effect is shown in Figure 6.

As shown in Figure 6, the features with the absolute value of the Pearson correlation coefficient greater than 0.1 were selected to participate in the training process of the conscientious personality classification model, and finally only 8 facial features were obtained. While using the SVM-RFE method to extract the coincident 5 facial features, 11 image style features were also extracted. While compared with the multisource experimental results, the average accuracy of the four improved conscientious prediction models increased from 63.5.0% to 65.3%, and the F1 average increased from 63.7% to 64.0%, and the overall performance of the model improved. The accuracy and F1 value of the Gaussian kernel SVM and the Naive Bayes classification model have improved, but the two evaluation indicators of the k-nearest neighbor model have both decreased. By changing the feature selection method, the highest prediction accuracy for conscientiousness was improved to 69.2% and the F1 value to 70.2%.

When using the image predictions published by users daily, due to the increase in the number of images, the two evaluation indicators of the four classification models of conscientiousness have all improved, and the same model has the same prediction effect in the two types of images. Among them, consistent with the results of experiments using avatars, the k-nearest neighbor model is still the worst

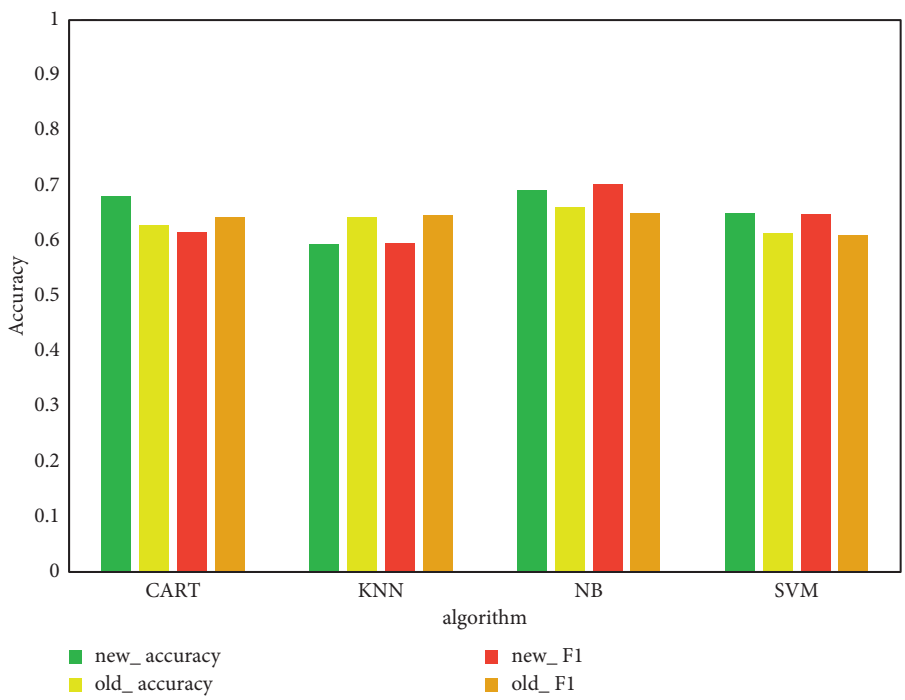

Figure 6: Comparison of the predicted effects of conscientiousness.

performing classification model in the conscientious prediction task. The Naive Bayes classification model maintains the best classification effect in both methods, and the results of the conscientiousness experiment are shown in Table 4.

As shown in Table 4, when inferring conscientiousness using images posted by users daily, the accuracy of the Naive Bayes classification model was 80.0%, and the F1 value was 79.2%, both of which were the optimal values for this task. The Gaussian kernel SVM has the highest accuracy improvement at 0.134. The F1 value of the CART classification algorithm has the most obvious improvement, with an increase of 0.139. Through this part of the experiment, it is found that when using multiple images published by users to predict conscientiousness, the classification models have excellent performance, and are better than when only one user image was used. The effectiveness of the experimental method and image features was verified. However, the highest prediction accuracy rate was only 80.0%, which also showed that although the features considered in the experiment are effective, they also have the problem of imperfect features.

3.2. Identification Results of Students' PWB Problems. Through each network layer in the DeepPsy model, the parameters of each layer would be described next. During model training, the number of iterations is 60, the batch_size is set to 4, and the optimization algorithm adopts Adam optimization. The experimental results of the DeepPsy model were compared. In order to facilitate the intuitive comparison, the two sets of results were displayed visually. The comparison effect between the DeepPsy model and the multisource data model is shown in Figure 7.

As shown in Figure 7, it can be seen that the DeepPsy model is higher than the multisource model in all the three evaluation indicators. In particular, the Recall indicator has the most obvious improvement. The goal is to identify students with PWB issues, hopefully identifying as many of these students as possible and giving them more attention. According to the definition of recall, this represents the proportion of positive samples that predicted students to positive samples that were actually positive. The Recall value of the model was been paid more attention to. The Recall of the DeepPsy model reached 0.75, which was 19% higher than that of the multisource algorithm, which meant that the model can identify 75% of students with PWB problems.

It is not known how the features affect the results. This paper uses these feature sets to train the model:

The feature types included in feature set I are: network feature, achievement feature, consumption feature, and access control feature. Feature set II removes network features on the basis of feature set I, including: performance features, consumption features, and access control features. Feature set II removes the achievement features on the basis of feature set II, including: consumption features, access control features. Feature set IV excludes consumption features on the basis of feature set II, and only includes access control features. The visualization of the experimental results of four different feature combination sets is shown in Figure 8.

As shown in Figure 8, the experimental result of feature set I is the best, and the experimental effect gradually deteriorates with the reduction of feature types, especially the decline of feature set IV is larger. This is because the number of consumption features is large, which greatly affects the

Table 4: Conscientiousness experiment results.

Classification algorithm	Based on user avatar		Based on daily multiple images	
	Accuracy	F1	Accuracy	F1
RBF SVM	0.647	0.646	0.781	0.742
Naive bayes	0.692	0.702	0.800	0.792
k-NN	0.594	0.596	0.636	0.630
CART	0.68	0.616	0.714	0.755

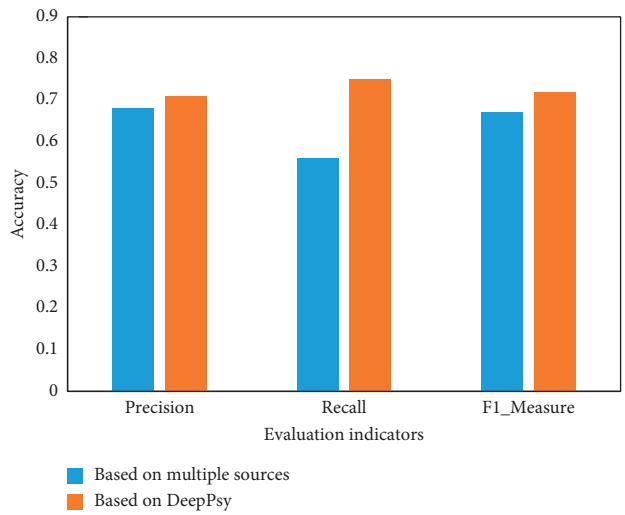

Figure 7: Comparison of DeepPsy model and multisource data model.

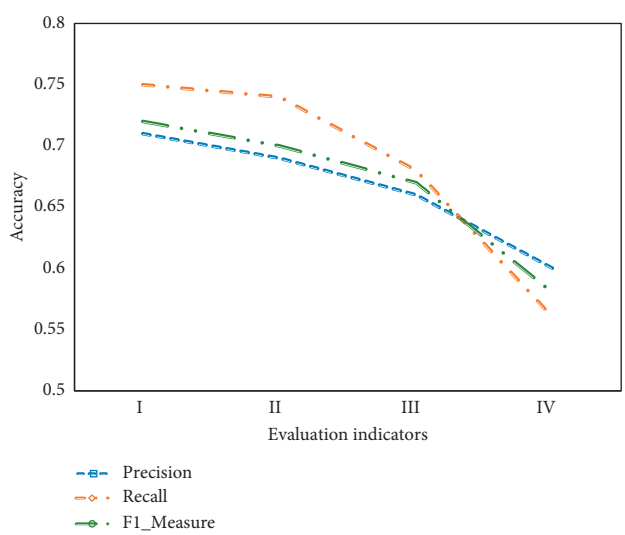

Figure 8: Visualization of experimental results for four different feature combination sets.

results. The number of iterations was seated to 60, for the parameter batch_size, if other parameters remain unchanged, also take $n = 1, 2, 3, 4, 5$, as shown in Figure 9.

Figure 9 illustrates how the number of convolution kernels is typically set to 2 when all other parameters are left unchanged. The five sets of experimental data are compared in Figure 9(a). Precision, Recall, and F1-Measure fluctuation ranges are, respectively, 4 percent, 6 percent, and 3 percent, showing that the number of convolution kernels in the first convolutional layer has no impact on the experimental outcomes. The five groups of experimental data are compared in Figure 9(b). Precision, Recall, and F1-Measure

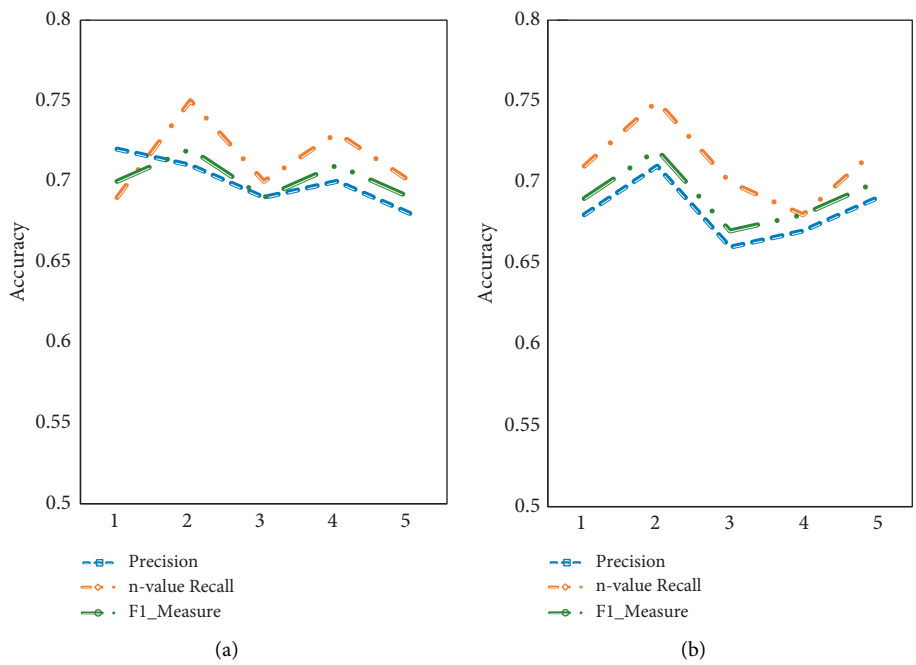

Figure 9: Experimental results. (a). Experimental results of different number of convolution kernels. (b). Experimental results of different batch_size.

fluctuation ranges are 5 percent, 7 percent, and 5 percent, respectively. The outcomes of the experiment are slightly more affected by batch size than by the quantity of convolution kernels in the first convolutional layer.

4. Conclusions

The traditional questionnaires on PWB problems have problems that are easy to conceal and small in scale. In recent years, methods for identifying PWB problems based on Internet logs have emerged. This method makes up for the shortcomings of the questionnaire survey method, but the students have various behaviors on campus, and online behavior is only a part of it, which is not enough to reflect all the psychological activities of students. At the same time, the method of identifying PWB problems based on Internet logs still uses questionnaires to obtain labels, so the labels are still unreliable. This paper uses multisource data to identify the PWB problems of college students, and proposes a PWB problem identification algorithm based on the DeepPsy model. Then, use user avatars for character data analysis to design a deep learning network that combines basic functions and online trajectory patterns. The experimental results showed that the proposed algorithm has higher practicability. The algorithm proposed in this paper identified those students with undiscovered PWB problems and personality defects, and can provide timely psychological counseling to these students to prevent further deterioration. In future work, it is hoped to be able to predict the severity of students' mental health problems.

Data Availability

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declare that there are no conflict of interest with any financial organizations regarding the material reported in this study.

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Research Article

Construction of the Mathematical Model for Teaching Classroom Evaluation in Colleges and Universities Using an Optimized Apriori Algorithm

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In order to increase the effectiveness and teaching quality of numerous classroom activities in colleges and universities, this paper puts forward the effectiveness assessment technique of teaching activities in colleges, universities, and institutions of higher education based on the optimized Apriori algorithm. A mathematical model for assessing the efficacy and usefulness of classroom activities in colleges and universities is constructed. Teaching contents, teaching attitudes, teaching methods, teaching effects, test results, and students' performance are introduced as comprehensive evaluation factors, and a decision-making model for assessing the success and efficiency of classroom activities in colleges and universities is established by adopting scientific, reasonable, and systematic teaching methods. Through the grey correlation analysis of classroom teaching quality, the delay characteristic analysis and the adaptive parameter adjustment method are adopted. This paper constructs the optimal Apriori algorithm model of college teaching classroom activities, constructs the optimal evaluation function model of college teaching classroom activities effectiveness evaluation by the method of support-confidence joint estimation, extracts the optimal quality parameter set of college teaching classroom activities by the optimization detection method and association rule mining, and realizes the effectiveness evaluation and multi-dimensional parameter estimation of college teaching classroom activities by the optimized Apriori algorithm. The test outcomes confirm that this technique is reliable in evaluating the effectiveness of classroom activities in colleges and universities, and the directional distribution of association rules of classroom quality in colleges and universities is significant, which meaningfully advances the classroom teaching levels and quantitative evaluation abilities.

1. Introduction

The effectiveness evaluation of teaching activities in colleges and institutions of higher education is the key to improve the quality of teaching activities. By adopting the quantitative index analysis method, this paper puts forward an effective assessment model of teaching accomplishments in colleges, universities, and institutions of higher education, analyzes the functional parameters of the effectiveness in evaluation of teaching accomplishments, and realizes the effectiveness evaluation and model parameter identification from different angles through different index parameter analysis [1]. In fact, this is of prodigious importance to increase the reliability and effectiveness of the effectiveness evaluation of teaching activities in colleges, universities, and institutions of higher education and to study the effectiveness evaluation methods of teaching activities in colleges and academies, so as to enhance the management of teaching activities and encourage the teaching reform in colleges and academia [2].

From the selection purpose of effectiveness assessment of teaching classroom activities in colleges and academies, the function of effectiveness evaluation of teaching classroom undertakings in colleges and academies can be expressed as follows: (i) the function of qualification appraisal, that is, the qualification standard is an important starting point to distinguish between qualified and unqualified ones; (ii) the evaluation of the effectiveness of teaching events in colleges and institutions of higher education also has the function of advanced selection, that is, the evaluation of the usefulness of teaching events in colleges and academies can distinguish

the advanced from the backward and encourage the advanced and spur the backward; and (iii) the third is the evaluation of the effectiveness of teaching undertakings in colleges and academies, which has the function of checking and accepting teaching results, that is, the evaluation of the usefulness of teaching happenings in colleges and academies can realize the acceptance, development, and promotion of teaching results. From the viewpoint of the influence of teaching assessment on the teaching practice, the functions of effectiveness evaluation of teaching classroom activities in colleges and academies can be expressed as follows: (i) to realize the functions of teaching judgment, that is, measurement evaluation, fact judgment, value judgment, problem diagnosis, discrimination, and selection; (ii) through evaluating the effectiveness of college classroom activities, improving teachers' teaching quality, adopting the evaluation model of college classroom activities, fully understanding students' starting point behavior, improving college classroom activities and teaching ability, providing reference for the effectiveness evaluation of college classroom activities, remedying the basis of teaching defects, and ensuring the achievement of teaching objectives, it can be seen and well-understood that the effectiveness evaluation of college classroom activities is a scientific and systematic project [3].

The effectiveness evaluation of classroom activities in colleges and academies is the basic work to promote the optimization of classroom teaching quality. In fact, it is not only an imperative part of teaching quality monitoring in colleges and academies but also a complex systematic project. Due to the complexity, fuzziness, and multi-factors of the teaching phenomenon in the effectiveness evaluation of teaching accomplishments in colleges and academies, there is a problem with qualitative analysis and accuracy in the effectiveness evaluation of teaching undertakings. By constructing an optimized assessment model of teaching actions in colleges and academies, combining with the teaching quality evaluation of the classroom, the scientific, reasonable, and fair index parameter analysis technique are implemented to comprehend the effectiveness analysis and dynamic assessment of teaching events in colleges and academies, thus ensuring and steadily improving the teaching quality [4]. Generally, the evaluation index system for the effectiveness evaluation of classroom actions in institutions of higher learning should include two factors: (i) one is the index that can fully reflect the effectiveness and teaching quality of classroom accomplishments in institutions of higher learning; and (ii) the other is the weight of each index on the effectiveness and importance of classroom happenings in institutions of higher learning.

Many domestic experts and instructors have made in-depth research on the production of the evaluation index system of the effectiveness of teaching happenings in institutions of higher learning, which can be divided into two approaches: (i) the first approach is the traditional technique, through the expert system analysis of the effectiveness evaluation of teaching accomplishments in colleges and academies, through which the experts of teaching activities in institutions of higher learning and educational management institutions formulate questionnaires containing evaluation indexes and weights, that is, learners are the chief body. With the aim of students' satisfaction, the scoring table of college teaching classroom activities is compiled, the mathematical statistics method of college teaching classroom activities is realized according to the optimized scoring method, and the preliminary survey data is processed to obtain the index system items and weights that cannot be obtained intuitively. Through the evaluation and detection of the effectiveness of college teaching classroom activities, the integration and database construction of the quality constraint parameters of college teaching classroom activities are carried out. Among the traditional methods, the evaluation of the quality constraint parameters of college teaching classroom activities mainly includes the fuzzy PID evaluation method and the evaluation method of college teaching classroom activities based on fuzzy parameter detection. By analyzing the quality parameters of college teaching classroom activities, the effectiveness of college teaching classroom activities are performed. In [4], a design approach for the effectiveness of intelligent control of college teaching classroom activities is proposed, which combines the distribution characteristics of mobile Internet and data analysis technology in college teaching classroom activities and improves the effectiveness of college teaching classroom activities through big data fusion. However, this method is ambiguous and has poor detection performance [5].

Aiming at the above problems, in this paper, we suggest an evaluation method of the effectiveness of college teaching classroom activities based on the optimized Apriori algorithm. Firstly, a mathematical model for assessing the usefulness of classroom activities in institutions of higher learning is constructed, and the teaching content, teaching attitude, teaching methods, teaching effect, test results, and students' performance are introduced as comprehensive evaluation factors. Secondly, a decision-making model for estimating the efficiency of classroom activities in colleges and universities is established by adopting scientific, reasonable, and systematic teaching methods. Through the grey correlation analysis of classroom teaching quality, the delay characteristic analysis and the adaptive parameter adjustment method are adopted. This paper constructs the optimal Apriori algorithm model of college teaching classroom activities, constructs the optimal evaluation function model of college teaching classroom activities effectiveness evaluation by the method of support-confidence joint estimation, extracts the optimal quality parameter set of college teaching classroom activities by the optimization detection method and association rule mining, and realizes the effectiveness evaluation and multi-dimensional parameter estimation of college teaching classroom activities by the optimized Apriori algorithm. To end with, the simulation-based experiments and test analysis demonstrations confirm the greater performance of this approach in increasing the effectiveness evaluation aptitude of college teaching classroom activities. The fundamental ideas presented in this article are as follows:

(i) A mathematical model for appraising the effectiveness of classroom activities in institutions of higher learning is constructed.

(ii) A decision-making model for appraising the usefulness of classroom accomplishments in institutions of higher learning is established.

(iii) This paper constructs the optimal Apriori algorithm model of college teaching classroom activities and constructs the optimal evaluation function model of college teaching classroom activities.

(iv) The attained outcomes indicate that this approach is reliable in evaluating the effectiveness of classroom accomplishments in colleges and institutions of higher learning.

The rest of the paper contents are organized in the following way. The numerical investigation and feature extraction of effective indicators of classroom accomplishments in institutions of higher learning are elaborated in Section 2. Optimization of the effectiveness evaluation algorithm of teaching classroom actions in institutions of higher learning are discussed in Section 3. This section also talks over the proposed methods and algorithms in detail. Simulation tests and outcomes are deliberated in Section 4. Lastly, Section 5 summarizes the article and puts forward numerous guidelines and suggestions for future research.

2. Statistical Analysis and Feature Extraction of Effective Indicators of Classroom Activities in Colleges and Universities

2.1. Statistical Analysis of Living Quality Indicators in College Teaching Classes. In order to realize and understand the construction and mathematical design of the effectiveness evaluation model for college teaching activities, the first approach is based on the Web Service platform. Furthermore, in order to realize the effectiveness evaluation of college teaching activities, the second approach is based on the optimized Apriori algorithm [6]. Firstly, an effectiveness characteristic analysis model of college teaching activities is built, and a distributed information perception model of college teaching activities is built by combining the analysis of index parameters of college teaching activities, and the characteristic sequence analysis of the time series of quality constraint parameters of college teaching activities is comprehended by conjoining the fuzzy correlation analysis approach [6, 7]. The overall realization structure of effectiveness evaluation of college teaching accomplishments is given away in Figure 1.

According to the general structure model of distributed effectiveness evaluation of college teaching classroom activities, as shown in Figure 1, the hierarchical weighted combination structure model of college teaching classroom activities quality constraint parameters is assembled. Moreover, the hierarchical feature information fusion coefficient of college teaching classroom activities quality constraint parameters is given by $W = \{u, w_1, w_2, \ldots, w_k\}$. Under the control of steady growth trend mode, the statistical feature quantity of feature parameter fusion of college teaching classroom activities quality constraint parameters is characterized by w_{tj}. Assuming that M university teaching classroom activity quality constraint parameters are transmitted to the link layer in layers, the principle of combining expert evaluation with mass evaluation is adopted. Through block regional integration, the hierarchical combination scheduling form of university teaching classroom activity quality constraint parameters is given by $x(k-1), \ldots, x(k-M)$. Similarly, the configuration model of the university teaching classroom activity effectiveness differential integration parameters is given by $x_s = [x(\eta_1), \ldots, x(\eta_N)]^T$. In last, the estimated value of regional module characteristics of university teaching classroom activity quality constraint parameters stored in layers is obtained using the following equation:

$$\hat{x}_s = W_s^T y, \tag{1}$$

where W_s^T is the joint decision-making parameter of the effectiveness of college classroom activities and y is the standard quantitative parameter of the quality constraint parameter of college classroom activities. A mathematical model of the effectiveness evaluation of college classroom activities is built, which takes teaching content, teaching attitude, teaching method, teaching effect, test results, and students' performance as comprehensive evaluation factors, adopts scientific, reasonable, and systematic teaching methods, establishes a decision-making model of the effectiveness evaluation of college classroom activities, and gets the effectiveness evaluation of college classroom activities based on the priority division method [7]. The index system of effectiveness evaluation of classroom activities in colleges, universities, and institutions of higher learning is given away in Figure 2.

The certain method is used to select the most critical factors as the evaluation indexes, and constructing the fusion characteristic parameter analysis model of the constraint parameters of teaching classroom accomplishments in colleges, academies, and institutions of higher learning is as follows in equations (2) and (3):

$$r(t) = \sum_i \sum_{j=0}^{N_f-1} \sum_{l=0}^{L-1} b_i \alpha_l p\left(t - iT_s - jT_f - c_j T_c - \tau_l\right) + \omega(t) = \sum_i \sum_{j=0}^{N_f-1} b_i p_h\left(t - iT_s - jT_f - c_j T_c - \tau_0\right) + \omega(t), \tag{2}$$

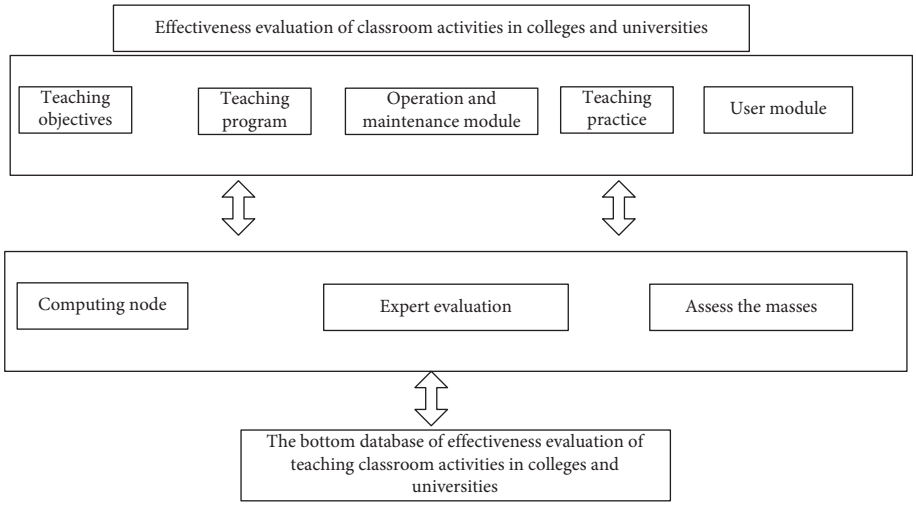

Figure 1: Overall implementation structure of effectiveness evaluation of distributed college teaching classroom activities.

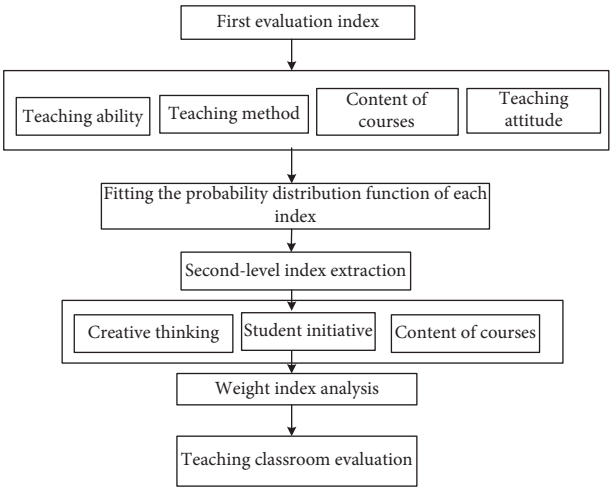

Figure 2: The Index system of effectiveness evaluation of classroom activities in colleges, universities, and institutions of higher learning.

where

$$p_h(t) = \sum_{l=0}^{L-1} \alpha_l p\left(t - \tau_{l,0}\right). \tag{3}$$

Furthermore, $\omega(t)$ is the dimension of hierarchical storage of quality constraint parameters of college teaching classroom activities and $p_h(t)$ is the joint feature distribution function of college teaching classroom activities. According to the above analysis, the weight of each index is determined and statistical analysis is performed to comprehend the effectiveness evaluation of teaching classroom activities in colleges and universities [8].

2.2. College Teaching Classroom Activity Quality Constraint Parameter Feature Extraction. Combining the fuzzy correlation analysis approach to comprehend the feature space structure reorganization of the time series of constraint parameters of college teaching classroom activities [9], and combining the analysis method of accumulating redundant parameters of college teaching classroom activities, a storage structure model of college teaching classroom activities quality distribution is created. Subsequently, the created model is improved through integrating the evaluation index system of college teaching quality and the fuzzy feature sampling information sample set of feature point i at t time is denoted as $(w_{1,j}, w_{2,j}, \ldots, w_{tj})$, whereas t represents the steady-state parameter of the characteristic distribution of the quality constraint parameters of college teaching classroom activities. Through spatial distributed grid matching, the block fusion judgment criterion of the quality constraint parameters, as given by two criteria denoted by equations (4) and (5), of college teaching classroom activities can be obtained:

Criterion (1):

$$\sqrt{\frac{R^2_{(m+1)n} - R^2_{mn}}{R^2_{(m+1)n}}} = \frac{\left|x_{\eta(n)+m\tau} - x_{n+m\tau}\right|}{R_{(m+1)n}} \geq R_{tol}. \tag{4}$$

Criterion (2):

$$\frac{R_{(m+1)n}}{\sqrt{1/N \sum_{k=1}^{2} \left[x_k - 1/N \sum_{k=1}^{N} x_k\right]^2}} > A_{tol}, \tag{5}$$

wherein, x_k is the hierarchical combination sequence of effectiveness evaluation of college teaching activities, A_{tol} is the decision threshold of effectiveness evaluation of college teaching activities, and $x_{\eta(n)+m\tau}$ is the output delay of effectiveness evaluation of college teaching activities. Moreover, $x_{n+m\tau}$ is the spatial fusion parameter of effectiveness evaluation of college teaching activities, $R_{(m+1)n}$ is the N-order decision statistical variable of effectiveness evaluation data of college teaching activities, and R_{tol} is the convergence threshold, and the sparse and heterogeneous characteristic point set of the ith constraint parameter of quality of college teaching activities is $P_i = (p_{i1}, p_{i2}, \ldots p_{iD})$. This should be noted that R_{mn} is the detection statistical distribution set of effectiveness evaluation of college teaching activities [10].

Combining the fuzzy correlation analysis approach to comprehend the feature space structure reorganization of the time series of the quality constraint parameters of college classroom activities [11] and combining the dynamic parameter analysis method, the hierarchical attribute feature quantity of the quality constraint parameters of college classroom activities is $\{u_1, \ldots u_N\}$. Based on the heterogeneous fusion of virtual spaces, the hierarchical fusion feature distribution set $\{v_1, \ldots, v_M\}$ of the effectiveness evaluation of college classroom activities is obtained, and through the semantic ontology fusion, the block detection feature quantity of the quality constraint parameters of college classroom activities is $R = [R_{u,v}]_{N\times M}$. According to the above analysis, the effectiveness evaluation and block detection of college classroom activities are realized [12].

3. Optimization of the Effectiveness Evaluation Algorithm of Teaching Classroom Activities in Colleges and Universities

3.1. Optimal Scheduling of Effectiveness Evaluation of Teaching Classroom Activities in Colleges and Universities. Through combining with the template feature matching approach, the weighting coefficients of the effectiveness evaluation of college teaching classroom activities are obtained [13]. Subsequently, the fuzzy similarity feature quantity of the effectiveness evaluation of college teaching classroom activities is established, and the statistical feature quantity of the distribution feature set of the effectiveness evaluation of college teaching classroom activities is calculated. Finally, the trust level of the effectiveness evaluation of college teaching classroom activities and actions is acquired as follows in the following equation:

$$I\mathrm{Trust}_{a\longrightarrow c} = \frac{\sum_{b\in adj(a,c)} D\mathrm{Trust}_{a\longrightarrow b} \times \left(D\mathrm{Trust}_{b\longrightarrow c} \times \beta_d\right)}{\sum_{b\in adj(a,c)} D\mathrm{Trust}_{a\longrightarrow b}}, \tag{6}$$

where β_d is the multi-port matching node of the effectiveness evaluation of college teaching classroom activities under the multi-dimensional feature distribution mode, D is the sample regression distribution set, and $\mathrm{Trust}_{b\longrightarrow c}$ is the trust function of the effectiveness evaluation of college teaching classroom activities [14, 15]. According to the spectrum feature decomposition, calculate the parameter matching feature quantity of the quality constraint parameters of college teaching classroom activities and get the standard normal distribution of β_d. The analytical model of the joint autocorrelation constraint parameters for the effectiveness evaluation of college teaching classroom activities is as follows:

$$\beta_d = \frac{(MPDist - d + 1)}{MPDist, d \in [2, MPDist]}, \tag{7}$$

where $adj(a, c)$ represents the amount of output reconstruction feature vectors $a \longrightarrow c$ of the effectiveness evaluation of college teaching classroom activities. Considering a number of wide-ranging assessment indexes of the usefulness of teaching accomplishments in colleges and academies, the characteristic recombination model of the quality constraint parameters of teaching accomplishments in colleges and academies, the correlation mapping is expressed as $A \longrightarrow B$, $B \longrightarrow C$. This should be noted that the regression analysis model of the effectiveness assessment parameters of teaching activities in schools and institutions of higher education is as follows:

$$MSD_{a\longrightarrow b} = 1 - \frac{\sum_{i=1}^{|I_{a,b}|} \sqrt{\left(d_{a,i} - \overline{d}_a\right)^2 + \left(d_{b,i} - \overline{d}_b\right)^2}}{\left|I_{a,b}\right| \times \sum_{i=1}^{|I_{a,b}|} \left[\sqrt{\left(d_{a,i} - \overline{d}_a\right)^2} + \sqrt{\left(d_{b,i} - \overline{d}_b\right)^2}\right]}, \tag{8}$$

where $d_{a,i}$ is the adjustment parameter of the effectiveness evaluation of college teaching classroom activities, $\overline{d}_a$ is the supply chain parameter of the effectiveness evaluation of college teaching classroom activities, and $d_{a,i}$ is the characteristic quantity of block sample regression analysis of the effectiveness evaluation of college teaching classroom activities, using statistical analysis method [16, 17].

By using the analytical target cascading (ATC), the mutual information of hierarchical evaluation of the usefulness of teaching happenings in colleges and academies is as follows:

$$I(Q, S) = H(Q) - H(Q|S), \tag{9}$$

where

$$H(Q|s_i) = -\sum_j \left[\frac{p_{sq}(s_i, q_j)}{p_s(s_i)}\right] \log_2 \left[\frac{p_{sq}(s_i, q_j)}{p_s(s_i)}\right], \tag{10}$$

where $H(Q)$ is the cooperative probability magic parameter of the effectiveness evaluation of college teaching classroom activities and $H(Q|S)$ is the relevant probability density. Similarly, $p_{sq}(s_i, q_j)$ is the cooperative statistical parameter of the time series of the quality constraint parameters of college teaching classroom activities and $p_s(s_i)$ is the autocorrelation information component. Combined with the mutual information feature matching, the effectiveness evaluation of college teaching classroom activities is analyzed [18, 19].

Table 1: The descriptive statistical study outcomes of quality constraint parameters of college teaching classroom activities.

Sample set	Data size	Regression value	Quadratic fitting	Statistical value
Attendance rate	407	0.935	0.080	0.504
Classroom performance	408	0.963	0.689	0.303
Job completion	426	0.879	0.129	0.732
Teaching objectives and conditions	414	0.745	0.234	0.131
Evaluation scheme	413	0.786	0.638	0.904
Evaluator	423	0.528	0.523	0.478
Evaluation	411	0.460	0.642	0.990
Information materials	406	0.930	0.806	0.855
Synthetic judgment	427	0.236	0.914	0.346
Didactics	409	0.229	0.398	0.547
Classroom theory	408	0.387	0.174	0.703

3.2. Optimization of Effectiveness Evaluation of Classroom Activities in Colleges and Universities. The optimal Apriori algorithm model, in particular for college classroom activities, is created, and the optimal evaluation function model of the effectiveness assessment of college classroom activities is constructed by the method of joint estimation of support and confidence. The constraint parameter set of college classroom activities quality is obtained by the method of multiple evaluations $X = \{x_1, x_2, \ldots, x_n\}$; n is the amount of data set X, and the P-dimensional vector of fluctuation characteristics of each element table is in $\{x_{i1}, x_{i2}, \ldots, x_{im}\}$ D. The similarity characteristic variable of the time series of the quality constraint parameters of college classroom activities at the ith moment is SD, and the correlation distribution type of the corresponding time series of the quality constraint parameters of college classroom activities is y_i, with the value of 1 or −1, where 1 represents normal and −1 represents abnormal [20]. The optimal quality parameter set of college classroom activities is extracted by implementing the optimization detection approach and association rule mining, and the effectiveness evaluation and multi-dimensional parameters of college classroom activities are realized by using the optimized Apriori algorithm. Through applicability analysis and model measurement analysis, the results show that the following criteria is met:

$$p_i^* = \frac{1}{\sum_{j=i}^{N} 2m_j / \sum_{k=j+1}^{N+1} L_k p_k - \sum_{k=j}^{N} E_k} - 1, \quad i = 1, \ldots, N+1, \tag{11}$$

where $CIntra_i(n)$ is characterized to designate the optimal interval between visiting nodes for the effectiveness evaluation of classroom activities in colleges and universities and $CInter_i(n)$ indicates the distribution time slot of quality constraint parameters of classroom activities in colleges and universities. Through applicability analysis and model measurement analysis, the scheduling and information fusion of quality constraint parameters of classroom activities in colleges and universities are comprehended, and the optimal scheduling model is achieved as follows using equations (12) and (13):

$$\operatorname{sgn}[x] = \begin{cases} 1, & x \geq 0, \\ -1, & x < 0, \end{cases} \tag{12}$$

$$w(n) = \begin{cases} \dfrac{1}{2N}, & 0 \leq n \leq N-1, \\ 0, & \text{else}, \end{cases} \tag{13}$$

where N represents the distribution node of the effectiveness evaluation data of college teaching classroom activities, thus obtaining the average membership degree of each kind of samples in the time series of the quality constraint parameters of college teaching classroom activities $E_j = \sum F_{ij} K_j (i \in K_j, \quad j = 1, 2, \ldots, N$, and K_j is the entire quantity of samples in the time series of the jth class of college teaching classroom activities, and the distribution value of the test statistics of the effectiveness evaluation of college teaching classroom activities is $BL \times K_j (j = 1, 2, \ldots, N)$ [21–23]. In fact, through adopting the joint parameter analysis method, realize the scheduling and information fusion of the quality constraint parameters of college teaching activities, such as SDF, adopt the optimization detection method and association rule mining, extract the optimal quality parameter set of college teaching activities, and adopt the optimized Apriori algorithm to realize and comprehend the effectiveness evaluation and multi-dimensional parameter estimation of college teaching activities.

4. Simulation Tests and Results

On the foundation of the certain assumptions, simulation tests, and SPSS statistical exploration method, the application performance of the suggested approach for the assessment of the effectiveness of college teaching classroom activities is verified [24]. The descriptive statistical analysis and attained outcomes of the sampling of constraint parameters of college teaching classroom activities are shown in Table 1 below.

Based on the descriptive statistical investigation and the achieved outcomes, as shown in Table 1, the effectiveness evaluation and scheduling of teaching classroom activities in schools and institutions of higher education are realized. The distribution amplitude of data sampling is shown in Figure 3.

Taking the sample sequence of Figure 4 as the research object, the Apriori algorithm model for optimizing college teaching classroom activities is constructed, and the optimization evaluation function model for evaluating the effectiveness of college teaching classroom activities is constructed by the method of joint estimation of support and confidence, so as to realize the evaluation of teaching effect. The convergence curve distribution of the evaluation is shown in Figure 4.

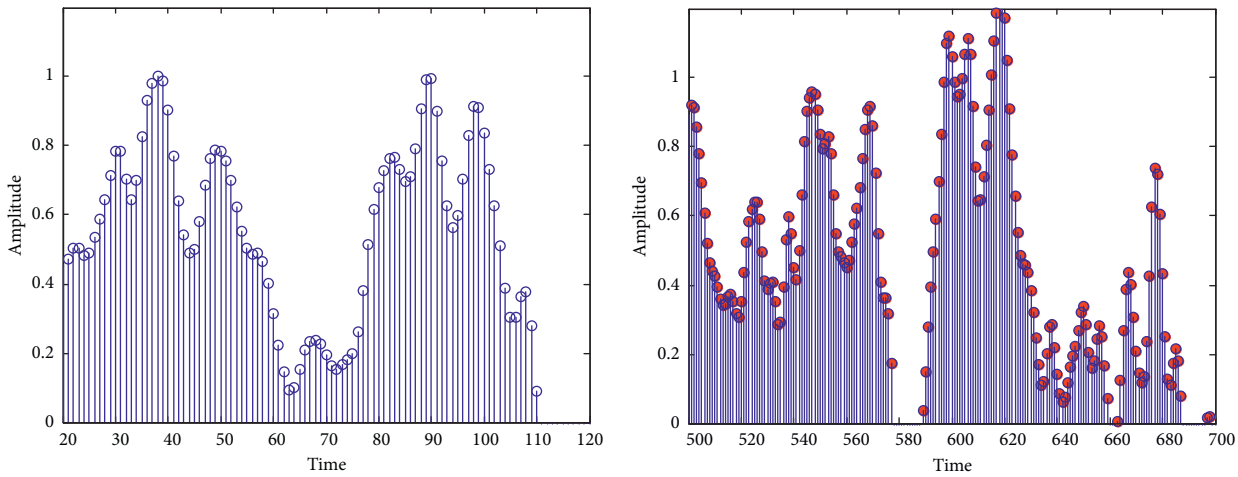

Figure 3: Sampling distribution amplitude of quality constraint parameters of college teaching classroom activities. (a) Test sequence. (b) Training sample sequence.

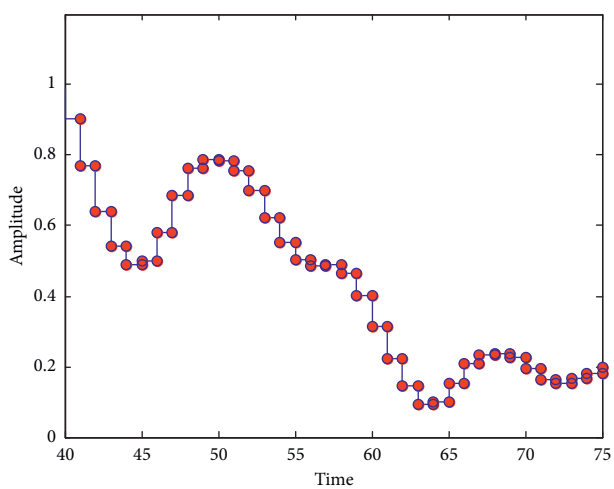

Figure 4: Convergence curve of teaching effect evaluation.

Table 2: Comparison of accuracy of quality evaluation of classroom activities in schools and institutions of higher education.

Test times	Method of this paper	[4]	[5]
10	0.931	0.623	0.613
20	0.940	0.619	0.597
30	0.929	0.617	0.589
40	0.943	0.620	0.602
50	0.925	0.626	0.625
60	0.927	0.625	0.619
70	0.919	0.627	0.628
80	0.923	0.621	0.606
90	0.928	0.623	0.613
100	0.919	0.621	0.606
110	0.916	0.624	0.616
120	0.912	0.627	0.631
130	0.917	0.620	0.599
140	0.906	0.621	0.604
150	0.938	0.626	0.625
160	0.937	0.613	0.570

According to the analysis of Figure 4, this method can effectively evaluate the quality constraint parameters of college classroom activities, improve the clustering level of data and test the fusion degree of different methods in evaluating the quality constraint parameters of college classroom activities. The assessment and comparative outcomes with the [4, 5], are given away in Table 2, which shows that the correctness of the suggested approach in evaluating the quality of college classroom activities is high.

5. Conclusions and Future Research

In this paper, the effectiveness assessment method of college teaching classroom activities grounded on the optimized Apriori algorithm is proposed. A mathematical model for assessing the usefulness of classroom activities in colleges and universities is constructed. Teaching contents, teaching attitudes, teaching methods, teaching effects, test results, and students' performance are introduced as comprehensive evaluation factors, and a decision-making model for assessing the usefulness of classroom activities in colleges and universities is established by adopting scientific, reasonable, and systematic teaching methods. Through the grey correlation analysis of classroom teaching quality, the delay characteristic analysis and the adaptive parameter adjustment method are adopted. This paper, firstly, constructs the optimal Apriori algorithm model of college teaching classroom activities. Secondly, it constructs the optimal evaluation function model of college teaching classroom activities effectiveness evaluation by the method of support-confidence joint estimation. Thirdly, it extracts the optimal quality parameter set of college teaching classroom activities by the optimization detection method and association rule mining and, finally, realizes the effectiveness evaluation and multi-dimensional parameter estimation of college teaching classroom activities by the optimized Apriori algorithm. The research demonstrates that the approach implemented in this work is trustworthy in evaluating the effectiveness of

classroom accomplishments in colleges and academies, and the directional distribution of association rules of classroom quality in colleges and academies is significant, which improves the classroom teaching level and quantitative evaluation aptitude in schools and institutions of higher education.

We believe that the suggested method has a good application value in classroom teaching assessment in schools and academies. Therefore, in the future we will continue suggesting more robust and effective algorithms so that the task can be optimized. In essence, we will consider particle swarm and other evolutionary methods because they have shown good results in similar optimization problems. Furthermore, we will increase the amount of objectives and transform the problem into many-objective optimization issues and then will suggest some swarm evolutionary methods to improve the optimization results.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Research on Personalized Recommendation Method of Intangible Social Heritage and Materials in Schools under Double Reduction Policy

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Individualized recommendation of imperceptible social heritage and materials in schools under the double reduction policy is to evaluate and judge students' learning interests and specialties and recommend suitable imperceptible social heritage and materials to students. Aiming at the problem that the collaborative filtering recommendation method does not match the individualized needs of primary and secondary school students under the double reduction policy, in this paper, we suggest a personalized recommendation system of imperceptible social heritage and materials in schools under the double reduction policy based on joint template feature matching and interest feature point mining. First, taking the information management platform of imperceptible social heritage and materials in schools as the structural model, the grading model and homomorphic distribution attribute model of imperceptible social heritage and materials for primary and secondary school students under the double reduction policy are constructed. Second, the probability density characteristic analysis method of joint template matching is used to construct the personalized recommendation model of the imperceptible social heritage and materials in schools. Third, then the personalized characteristic distribution and fitness parameter extraction of the imperceptible social heritage and materials in schools under the double reduction policy are carried out, so as to realize the reasonable matching of personalized characteristic requirements and project interest points and realize the personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy. Finally, a simulation experiment was carried out to test and evaluate the outcomes. The outcomes express that the personalized recommendation items of imperceptible social heritage and materials in schools with this method have higher scores, and the average absolute error and root mean square error are smaller, which improves the quality of dynamic and accurate matching between imperceptible social heritage and materials and students' hobby characteristics.

1. Introduction

The implementation of the policy of "double reduction" in education is the main way to implement our party's and government's educational policies. The improvement of school education quality and the healthy development of middle school students is also an important opportunity for the deepening of school education reform. Therefore, in the classroom teaching of rural junior middle schools, it is necessary to actively implement the "double reduction" policy and pay attention to the all-round development of students and their growth and development needs. Through the improvement of teaching quality inside the school and the standardization of training institutions outside the school, the efficient teaching can be realized, and at the same time, the learning burden of students can be reduced. Under the double reduction policy, people pay attention to how to carry forward Chinese cultural traditions and improve the learning quality of primary and secondary school students.

In fact, this is of prodigious importance to build a personalized recommendation model of imperceptible social heritage and materials in schools and to develop and design a personalized recommendation model of imperceptible social heritage and materials in schools under the double reduction policy, which will improve the push degree of imperceptible social heritage and materials in schools. Furthermore, it will also improve and progress the audience and teaching quality level of imperceptible social heritage and materials in schools. This should be noted that it is of prodigious importance to examine and investigate the personalized recommendation model of imperceptible social heritage and materials in schools under the double reduction policy of primary and secondary school students.

Individualized recommendation of imperceptible social heritage and materials in schools under the double reduction policy is based on the matching relationship between the individualized characteristics of primary, as well as, the secondary school pupils under the policy of double reduction. Moreover, by browsing and evaluating the prior information of school learners under the policy of double reduction, the individualized needs are formulated, and the resource distribution structure of imperceptible social heritage and materials and the needs of primary, as well as, the secondary institute pupils under the policy of double reduction are comprehensively considered. In fact, the personalized service items are formulated to realize information push and web page recommendations, which lays the foundation for a more efficient network experience. At the moment, the usual and classical personalized recommendation approaches predominantly include the collaborative filtering recommendation method, as suggested in Ref. [1], the recommendation method based on meta-path attention mechanism, and the recommendation model of penetration path based on reinforcement learning [2].

However, with the increase of the scale of imperceptible social heritage and materials in schools and the diversified growth of primary, as well as, the secondary college students' information under the policy of double reduction, the accuracy of recommendation is not high, while the matching degree of collaborative filtering recommendation method to the individualized needs of school scholars under the policy of double reduction is also not high. Therefore, in order to solve the inadequacies of classical and old style approaches, in this paper, we suggest a personalized recommendation algorithm of imperceptible social heritage and materials in schools under the double reduction policy based on joint template feature matching and interest feature mining. First, taking the information management platform of imperceptible social heritage and materials in schools as the structural model, the grading model and homomorphic distribution attribute model of imperceptible social heritage and materials for primary and secondary school students under the double reduction policy are constructed.

The probability density characteristic analysis method of joint template matching is used to construct the personalized recommendation model of the imperceptible social heritage and materials in schools, and then the personalized characteristic distribution and fitness parameter extraction of the imperceptible social heritage and materials in schools under the double reduction policy are carried out, so as to realize the reasonable matching of personalized characteristic requirements and project interest points and realize the personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy. Finally, the performance test through simulation experiment shows the superiority of this method in improving recommendation quality. The fundamental contributions of the work presented in this paper are as follows:

(i) In this paper, we suggest a personalized recommendation procedure under the double reduction policy based on joint template feature matching and interest feature point mining.

(ii) Taking the information management platform as the structural model, the grading model and homomorphic distribution attribute model of imperceptible social heritage and materials under the double reduction policy are constructed.

(iii) The probability density characteristic analysis method of joint template matching is used to construct the personalized recommendation model.

(iv) The personalized characteristic distribution and fitness parameter extraction of the imperceptible social heritage and materials under the double reduction policy are carried out, so as to realize the reasonable matching of personalized characteristic requirements and project interest points under the double reduction policy.

The remaining part of the manuscript is structured as discussed in the subsequent statements. The model building and information preprocessing are presented in Section 2. The suggested algorithm for optimization and its implementation is debated in Section 3. Analysis of investigational outcomes and conversation is given in Section 4. To conclude, Section 5 completes this study and discusses several guidelines and recommendations for future research.

2. Model Building and Information Preprocessing

2.1. Distribution Structure Model and Recommendation Rules of Cultural Materials of Imperceptible Social Heritage. The collaborative recommendation technology deliberated in this paper is founded on the information management platform model of imperceptible social heritage in schools. The information management platform of imperceptible social heritage in schools is a network composed of the matching relationship of all primary and secondary school students' personalized characteristics in the distribution network of imperceptible social heritage, which is abstracted into the trust communication mechanism of the network through the relationship between primary and secondary school students under the double reduction policy. Considering the trust model and confidence of network nodes, the project attribute classification and subject matching are carried out. According to the multi-agent negotiation

mechanism, the trusted nodes are located and the trust degree of primary and secondary school students is analyzed under the double reduction policy. Thus, the overall structure model of personalized recommendation of imperceptible social heritage and materials in schools is obtained as shown in Figure 1.

According to the overall design of personalized recommendation model of schools' imperceptible social heritage and materials under the double reduction policy, the information management platform of schools' imperceptible social heritage and materials will integrate the trust and interest features of primary and secondary school students under the double reduction policy, build a network structure model, and carry out the feature retrieval of college students' information under the policy of double reduction. Moreover, the trust relationship model of university scholars under the double reduction policy in the information management platform of schools' imperceptible social heritage and materials is expressed in the form of the following undirected graph model [3, 4]: $G = (V, E, C)$. In which, V represents the node set of collaborative filtering of the information management platform of imperceptible social heritage in schools, and each node represents the individual primary and secondary school students under the double reduction policy in the network; E represents the set of edges, representing the correlation recommended by friends of social networks, and the correlation characteristics existing between two individuals; indicates the weight value of $C = \{c_{uv}\}$ edge. The greater the weight, the higher the trust, and the better the accuracy of the recommendation [5, 6].

Assuming that the edges in the information management platform diagram of imperceptible social heritage in schools are directed and the network diagram is directed, in the personalized recommendation system of imperceptible social heritage in schools under the double reduction policy, $\{u_1, ..., u_N\}$ stands for the set of elementary and secondary school students under the double reduction policy, $\{v_1, ..., v_M\}$ stands for the set of untrustworthy nodes, and $R = [R_{u,v}]_{N\times M}$ stands for the score matrix of primary and secondary school students under the double reduction policy, where $R_{u,v}$ stands for the evaluation of primary and secondary school students' attribute interest in item V under the double reduction policy under the constraint of association rules. $R_{u,v}$ can be any real number. In social networks, the scores of primary and secondary school students can reasonably reflect the quality of the recommended model under the double reduction policy determined by data sparsity [5]. Therefore, it is not uncommon to use the scoring mechanism to evaluate the quality of the recommended model. In this paper, the scoring interval of students is set to [0, 1]. By using the scoring method of primary, as well as, the secondary college students' items under the policy of double reduction, the semantic features of school and college students' items under each double reduction policy are expressed as: the correlation matching degree of network distribution units to nodes is expressed, and its values range from [0, 1], with 0 indicating complete mismatch and 1 indicating complete matching.

According to the trust model and recommendation rules of the information management platform of imperceptible social heritage in schools set above, the density expression of characteristic probability function of primary and secondary school students' trust evaluation under the double reduction policy is obtained as follows in equation (1):

$$p(y|\alpha, \theta) = \sum_{k=1}^{K} \alpha_k p_k \left(y \mid \mu_k, \sum_k \right). \tag{1}$$

The feature vector retrieval technology [7, 8] to search the prior feature information of school students under the policy of double reduction in the feature space of mutual trust is used, the key information retrieval vector model of primary and secondary school students' interests and hobbies under the double reduction policy in the retrieval area is given by equation (2):

$$\Delta d = \frac{1}{2} \times t \times u \times \sum_{i=1}^{t} \sum_{j=1}^{u} \left\| \bar{d}_i - \mathrm{M}\hat{d}_i^{j} \right\|^2. \tag{2}$$

The semantic concept tree [9] and analysis of the binary relationship between student object and item attribute set in the information management platform of imperceptible social heritage in schools are constructed. The binary feature tree [10] $K = (O, a, r)$ to describe the information distribution list of personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy is constructed, where o is the collection of primary and secondary school students' objects under the policy and strategy of double reduction, a is the collection of items to be recommended in the information management platform of imperceptible social heritage and materials in schools, and r is a binary relationship between o and a. The spatial dimension of the prediction score of personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy is set as M. Through the evaluation of personalized characteristics of primary and secondary school students' interests under the double reduction policy, the correlation degree between primary and secondary school students' behaviors and preferences under the double reduction policy is obtained as follows in equation (3):

$$x_t = \mathrm{MSF}(t) \sum_{k \in K_t} \beta_{t,k}. \tag{3}$$

Based on the analysis of the correlation between behavior and preferences, the scores of school pupils under the strategy of double reduction are mapped to the [0, 1] interval, and the prediction model of primary, as well as, the secondary school students' scores under the strategy and policy of double reduction of the recommended model is constructed.

2.2. Construction of Personalized Recommendation Model of Imperceptible Social Heritage and Materials in Schools. Using the probability density characteristic analysis method [11, 12] of joint template matching, the personalized

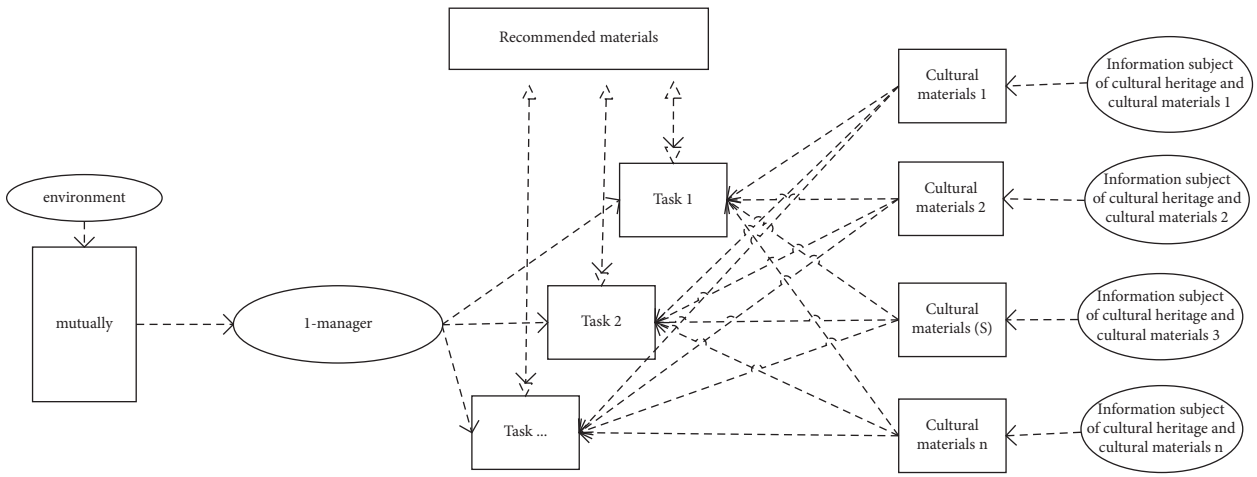

Figure 1: Overall structure model of personalized recommendation of imperceptible social heritage and materials in schools.

recommendation model of imperceptible social heritage and materials in schools is constructed. The conditional probability formula of the trust degree of any two items X and Y recommended to primary and secondary school students under the social double reduction policy is as follows in Equations (4) to (6):

$$\text{WebJaccard}\,d(X,Y) = \frac{P(X\cap Y)}{P(X)+P(Y)-P(X\cap Y)}, \tag{4}$$

$$\text{WebOverlap}(X,Y) = \frac{P(X\cap Y)}{\min\,(P(X),P(Y))}, \tag{5}$$

$$\text{WebDice}(X,Y) = \frac{2P(X\cap Y)}{P(X)+P(Y)}, \tag{6}$$

where $P(X)$ and $P(Y)$ are the comprehensive weights of the imperceptible social heritage cultural recommendations of projects X and Y, respectively, and are joint conditional probability density functions, which represent the distribution weights of the accurate scores of imperceptible social heritage cultural recommendations of projects X and Y in the [0, 1] interval. Revise each vector v_i, and the process of predicting and scoring all items is represented by vi, that is $v_i = ((w_1,t_1),(w_2,t_2),\ldots(w_m,t_m))$. To calculate the central vector $C(Y)$ of each personalized feature distribution in the information management platform of imperceptible social heritage in schools, the formula for calculating the trust degree of X and Y is mathematically illustrated in Equation (7):

$$\text{Sim}(X,Y) = \text{Cos}(X,Y) = \frac{C(X)\cdot C(Y)}{|C(X)|\cdot|C(Y)|}. \tag{7}$$

Ignore the link structure information of the cultural materials of imperceptible social heritage in schools, and conduct information retrieval according to the differentiated characteristics of primary and secondary school students' prior keyword semantic information w_1 and w_2 under the double reduction policy. The effective value of the retrieval is $\text{dis}(w_1,w_2)$, which indicates the degree of understanding and acceptance of students in the cultural materials of imperceptible social heritage in schools.

The revised weights of the personalized recommendation model of the imperceptible social heritage and materials in schools of all neighboring nodes $v \in N_u$ established are mathematically expressed in equation (8):

$$\overline{R}_{ik} = \sum_{j\in N_u} C^*_{i,j} R_{jk}, \tag{8}$$

where $\overline{R}_{ik}$ represents the direct trust of primary and secondary school students' u_i to project v_j under the double reduction policy, R_{jk} represents the extracted value of interest characteristics of primary and secondary school students' u_j to the overall structural information of project v_k under the double reduction policy, and $C^*_{i,j}$ is a modified weighted vector. Then, the predicted score of primary and secondary school students' U to semantic information retrieval under the double reduction policy in the information management platform of imperceptible social heritage in schools can be expressed as follows in equation (9):

$$\begin{pmatrix} \overline{R}_{i,1} \\ \overline{R}_{i,2} \\ \ldots \\ \overline{R}_{i,m} \end{pmatrix} = \begin{pmatrix} R_{1,1} & R_{2,1} & \ldots & R_{n,1} \\ R_{2,1} & R_{2,2} & \ldots & R_{n,2} \\ \ldots & \ldots & \ldots & \ldots \\ R_{1,K} & R_{2,K} & \ldots & R_{n,m} \end{pmatrix} \begin{pmatrix} C^*_{i,1} \\ C^*_{i,2} \\ \ldots \\ C^*_{i,n} \end{pmatrix}. \tag{9}$$

According to the actual situation of the collaborative filtering system, combined with the behavior characteristics and interest distribution of primary and secondary school students under the double reduction policy, the recommendation model is constructed.

3. Algorithm Optimization Implementation

3.1. Question and Personalized Characteristics Analysis. On the basis of the design of the network structure model and the construction of recommendation rules, the optimization design of the collaborative filtering algorithm [13] is carried out. In this paper, a personalized recommendation

algorithm of schools' imperceptible social heritage and materials based on the double reduction policy of joint templating feature matching [14] and interest feature mining [15] is proposed, and the personalized recommendation model of schools' imperceptible social heritage and materials is constructed by using the probability density feature analysis method of joint templating matching. The personalized feature distribution and fitness parameter extraction of the imperceptible social heritage and materials in schools under the double reduction policy are carried out. Based on the recommendation constraint model of credibility, the fuzzy distribution matrix C_{kv}^{*} of personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy is constructed according to the revised weights. Therefore, for the recommended items, the trust matrix satisfies the constraint as given in equation (10):

$$\overline{R} = TR. \tag{10}$$

In the joint recommendation of student a to primary, as well as, the secondary school students' neighbor node B under the strategy and policy of double reduction, the conditional probability of primary, as well as, the college and secondary school students' scoring under the strategy of double reduction is expressed as follows in equation (11):

$$p\left(R \mid U, V, \sigma_R^2\right) = \prod_{i=1}^{n}\prod_{j=1}^{m}\left[N\left(R_{ij} \,\middle|\, g\left(U_i^T V_j\right), \sigma_R^2\right)\right]^{I_{ij}^R}, \tag{11}$$

where $N(x \mid \mu, \sigma^2)$ indicates that the item characteristic distribution variable x obeys a standard normal distribution with mathematical expectation μ and standard variance σ^2, and $I_{ij}^R$is a sparse indicator function. If the primary and secondary school students' u_i have personalized demand for items v_j under the double reduction policy, the score indicator is 1; otherwise, the score indicator is 0, thus completing the personalized characteristic analysis of primary and secondary school students under the double reduction policy [16].

3.2. Implementation of Personalized Recommendation Algorithm for Imperceptible Social Heritage and Materials in Schools. Taking the information management platform of imperceptible social heritage in schools as the structural model, the grading model and homomorphic distribution attribute model of imperceptible social heritage in schools under the double reduction policy are constructed [17]. Starting from the social trust network, the matching probability distribution of personalized feature demand is as follows in equation (12):

$$p\left(R \mid T, U, V, \sigma_R^2\right) = \prod_{i=1}^{n}\prod_{j=1}^{m}\left[N\left(R_{ij} \,\middle|\, g\left(\sum_{k \in N_u} w_{ik} U_k^T V_j\right), \sigma_T^2\right)\right]^{I_{ij}^R}. \tag{12}$$

Based on the analogical explanation of the recommendation of cultural materials of imperceptible social heritage in schools under the double reduction policy, the Bayesian inference [18, 19] can be used to obtain the following expression in equation (13):

$$p(y|\alpha, \theta) = \sum_{k=1}^{K} \alpha_k p_k\left(y|\mu_k, \sum_k\right). \tag{13}$$

In the mutual information area of feature space, if the scoring model and project attributes are independent of each other, the trust weight of personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy is expressed as follows in equation (14):

$$\begin{aligned} p\left(U, V \mid R, w, \sigma_w^2, \sigma_U^2, \sigma_V^2\right) &\propto p\left(R \mid w, U, V, \sigma_w^2\right) p\left(U \mid \sigma_U^2\right) p\left(V \mid \sigma_V^2\right) \\ &= \prod_{i=1}^{n}\prod_{j=1}^{m}\left[N\left(R_{ij} \,\middle|\, g\left(\sum_{k \in N_u} w_{ik} U_k^T V_j\right), \sigma_w^2\right)\right]^{I_{ij}^R} \times \prod_{i=1}^{n} N\left(U_i \mid 0, \sigma_U^2 \mathrm{I}\right) \times \prod_{J=1}^{m} N\left(U_j \mid 0, \sigma_V^2 \mathrm{I}\right). \end{aligned} \tag{14}$$

In order to achieve a reasonable match between the personalized feature requirements and the interest points of the project, considering the overall structure information in the information management platform of imperceptible social heritage in schools, through personalized feature extraction [20], the trust degree of information fusion is recorded as C_{uv}^{*} and is mathematically expressed in equation (15):

$$C_{uv}^{*} = \sqrt{\frac{d_{\text{in}}(v)}{d_{\text{out}}(u) + d_{\text{in}}(v)}} \times C_{uv}. \tag{15}$$

The matrix decomposition technology is used to decompose the eigenvectors of primary and secondary school students' needs and recommended items under the double reduction policy [21]. The process is given by equation (16):

$$\begin{aligned} x_i(t) = &\sum_{k=1}^{p}\sum_{l=0}^{2} \varphi_{kl}\left[w_{i1}^l, \cdots, w_{in}^l\right]\left[x_1(t-k), \cdots, x_n(t-k)\right]^T \\ &- \sum_{k=1}^{q}\sum_{l=0}^{2} \theta_{kl}\left[w_{i1}^l, \cdots, w_{in}^l\right]\left[\varepsilon_1(t-k), \cdots, \varepsilon_n(t-k)\right]^T + \varepsilon_i(t). \end{aligned} \tag{16}$$

The formula will be expanded by l, therefore, leading to equation (17):

$$x_i(t) = x_i^1(t) + x_i^2(t) + x_i^3(t). \tag{17}$$

Semantic similarity of attribute [22, 23] set i_x, i_y of recommended items of imperceptible social heritage and materials in schools is as follows in equation (18):

$$JL_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} \frac{\sqrt{\left(A_{iseq} - B_{jseq}\right)^2 + 1}}{\left|A_{iq} - B_{jq}\right| + 1}, \tag{18}$$

where N is the amount of nodes in this particular layer of the information management platform of imperceptible social heritage in schools, m is the modulus vector negotiated by the main body, which indicates that the weighted vector of elements in the first row is $i, i = 1, 2, \cdots, n$ and w_{i1}^{1k}'s personalized feature extraction output, B_{jseq} indicates the accurate position serial number of imperceptible social heritage in schools, and A_{iq} is the intra-cluster error, so as to realize the reasonable matching of personalized feature requirements and project interest points and realize personalized recommendation of imperceptible social heritage in schools under the double reduction policy [24].

4. Analysis of Experimental Results

During the experiment of personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy, the simulation platform is MyEclipse 8.0 which is an investigational simulation environment, and the algorithm is developed and designed by Java platform and programming language. This should be noted that the data used in all experiments come from an online website of the information management platform of imperceptible social heritage and materials in large schools in Slashdot, and these data are captured by the web crawler. The information management platform of imperceptible social heritage in schools includes 200 primary and secondary school students' comments under the double reduction policy and 399,322 sides of the double reduction policy, which is used as the prior instruction statistics set suggested by the network. Similarly, the other important and relevant parameters are: $Q = 45$, $c_1 = 122$, $c_2 = 210$, $c_r = 24$, $\mu_1 = \mu_2 = 0.332$, $\rho_1 = \rho_2 = 0.43$, and $\delta = 0.8$. In order to associate the benefits and drawbacks of the recommendation algorithm, in the recommendation quality evaluation, the average absolute error (MAE) and root mean square error (RMAE) are implemented in order to analyze the quality of personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy. The definitions of the two qualities are described as follows in equations (19) and (20) The MAE is defined by equation (19) given as follows:

$$MAE = \frac{\sum_{i,j}\left|r_{i,j} - \overline{r}_{i,j}\right|}{N}, \tag{19}$$

wherein, it indicates the actual scores of students interested in items in the information management platform of imperceptible social heritage in schools and indicates the predicted scores of items after personalized feature analysis by adopting the personalized recommendation model of imperceptible social heritage in schools under the double reduction policy, N is the crawling times of crawlers [25]. This should be noted that the RMSE represents the square sum of the unconventionality and deviations amongst the observed value and the true significance of primary and secondary school students' scores under the double reduction policy for the personalized recommendation of imperceptible social heritage and materials in schools. Its definition of the RMSE metrics is as follows in equation (20):

$$\text{RMSE} = \sqrt{\frac{\sum_{i,j}\left(r_{i,j} - \overline{r}_{i,j}\right)^2}{N}}. \tag{20}$$

The parameter description in the formula is the same as above. RMSE can effectively reflect the satisfaction of primary, as well as, the college and secondary school students under the strategy of double reduction in the process of personalized recommendation of imperceptible social heritage and materials in schools. According to the above-mentioned simulation environment setting and the quality evaluation index, the recommendation performance analysis is carried out, in which the number of primary and secondary school students under the double-reduction policy of grading is divided into groups, which are, respectively, set as "1~10," "11~20," "21~40," "41~80," "81 ~160," and "> 160 [26].

Figure 2 describes the fuzzy matching distribution model of schools' imperceptible social heritage and cultural data recommendation, and on this basis, it realizes the recommendation of schools' imperceptible social heritage and cultural data. It tests the average absolute error of the evaluation of schools' imperceptible social heritage and cultural data recommendation by using this algorithm and traditional recommendation algorithm and procedure. The investigation demonstrates that the MAE of this approach has the lowest value among primary and secondary school students under each grading double reduction policy, which indicates that the matching degree of personalized feature needs and project interest points is the highest. The MAE comparative experimental results are shown in Figure 3.

Figure 4 describes the comparison results of RMSE value of different methods and approaches for the personalized recommendation of imperceptible social heritage and materials in schools and colleges under the double reduction policy. Similarly, it can be concluded that the RMSE value of this method is the lowest, indicating that primary and secondary school students have the highest score and the best satisfaction with the recommendation results under this method under the double reduction policy and strategy.

5. Conclusions and Future Research

In this paper, the personalized recommendation of imperceptible social heritage and materials in schools under the policy and strategy of double reduction is studied to meet the individualized needs of primary, as well as, the colleges and secondary schools' students under the policy and strategy of double reduction and improve the quality of network

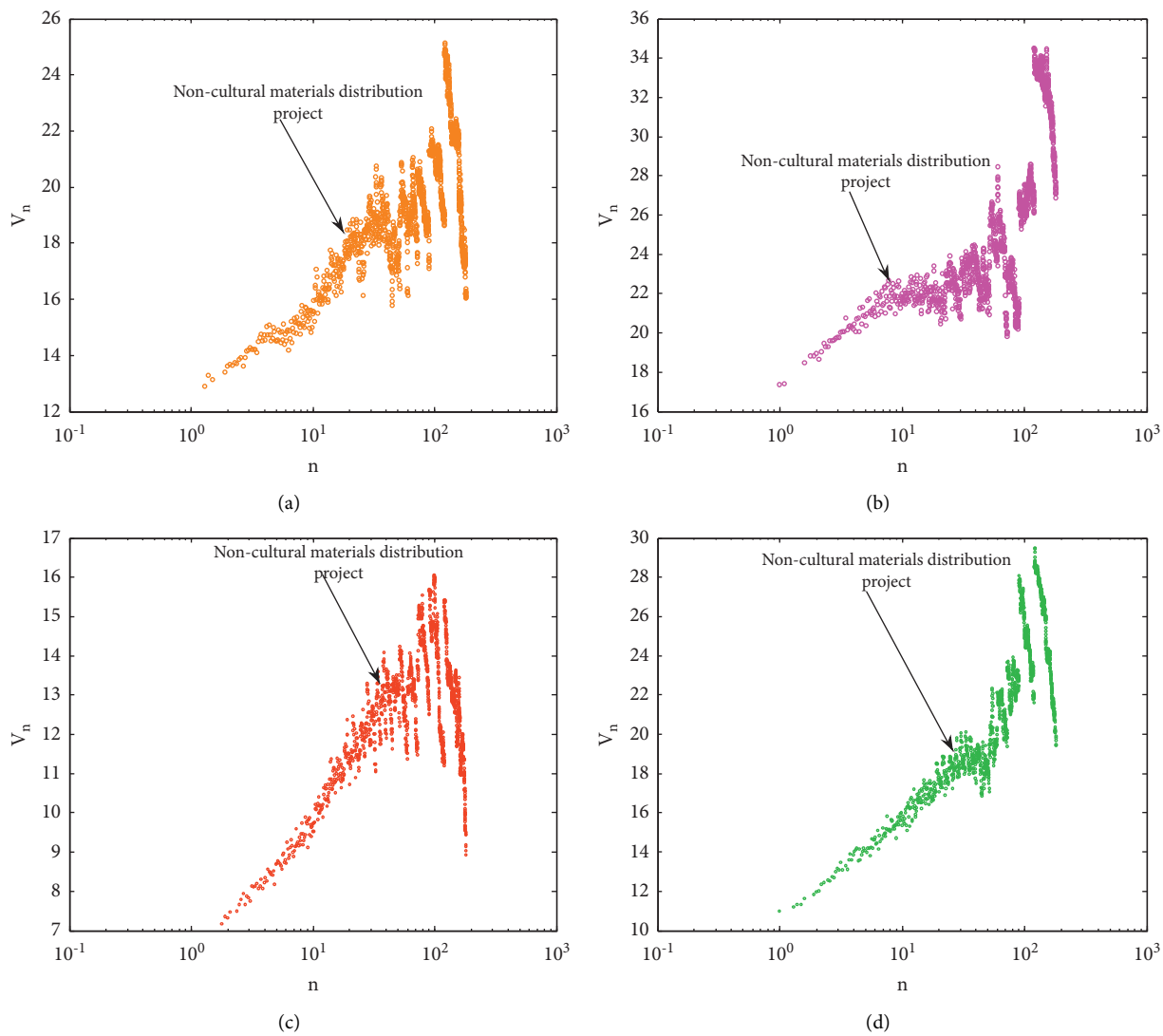

Figure 2: Fuzzy matching project set recommended by cultural materials of imperceptible social heritage in schools. (a) Group 1. (b) Group 2. (c) Group 3. (d) Group 4.

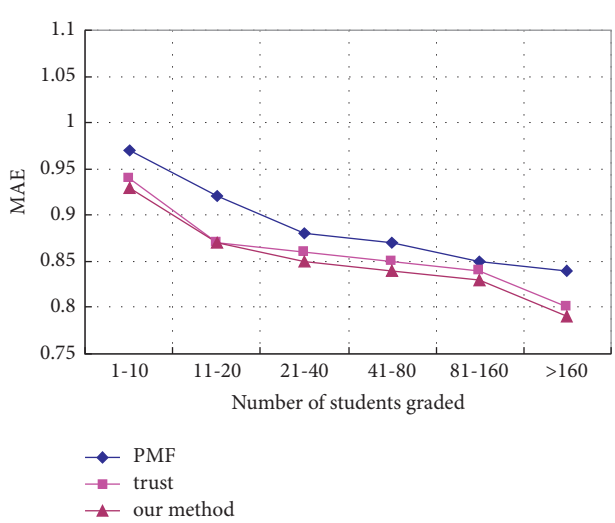

Figure 3: The MAE comparative experimental results.

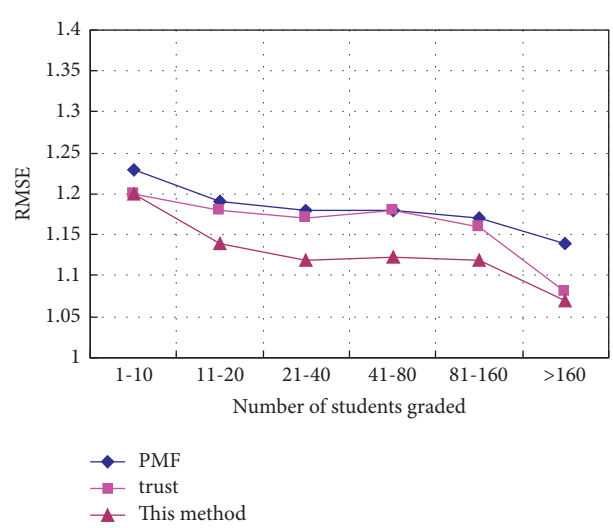

Figure 4: The RMSE comparative experimental results.

service. A personalized recommendation algorithm of imperceptible social heritage and materials in schools under the double reduction policy based on joint template feature matching and interest feature point mining is proposed. First, the grading model and homomorphic distribution attribute model of imperceptible social heritage and materials for primary and secondary school students under the double reduction policy are constructed by taking the information management platform of imperceptible social heritage and materials in schools as the structural model. The probability density characteristic analysis method of joint template matching is used to construct the personalized recommendation model of the imperceptible social heritage and materials in schools, and then the personalized characteristic distribution and fitness parameter extraction of the imperceptible social heritage and materials in schools under the double reduction policy are carried out, so as to realize the reasonable matching of personalized characteristic requirements and project interest points and realize the personalized recommendation of imperceptible social heritage and materials in schools under the double reduction policy.

The results show that the personalized recommendation of imperceptible social heritage and materials in schools with this method has a high score, and the average absolute error and root mean square error are small, which improves the recommendation quality of imperceptible social heritage and materials in schools and has a good application prospect. In the future, we will extend this work with a deep learning-based neural network mode. And will investigate the study of model precisions. Moreover, we will work toward proposing an updated version of the proposed algorithm, where, machine learning methods should be used to enhance the accuracy and performance quality. Using big data, and the graph convolutional network model will definitely improve the performance of the proposed technique. The filtering task is to compute intensive and the matching time could be significantly reduced using big data analytics and edge computing model.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

A Resource Sharing System for Music Education Using the Entropy Technology

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In order to improve the sharing level of music quality and educational resources within the background of emerging digital world, it is essential to design new methods. In this paper, we design a method for music quality education and a resource sharing system within the context of digital world which is established over the entropy technology. The designed structure includes the collection module of music quality education resources, the interactive compilation module of music education resources, the bottom data detection module, the cross bus control module, and the man-machine interface module under the background of digital technology. The information entropy feature extraction technology is adopted to schedule the bus in the process of sharing and transmitting music quality educational resources under the background of digital technology, and the transmission model of music quality education resources is designed. The modular design method of bottom database is adopted to realize the interactive and storage design of music quality education resources under the background of digital technology. Under the background of digital technology, the average mutual information entropy and feature distribution of association rules of music quality education resources are extracted. Furthermore, the method of fuzzy subspace information scheduling is combined with the entropy approach to share and schedule music quality educational resources, so as to comprehend the software development and, therefore, the design of music quality education and resource sharing system under the background of digital knowledge. The simulation outcomes confirm that under the background of digital technology, the music quality education and resource sharing system has good output stability and, therefore, strong human-computer interaction ability.

1. Introduction

Under the background of digital technology, music quality education is an important platform and base to improve national quality and students' sentiment. Music, as a popular form of amateur entertainment, needs more professional guidance and richer information exchange. Universities and society have rich and distinctive musical cultural resources, such as professional teachers, top students of music major, modern music hardware teaching facilities, and project research funds. According to the social group characteristics, a resource sharing system of music quality education under the background of digital technology is established, and resources such as a large number of music lovers, mass music venues, and special funds for music and cultural activities in the society are integrated into music education in schools and institutions of higher education. Therefore, the sharing and integration of music education resources is by no means a one-way method for academies and institutions of higher education to provide the output and service of education resources for urban and rural communities, but a process of mutual penetration and mutual benefit between the two to accomplish the ideal distribution of education resources [1]. It is of prodigious importance to learn the design method of music quality education and resource sharing system within the context of digital expertise [2].

The establishment of resource sharing systems for music quality education within the context of digital technology is achieved though combining the information fusion and big data mining of the resources of music quality education. Furthermore, we design the resource sharing system of music quality education under the background of digital expertise and improve the capability of integration of the resources of music quality education within the background

of digital expertise [3]. The research on the design method of the resource sharing system of music quality education within the context of digital technology has attracted great attention. This is due to the fact that the design of music quality education and resource supervision structure under the background of digital knowledge is grounded on the diagnosis and treatment design of music quality education resource under the background of digital technology, combined with data fusion scheduling technology, to share music quality education resources under the background of digital technology and to establish the music quality education resource sharing scheme within the context of digital knowledge through network information management design [4].

At present, the exploration of the design method for music quality education resource sharing scheme within the context of digital knowledge is based on the fusion scheduling and information detection of music quality education resources under the background of digital technology, and the fusion and database construction of music quality education resources under the background of digital technology are carried out through fuzzy feature mining. In fact, the multi-sample feature information sampling approach is implemented to build a dynamic big data analysis prototype for music quality education resources under the background of digital technology. Similarly, the sharing of music quality and needed educational possessions within the context of digital technology is realized through fuzzy information fusion. However, the traditional method of sharing music quality education resources under the background of digital technology has poor feature recognition ability and low level of information sharing [5].

Targeting at the above research issues, in this paper we put forward a design method of music quality education resource sharing system under the background of digital technology based on entropy technology. The music quality education resources under the digital technology background should include the acquisition module, the music education resources interactive compilation module, the underlying data detection module, the cross type bus control module, and the human-computer interaction interface module; the information entropy feature extraction technology is adopted to schedule the bus in the process of sharing and transmitting music quality education resources under the background of digital technology; the transmission model of music quality education resources under the background of digital technology is designed; the bottom database modular design method is adopted to design the interaction and storage of music quality education resources under the background of digital technology. To conclude, the simulation test analysis expresses the greater performance of the suggested system which is designed in this paper in humanizing the sharing ability of music quality education resources under the background of digital technology. The major contributions of this work are listed as follows:

(1) The design method of music quality education resource sharing scheme within the context of digital knowledge which is grounded on the entropy expertise is suggested.

(2) The information entropy feature extraction technology is adopted to schedule the bus in the process of sharing and transmitting music quality education resources under the background of digital technology.

(3) The transmission model of music quality education resources within the background of digital expertise is designed.

(4) The modular design method of bottom database is adopted to realize the interactive and storage design of music quality education resources under the background of digital technology.

The rest of this paper is organized in the subsequent style. In Section 2, the overall design and construction of the system and the database access of music teaching resources are elaborated. In Section 3, digital technology background music quality education resource sharing design is suggested based on the entropy technology. In Section 4, system software implementation and simulation test are discussed and the attained outcomes are deliberated along with figures. To conclude this paper, Section 5 discusses the major outcomes and provides some future ideas that can be considered for further research.

2. General Design and Construction of the Scheme and the Database Access of Music Teaching Resources

2.1. General Design Organization of the Scheme. In order to comprehend and understand the design of the sharing system of music quality education resources under the background of digital technology, the complete and general organization model of the suggested resource sharing system for music quality education and resources within the context of digital technology is first constructed [6]. The sharing system of the music quality education resources within the context of digital knowledge predominantly includes database design, sharing scheduling algorithm design and software development design, and so on, and the information collection module of the sharing system of music quality education resources under the background of digital technology is assembled. Then, joined with the modular sleep technique of the underlying database, the kernel control and integrated information scheduling of the music quality education resource sharing system under the background of digital technology are carried out, and the interactive compilation module of the music quality education resource sharing system under the background of digital technology is constructed [7].

The network networking design of the music quality education resource sharing system under the background of digital technology is carried out within the Internet of Things (IoT) surroundings, and the component library, i.e., ADO.NET, is then cast off to cooperate with the music

quality education resource sharing database under the background of digital technology [8]. The information entropy feature extraction technology is adopted to schedule the bus in the process of sharing and transmitting music quality education resources under the background of digital technology, and the complete design framework of the suggested scheme is obtained as displayed in Figure 1.

The LOCAL bus is used as the output bus transmission method of the music quality and education resource sharing system under the background of digital technology. The two columns of the VXI additional bus pins are cast off to incorporate the music quality educational resources under the background of digital technology, and the bottom-level B/S architecture system is used to design the bottom-level modular design of music quality education resource sharing system within the context of digital knowledge and skill. The functional components of the suggested scheme are shown in Figure 2.

According to the functional structure module shown in Figure 2, Zigbee is adopted to collect and integrate information of music quality education resources within the background and context of digital knowledge, and the man-machine interaction strategy of music quality education resources within the context of digital technology is performed over the network communication module, and the man-machine interaction interface module is constructed [9].

2.2. Optimization of Patient Information Database Access and Storage Structure. The B/S technology is used to manage music quality education resources under the background of digital knowledge, and the fuzzy PID control method is implemented to monitor and control the entire process of sharing music quality education resources under the background of digital technology [10]. This should be noted that the big data fusion model and database storage model of music quality education resources under the background of digital technology are assembled, and the dispersed recognition and clustering of music quality education resources under the background of digital technology are performed through using fuzzy regional information fusion technique [11]. The dynamic matching method is adopted to mine the relevance of music quality education resources, and the feature matching model of music quality education resources under the background of digital technology is constructed. The fuzzy correlation feature quantity of music quality education resource sharing under the background of digital technology is obtained as

$$r_k(1) = 0, v = 1, \nu(1) = 0, p \in P, v = 1, \tag{1}$$

where P represents autocorrelation characteristic quantity and v represents correlation coefficient, which gives the flow matrix of music quality education resources under the background of digital technology. Under a certain period of sampling, the fusion scheduling of music quality education resources under the background of digital technology is carried out, and the fuzzy membership function of music quality education resources under the background of digital technology is extracted by using the big data information fusion method, so as to obtain the feature detection model of music quality education resources under the background of digital technology, and the fuzzy iterative formula is as follows:

$$F_k(v+1) = \sum_{x \in X} \frac{DU(v)j}{K(K+U(v))}, \tag{2}$$

where K represents the distribution entropy of music quality education resources and D represents mutual information. Furthermore, $U(v)$ is the statistical characteristic quantity of music quality education resources, and j is the fuzziness of music quality education resources. According to the linear programming parameter distribution model, dynamic optimization is carried out, and the music quality education resource sharing and fusion clustering is carried out under the background of digital technology, and the detection model of music quality education resources under the background of digital technology is obtained, and the characteristic distribution of association rules of music quality education resources fusion under the background of digital technology satisfies the constraint in the following equation:

$$V_k = \sum_{p \in P} \nu(v+1) i_{jx}, \tag{3}$$

where ν is the multi-dimensional information entropy of music quality education resources and i_{jx} is the subspace scheduling set. Combining with multi-dimensional information distribution, the dynamic distribution function of music quality education resources under digital technology background is constructed, and the characteristic function $f(X)$ of music quality education resource detection under digital technology background under subspace fusion clustering environment is obtained, which meets the following conditions:

$$\|f(X) - f(Y)\| \leq N\|X - Y\|, \tag{4}$$

where N is the statistical sample number of music quality education resources and X and Y are the sharing factors of music quality education resources in the ontology fusion feature distribution domain. This should be noted that the optimal solution of the dynamic distribution of music quality education resources under the background of digital technology is obtained. The distribution length of music quality education resources under the background of digital technology is N, and $L_x = a_i$ is converted into $2N + 1$ strings to obtain the clustering center of music quality education resource distribution under the background of digital technology. Based on the underlying data fusion technology, the sharing design of music quality education resources under the background of digital technology is realized [12].

3. Digital Technology Background Music Quality Education Resource Sharing Design

3.1. Integration of Music Quality Education Resources under the Background of Digital Technology. The information

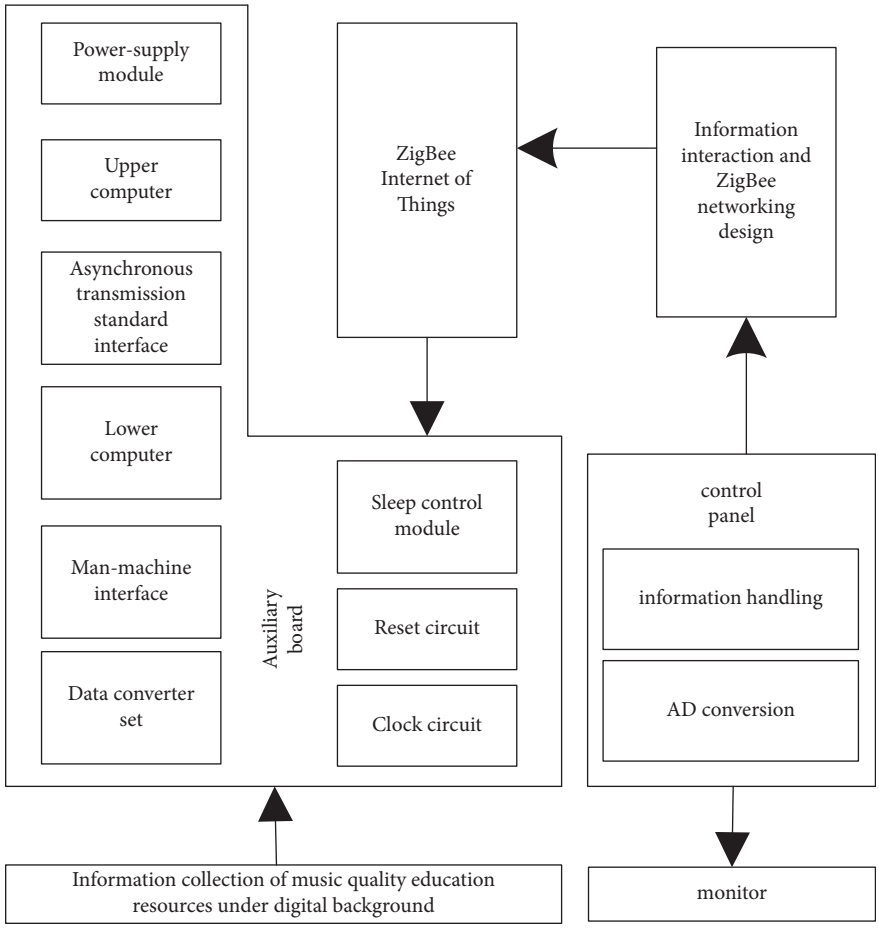

Figure 1: A complete design framework of the suggested scheme.

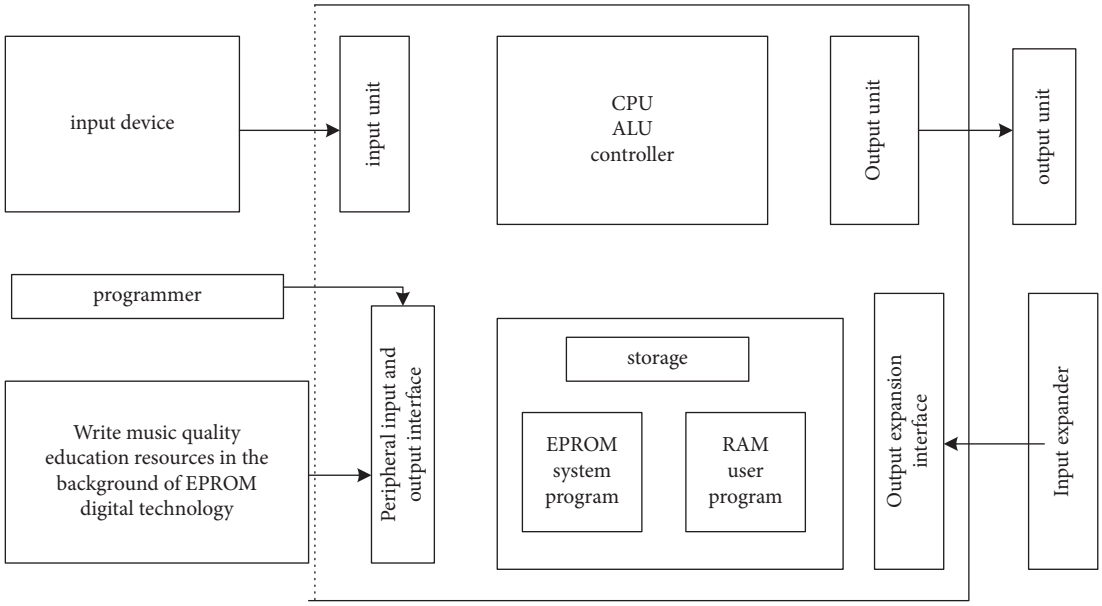

Figure 2: Structure design of numerous functional components of the suggested scheme.

entropy feature extraction technology is adopted to schedule the bus in the process of sharing and transmitting music quality education resources under the background of digital technology, the transmission model of music quality education resources under the background of digital technology is designed, the dynamic control of music quality education resources management system under the background of digital technology is carried out, and the fuzzy clustering function of music quality education resources under the background of digital technology is obtained as follows(:

$$\begin{aligned} v_1 &= \{>a_1, >a_2 \ldots, >a_{i-1}\}, \\ v_2 &= \{\geq a_1, \geq a_2 \ldots, \geq a_i\}, \\ v_3 &= \{<a_{i+1}, <a_{i+2} \ldots, <a_N\}, \\ v_4 &= \{\leq a_i, \leq a_{i+1} \ldots, \leq a_N\}, \\ v_5 &= \{= a_i\}, \end{aligned} \tag{5}$$

where $a_1, a_2 \ldots, a_{i-1}$, respectively, represent the fuzzy clustering parameters of music quality education resources under the background of digital technology. Grounded on the aforementioned exploration, the optimization mining and feature reconstruction of the music quality education resources under the background of digital technology are carried out, the fuzzy information entropy of music quality education resources under the background of digital technology is extracted, and the music quality education resources are scheduled under the background of digital technology. The binary feature planning model of music quality education resources integration under the background of digital technology is obtained as follows:

$$x(k) = \begin{cases} n(k), & H_0, \\ hs(k) + n(k), & H_1, \end{cases} \tag{6}$$

where h is the fusion function of music quality education resources under the background of digital technology, $n(k)$ is the interference factor of music quality education resource fusion under the background of digital technology, $s(k)$ is the joint spectral density of music quality education resources, and H_0 and H_1 are the assumptions of music quality education resources, respectively. The heterogeneous storage model of music quality education resources under the background of digital technology is constructed [13], and the dynamic characteristic quantity of music quality education resources under the background of digital technology is extracted, and the fusion degree function of music quality education resources under the background of digital technology is obtained using the following equation:

$$R_\beta X = U\left\{\frac{E \in U}{R} | c(E, X) \leq \beta\right\}, \tag{7}$$

where $\cdot$ is the fusion operation of music quality education resources on X, the convolution operation of music quality education resources are Y, $c(E, X)$ is the sharing reliability distribution set of music quality education resources, β is the classification feature set of music quality education resources, $R$is the intermediate scheduling coefficient of music quality education resources sharing, and R is a real function. Combined with the detection and statistical analysis method, the block detection of music quality education resources under the background of digital technology is carried out, and the data blocks of patient information interaction in large public hospitals and $m_{i,j}(1 \leq i \leq n, 1 \leq j \leq k)$ of music quality education resources under the background of digital technology are obtained. The feature mapping Φ: X $\longrightarrow$ Y of music quality education resource sharing under the background of digital technology is obtained by using the fusion vector machine learning method, as given in the following equation:

$$\Phi(x \cdot y) = \Phi(x) \circ \Phi(y), \tag{8}$$

where $\Phi(x), \Phi(y)$ means to map the information entropy of music quality education resources. Using information entropy feature extraction technology, the dynamic security detection of music quality education resource management system under the background of digital technology is carried out, and the similarity feature quantity of music quality education resources under the background of digital technology is obtained as follows:

$$\begin{aligned} \dot{x}_i &= f_i(x_i, u_i) D\big(x_i, A_j(L)\big) \\ &= \min\big\{D\big(x_i, A_j(L)\big)\big\}, \end{aligned} \tag{9}$$

where $x_i \in R^n$ represents the state vector of music quality education resources under the background of digital technology, $u_i \in R^m$, $f_i(x_i, u_i)$ are joint probability density functions, and $A_j(L)$ is the characteristic solution of closed frequent term. The incremental fusion filtering is carried out on music quality education resources under the background of digital technology in times field, and the fuzzy characteristic distribution set of music quality education resources under the background of digital technology is obtained as m. Let $A_j(L)$ be the cluster center of music quality education resources under the background of digital technology, in which $j = 1, 2, ..., k$, in r different cluster centers, gets the dynamic characteristic detection output of music quality education resources under the background of digital technology as follows:

$$u = Me + Ne, \tag{10}$$

where $M \in R^{3\times3}$ is the ambiguity matrix; N is the inertia constant of the distribution of music quality education resources under the background of digital technology; $e = X - Y$ is the sharing level of music quality education resources under the background of digital technology; and SD is expressed as differential error, including the mathematical illustration given in the following equation:

$$\begin{aligned} \dot{e} &= \dot{X} - \dot{Y} \\ &= Ae + B[f(X)] - f(Y) - u], \end{aligned} \tag{11}$$

where A and B are empirical mode amplitudes, $f(X)$ and $f(Y)$ are similarity distribution functions of resource

sharing, and u is distribution characteristic quantity of deep knowledge perception. Through the above design, information fusion and similarity detection are used to design the resource management and sharing of music quality education under the background of digital technology [14].

3.2. Digital Technology Background Music Quality Education Resource Sharing Scheduling. The method of fuzzy subspace information scheduling is used to share and schedule the resources of music quality education under the background of digital technology [15, 16]. The average mutual information entropy and the feature distribution set of association rules of music quality education resources under the background of digital technology are extracted, and the grouping detection of music quality education resources under the background of digital technology is carried out by using the feature matching, block fuzzy, fusion, and clustering method [17]. In fact, the expression of dynamic distribution feature quantity of music quality education resources under the background of digital technology is obtained as follows:

$$K\left(x_i, x_j\right) = \exp\left(\frac{\left\|x_i - x_j\right\|^2}{2\sigma^2}\right), \tag{12}$$

where x_i and x_j, respectively, represent the quantitative feature sets of resource distribution in different degrees and σ represents the knowledge map enhancement parameters of music resources. Based on the method of cluster head node fusion, the grouping detection and information fusion of music quality education resources under the background of digital technology are carried out, and the adaptive weighting coefficient is obtained as follows:

$$\mathrm{w}_{ji}(k+1) = w_{ji}(k) - \alpha\frac{\partial F}{\partial w_{ji}}, \tag{13}$$

where $w_{ji}(k)$ is the weighting coefficient of music quality education resources grouping, F is the Laplace noise term, and α is the reliability fusion clustering weighting coefficient of music quality education resources grouping, and the fuzzy correlation feature quantity of music quality education resources under the background of digital technology is mined. When there are no abnormal features of music quality education resources under the background of digital technology, $\widehat{R}_{rj}(\mathbf{T}_{rj}^0) \le \overline{R}_{ir}(\mathbf{W}_i^0)$, and there are no $P_i' < P_i$ and $P_j' = P_j$, the multi-resolution feature solution of music quality education resources under the background of digital technology and convergence conditions are met, and the fuzzy iterative function of dynamic detection of music quality education resources under the background of digital technology is obtained as follows:

$$\dot{x}(t) = Ax(t) + Bx\left(t - d_1(t) - d_2(t)\right), \tag{14}$$

where $x(t) = \phi(t), t \in [-h, 0]$, and $\left\{\mathbf{W}_i', \mathbf{W}_j'\right\}$ is the binary ontology feature distribution of music quality education resources under the background of digital technology and obtains the feature solution of music quality education resource sharing under the background of digital technology satisfying $R^{mac}(\mathbf{W}_1', \mathbf{W}_2') = R^{bc}(\mathbf{T}_{r1}^0, \mathbf{T}_{r2}^0)$ and $\overline{R}_{jr}(\mathbf{W}_j') \ge \widehat{R}_{ri}(\mathbf{T}_{ri}^0)$ in the data non-stationary distribution set. Using spatial cluster analysis method, on this technology, the average mutual information entropy and association rule feature distribution set of music quality education resources under the background of digital technology are extracted, and the music quality education resource distribution and allocation under the background of digital technology are performed through the fuzzy subspace information scheduling method, as given mathematically in (15), so as to obtain the distribution of music quality education resources under the background of digital technology [18].

$$\beta_i^c = -\sum_{k \in S_s} R_{ik} Q_{kc} - R_{i1} y_c, \tag{15}$$

where R_{ik} is the resource distribution scheduling parameter on dataset D, Q_{kc} is the sharing factor of music quality education resources, R_{i1} is the representation vector, and y_c is the degree of user's interest in music education resources [19]. To sum up, to realize music quality education resource sharing under the background of digital technology, the algorithm realization flow is shown in Figure 3.

4. System Software Implementation and Simulation Test

The MICRO DSP intelligent signal processor is used to realize VCC detection of music quality education resources under the background of digital technology, CC2530 is connected to the OUT port to control the IO output of music quality education resources under the background of digital technology, and PCI9054 LOCAL bus is selected as the output bus transmission mode of music quality education resource sharing system under the background of digital technology. Sampling of music quality education resources under the background of digital technology is realized under the fusion of entropy functions, and the system software is designed under the B/S framework system [20–22]. The system includes music quality education resource collection module, music education resource interactive compilation module, bottom data detection module, cross bus control module, and man-machine interface module under the background of digital technology. The system software realization structure diagram is shown in Figure 4.

Under the background of digital technology, the sample length of the music quality education resources is 1024, and the training set of music quality education resource distribution under the background of digital technology is 300. The obtained resource information data sample is shown in Figure 5.

The characteristic clustering output of music quality education resources under the background of digital technology is shown in Figure 6.

According to the analysis of Figure 6, the characteristics of sharing and scheduling of music quality education resources with this method are clustered well under the

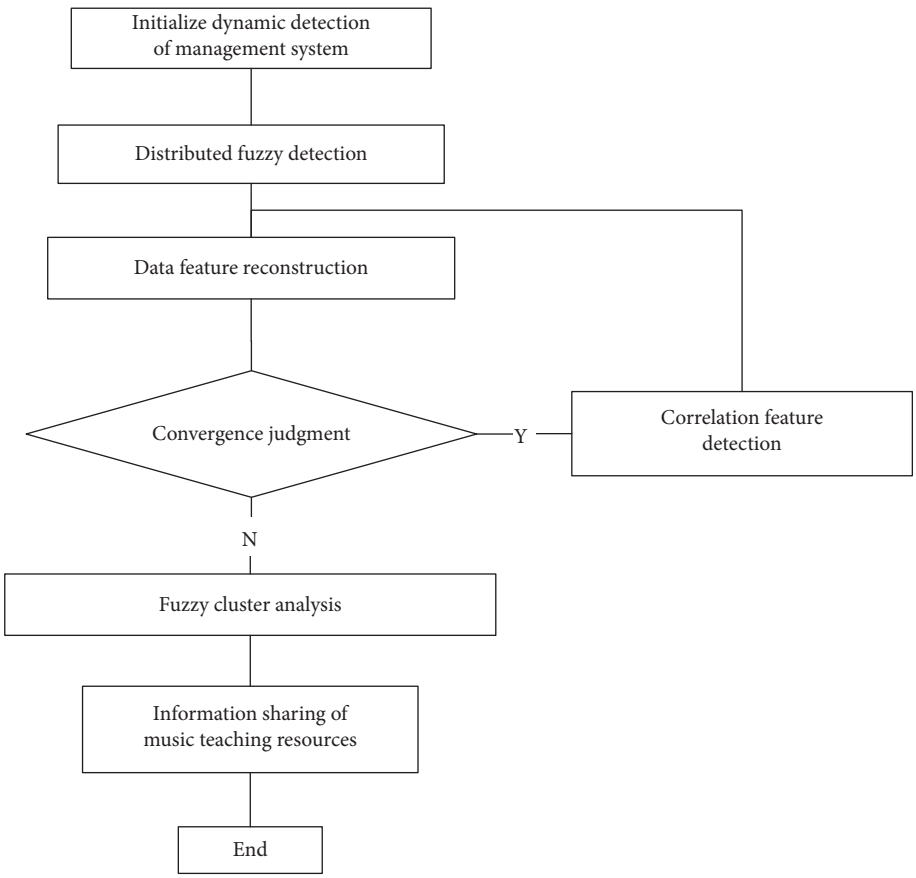

Figure 3: Realization process of music quality education resource sharing under the background of digital technology.

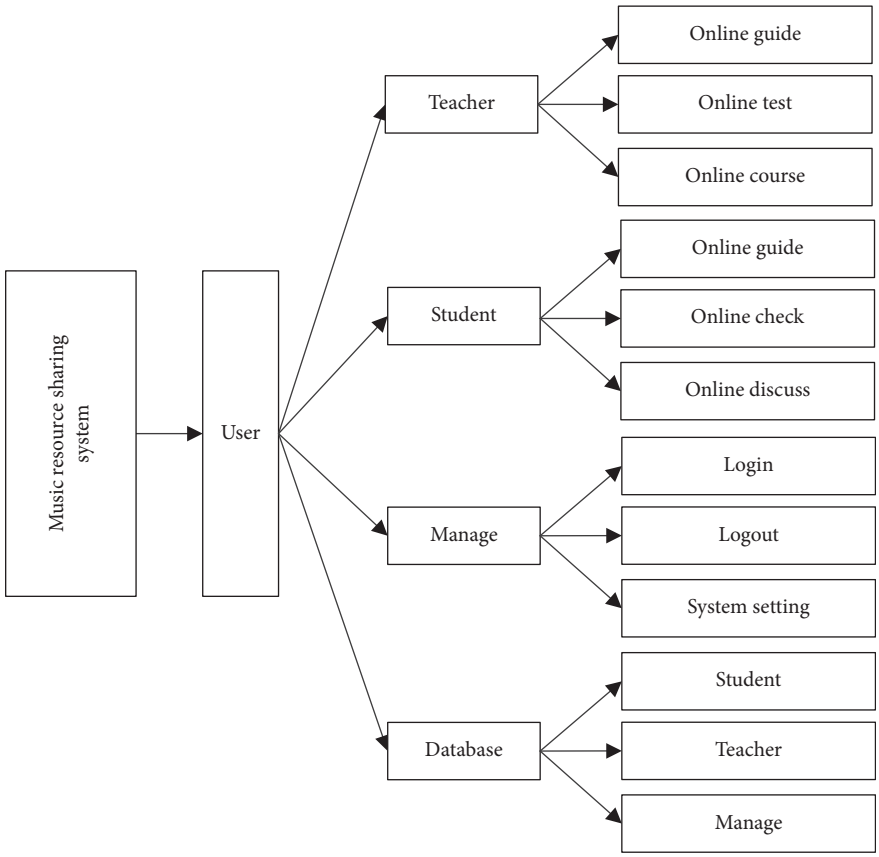

Figure 4: The system software implementation structure diagram.

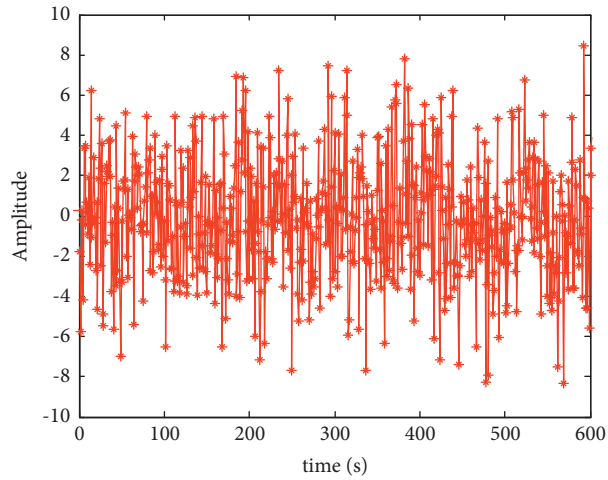

Figure 5: Data sample of music quality education resources.

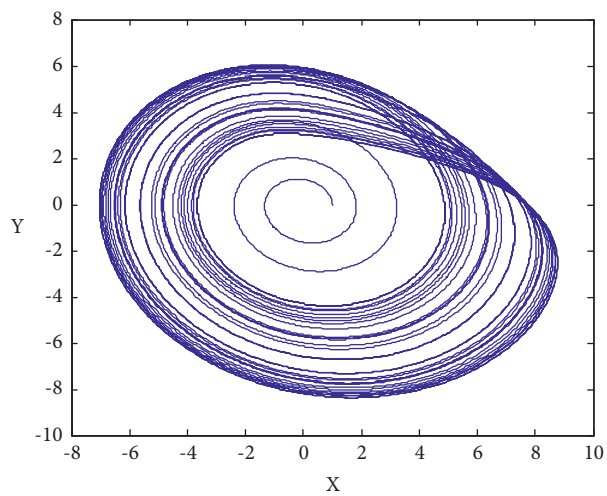

Figure 6: Characteristic clustering output of music quality education resources under the background of digital technology.

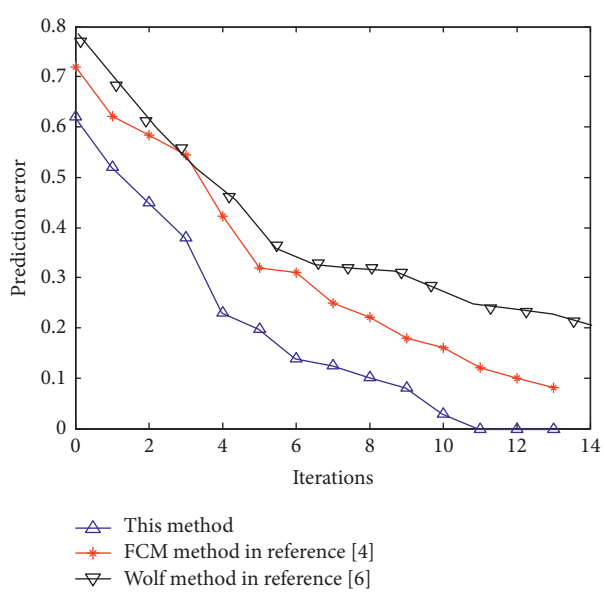

Figure 7: The convergence curve test.

background of digital technology [23, 24]. Test the convergence of music quality education resource sharing under the background of digital technology, and get the convergence curve as shown in Figure 7.

From the analysis of Figure 7, it can be seen that the convergence of music quality education resource sharing is better, the output stability of information sharing system is better, and the human-computer interaction ability is stronger.

5. Conclusions and Further Research

In this paper, the resource scheme of music quality education under the background of digital technology is constructed, and the information fusion and big data mining of music quality education resources within the context of digital technology are combined to design the resource sharing system of music quality education within the context of digital technology, so as to improve the diagnosis and treatment level of large public hospitals. In this paper, we make known the design method of the resource sharing

system of music quality education within the context of digital tools that are grounded on the entropy knowledge. In the Internet of Things (IoT) environment, the network design of music quality education resource sharing system under the background of digital knowledge is carried out. The B/S expertise is used to manage music quality education resources under the background of digital technology. Combined with fuzzy PID control method, the process control of music quality education resource sharing under the background of digital technology is carried out, and the characteristic matching model of music quality education resources under the background of digital knowledge is constructed to comprehend and understand the allocation of music quality educational possessions under the background of digital technology. The analysis illustrates that the designed scheme has decent man-machine interaction and strong convergence, which improves the level of music quality education resource sharing under the background of digital technology.

In the future, we will account for some real dataset and will investigate further how the suggested model can be applied into a real-world application. Similarly, we will optimize the training phase to train the model quickly and reduce the prediction time. Furthermore, deep learning methods such as LSTM and RNN can also be used to enhance the performance of the model. In fact, the emerging technologies like cloud, big data, and edge computing can also be utilized to optimize the suggested model. We will investigate the prediction outcomes more deeply while accounting for evaluation metrics like precision, recall, and RMSE with respect to other approaches.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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Research Article

A Secure Cloud Storage Algorithm for University Financial Data Based on the Blockchain Technology

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In order to increase the secure storage capacity of university financial system process operation data under the blockchain environment, a secure cloud storage algorithm of university financial data based on the blockchain technology is proposed. The blockchain storage structure model of university financial system process operation data is first constructed, and then the mapping method of Atlas features is adopted. Finally, the blockchain equilibrium configuration parameter analysis model of university financial system process operation data is established. According to the outcomes of the feature extraction process of cloud resource storage Atlas of university financial system process operation data, the fuzzy clustering method is implemented to comprehend the rational planning of cloud storage space. The resource cloud storage structure configuration of university financial system process operation data in cloud environment is realized by using the method of block link fusion and channel equilibrium configuration. The multi-layer modal structure decomposition and fuzzy clustering processing are carried out on university financial system process operation data storage information in blockchain environment by using the empirical mode decomposition method. According to the data graph clustering results, the cloud resource graph of university financial system process operation data becomes smooth in the adjacent wave domain through cloud information fusion and block clustering, which effectively reduces the data storage overhead and improves the secure cloud storage capability of university financial data. The simulation outcomes indicate that this approach can significantly increase the storage performance of process operation data of university financial system under blockchain environment, with better data classification storage, internal structure information fusion performance of university financial data, and lower storage overhead than other methods. We observed that this improvement, in terms of storage overhead costs, can be as high as 43.67% higher than the wavelet method and 30.45% higher than the mode decomposition approach.

1. Introduction

With the uninterrupted upgrading of information management of university financial system, higher necessities are put forward for the security of university financial system process operation data. Combined with the process control of university financial system process operation data, the secure cloud storage design improves the secure cloud storage capability of university financial system process operation data. The secure storage design of university financial system process operation data is based on the encryption design of process operation data information, combined with the information encryption of university financial system process operation data, and carries out information perception and coding storage of university financial system process operation data under blockchain environment [1].

In the cloud storage environment, a large number of university financial system process operation data in blockchain environment need to be stored and scheduled by cloud storage, which provides users with large-scale integrated information storage space [2]. The cloud storage of university financial system process operation data in blockchain environment can be divided into public cloud,

private cloud, and hybrid cloud. The reasonable planning of university financial system process operation data cloud storage space in blockchain environment can improve the ability of data receiving and dispatching and integrated scheduling of university financial system process operation data in blockchain environment [3]. In the cloud storage system of university financial system process operation data under blockchain environment, it is necessary to extract the Atlas features of university financial system process operation data under blockchain environment. These Atlas features include high-order spectrum, time spectrum, wavelet information spectrum, LORFA spectrum, etc. The Atlas features of university financial system process operation data under blockchain environment can effectively reflect the data storage structure and internal characteristic performance in cloud storage. Combined with the method of spectrum feature extraction, cloud storage control of university financial system process operation data under blockchain environment can be realized [4].

The high-order spectral characteristic features of university financial system process operation data in blockchain environment can effectively reflect the internal inherent modal characteristics of the data and extract the high-order spectral characteristic feature map information of university financial system process operation data in blockchain environment, which can, in fact, diminish the storage cost of data cloud resources. Traditionally, the Atlas design and feature extraction methods of university financial system process operation data in blockchain environment mainly include Atlas feature extraction method based on time-frequency analysis, Atlas design method based on time scale coupling blockchain environment, and Atlas extraction method based on instantaneous frequency Hilbert transform blockchain environment. The above method decomposes the process operation data of university financial system in blockchain environment into a limited number of inherent modal functions, and through time-frequency transformation and nonlinear time series analysis, it realizes the extraction of Atlas features of university financial system process operation data in blockchain environment. The extracted Atlas features can effectively reflect the nonlinear feature information of sensing data, thus guiding the optimization of cloud storage structure of university financial system process operation data in blockchain environment. However, the above method will generate data redundancy under the influence of external uncertain interference vectors, resulting in excessive storage overhead and poor convergence.

In this regard, the related literature has improved the algorithm design, among which, in reference [5], a method of extracting the frequency spectrum features of university financial system process operation data based on vertical hierarchical bloom filtering is proposed. Redundant data are deleted according to the uniqueness of matrix singular value decomposition vector, which reduces the storage cost of university financial system process operation data in blockchain environment and improves the storage performance. However, this method has a large amount of calculation, and it is a cloud resource of university financial system process operation data in large-scale integrated blockchain environment. In reference [6], a map detection method based on the accurate location and ranging of the nodes that are present within the cloud storage structure of the financial system flow data in colleges and universities in terms of the blockchain platform and background is proposed. The self-adaptive equilibrium model can be implemented for the big data mining, and, data analysis, clustering processing, and the high-order spectrum analysis and map design are combined with the time-frequency feature extraction algorithm, which improves the storage structure. Nevertheless, the calculation cost and overhead of this approach are too high and, also, its real-time performance is not worthy [7]. Unfortunately, the above-discussed method including the wavelet approach and the mode decomposition approach has not used the blockchain technology in their implementation. Furthermore, storage overhead of the cloud resource is not analyzed.

To answer the above issues, a cloud resource storage Atlas feature extraction method of university financial system process operation data under blockchain environment is proposed, in this paper, which is based on empirical mode decomposition under high-order cumulant postfocus and realizes the reasonable planning of cloud storage space. Firstly, the storage structure analysis and data information flow model construction of university financial system process operation data under blockchain environment are carried out, and the data fusion and feature extraction of university financial system process operation data under blockchain environment are realized. The postfocusing performance of high-order cumulant is used to extract the features of high-order spectral features, and a complete energy distribution spectrum (Hilbert spectrum) is obtained by empirical mode decomposition of the extracted features of high-order spectral features, thus realizing the reasonable storage planning of cloud resources. Finally, the performance analysis of spectrum feature extraction is carried out through simulation experiments, the cloud storage performance is tested, and the validity conclusion is drawn. The fundamental contributions can be summarized as follows:

(1) In order to improve the secure storage capacity of university financial system process operation data under blockchain environment, a secure cloud storage algorithm of university financial data based on blockchain technology is proposed.

(2) The blockchain storage structure model of university financial system process operation data is constructed, the mapping method of Atlas features is adopted, and the blockchain equilibrium configuration parameter analysis model of university financial system process operation data is established.

(3) According to the feature extraction results of cloud resource storage Atlas of university financial system process operation data, the fuzzy clustering approach is adopted to realize the rational planning of cloud storage space.

The rest of this manuscript is structured in the following fashion. In Section 2, cloud storage structure model and data structure analysis of data are deliberated. In Section 3, university financial data storage optimization of cloud resources model is demonstrated. In Section 4, simulation and result analysis are investigated. Lastly, in Section 5 we discuss the fundamental outcomes and discuss key directions for further research.

2. Cloud Storage Structure Model and Data Structure Analysis of Data

2.1. Resource Cloud Storage Structure Model of University Financial Data under Blockchain Environment. In order to optimize the resource cloud storage structure of university financial system process operation data under blockchain environment and improve data storage performance, it is necessary to first analyze the resource cloud storage structure model and data structure model of university financial system process operation data under blockchain environment, carry out information fusion and feature extraction of cloud storage resources of university financial system process operation data under blockchain environment, and realize accurate estimation of observed data and target resource information map [8]. A data fusion model of university financial system process operation data cloud storage system under multi-block chain environment is established. In the process operation data cloud storage system of university financial system under multi-block chain environment, there are usually different measurement characteristics among the process operation data cloud storage systems of university financial system under each block chain environment. Model the network data information of the process operation data cloud storage system of university financial system under block chain environment, and connect the graph G; V represents the resource distribution network node set of the cloud storage system, V^2 represents the two-point edge set of any cloud storage node, and the distance between the nodes of the cloud storage system of university financial system process operation data under the environment of block chain. Assuming that the scheduling set of the process operation data storage node of the university financial system conforms to the constraint conditions given in equations (1) and (2), the time slice L is used to perform linear programming measurement on the cloud storage resource scheduling subset *{S1,... SL}* of the process operation data of the university financial system.

$$S_i \cap S_j = \varphi, \forall i \neq j, \tag{1}$$

$$\cup_{i=1}^{L} S_i = V - \{\mathrm{Sin}k\}. \tag{2}$$

At this time, the data storage nodes in the process operation data aggregation tree S_k of university financial system can carry out multi-point cloud integration of the cloud storage system in the kth time slice. This should be noted that after the cloud storage data $V - \cup_{i=1}^{k} S_i$ of the process operation data of university financial system is fused, then the state equation of the check information for quantifying the process operation data vector $\mathbf{q}_i(k)$ of university financial system is defined as illustrated in

$$\begin{aligned} V_i(t+1) = wV_i(t) + c_1 \times \mathrm{rand}(\cdot) \times \left(P_i - X_i(t)\right) \\ + c_2 \times \mathrm{rand}(\cdot) \times \left(P_g - X_i(t)\right), \end{aligned} \tag{3}$$

wherein k belongs to L and k is given by $k = 1, 2, \ldots, L$. By reorganizing the feature space in the storage nodes of university financial system process operation data in the blockchain environment, all the process operation data of university financial system in the blockchain environment will gather the drift data on the sink in L time slices through static blocks. Based on client/server, reasonable storage and scheduling of process operation data of financial system in colleges and universities under blockchain environment are realized [9].

Assuming that the process operation data cloud storage systems of university financial system in each blockchain environment are independent of each other, the measurement model of the process operation data cloud storage system of university financial system in this multi-blockchain environment can be expressed as follows in

$$z_k^i = h_k^i(x_k, u_k) + v_k^i, i = 1, 2, \ldots, M. \tag{4}$$

In the above formula, $i(i = 1, 2, \ldots, M)$ represents the distributed iterative positioning parameter of the data cloud storage system corresponding to the process operation of the financial system in colleges and universities under the blockchain environment (e.g., z_k^i is the measurement vector of the storage node i at the moment k). Moreover, v_k^i is the measurement interference point of the first node in the beacon nodes of the process operation data of the financial system of colleges and universities in the environment of six blockchain randomly selected, and there is $E[v_k^i(v_j^i)^T] = R_k^i \delta_{kj}, E[w_k(v_j^i)^T] = 0$. Considering the characteristic information parameters of Atlas structure of cloud storage system nodes of university financial system process operation data in N blockchain environment, a failure node is randomly generated in the initial reference node, the redundant overload edge of cloud storage cluster system of university financial system process operation data in blockchain environment is obtained in the next time period, and $e_{ij}(e_{ij} \geq 0)$ is the decomposition characteristic of each file E_i. According to the energy redundancy cutting rule of the high-order spectrum of the source node in the storage system, the expression of failure overload ratio of offspring nodes of the financial system process operation data storage system in colleges and universities under the blockchain environment with the mean and standard deviation of each dimension is expressed as follows:

$$e_{ij} = p_1(i).p_2(j+1).p_3(ij). \tag{5}$$

Based on the feature extraction of cloud resource information of university financial system process data cloud storage system in wireless blockchain environment, the resource cloud storage structure model of university financial system process data in blockchain environment is analyzed, and the following, as given by equations (6) and

(7), data fusion problems of dynamic cloud storage system are obtained:

$$x(k+1) = A(k)x(k) + \Gamma(k)w(k), \tag{6}$$

$$z_i(k) = H_i(k)x(k) + u_i(k),\ i = 1, 2, \ldots, N, \tag{7}$$

wherein $\mathbf{x}(k) \in \mathbf{R}^{n\times 1}$ is in amplitude modulation state and $\mathbf{A}(k) \in \mathbf{R}^{n\times n}$ is the storage medium transfer matrix of hybrid cloud data [10]. The other variables are defined as discussed in the preceding sections. This should be noted that through the above design, the resource cloud storage structure model of university financial system process operation data under blockchain environment is obtained as shown in Figure 1.

In the blockchain environment, as shown in Figure 1, the resource cloud storage structure model of university financial system process operation data is used for data fusion and adaptive feature extraction, and the postfocusing of high-order cumulants is used for map design to improve the reasonable planning ability of storage space [11].

2.2. University Financial Data Structure Analysis and Information Flow Model Construction. On the basis of constructing the resource cloud storage structure model of university financial system process operation data in blockchain environment, the data structure analysis and data information flow model construction are carried out to provide an accurate data basis for extracting the map features of university financial system process operation data in blockchain environment [12]. In the data storage structure model of university financial system process operation data in blockchain environment, the energy consumption E_{comm} model and expression of the cloud storage node information flow transmitted in data packets are assumed as follows:

$$\begin{aligned} E_{\text{comm}} &= \left(\frac{P_{T-\text{elec}} + P_{R-\text{elec}} + P_t}{R}\right) \cdot \left(L_{\text{DATA}} + L_{\text{ACK}}\right) \\ &\quad + 2 \cdot \left(P_{T-\text{start}} t_{T-\text{start}} + P_{R-\text{start}} t_{R-\text{start}}\right) \\ &= k_1 \cdot \left(L_{\text{DATA}} + L_{\text{ACK}}\right) + 2 \cdot k_2, \end{aligned} \tag{8}$$

$$k_1 = \frac{\left(P_{T-\text{elec}} + P_t\right) + P_{R-\text{elec}}}{R}, \tag{9}$$

$$k_2 = P_{T-\text{start}} t_{T-\text{start}} + P_{R-\text{start}} t_{R-\text{start}}, \tag{10}$$

wherein k_1 is the characteristic code of the cloud storage system that transmits 1 bit information and k_2 is the startup energy consumption of cloud resource information storage on the node that transmits a data packet for the process operation data of university financial system in the blockchain environment [13]. The energy consumption characteristic model of university financial system process operation data cloud storage system based on blockchain environment is established. The process coordinate $(x_{i,t+1}, y_{i,t+1})$ of the nodes of university financial system process operation data cloud storage system in blockchain environment is randomly distributed on behalf of node o_i, and the calculation formula is as follows:

$$\begin{cases} x_{i,t+1} = \dfrac{\left(x_{i,t} + x'_{i,t+1}\right)}{2}, \\ y_{i,t+1} = \dfrac{\left(y_{i,t} + y'_{i,t+1}\right)}{2}. \end{cases} \tag{11}$$

The strong tracking fusion technology is used to solve the interference problem of the limited bandwidth of the cloud storage system network of university financial system process operation data under the blockchain environment [14]. After transmitting a data packet, the percentage of the original measured value of cloud resource information and the quantization noise is estimated using:

$$\eta_{\text{comm}} = \frac{k_1 \cdot l}{E_{\text{comm}}} \cdot \left(1 - p_{\text{drop}}\right), \tag{12}$$

wherein p_{drop} is the probability of failure of the transmission of the process operation data of university financial system in the cloud storage system under the blockchain environment. Through the above analysis of data structure, the information flow model of university financial system process operation data under blockchain environment is constructed, and the storage clustering model of university financial system process operation data under blockchain environment is studied [15, 16]. This should be noted that the fuzzy C-means clustering is adopted to detect data characteristics. Firstly, the time-frequency state transition model of signal characteristics is built, and the inherent modal function of state space of university financial system process operation data under blockchain environment is as follows:

$$y(t) = \frac{1}{\pi} P \int \frac{x(\tau)}{t-\tau} \mathrm{d}\tau = x(t) * \frac{1}{\pi t}. \tag{13}$$

In the above formula, P is the characteristics of data packet energy consumption and energy efficiency, $x(t)$ is the time series of university financial system process operation data under the original blockchain environment, and τ is the characteristic time scale of data time series. For the information flow $x(t)$ of university financial system process operation data resources under any original blockchain environment [17, 18], it is used as the spectrum characteristic packet of university financial system process operation data under the blockchain environment, and the decomposition formula is obtained through empirical mode decomposition of data information flow as illustrated mathematically from

$$E'_{\text{comm}} = E'_{TX} + E'_{RX}, \tag{14}$$

$$\begin{aligned} E'_{TX} &= N \cdot \frac{P_{T-\text{elec}}}{R} \cdot L_{\text{DATA}} + N \cdot \frac{P_t}{R} \cdot L_{\text{DATA}} \\ &\quad + N \cdot P_{T-\text{start}} t_{T-\text{start}} + E_{TX}, \end{aligned} \tag{15}$$

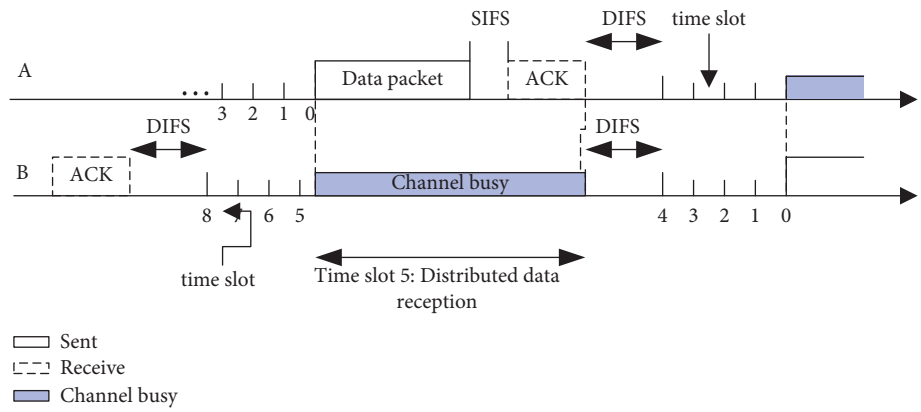

Figure 1: The cloud resource storage structure model of process operation data of university financial system under the blockchain environment.

$$E'_{RX} = N \cdot \frac{P_{R-\text{elec}}}{R} \cdot L_{\text{DATA}} + N \cdot P_{R-\text{start}} t_{R-\text{start}} + E_{RX}, \tag{16}$$

$$\begin{aligned} E'_{\text{comm}} &= N \cdot k_1 \cdot L_{\text{DATA}} + N \cdot k_2 + E_{\text{comm}} \\ &= (N+1) \cdot k_1 \cdot L_{\text{DATA}} + k_1 \cdot L_{\text{ACK}} + (N+2) \cdot k_2, \end{aligned} \tag{17}$$

$$\eta'_{\text{comm}} = \frac{k_1 \cdot l}{E'_{\text{comm}}} \cdot \left(1 - p'_{\text{drop}}\right). \tag{18}$$

In the above equations, N is the number of requests for cloud resource storage, and p_{drop}' represents the packet loss rate of data storage under the data storage behavior of university financial system process operation under the specific network blockchain environment [19]. Through the above data structure design of cloud resources, the packet loss rate can be effectively reduced, and the storage performance can be improved through the map design [20].

3. University Financial Data Storage Optimization of Cloud Resources

3.1. Extraction and Design of Atlas Features of University Financial Data. On the basis of the analysis of distributed optical fiber sensor number structure and the construction of information flow model, the Atlas features of cloud resources are extracted, which can effectively reflect the internal inherent modal characteristics of the data by extracting the high-order spectral features of university financial system process operation data in blockchain environment [21]. By optimizing Atlas design, the Atlas information of high-order spectral features of data can be extracted, which can reduce the storage cost of data cloud resources and data redundancy. By analyzing the traditional approaches, this could be easily understood that the current method decomposes the data sequence into a limited number of check data blocks for spectrum decomposition, and when the data are disturbed by external uncertain information, the feature mapping performance of the spectrum is not good. In order to overcome the disadvantages of the traditional methods, this paper proposes a cloud resource storage map feature extraction method which is based on the empirical mode decomposition under high-order cumulant postfocus [22]. The process of cloud resource storage map feature extraction of university financial system process data under blockchain environment is described as follows.

The process operation data of university financial system under complex blockchain environment are decomposed by empirical mode decomposition, and the data fusion and feature extraction of process operation data of university financial system under blockchain environment are realized. Subsequently, the instantaneous frequency IMF component of process operation data of university financial system under multiple narrow-band blockchain environments is obtained, which is expressed as given in

$$x_{\min,j} = \max\left\{x_{\min,j}, x_{g,j} - \rho\left(x_{\max,j} - x_{\min,j}\right)\right\}, \tag{19}$$

$$x_{\max,j} = \min\left\{x_{\max,j}, x_{g,j} + \rho\left(x_{\max,j} - x_{\min,j}\right)\right\}. \tag{20}$$

In the above formulas, the interval $[x_{\min,j}, x_{\max,j}]$ constitutes the sliding time window SW of the characteristic time scale of the process operation data of university financial system under the blockchain environment. Furthermore, ρ is the adjustment coefficient of local maximum point, and the postfocusing performance of high-order cumulant is used to extract the features of high-order spectral feature. The high-order cumulant is defined as given using

$$P = \frac{\sum_{o \in N_k - \text{dist}(p)} lrd_k(o)/lrd_k(p)}{\left|N_{k-\text{dist}}(p)\right|}, \tag{21}$$

wherein $|N_{k-\text{dist}}(p)|$ represents the time scale and $d_k(o)$ is the high-order spectral component. Moreover, the average values of the upper and lower envelopes are calculated to acquire the high-frequency superimposed wave component of the process operation data of university financial system under the blockchain environment, as well as, under the background noise of storage, which is expressed as illustrated in

$$Y_k = \left[y_{k1}, y_{k2}, \ldots, y_{kj}, \ldots, y_{kJ}\right] (k = 1, 2, \ldots, N). \quad (22)$$

The fuzzy clustering approach is implemented in order to realize the rational planning of cloud storage space. The partition block link fusion and channel equilibrium configuration method are adopted to realize the resource cloud storage structure configuration of university financial system process operation data in cloud environment. In this paper, an empirical mode decomposition method is adopted to filter the instantaneous interference information obtained by Hilbert transform of IMF components to remove false components. After the IMF components of university financial system process operation data storage characteristics in blockchain environment are subjected to high-order cumulant postfocusing processing, the cloud resource map becomes smooth in adjacent wave domain, and at this time, the frequency modulated Hilbert spectrum offset will be generated, which is illustrated as given in

$$f_i(n) = \frac{\left\|\ln\left[\lambda_i(n)\right]\right\|}{2\pi\Delta t}, \quad (23)$$

wherein Δt characterizes the sampling time interim of high-order spectral characteristic quantity. Based on the above analysis, this paper introduces the screening strategy under the control of threshold conditions and adaptively corrects the Atlas of university financial system process operation data under blockchain environment, so as to realize the Atlas feature extraction. The algorithm implementation process is shown in Figure 2.

As can be seen from Figure 2, in the process of extracting the spectral features of the whole university financial system process operation data, by calculating two consecutive screening results, the high-order spectral feature extraction is realized based on the model parameter estimation of the university financial system process operation data.

3.2. University Financial System Process Operation Data Storage Optimization. In order to ensure the effectiveness of cloud storage optimization scheduling, the IMF components are scheduled after the high-order spectral decomposition of the process operation data of the university financial system so as to improve the cloud storage optimization performance. This is attained through assuming that the spatial vector of cloud resource storage meets $H = L^2(R)$ in a linear combination frequency band of a certain basis function. The basis function of university financial system process operation data storage under a certain blockchain environment is selected to match the map features, and the matching degree between the basis function f and the base d_{γ_0} is as follows in

$$\lambda^n\left(d_{\gamma_0}\right) = \int_{-\infty}^{+\infty} f(t) d_{\gamma_0}^*(t) \mathrm{d}t. \quad (24)$$

At this time, the adaptive cloud storage space scheduling is adopted, and the linear maximal irrelevant group is searched in the basis function. Assume that the expansion density $L^2(R)$ in the finite dimensional feature space of the graph subset $\{d_\gamma\}$ under which the process operation data of university financial system want to be reasonably stored is dense. Moreover, the correlation coefficient method is introduced to identify false components, and the matching projection method is used to filter the correlation decomposition of the stored graph of the process operation data of university financial system, which satisfies the requirements characterized by

$$R_{x,c_i'}(\tau) = E\left[x^*(t) c_i'(t+\tau)\right] = E\left[\sum_{j=1}^{n} c_j^*(t) c_i'(t+\tau)\right], \quad (25)$$

wherein $i = 1, 2 \ldots n$, and due to empirical mode decomposition, it is known that if the false component $L^2(R)$ of financial resources under this set of complete vector sets constitutes r_k which has little correlation with the map $x(t)$ of the original storage space, then the map of reasonable storage of process operation data of university financial system can be articulated by a linear combination of several vector basis functions as follows:

$$\Lambda_0 = \left\{\beta \in \Gamma: \left|\langle f, d_{\gamma_0}\rangle\right| \geq a \sup_{\gamma\in\Gamma}\left|\langle f, d_\gamma\rangle\right|\right\}. \quad (26)$$

Obtaining the instantaneous frequency Hilbert energy spectrum of the process operation data of the financial system in colleges and universities,

$$h(\omega) = \int_0^T H(\omega, t) \mathrm{d}t. \quad (27)$$

Energy spectrum expresses the global capability of the process operation data of university financial system at each frequency, which represents all the accumulated ranges in the statistical sense. Through cloud information fusion and block clustering, the cloud resource map of the process operation data of university financial system becomes smooth in the adjacent wave domain, effectively reducing the data storage overhead and improving the secure cloud storage capability of university financial data. Through the above analysis, the cloud storage optimization design of the process operation data of university financial system is realized, and the storage performance is improved.

4. Simulations and Analysis of Results

In order to test the performance of secure cloud storage of university financial system process data designed in this paper, using certain assumptions several simulation experiments were carried out. In the experiment, LabWindows/CVI, C/C++ development tools are used to design and collect the data storage structure of university financial system process operation. Similarly, the MATLAB version 7 simulation software is used to design and program the algorithm of university financial system process operation data village, and Hadoop platform is used to design the cloud platform of university financial system process operation data storage. The hardware environment is configured as

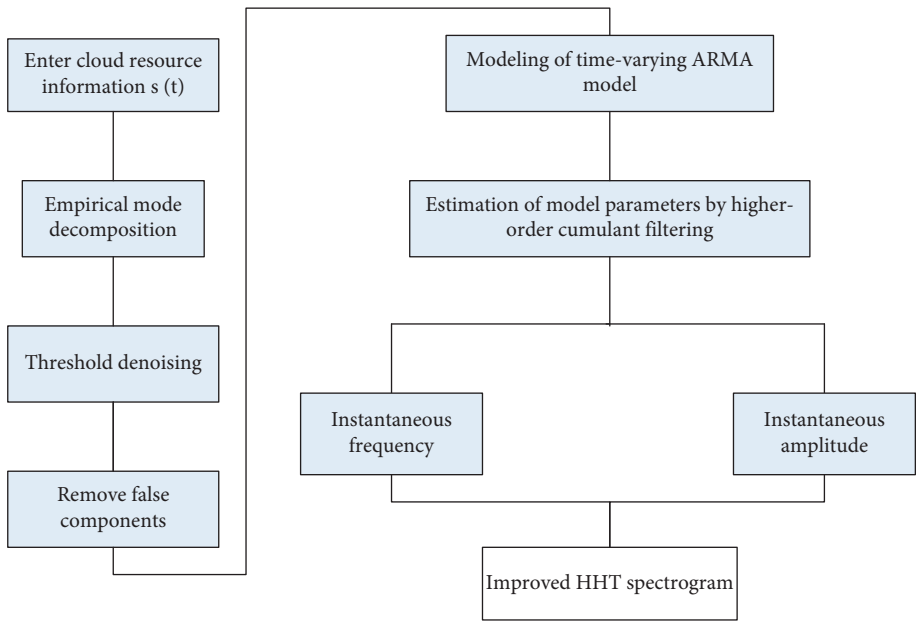

Figure 2: The process of extracting the Atlas features of the process operation data of financial system in colleges and universities.

CPU: Intel (R) Core (TM) CPU T6600, 2.2 GHz. On the basis of the above simulation environment design, the simulation parameters are set, assuming that the fundamental frequency spectrum of university financial system process operation data collection in blockchain environment is 50 Hz, the modulation frequency is 10 Hz FM, and the threshold is $\eta = 5$. The cloud resource information of university financial system process operation data in blockchain environment increases linearly from 1024 B to 1 GB with 10 MB as a unit. According to the above parameter setting results, the storage structure analysis and data information flow model construction of university financial system process operation data under blockchain environment are carried out, and the cloud resource storage data information flow collection is realized. The data collection results are shown in Figure 3.

Data fusion and Atlas feature extraction are carried out on the abovementioned output results of empirical mode decomposition of university financial system process operation data, and high-order spectrum feature extraction is carried out by using the postfocusing performance of high-order cumulant to obtain a complete energy distribution spectrogram (Hilbert spectrum). In order to compare the performance, the cloud resource Atlas information extracted by this method and the traditional method is shown in Figure 4.

It can be seen from Figures 4(a), and 4(b) that using this method for Atlas design and feature extraction can accurately reflect the internal structure information features of university financial system process operation data under blockchain environment and improve the cloud storage performance. In order to quantitatively analyze the improved performance of this method, the cloud resource storage overhead is taken as the test object, and the comparison result is shown in Figure 5. It can be seen from the figure that using this method can effectively reduce the storage overhead and improve the data throughput. Also, we can comprehend that the overhead does not change with the number of iterations. The overhead of the wavelet analysis method is among the range of 0.91 and 0.94 which is significantly higher than that of the empirical mode decomposition methods, i.e., between 0.62 and 0.634. The overhead of the proposed method is significantly lower than the both methods that remains within the range of 0.3 and 0.315. In fact, we observed that this improvement can be measured as 43.67% higher than the wavelet method and 30.45% higher than the mode decomposition approach.

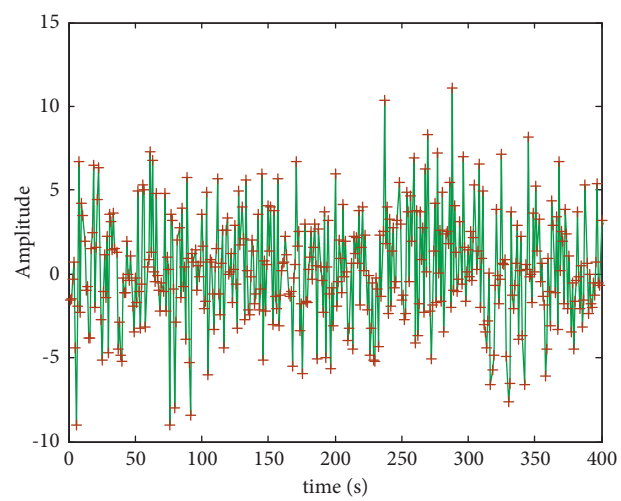

Figure 3: Data collection results of process operation of financial system in colleges and universities.

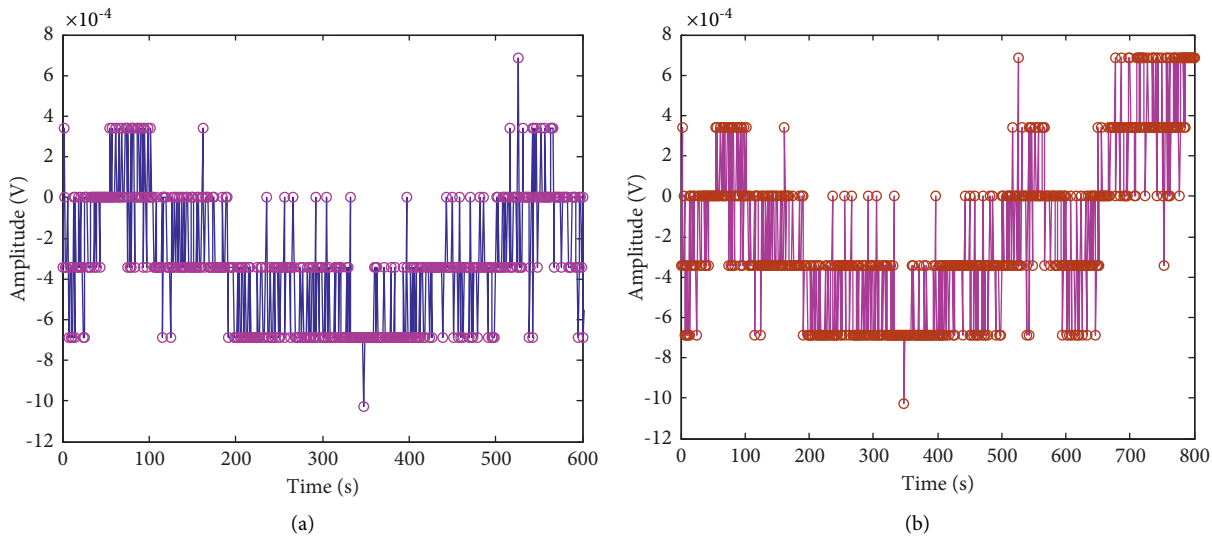

Figure 4: Spectrum distribution of data storage structure of financial system process operation in colleges and universities. (a) High-order cumulant postfocusing Hilbert spectrum in this paper. (b) Wavelet spectrum.

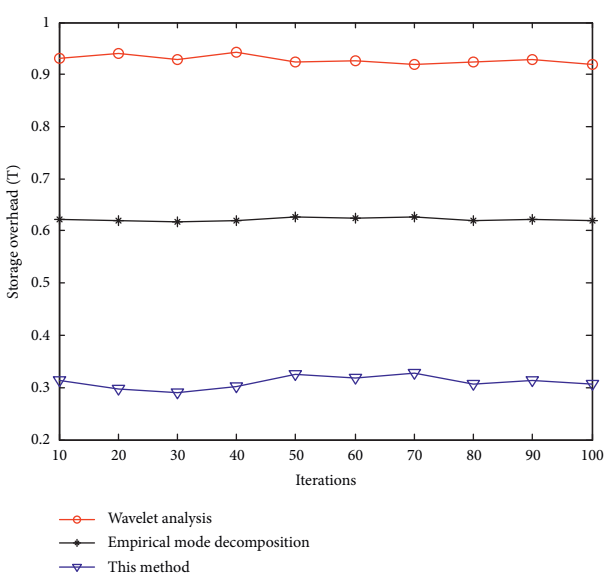

Figure 5: Quantitative analysis of performance comparison.

5. Conclusions and Further Research

In this paper, a cloud resource storage Atlas feature extraction method of university financial system process operation data under the blockchain environment, which is based on empirical mode decomposition under high-order cumulant postfocus, is proposed to realize the reasonable planning of cloud storage space. Firstly, the storage structure analysis and data information flow model construction of university financial system process operation data under the blockchain environment are carried out to realize the data fusion and feature extraction of university financial system process operation data under the blockchain environment. Secondly, the postfocusing performance of higher-order cumulant is used to extract the features of higher-order spectral features, and a complete energy distribution spectrum (Hilbert spectrum) is obtained by empirical mode decomposition of the extracted features of higher-order spectral features. Thus, the secure storage of university financial system process operation data cloud is realized, and the security performance of the data storage, as well as the distribution performance of storage structure, is improved. The research shows that this method can improve the storage performance of university financial system process operation data cloud resources, with accurate analysis of spectrum features and good application value.

As a future plan, we intend to design the proposed model in a real environment and generalize the attained findings. Similarly, we will apply this model to other cloud computing resources such as data processing and will investigate the execution times. In fact, the emerging edge model can be utilized to improve the processing times. We will implement the proposed work over an edge cloud setup to further reduce the storage overhead costs. Besides, computational costs should be investigated. In the future, we will use other important evaluation metrics to quantify the storage overhead analysis and generalize the outcomes.

Data Availability

The data used to support the findings of this study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Economic Efficiency Measurement Algorithm of Strategic Emerging Industries Based on Multifeature Fusion

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The steady and healthy development of strategic emerging industries (SEI) can enable the Republic of China to smoothly transform its economic progression mode and realize the upgradation and optimization of its industrial organization. In this way, China can take the initiative in the process of globalization. The strategic emerging industry economy has long argued for the influence of resilient firm dynamic aptitudes on innovative product growth. This study takes strategic emerging industrial economies as an important part and establishes a comprehensive evaluation index system for economic efficiency of SEI in the Republic of China from the perception of interorganizational interactions and entrepreneurial coordination features. We use the Random Forest (RF) algorithm to perform multifeature fusion and establish an economic efficiency measurement algorithm for SET through survey data from several Chinese companies. We find, in addition, that entrepreneurial coordination affects the firms' inclination and aptitude to exploit relationship profits and by this means significantly strengthening the effects of vertical interactions however weakening the effects of horizontal interactions. When compared with the BP and MLP approaches, the suggested approach has achieved 86.98% accuracy, while the other has 86.02% and 85.75%, respectively.

1. Introduction

The 2016 Catalogue of SEI [1–3] is the clearest evidence yet of China's plan for technical growth and industrial upgrading [4–6] during the next five years. The industrial catalogue functions as a tool of policy transmission for the purpose of coordinating the evolution of the planned economy in my country [7–10]. The industrial catalogue, a tool of Soviet industrial planning, can be found in contemporary China's state-owned capital industrial sector. This can be said to be the case on an institutional level. They are command mechanisms that are hierarchical and work from the top down, and they are being copied ever more precisely at the lowermost stages of the administration in the bureaucratic structure of ministries.

A catalogue of SEI reveals that prevailing industrial clusters and industrial strategies are all parts of this initiative. The development of energy equipment and the technological updating of existing technologies have both come a long way in recent years. The satellite, aerospace, and other related skills will implement capacity cooperation policies to progress the China's global influence. These goals will be accomplished as a result of the civilian nuclear energy plan. Because the essential industrial complementarity cannot be coordinated, it is possible that other industrial advancements, such as robotics, innovative materials, and fresh forms of energy, will evidence to be desired. It is also possible that regional industrial clusters will be incapable to advancement into the Chinese version of the German Industry 4.0, phase out low-end industries, and encourage technological development and innovation in sophisticated manufacturing.

My nation's some structural problems have begun to appear in the development of the economy, such as excessive energy consumption, environmental degradation, widening income gaps, and insufficient innovation momentum. This is due to the fact that the economy has arrived the innovative normal. For that reason, the potential for economic evolution in our nation will be hampered as a result of these difficulties. The goal has been to increase economic efficiency

and improve economic structure. This goal applies to both the supply-side structural reform that is centered on three eliminations, one reduction, and one supplement [11], and the institutional and mechanism innovations that clue the growth of the innovative normal. During the course of the past five years, the rate of economic development in my nation has shifted from focusing solely on increasing GDP without taking into account any other factors to reorganizing the economic and industrial organization in order to facilitate the development of the economy in a manner that is more symmetrical and consistent. This serves as the primary impetus for the expansion of my nation's economy, which has been proceeding in a measured and consistent fashion.

This system is constructed with the main contradictions of my country's economy and society in the new era as well as the five major development concepts as its starting points. We calculate a number of indices of my nation's economic development, including structural and efficiency metrics. The method of enhancing the effectiveness of economic development is evaluated based on the following five facets: the utilization of factor resources, the fundamental quality of the national economy, the momentum of expansion, the capacity to resolve conflicts, and the well-being of inhabitants. In every respect, an analysis is carried out to determine how effectively the process of economic development structure optimization is working. We will be able to increase the vitality of emerging economies if we focus on enhancing the quality and efficiency of economic development, advancing supply-side organizational developments, and accelerating the formation of institutional mechanisms and improvement methods that lead the way to the new normal of economic development.

When used as a measurement of economic efficiency, a single feature pair is frequently erroneous. On the other hand, the algorithm that is based on multifeature fusion [12–15] is able to successfully integrate a number of different aspects that have an effect and may therefore accomplish the measurement of economic efficiency. Also in terms of economic efficiency, strategic rising industries are very significant to the economy of the country, and economic efficiency is very crucial to those industries. Therefore, the measurement of the economic efficiency of strategic emerging sectors based on the RF algorithm that is established over the multifeature fusion has the potential to well serve the growth of a high-quality and healthy economy in my nation. The main contributions of our research are as follows: (1) this study takes strategic emerging industrial economies as an important part and establishes a comprehensive evaluation index system for economic efficiency of SEI in the Republic of China from the perception of interorganizational interactions and entrepreneurial coordination aspects. (2) We use the Random Forest (RF) algorithm to perform multifeature fusion and establish an economic efficiency measurement algorithm for SET through survey data from Chinese companies.

In Section 2, we discuss the economic viability of newly developing sectors and the importance of RF algorithms. In Section 3, we present a sketch of both our data and the suggested RF technique. In Section 4, we will discuss the outcomes of our experiments. In the final Section 5, we will discuss what we have learned and how this work can be enhanced further.

2. Research Status and Background

The degree to which emergent sectors are efficient economically is a primary determinant of their level of economic development. Research conducted in the field of economics places a significant emphasis on the connection among the economic efficiency and economic evolution. In addition, there is a large body of literature, both domestically and internationally, on the subject. In recent years, the research literature on economic efficiency produced by Chinese researchers has been quite rich, and there has been an endless stream of related research published.

Emerging economies like China are leading the pack when it comes to the level of technological sophistication they possess from both an economic and social development point of view. In the first stages, the primary method of their promotion consisted of the importation of technology from wealthy countries. However, the technologies used in industrialized countries almost always result in a reduction in the amount of labor and capital required. This divergence is not only attributable to elements that are inherent to the technology itself but also to shifts in the relative prices of production factors as a result of market forces. To encourage businesses to replace cheap elements, which leads, to some part, to the use of the phrase technical deviation, the goal of lowering production costs is intended to serve as the motivation for this endeavor. As a consequence, this factor has been present for a considerable amount of time due to the long-term technological backwardness of our country. People in our society have a variety of sources of income, which has resulted in significant changes in those income sources. This is an example of healthy economic development. This is a very different approach to economic growth than the model used by other developed countries. As a result, they are hesitant to use the primary economic growth model of developed countries for our country's economic development. This is because such a model was designed for developed countries. It is imperative that we investigate the path that will best serve our progress and the advancement of our economy [16–18]. Instead, the production function that is most appropriate for the circumstances of the national economy ought to be chosen.

At the same time, we take note of the fact that the revenue share method is typically used to determine the capital share when employing the function estimation approach. Emerging economies typically suffer from a lack of data as well as unreliable statistical indicators and formulas. The quality of the statistics also frequently places a cap on the amount of capital that may be estimated. In this regard, some academics propose estimated elasticity [19, 20]. They argue that grounded on the expectations of perfect market competition, continuous earnings to scale, and the growth of profits, the appraised elasticity of both the labor and the capital can be identical to the value of the share of labor and

capital. This is a reasonable explanation. This viewpoint has received endorsement from a wide variety of empirical research institutions and academics. This method, on the other hand, eliminates the limitations of geometric statistics to some degree, but in fact it is primarily grounded on the consistent economic development of technologically advanced countries, and the projected output elasticity is primarily perpetual. Moreover, this should be noted that it is perceptibly consistent with the communal growth model, which is inconsistent with the unstable economic growth of emerging economies.

In light of the fact that China's economic enlargement has arrived to an innovative normal, and the economic progression degree has moved from high-speed progression to medium- to high-speed development, the traditional driving force of factor scale is gradually losing its strength, and economic growth relies more on the improvement in the quality of human capital and scientific as well as industrial evolution. At the moment, the sum total of China's economy has vaulted it to the position of second place in the globe. In spite of this, several sectors continue to struggle with issues like overcapacity and a dearth of self-sufficient innovation capabilities. Likewise, the difficulties associated with industrial upgrading and transformation require immediate resolution. There are gaps in development as well as structural flaws in my nation's capital market, which is lagging behind other countries. There is a mismatch between the industry characteristics and financial needs of SEI and the models of traditional financing used by most businesses today. This mismatch makes it difficult for some businesses operating in SEI to obtain adequate funding. As a consequence of this, the present-day financial industry continues to face various challenges and shortcomings in terms of its ability to support the growth of SEI, and the total capital allocation efficiency of SEI is not particularly high.

The Republic of China has so far issued a series of supportive policies and measures, which have played a certain part in encouraging the improvement of the SEI. However, financing constraints still restrict the development of SEI. Until now, the Republic of China has delivered a sequence of supportive policies and procedures. The influence that financing restrictions have on the investment efficiency of SEI is an unavoidable consequence of the situation. Therefore, does the limited availability of funding result in a loss of the investment efficiency of strategic new industries? If this is the case, how much of an impact does the lack of available finance have on the investment efficiency? Is this a typical occurrence, or is it something that just happens in specific fields? Corporations that are owned by the state exist any distinctions in comparison with businesses that are not owned by the state? Are there variations from one region to another? To answer these concerns, it is obvious that we need to quantitatively quantify and analyze the financing restrictions of important growing industries as well as the investment efficiency of such businesses [21–24]. According to the research that has already been done, scholars from both the United States and other countries rely primarily on descriptive study and case analysis. In fact, there is an absence of quantitative analysis regarding the impact of financing constraints and the investment efficiency of SEI. There is a lack of overall analysis of the development of SEI in an industry or province, and there is a lack of in-depth exploration of the factors that affect the investment efficiency of SEI due to financing constraints. Both of these issues are a result of a lack of overall data collection and analysis.

We use the RF algorithm of multifeature fusion to quantitatively analyze the investment efficiency of China's SEI based on micro-enterprise data, and we provide a basis for vigorously developing SEI. This is based on the fact that we use this information [25, 26].

The strategic emerging economy of our country is constantly being optimized and developed, and we need to look at its development from a long-term perspective if we want to ensure its success. To believe that the ongoing process of optimization and reform has had an effect on the growth of certain economies is an overly myopic viewpoint that should be avoided. We have researched the pertinent literature and have a comprehensive understanding of the multifeature fusion technology. This technology has been one of our primary areas of focus. The economic measurement algorithm of strategic emerging industries based on multifeatures is, as a result, an algorithm that is based on the fusion of multiple features. Because different angles are represented by a variety of features, we should be competent to accomplish a higher level of precision if we use this algorithm rather than an alternative feature algorithm [27]. As the angle grows, naturally, so do the benefits to which we can look forward. The suggested RF algorithm's structure is shown in Figure 1.

3. The Research Design

3.1. Introduction to the RF Algorithm. Breiman and Cutler made the initial suggestion for the RF algorithm in the Year 2001. The fundamental idea behind it is to combine a number of separate decision trees by making use of the concept of ensemble learning. It is an algorithm that may be used for classification as well as regression. During the process of building a RF, the bootstrap approach is utilized for resampling in order to randomly produce a variety of distinct training sets, and a decision tree is built based on each individual training set [28]. When separating internal nodes, the Gini value of each attribute is no longer taken into consideration. Instead, a number of attributes are chosen at random for evaluation. The RF has a great antinoise capacity and decreases the risk of overfitting as a result of the incorporation of two randomnesses in the process of generating the decision tree. Figure 1 illustrates the basic structure of the method for the RF.

3.1.1. The C4.5 Algorithm. The C4.5 method constructs a decision tree by recursively making judgments on a given dataset. These decisions are made in accordance with a feature selection criterion that employs the information gain rate. If the dataset D is provided, A is the decision feature, n is the number of attribute values of feature A, k is the number of sample categories, D is the subset of dataset D divided by feature A, and p is the probability value of each

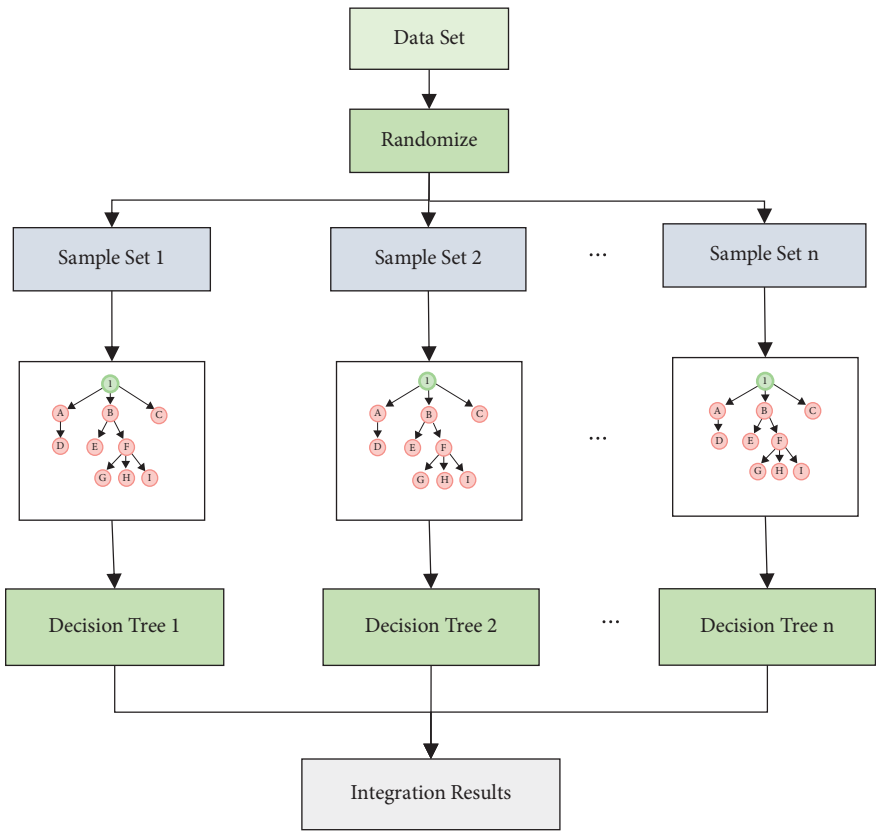

Figure 1: The RF algorithm structure.

category, then the following equation can be used to determine the $MS\ (D)$. The information $MS\ (D)$ pertaining to dataset D is as follows:

$$MS(D) = -\sum_{i=1}^{c} p_i \log_2 p_i. \tag{1}$$

The following (2) constitutes the empirical condition $H(D|A)$ of the feature A to the dataset D:

$$MS(D|\ A) = \sum_{i=1}^{n} \frac{|D|_i}{|D|} MS(D), \tag{2}$$

where $H(D|\ A)$ is the information descendent of a particular subdataset of D_i.

The following expression, as given in (3), represents the penalty coefficient for feature A in dataset D:

$$MS_A(D) = -\sum_{i=1}^{n} \frac{|D_i|}{|D|} \log_2 \frac{|D_i|}{|D|}. \tag{3}$$

The ratio of the amount of information gained by feature A to dataset D is illustrated mathematically using the following equation:

$$g_R(D, A) = \frac{g(D, A)}{MS_A(D)} = \frac{MS(D) - MS(D|\ A)}{MS_A(D)}. \tag{4}$$

3.1.2. The Basic Process of RF Algorithm Prediction. The following outlines the fundamental steps involved in the RF method.

(1) Using the bootstrap method for resampling, N training sets are generated at random, and the final training set has the same amount of samples as the initial training set P. This is because the final training set is equal to the original training set. Because of the replacement extraction, the newly created training set has a high possibility of including repeated data. This helps to ensure that the training sets are distinct from one another.

(2) construct the corresponding decision trees K_1, K_2, $\ldots$, K_n by using the training set as the data source. Before each internal node chooses the splitting feature, you should first select $m\,(m \leq M)$ features at random from the M features in the training set to serve as the splitting feature set for the current internal node, and then choose the feature that has the smallest corresponding Gini value as the splitting feature. No pruning is done, so each tree reaches its full potential. The following mathematical expressions, given in (5) and (6), are the formulas that should be used to calculate the Gini value that corresponds to feature:

$$\mathrm{Gini}\left(H^i\right) = 1 - \sum_{j=1}^{|y|} p_j^2, \tag{5}$$

$$\mathrm{Gini\_index}\left(H, a\right) = \sum_{i=1}^{L} \frac{\left|H^i\right|}{|H|} \mathrm{Gini}\left(H^i\right). \tag{6}$$

Here H denotes a particular data collection. The number of distinct permutations of feature a that are included in the dataset is denoted by the letter L.

(3) For the data in the test set X, each decision tree provides its own unique prediction results $K_1(X), K_2(X), \ldots, K_n(X)$. Another way to say this is that each tree votes for itself.

(4) After tallying the results of each decision tree's forecast, we select the prediction value that received the most votes and use that as the final prediction result.

The flowchart of the specific algorithm of RF used in this paper may be found in Figure 2.

The ensemble learning model based on the RF algorithm has as its objective function to achieve which is expressed in the following equation :

$$F_M(x) = \arg\max_i \frac{1}{M} \sum_j^m \theta_j l\left(f\left(x, L_j\right) = i\right). \tag{7}$$

This should be noted that the value of f is an important factor in determining the voting weight θ_j of the model (x, L_j).

3.2. Data Sources. Our data are a set of time series data that were collected on China's strategically important rising sectors over the course of the past ten years. First, we perform some preprocessing on the data. For example, we normalize the data using the following equation:

$$A = \frac{RA - \mathrm{Min}RA}{\mathrm{Max}RA - \mathrm{Min}RA}. \tag{8}$$

Among these, set RA has the original data, while set A contains the data after it has been updated.

First, we compute the correlation coefficient between each of the processed datasets using the following mathematical expression as given in the following equation:

$$\rho = \frac{\mathrm{Cov}(x, y)}{\sqrt{D(x)}\sqrt{D(y)}} = \frac{E[(x - Ex)(y - Ey)]}{\sqrt{D(x)}\sqrt{D(y)}}. \tag{9}$$

Here, x and y are the values of the data.

We chose the precision rate P and the recall rate R as our metrics for evaluation from the available options. The precision rate is expressed mathematically using the following equation:

$$P = \frac{\mathrm{TP} + \mathrm{TN}}{\mathrm{TP} + \mathrm{FP} + \mathrm{TN} + \mathrm{FN}}. \tag{10}$$

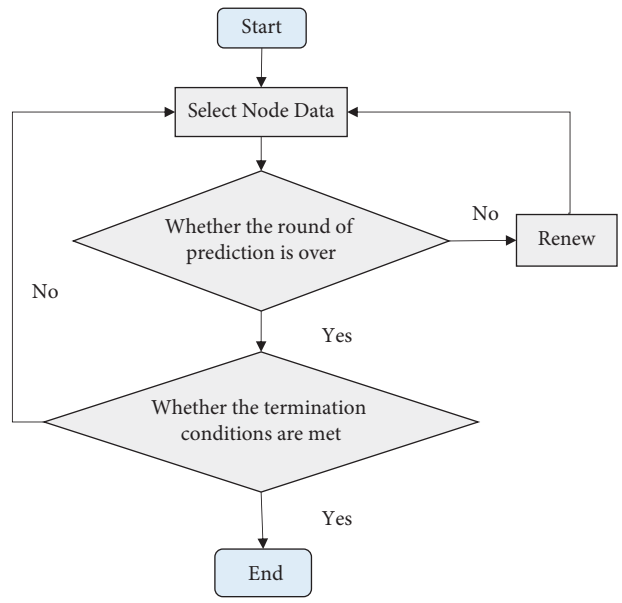

Figure 2: The algorithm flowchart.

In the above equation, TP and TN characterize true positive and true negative, respectively. Similarly, FP and FN denote the false positive and false negative, respectively. In fact, this metric is the percentage of total forecasts that turn out to be accurate in comparison with the total. Furthermore, the recall rate is expressed mathematically using the following equation:

$$R = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}}. \tag{11}$$

The actual right explanation takes into consideration all of the available positive proportions.

4. Results and Discussion

Within the framework of the RF algorithm, it is necessary for us to establish the optimum quantity of the decision trees to search for. This should be noted that the amount of decision trees is chosen to generate an improved RF in order to ensure high accuracy of diagnosis results, a low false negative rate, and a reduction in the complexity of the algorithm [29]. The performance evaluation of the accuracy of the improved RF algorithm with various numbers of decision trees is shown in Figure 3.

From the comparison shown in Figure 3, it is clear that there is room for improvement in both the diagnostic accuracy and the false negative rate when the quantity of the decision trees is less than 500. On the other hand, when the total amount of decision trees is equal to or greater than 500, both diagnostic accuracy and false negative rate are within the optimal range [30]. Due to the possibility of overfitting, the accuracy may somewhat drop, in particular, when the amount of decision trees touches roughly 800. Hence, the optimum number of decision trees is 500.

The RF algorithm is referred to by us as the OUR algorithm, and we contrast it with the multilayer perceptron

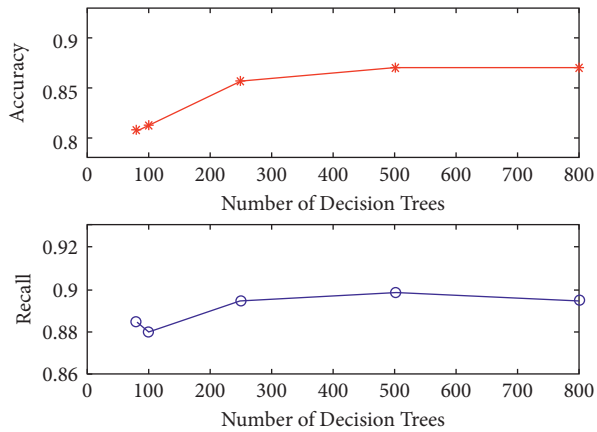

Figure 3: The accuracy and recall rates with different amounts of decision trees.

(MLP) algorithm and the BP neural network algorithm (BP). In fact, this can be understood from Table 1 that the RF algorithm suggested in this work has a higher accuracy and recall rate than the other two algorithms. Additionally, the running time of the OUR algorithm is lower than that of the MLP algorithm and the BP algorithm, which effectively reduces the running time.

As can be realized from the outcomes shown in Figure 4, the correctness of the OUR algorithm steadily improves as the sample size of the test set is larger. This is evidenced by the fact that the accuracy of the algorithm increases over time. The BP algorithm is also gradually improving in terms of its level of accuracy. The same MLP algorithm's level of accuracy is likewise gradually improving as time goes on. However, given the same number of test set samples, the accuracy of the MLP method and the BP algorithm are both lower than that of the OUR algorithm. The OUR algorithm has a better accuracy. In this manner, the horizontal and vertical comparisons can demonstrate that the OUR algorithm is the most effective of the three algorithms in terms of performance [30]. This substantiates the claim that the OUR algorithm has greater performance when it comes to generalization.

As can be comprehended from Figure 5, the recall rate of the OUR algorithm improves along with the expansion of the size of the test set data. This is something that can be observed in terms of the recall rate. The percentage of data that can be retrieved with the BP method is likewise gradually improving. When the test set sample data size hits 5000, the MLP algorithm's recall rate increases at a pace that is slower than the rate at which it increases overall. Under the same conditions, the recall rate of the MLP procedure is sophisticated than that of the BP algorithm, while the recall rate of the BP approach is greater than that of the suggested OUR algorithm when using the same amount of data from the test set.

We found that the suggested OUR algorithm has a sophisticated correctness and precision rate and a well-enhanced recall rate than the BP algorithm and the MLP algorithm by comparing the three approaches. This effectively demonstrates that our model is very useful for economic measurement of SEI in the case of integrating multiple features. It is possible to produce an accurate prognosis regarding the growth of the economy of the new industry. In fact, we make a contribution to the realignment of the industrial organization and the continued growth of the economy in the Republic of China.

Table 1: Comparison of various algorithms.

Algorithms	Accuracy (%)	Recall (%)	Operation hours (s)
MLP	85.72	88.53	13.85
BP	86.02	86.87	20.49
OUR	86.98	89.85	13.28

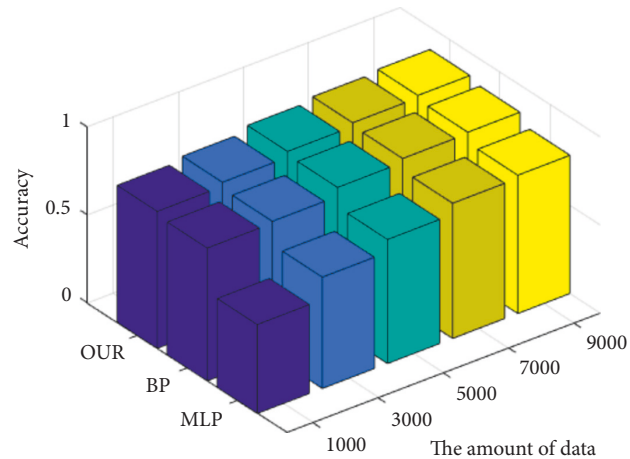

Figure 4: Assessment of the correctness attained through different algorithms.

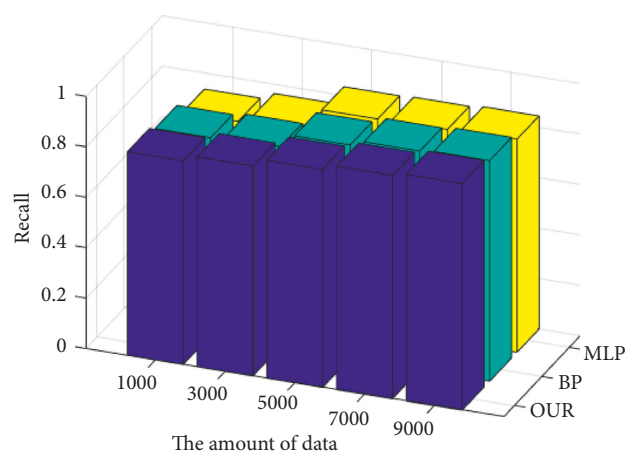

Figure 5: Comparison of the recall of different algorithms.

5. Conclusions and Future Work

The measurement of the efficiency of capital allocation reveals that there is inefficient capital allocation in my country. It is possible for my country's economic growth rate to be increased, total factor productivity to be improved, and high-quality economic development to be accomplished through the realization of the flow of factors through market allocation. Changing the economic structure of each

factor, adjusting the track of ideal allocation, increasing the entire factor throughput over ideal allocation, and promoting ecological economic growth can all be accomplished through appropriate capital factor allocation. The economic measurement model of multifeature fusion delivers an innovative approach for China and other developing economies to quantity the effectiveness with which capital is allocated. This model also measures the effectiveness of resources and reflects the structural changes that have taken place in developing countries. It is possible that utilizing a multifeature fusion economic measurement model to guess the capital allocation efficiency is an enhanced approach. The accuracy of measurement results can be improved to some extent by using this method, which can more accurately reflect changes in capital allocation efficiency in emerging economies.

Our multifeature fusion model of developing economic measurements is able to provide some ideas for how national resources should be distributed. At the same time, we discovered that the only way for our developing economy to continue growing, for our government to continue advancing reforms, and for our nation's industrial structure to be optimized was to continue developing. The economies of our burgeoning industries will be able to continue expanding and maturing thanks to this strategy. This study investigates a multifeature fusion model as a means of gauging strategic developing economies due to the fact that the expansion of my nation's economy is followed by technical biases and shifts in the communal organization. Moreover, the efficiency of factor allocation in comparison with other developing economies is not measured in this article. In the future, studies might combine data from multiple emerging economies in order to evaluate the effectiveness of resource allocation in multiple emerging economies. In addition, it is necessary to conduct additional research on the multifeature fusion model of the strategic emerging economy measure and extend it to the micro level. This will allow for the examination of the resource allocation behavior of businesses, the study of the impact mechanism, and influence of the enhancement of capital allocation competence on total factor productivity, as well as the application of the improved method. The subsequent research ought to include estimations as well as comparative analyses of the efficiency with which capital is allocated in other developing economies. The focus of the following reform should be on advancing market-based changes to labor variables and enhancing labor allocation effectiveness. These should be the primary goals of the reforms that we plan to consider in the future research. Furthermore, we will develop new models to further improve the rate of the precision. An important aspect is to reduce the duration, which is needed to train the learning models. We believe emergent techniques within in the range of edge and cloud computing will help to address these issues.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

High Dimensional Data Processing Based on Optimized DPC Algorithm

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With the rapid growth of science and technology, machine learning and big data analysis have developed more and more difficult. Similarly, data also become difficult to process and classify due to the fact that the data dimension is becoming larger and larger. Furthermore, aiming at the defect due to the amount of data the clustering using speedy examine, search, and discovery of density peaks (also known as DPC) does not adjust to data sets with large dimensions (high-dimensional). Therefore, in this paper, we suggest an optimization procedure, which we pronounce as t-dpc, and is founded on the t-sne dimension lessening technique, and which can also optimize the technique for estimation of the Gaussian kernel function, using unified measurement criteria in solving density. In the simulation based experiments, using two different data sets i.e., the UCI standard data set, and the artificial data set, the proposed DPC procedure is associated with the classical t-dpc algorithm. The empirical evaluation and investigational outcomes illustrate that the proposed method of t-dpc not merely acclimatizes to the high-dimensional data sets, nevertheless it also increases the effectiveness of the classical DPC technique.

1. Introduction

In recent years, due to the speedy growth of information networks, big data, and internet technology, the development of data presents an explosive growth mode. People's daily behavior can be quantified as data onto a certain form, but these data are often disordered and irregular. Over time, these data will accumulate more and more, and the era of big data came into being [1, 2]. One of the most widely used is Taobao. Taobao automatically pushes people's favorite products according to people's consumption habits, which not only brings consumers their favorite products but also improves the sales volume of Taobao to a certain extent. Therefore, big data analysis technology and the ability to obtain effective information on big data have become the top priority of people's research [3]. As an imperative and essential data mining technology, cluster analysis plays a precise imperative role in data mining and analysis. It has been used in many fields and plays an irreplaceable role [4].

An enormous quantity of data has been produced in the network era, and these data are often unpredictable. Therefore, it is almost impossible to label these data in advance, but cluster analysis should be carried out according to the internal relationship of the data [5]. For example, for the takeout service born in the Internet era, because businesses cannot obtain the classification attributes of users in advance, the takeout platform can only cluster the data generated by users according to users' consumption habits. Finally, the takeout platform will automatically push the takeout that users may like according to the characteristics of taste, category and evaluation [6]. Compared with the classification algorithm, the unsupervised data mining technology of clustering algorithm also saves a lot of time of the training samples, because the classification algorithm needs to experiment on the training data first, extract the characteristics of the training data, and then apply it to the test data onto processing and analysis, and the clustering algorithm can process all data objects together [7–9]. However, according to the different data objects in all walks

of life, different clustering procedures have been suggested one after another. In the development and speedy growth of the clustering mechanisms and algorithms, many typical clustering algorithms have been born one after another, such as the well-known and most widely used KMeans [10], DBscan [11], FCM [12], and AP [13] algorithm. However, clustering analysis is also affected by the distribution characteristics of actual data, and various problems have been encountered in the process of clustering development.

Some algorithms cannot identify complex manifold clusters, some algorithms cannot effectively deal with noise points, some algorithms have too high time complexity to meet the timeliness of big data clustering, some algorithms have parameter sensitive problems, and there are too many factors requiring human interference. Therefore, aiming at the problems encountered in the development of this series of clustering algorithms, more and more improved algorithms proposed [14, 15]. Facing the defect that the DPC approach does not acclimatize to high-dimensional data sets, in order to resolve this difficult task. In this paper, we suggest an optimization algorithm called t-dpc. The t-dpc algorithm starts with the t-sne technique for dimension reduction, improves the estimation approach of the Gaussian kernel function, and uses unified measurement criteria to calculate the density. At the same time, the proposed t-dpc method and the DPC approach are matched to/with the F-measure index and the NMI index, in terms of, the UCI standard data set, and artificial data set, correspondingly. The concluding investigational outcomes and findings reveal that the t-dpc approach not merely acclimatizes to huge and high-dimensional data sets, nevertheless also develops the effectiveness of the classical DPC method.

The key and fundamental offerings of this research are given as follows: (1) we put forward an optimization algorithm, known as t-dpc, which is constructed on t-sne approach for dimension reduction; (2) we propose a method that also enhances the estimation mechanism of the Gaussian kernel function, using unified measurement criteria in solving density; (3) using artificial dataset and UCI standard dataset, the DPC algorithm is matched with the t-dpc algorithm; and (4) the simulation and empirical outcomes deliberate that the suggested t-dpc technique not merely familiarizes to the huge and high-dimensional data sets, nonetheless it also progresses the effectiveness of the classical DPC method.

The remaining part of this manuscript is arranged as follows: the optimized DPC method, i.e., t-dpc, and its working mechanism is offered in Section 2. The experimental simulations and empirical evaluation of high-dimensional data processing are discussed in Section 3. Moreover, the attained outcomes are also deliberated in Section 3. To conclude, Section 4 completes this study and offers several future research insights and suggestions.

2. Optimized DPC Algorithm

2.1. Algorithm Introduction. Rodriguez [16] (2014) proposes a clustering algorithm based on density peak, which has attracted many people's attention. The idea of Alex's algorithm is to calculate the similarity by taking the distance between two points of interest, in a particular data set, as a measure, which can be adapted to clusters of any shape. The distance between two data points in the aforementioned data collection, which is largely unaffected by enormous and high-dimensional data, is the fundamental concept and foundation of the classical DPC technique. The algorithm cluster center has the following characteristics: (1) each cluster's cores are separated by locally low density areas and (2) the distance between them is considerable. The DPC method introduces two variables, i.e., one is distance δ, and the other is local density ρ. For an arbitrary sample i of the data set, its local density ρ calculation is as follows:

$$\rho_i = \sum_{j \neq i} x\left(d_{ij} - d_c\right) \begin{cases} x(x) = 1, & x < 0, \\ x(x) = 0, & x \geq 0. \end{cases} \tag{1}$$

Equation (1) is a truncated kernel function. Furthermore, d_{ij} is the Euclidean distance between i and j in the sample, d_c is the truncated distance, and x is the criterion for judging that a particular value is greater than another and vice versa [17].

Han et al. [17] also suggested using the Gaussian kernel function to calculate the local density as a different way to compute it, as shown in the following equation:

$$\rho_i = \sum_{j \neq i} e^{-\left(d_{ij}/d_c\right)^2}. \tag{2}$$

The distance is defined as given by the following formula:

$$\delta_i = \min_{j:\, \rho_j > \rho_i} \left(d_{ij}\right). \tag{3}$$

The maximum local density points are

$$\delta_i = \max_j \left(d_{ij}\right). \tag{4}$$

The DPC algorithm, suggested in this paper, helps to obtain the peak density of decision graph. According to the calculated local density ρ and distance δ, and subsequently draw a decision diagram (ρ-δ) . In DPC algorithm, the points of large local density and distance are selected as the cluster center [18]. And then, each remaining point is assigned to the cluster where the density is higher than him and the nearest data point is located. Finally, the noise points are excluded.

2.2. Algorithm Optimization. With the rapid growth of data volume, the diversity of data is becoming stronger and stronger. As a result, most of the data onto life is rough data onto higher dimensions. However, DPC algorithm is powerless in the face of such high-dimensional data. To solve this problem, in this paper we adopt the t-sne dimension reduction mechanism which is constructed on radial transformation to systematize and normalize the data and optimize the suggested technique of forming t-dpc. The algorithmic flow of the suggested t-dpc method is as follows.

2.2.1. T-Sne Method Is Used for Data Standardization and Normalization. The input of the method are high-dimensional datasets denoted by $X = x_1, \ldots, x_n$, and the output of

the approach are low-dimensional datasets which is characterized by $Y^T = y_1, \ldots, y_n$. The process is as follows.

The SNE is the conditional probability that exchanges the high-dimensional Euclidean distance amongst data points of the similarity; that is, after a high-dimensional data set is given, the conditional probability is used to represent the similarity from point to point. This meaning can be understood as follows: if the neighbor is selected by the Gaussian distribution centered on, the probability that selects as its own neighbor is. If the data points are close, they are large. On the contrary, if the data points are very far away, they can be close to infinity [19]. The parameter is the variance between as the central point, which changes from the change of position. The definition of the conditional probability is illustrated mathematically, as shown in the following formula:

$$p_{(j/i)} = \frac{\exp\left(-x_i - x_j{}^2/2\delta_i^2\right)}{\sum_{k\neq i}\exp\left(-x_i - x_k{}^2/2\delta_i^2\right)}. \tag{5}$$

In the following formula, the conditional probability distribution of the low-dimensional data point is determined and relates to the high-dimensional data point.

$$q_{(j/i)} = \frac{\exp\left(-y_i - y^2\right)}{\sum_{k\neq i}\exp\left(-y_i - y_k{}^2\right)}. \tag{6}$$

The above two formulas represent the similarity, so both and are 0. At that moment, the distance amongst the two distributions Kullback Leibler diversities is enhanced, and its objective function is defined as shown in the following formula:

$$C = KL\left(P_iQ_i = \sum_i\sum_j p_{(i/j)}\log\frac{p_{(i/j)}}{q_{(j/i)}}\right). \tag{7}$$

Since, the conditional probability is not equal to, a large amount of calculation is required in gradient calculation [20]. The core of klt-e is to find the divergence of probability distribution by replacing the principle of probability E-T distribution. The optimized objective function changes, as shown in the following formula:

$$C = KL(PQ) = \sum_i\sum_j p_{(j/i)}\log\frac{p_{ij}}{q_{ij}}. \tag{8}$$

The calculation formulas for and shown in formula (8) have also changed accordingly. After the change, the calculation formulas are respectively as follows:

$$p_{ij} = \frac{p_{(i/j)} + p_{(j/i)}}{2}, \tag{9}$$

$$q_{ij} = \frac{\left(1 + y_i - y_j{}^2\right)^{-1}}{\sum_{k\neq 1}\left(1 + y_k - y_l{}^2\right)^{-1}}. \tag{10}$$

2.2.2. Iterations after T-sne Optimization. Calculation under low dimension according to formula (10), and then the gradient is calculated. The gradient calculation formula is as shown in the following formula:

$$\frac{\delta C}{\delta Y} = 4\sum_j\left(p_{ij} - q_{ij}\right)\left(y_i - y_j\right)\left(1 + y_i - y_j{}^2\right)^{-1}. \tag{11}$$

Formula (10), for example, must be included to the gradient descent process since it is very simple for it to go into the local optimal solution in the course of the optimization progression, as illustrated in (12) formula (12). This should be noted that the innovative low-dimensional data set can be obtained rendering to the following formula:

$$Y^{(t)} = Y^{(t-1)} + \eta\frac{\delta C}{\delta Y} + a(t)\left(Y^{(t-1)} - Y^{(t-2)}\right), \tag{12}$$

where $Y^{(t)}$ talks about the solution of the t iterations. Similarly, Y exemplifies the learning frequency and $a(t)$ characterizes the momentum of the t iterations. So far, the data standardization process is accomplished [21]. This should be highlighted here for the sake of understanding that the standardized data adapts to the DPC method while maintaining the majority of the properties of the original data set.

2.2.3. Find the Values of T-dpc, Local Density, And Standard Deviation δ. First of all, read the points of the data, and then determine the distance amongst the points, and gauge the value of t-dpc. Secondly, after manipulating the t-dpc value, protect and store the distance from a particular point j to another specified point i, that is, a reduced amount of than the ixj in the Z list to obtain a new Gaussian kernel function formula. Next we use, for instance, formula (12) to determine the local density, and use formula (3) to calculate the δ.

$$\rho_i = \sum_{j\neq i} e^{-\left(z[j]/d_c\right)^2}. \tag{13}$$

2.2.4. Complete Clustering According to the Subsequent DPC Algorithm. The subsequent DPC algorithm includes: drawing the decision diagram, manually selecting the clustering center, assigning points, and calculating noise points. Finally, clustering can be completed.

3. Experimental Simulation of High-Dimensional Data Processing

3.1. Simulation Environment. The experiment is completed by the software pycharm, and the experimental language is *Python* 3. Note that, all the experiments were completed on a computer with hardware configuration as follow: the CPU

model is i5-3337u with approximate spped of 1.80 GHz, and the system memory was 8 GB.

3.2. Data Acquisition and Pre-processing. With the purpose of confirming the legitimacy, as well as, the correctness of outcomes related to the suggested t-dpc method, we intend to select three (3) artificial data sets [22] and 5 standards [23]. The UCI data set is tested, and the parameters of various investigational data sets are specified away in Table 1. We assume that the data is in clean form and does not require any preprocessing method.

3.3. The F-Measure Metric. The F-measure index or evaluation metric is a frequently used assessment benchmark, particularly in the field of information retrieval and learning, which is weighted and balanced by precision and the recall. Furthermore, it is regarded as a manually labeled known cluster, and is the cluster designed at the completion of the clustering technique. The recall metric is also very commonly used in the learning assessment. The correctness or the accuracy rate is shown in formula (12), and the recall rate is shown in the following formula:

$$P\left(P_j, C_i\right) = \frac{\left|P_j \cap C_i\right|}{\left|C_i\right|}. \tag{14}$$

$$R\left(P_j, C_i\right) = \frac{\left|P_j \cap C_i\right|}{\left|P_i\right|}. \tag{15}$$

The comparison of F evaluation indexes of clustering results is shown in Table 2. Furthermore, Figure 1 shows the F evaluation values for both algorithms over different data sets. Note that, the higher values are better than the lower values. We can observe better values for the suggested t-dpc method as compare to the classical DPV approach.

This can be easily comprehended from the outcomes reported in Table 2 that for the three synthetic data sets, the F-measure index of DPC algorithm changes little compared with that of t-dpc algorithm. That is because it does not need to be reduced by t-sne, so the accuracy basically does not change. The change is comparatively more pronounced for high-dimensional UCI data sets. When compared to the F index before to the reduction of dimension, the values of all four data sets had significantly improved by approximately 7.0 percent, 5.2 percent, 1.1 percent, and 5.4 percent, correspondingly. Clearly, the performance of the data after t-SNE reduction method for dimension is better than the classical DPC approach.

3.4. Results of the NMI Evaluation Indicators. The idea of standard mutual information from descriptive information theory is utilised to quantify the similarity between two data distributions [24]. Presume that X and y are the distribution of n samples, as shown in the following formulas:

$$H(X) = \sum_{i=1}^{X} P(i)\log(P(i)). \tag{16}$$

$$H(Y) = \sum_{j=1}^{Y} P'(j)\log(P'(j)). \tag{17}$$

In formulas (16) and (17), $P(i) = |X_i|/N, P'$and$(j). = |Y_j|/N$. This should be noted that the mutual information (MI) amongst the X and Y is illustrated mathematically as, for example, given by the following formula:

$$MI(X,Y) = \sum_{i=1}^{X}\sum_{j=1}^{Y}(i,j)\log\left(\frac{p(i,j)}{p(i)p'(j)}\right)P. \tag{18}$$

In formula (16), $P(i, j) = |X_j \cap X_i|$/N. The next task is to standardize the mutual information (NMI) [25], such as illustrated mathematically in the following formula:

$$NMI(X,Y) = \frac{MI(X,Y)}{\sqrt{H(X)H(Y)}}. \tag{19}$$

The comparison results of NMI evaluation indicators are shown in Table 3. A graphical view of the attained results is shown in Figure 2. We can easily observe that the proposed t-dpc algorithm has similar values to the classical dpc algorithm; however, we noted that our method outperforms the dpc, in particular, for larger data sets.

Table 3 reveals the coincidence degree amongst the original, high-dimenstional, data set and the clustered, low-dimensional, data set. This should be observed that the NMI metric of the PID data set, wine data set, and the waveform data set under the suggested t-dpc method is lower than that which we observed under the classical DPC approach by 4.9%, 3.9%, and 3.6%, respectively. In fact, this shows that the coincidence degree of these four data sets is lower than that of the untransformed data set. Furthermore, we rose various parametric values in the residual two synthetic data sets, as well as, the iris data sets. In other word, in fact the aggregate data set and the d31 data set were increased by approximately 0.1% and 0.2%, correspondingly. Similarly, the iris data set was increased by approximately 7.3%. The R15 dataset did not alter, though. The synthesis demonstrates that when the dimension is high, the coincidence degree of the data set will drop, and when the dimension is low, the coincidence degree effect is better.

3.5. Results of Algorithm Efficiency. In our simulations, an average of 20 running periods is used as the final running time to reveal the correctness of the investigational outcomes, and the findings are displayed in Table 4. Furthermore, Figure 3 shows the running time of both algorithms over different data sets. Note that, the lower values are better than the higher values.

The assessment amongst the t-DPC approach and the classical DPC method, in terms of time efficiency, is shown

Table 1: The parameters of various investigational data sets.

Dataset	Aggregation	D31	R15	PID	Wine	Iris	Waveform	Seed
Record	788	3100	600	768	178	150	5000	210
Attributes	2	2	2	8	13	4	21	7
Clusters	7	31	15	2	3	3	3	3

Table 2: Comparison of the t-dpc and DPC methods for various data sets using the F assessment metric of the clustering outcomes.

Dataset	Aggregation	D31	R15	PID	Wine	Iris	Waveform	Seed
DPC	0.997	0.969	0.996	0.515	0.672	0.786	0.357	0.317
T-DPC	0.999	0.971	0.998	0.658	0.729	0.899	0.418	0.302

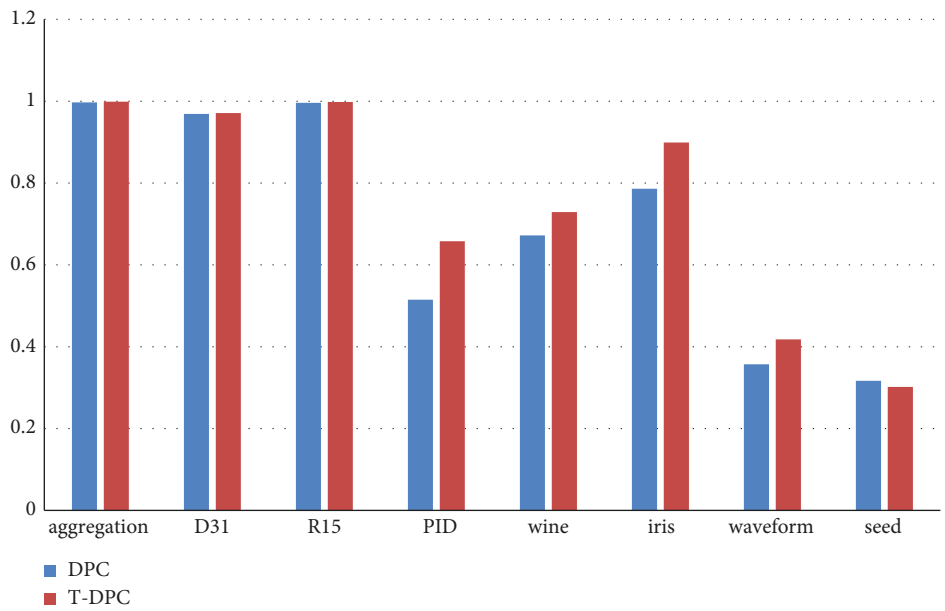

Figure 1: Comparison of the F assessment metric of clustering outcomes using different data sets [the higher values are better than the lower values].

Table 3: Comparison of the suggested t-dpc and the classical DPC methods using the NMI evaluation indicators.

Dataset	Aggregation	D31	R15	PID	Wine	Iris	Waveform	Seed
DPC	0.995	0.934	0.993	0.427	0.437	0.723	0.391	0.333
T-DPC	0.998	0.938	0.997	0.380	0.399	0.799	0.358	0.316

in Table 4. The new Gaussian kernel function has significantly reduced the whole running time. The t-DPC method runs approximately 116.1 s, 5 s, and 3 s faster than the classical DPC technique in the simulated three different data sets i.e., d31, aggregation, and R15, respectively. Furthermore, we observed that the standard set waveform and the PID were both improved at the same time, as are 334.5 s and 3 s, correspondingly. The wine dataset and the iris dataset, however, show no change for the reason of the little amount of data points in the data set. According to the aforementioned experimental findings and our deep analysis, the t-dpc technique is more suited for enormous data sets (several dimensions) than the small and only large data sets (have few dimensions). This major reason for this claim is that it can upsurge effectiveness and therefore, better suited for data from the actual world.

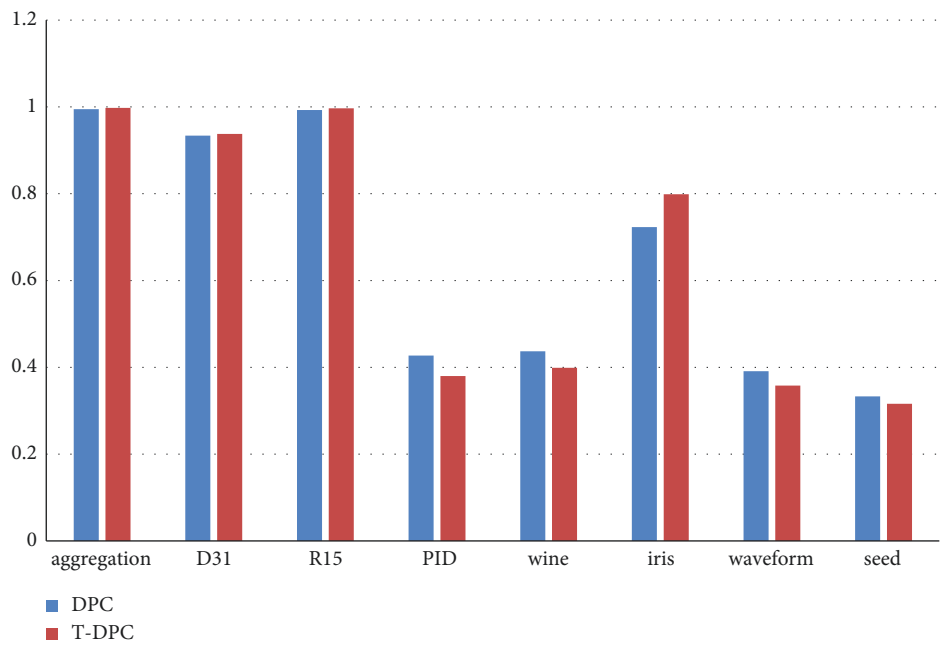

Figure 2: Comparison of the suggested t-dpc and the classical DPC methods using the NMI evaluation indicators.

Table 4: Comparison of running time of the two algorithms.

Dataset	Aggregation	D31	R15	PID	Wine	Iris	Waveform	Seed
DPC	22.2	310.2	14.2	23.5	3.5	3.1	846.7	3.7
T-DPC	17.2	194.1	11.2	20.5	3.5	3.1	512.2	3.5

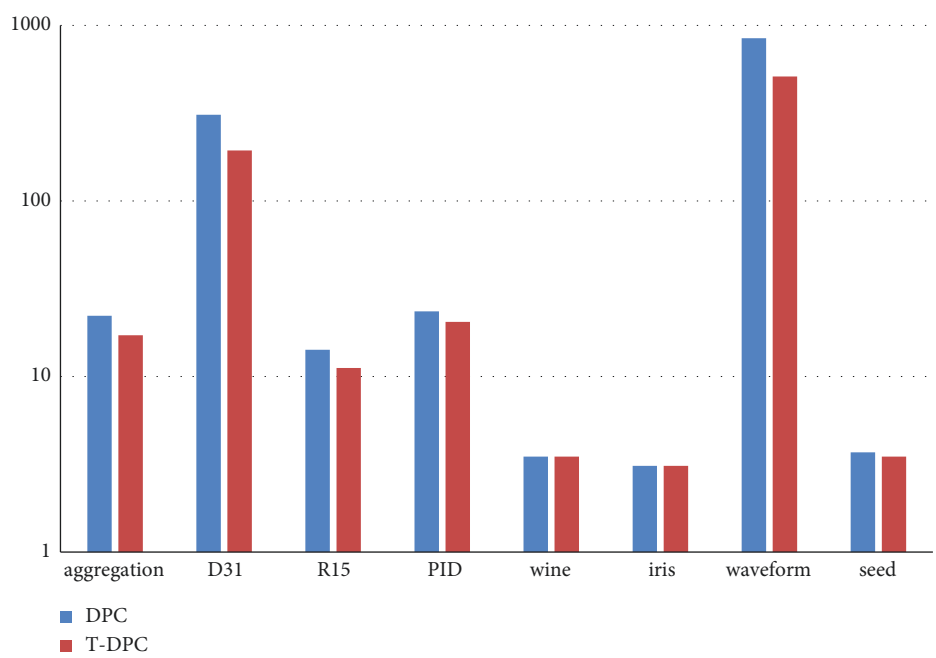

Figure 3: Comparison of running time of the two algorithms over different data sets [the lower values are better than the higher values].

4. Conclusions and Future Research

The method of clustering involves grouping the data set into various clusters based on how similar the data samples are to one another. The data objects belonging to various clusters must be as dissimilar from each other as feasible, while the data objects belonging to the same cluster must be as similar as possible. Compared with the classification algorithm, clustering analysis does not need to understand the classification attributes of data in advance. It is unsupervised. These data objects are divided completely according to the internal relationship between data objects, which is more in line with the development characteristics of the information age. This study analyses the time efficiency of the t-dpc algorithm and the DPC algorithm before using two efficient indexes to evaluate, namely the NMI index, and the F-measure index, to confirm the validity of the clustering effect of the t-dpc technique. Finally, this paper evaluates and analyses them as a whole according to the experimental results. This paper found that the effect of the t-dpc method and the DPC approach on low-dimensional data has no obvious change, nonetheless it has a relatively good enhancement, in particular, on very high-dimensional data sets. Then, the density calculation formula is unified and integrated into the t-dpc to improve the calculation effectiveness under enormous data sets.

In this paper, we have done some research on the optimization of DPC algorithm, and achieved some results, but there are still many deficiencies, which need to be further improved and improved. Although, the t-SNE algorithm and DPC algorithm have been preliminarily combined, the applicability of the combined algorithm needs to be improved. How to effectively combine the advantages of the algorithm and improving the applicability of the binding algorithm becomes a focus on the following research. Because, the DPC algorithm research involves the distance matrix calculation, therefore the improved algorithm is not out of this category and big data processing complexity and real-time implementation is of great challenge. Furthermore, this article is a kind of simple and shallow application, therefore how the algorithm can be applied to real life scenarios, to help people improve their quality of life, also will be the important direction of our future research.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
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Retraction

Retracted: Importance of Integrating Traditional Physical Education into Physical Education Teaching Using Big Data

Mobile Information Systems

Received 25 July 2023; Accepted 25 July 2023; Published 26 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

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Research Article

Importance of Integrating Traditional Physical Education into Physical Education Teaching Using Big Data

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In order to advance the assessment capability of the significance of integrating old-fashioned physical education into school physical education, an evaluation model of the significance of integrating old-fashioned physical education into school physical education founded on big data analysis of influencing factors of physical education quality is put forward. The big data analysis model of the significance of integrating old-fashioned physical education into school physical education was established, and the constraint parameter model was adopted to evaluate the significance of integrating old-fashioned physical education into school physical education by the method of objective elements collection of physical education teaching effect. Combined with the quantitative statistical analysis method of structural parameters of physical education system, the important parameter analysis model of integrating classical physical education into institution physical education was realized, and the inversion feature quantity of the significance evaluation of integrating classical physical education into institution physical education was extracted. Combining the questionnaire analysis method of influencing factors of institution physical education teaching quality, this paper realizes the piecewise linear estimation of the significance of classical physical education in institution physical education teaching, adopts the joint feature analysis method of quantitative rules, combines the quantitative analysis of indicators and the confidence test results of the significance of classical physical education in institution physical education teaching, and therefore realizes the fuzzy assessment of the significance of classical physical education in institution physical education teaching by fuzzy decision method. We realize the comprehensive evaluation decision of the significance of integrating classical sports into institution physical education. According to the big data mining results of the significance evaluation of integrating classical sports into institution physical education, realize the decision evaluation of the significance of integrating classical sports into institution physical education. The test outcomes express that this approach has good adaptability in evaluating the significance of integrating old-fashioned physical education into school physical education, and the confidence level of the evaluation results is higher than the other approaches.

1. Introduction

The concept of the specialty of classical ethnic sports can be found in the Brief Introduction to the First-class Discipline Award of Degree Granting and Talent Cultivation published by the Sixth Discipline Evaluation Group of the Academic Degrees Committee of the State Council in 2013, which clearly states that classical ethnic sports is a discipline that studies the essence, phenomenon, and law of Chinese martial arts, classical health-preserving sports, and Chinese folk sports. It takes Wushu, health-preserving, and other classical folk sports as the research objects, and is formed by the combination of Chinese classical culture and sports. Now, it has formed the research directions of Wushu theory and method, sports health-preserving theory and method, national folk sports development, Wushu culture and education, Wushu dissemination, etc. From the above concepts, it can be determined that the research objects of this discipline are martial arts, health preservation, and other national classical sports, and generally speaking, it is a

discipline that takes all Chinese national sports as its research objects. Among them, Wushu has been attached great significance by the party and the people since the founding of New China. Experts and scholars have been organized for many times to dig, sort out, and compile vast volumes of Wushu into books, which has greatly developed Wushu and basically matured in the 1990s [1]. However, although classical national sports have been bred, developed, and inherited in thousands of years of history in China, compared with martial arts, classical national sports have not been "consciously" developed, and it was not until 1980s that it began to enter the research field of vision. The term "national classical sports" first appeared at the National Classical Sports Work Conference in September, 1981 [2]. At that time, it was put forward that the national classical sports work should be "actively advocated, strengthened in leadership, reformed and improved, and steadily developed". So far, the national classical sports have been more systematically and forcefully excavated and sorted out, and the term "national classical sports" has been used up to now. With the continuous rise of classical sports and classical sports culture, people attach significance to the integration of classical sports into institution physical education, and the significance of studying the integration of classical sports into institution physical education has attracted people's attention [3].

The classical sport is an intangible cultural heritage, reflecting different national and regional characteristics. Each nation has its own different regional environment, and its unique cultural traditions, production and lifestyle, religious beliefs, etc. in the regional environment have created their own characteristics of intangible cultural heritage. For example, in mountainous areas, ethnic minorities will carry out some ethnic projects about climbing and mountain climbing. In water towns, other ethnic minorities mainly carry out water sports such as dragon boat races and diving games. At the same time, based on their unique regional environment, each ethnic minority has gradually formed a relatively stable psychological structure, which permeates all the aspects of national cultures, and also inevitably permeates the intangible cultural heritage of sports, and each embodies the cultural and psychological characteristics of each ethnic group [4].

Through combining big data mining and statistical analysis methods, in this paper we explore the significance data of the integration of classical physical education into institution physical education by extracting the reflected fuzzy features, and build a big data exploration model of the significance of the integration of classical physical education into institution physical education [5]. This paper adopts statistical analysis and judgment methods to evaluate the significance of integrating old-fashioned physical education into school physical education. This paper establishes a big data investigation model of the significance of integrating classical sports into institution physical education, adopts the method of objective elements collection of physical education teaching effect to carry out the constraint parameter model of the significance evaluation of integrating classical sports into institution physical education, realizes the significance parameter analysis model of integrating classical sports into institution physical education by combining the quantitative statistical analysis method of structural parameters of physical education scheme, and extracts the inversion feature quantity of the significance evaluation of integrating classical sports into institution physical education.

Furthermore, combining with the questionnaire analysis method of influencing factors of institution physical education teaching quality, this paper realizes the piecewise linear estimation of the significance of classical physical education in institution physical education, adopts the joint feature analysis method of quantitative rules, combines the quantitative analysis of indicators and confidence test results of the significance of classical physical education in institution physical education, and realizes the wide-ranging assessment of the significance of classical physical education in institution physical education, combining with the statistical analysis methods of Matlab and SPSS. The fundamental contributions of our research can be summarized as follow.

(i) an evaluation model of the significance of integrating old-fashioned physical education into school physical education founded on big data analysis of influencing factors of physical education quality is put forward.

(ii) The big data exploration model of the significance of integrating old-fashioned physical education into school physical education was established, and the constraint parameter model was adopted to evaluate the significance of integrating old-fashioned physical education into school physical education by the method of objective elements collection of physical education teaching effect.

(iii) Combined with the quantitative statistical analysis method of structural parameters of physical education system, the important parameter analysis model of integrating classical physical education into institution physical education was realized, and the inversion feature quantity of the significance evaluation of integrating classical physical education into institution physical education was extracted.

The remaining sections of the manuscripts are structured as discussed in subsequent sentences. In Section 2, we deliberate an analysis of the important variable parameters of the integration of classical physical education into institution physical education. The model constraints along with parameters construction are deliberated in Section 3. In Section 4, we demonstrate the optimization of assessment prototype of the significance of integrating physical education into institution physical education. Simulation and empirical analysis of the suggested approach is demonstrated in Section 5. To summarize the paper, Section 6 concludes this paper and puts forward few directions for further research along with the limitations of current work.

2. Analysis of the Important Variable Parameters of the Integration of Classical Physical Education into Institution Physical Education

There are many factors from macro to micro that affect the integration of ordinary classical physical education into institution physical education teaching quality. From the macro level, the factors that affect the integration of ordinary classical physical education into institution physical education teaching quality involve a wide range, including social factors such as the guidelines and policies of relevant government departments, relevant laws and regulations, the truth orientation of the public, and market values. In addition, it also includes school factors, such as school teaching ideas, teaching funds, teaching infrastructure, teaching management, and training system. It can be seen from the macro level that the factors influencing the integration of classical physical education into institution physical education are a very large and complex system, and it is very difficult to sort out the relationship among the factors, and it is difficult to grasp the key factors if there are too many influencing factors. In addition, we should consider the feasibility of data acquisition and our own ability. This paper principally investigates the important factors of integrating classical physical education into physical education teaching in schools and institutions of higher education. The theoretical analysis grounded on this level can be more specifically applied to physical education and successfully progress the superiority of physical education [6].

Therefore, it cannot resonate with the students. It will also discourage students' enthusiasm for participating in the classroom, which will hinder students' acceptance of knowledge and make it difficult for them to develop healthily. On the contrary, if teachers hold a positive teaching attitude, the students' enthusiasm to participate in the classroom will be greatly improved [7]. In order to test the significance evaluation of the approach, as suggested in this paper, firstly, the big data sampling and explanatory variables analysis of the significance of the integration of classical sports into institution physical education are carried out, mainly referring to the specific factors that affect the physical education activities, such as teaching methods, teaching environment, teachers, and students. This should be noted that the explanatory variable model of the significance evaluation of the integration of classical sports into institution physical education is given away in Figure 1.

The correlation of each explanatory variable, taking correlation degree is analyzed, ambiguity degree, fitness degree, and matching degree as the constraint characteristic quantity [8], and the analytical distribution of variables is obtained, as shown in Table 1.

Bestowing to the correspondence of big data, we first determine the weight of each index, and initialize the clustering centers $F(x_i, A_j(L)), i = 1, 2, \cdots, m, j = 1, 2, \cdots, k$ of the significance evaluation classification of classical sports integration into institution physical education. In next steps, we extract the correlation characteristic components of the

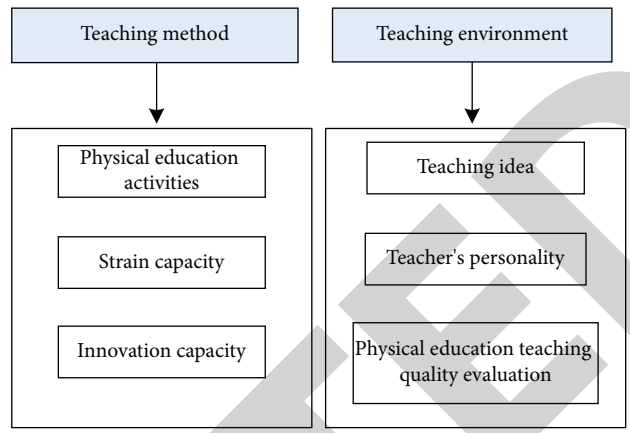

Figure 1: The explanatory variable model of the significance evaluation of integrating classical physical education into institution physical education.

significance evaluation of classical sports integration into institution physical education, and, then institute a big data investigation model of the significance of classical sports integration into institution physical education. Finally, we use quantitative recursive analysis in order to acquire the distribution of control variables of the significance evaluation of classical sports integration into institution physical education, which is displayed in Table 2.

According to the above variable parameter analysis, the constraint parameter model of the significance assessment of the integration of classical physical education into institution physical schooling is in fact performed through using the method of objective elements of physical education teaching effect. Moreover, the significance parameter analysis prototype of the integration of classical physical schooling into institution physical training is, then, realized and understood through conjoining the quantitative statistical analysis method of structural parameters of physical education system [9, 10].

The significance of assessment of the integration of classical physical schooling into institution physical education mainly analyzes its influence from four aspects: teaching philosophy, teaching methods and means, physical education instruction quality assessment scheme, and physical education coaching hardware. Through combing the literature, it is found that no matter from what angle these researchers divide the features that disturb the quality of physical education, they are inseparable from the essential elements that constitute the physical education. The most imperative feature that distresses the result of things is the formation process of things [11–13]. Therefore, the important factor that affects the excellence of physical instruction schooling is the teaching procedure. Bestowing to the seven elements of teaching, that is, teachers, students, teaching purpose, curriculum, teaching approaches, teaching environment, and feedback, the three elements of teaching purpose, curriculum, and feedback are all related to the physical education administrators, who have the highest decision-making power and overall planning power.

As far as the teaching process is concerned, in fact the tutors and the pupils are the chief factors, while teachers can

Table 1: Distribution of explanatory variables for the evaluation of the significance of integrating old-fashioned physical education into school physical education.

Explanatory variable	Correlation degree	Equivocation	Fitness	Matching degree
Ability quality	0.835	0.587	0.782	0.161
Teaching idea	0.413	0.134	0.267	0.887
Teacher's personality	0.951	0.707	0.203	0.749
Teaching means	0.707	0.103	0.260	0.661
Physical education teaching quality evaluation	0.474	0.449	0.924	0.736
Innovation capacity	0.154	0.076	0.575	0.249
Teaching environment	0.652	0.067	0.831	0.809
Teaching infrastructure	0.869	0.249	0.956	0.322
Teaching management	0.590	0.335	0.250	0.923
Teaching thought	0.996	0.235	0.629	0.251

Table 2: The control variable distribution.

Control variable	Correlation degree	Equivocation	Fitness	Matching degree
Teacher	0.695	0.895	0.392	0.781
Student	0.407	0.402	0.585	0.238
Academic goal	0.192	0.716	0.516	0.876
Course	0.668	0.838	0.117	0.108
Teaching method	0.419	0.271	0.565	0.026
Teaching environment and feedback	0.108	0.676	0.546	0.125
Student factor	0.513	0.183	0.631	0.975
Teaching method	0.291	0.724	0.778	0.425
Teaching environment	0.791	0.621	0.157	0.618

only improve the teaching purpose, syllabus, and feedback from the microlevel. Although it is not denied that these three factors have an influence on the eminence of physical education schooling, they are not the core factors, so this paper will not explore them in depth [14]. Therefore, allowing to the seven elements of instruction, the tangible circumstances of teaching and the summary of literature, this paper divides the factors that distress the eminence of physical education in academies and institutions of higher education into four dimensions, including teachers' factors, students' factors, teaching methods, and teaching environment [15].

3. Model Constraint Parameter Construction

By using the visual dynamic feature analysis method [16], the factor weight distribution of the significance evaluation of integrating classical physical education into institution physical education is obtained as follows in (1):

$$G_{k+1} = P^{xz}_{k+1|k}\left(P^{z}_{k+1|k}\right)^{-1}, \tag{1}$$

wherein, $P^{xz}_{k+1|k}$ is the interactive factor between teachers and students in the integration of classical physical education into institution physical education, and $P^{z}_{k+1|k}$ is an imperative secondary parameter that distresses the eminence of physical education teaching. Combined with the relevant literature, this paper explains the teacher factor as follows: in teaching activities, according to the first-level classification of the evaluation system of physical education level, the fluctuation exploration approach of the significance distribution of the integration of classical physical schooling into institution physical education is adopted [17], and the statistical distribution set structure of the significance evaluation of classical physical education into institution physical education is obtained [18]. By using weighting coefficient and expert evaluation, the covariance characteristic distribution of computation fault is as given in (2):

$$P_{k+1|k+1} = P_{k+1|k} - G_{k+1}P^{z}_{k+1|k}G^{T}_{k+1}, \tag{2}$$

wherein, $P_{k+1|k}$ is the influence factor of teachers' teaching attitude, G_{k+1} is the target evaluation index set of physical education teaching effect, G^{T}_{k+1} is the prior characteristic value of classical physical education integrating into institution physical education, n_z is the measurement of the feature set of the significance evaluation of classical physical education integrating into institution physical education. The statistical vector dimension of the significance evaluation of classical physical education integrating into institution physical education is analyzed, the state is corrected by using the correction function, and the fuzzy adjustment factor of the significance evaluation of classical physical education integrating into institution physical education is obtained by using the weighted coefficient and the statistical characteristic analysis results of expert evaluation, namely, as given in (3):

$$\varphi_k = L^{-1}\sum_{j=k-L+1}^{k}\tilde{z}_j\tilde{z}^{T}_j - \left(P^{z}_{k+1|k} + R_k\right), \tag{3}$$

wherein, L is the statistical characteristic quantity of the significance of integrating classical sports into institution physical education, $\tilde{z}_j$ is the evaluation index set of the

significance of integrating classical sports into institution physical education, R_k is the two-dimensional characteristic quantity, and $P^z_{k+1|k}$ is the fuzzy degree of the significance evaluation of integrating classical sports into institution physical education. Then, the statistical characteristic of φ_k's evaluation of the significance of integrating classical sports into institution physical education obeys the k distribution with freedom, and the values of n_z, χ^2 and q_k, Q_k, r_k are different at different times. The descriptive statistical feature distribution evaluation set of the significance evaluation of classical sports integration into institution physical education is **S**, $\{v_1, \cdots, v_M\}$ represents the fuzzy set of the significance evaluation of classical sports integration into institution physical education, and the whole decision-making system is set [19]. Based on the feature factor analysis and piecewise regression analysis, the state estimation sum of the significance evaluation of classical sports integration into institution physical education is obtained as $\widehat{q}_{k+1}, \widehat{Q}_{k+1}, \widehat{r}_{k+1}$ and $\widehat{R}_{k+1}$, which is described as illustrated in (4) and (5):

$$\widehat{r}_{k+1} = (1-d_k)\widehat{r}_k + d_k\left[z_{k+1} - m^{-1}\sum_{i=1}^{m} h_{k+1}\left(X_{i,k+1|k}, u_{k+1}\right)\right], \quad (4)$$

$$\widehat{R}_{k+1} = (1-d_k)\widehat{R}_k + d_k\left[\widetilde{z}_{k+1}\widetilde{z}^T_{k+1} - m^{-1}\sum_{i=1}^{m}\left(Z^*_{i,k+1|k} - \widehat{z}_{k+1|k}\right)\left(Z^*_{i,k+1|k} - \widehat{z}_{k+1|k}\right)^T\right], \quad (5)$$

wherein, $\widehat{r}_k$ is the research capability parameter of educational science, m is the marginal characteristic quantity that affects the quality of physical education teaching, $X_{i,k+1|k}$ is the prior probability density, and u_{k+1} is the unbiased estimation parameter. According to the unbiased estimation theory, this paper constructs a state parameter optimization planning model for evaluating the significance of integrating old-fashioned physical education into school physical education teaching, combining with the quantitative statistical analysis method of structural parameters of physical education system [20].

4. Optimization of Evaluation Model of the Significance of Integrating Physical Education into Institution Physical Education

4.1. Big Data Mining Model for the Evaluation of the Significance of Integrating Old-Fashioned Physical Education into School Physical Education. The four latent variables studied in this paper are: teaching environment, teachers' factors, teaching methods, and students' factors, but the latent variables cannot be directly measured and need to be explained by the corresponding observed variables. By summarizing the literature and experts' suggestions, the latent variables, explicit variables, and specific indicators in the model are obtained [21, 22]. Teachers' factors mainly include five observation variables: (i) teaching attitude, (ii) language expression ability, (iii) capability to detect and comprehend students, (iv) aptitude to organize, manage, and control teaching activities, and (v) ability to demonstrate actions. Teaching methods are mainly reflected by five indicators, which measure teaching methods from macro to micro. From the macro point of view, teaching method mainly refers to the big teaching strategy, which mainly means that teachers fully consider the effective combination of various teaching methods when designing teaching.

The second aspect mainly refers to the specific teaching methods used in class, mainly focusing on the diversity of teaching methods and arousing students' enthusiasm. The third aspect is to understand the teaching method from the micro level, which mainly refers to the teaching means, including the use of teaching AIDS, to effectively improve the learning effect. The student factor is mainly reflected by four indicators, the first one is the difference of students' sports foundation. Second is the difference of students' learning methods. The third and fourth indicators are students' learning interest and motivation. The teaching environment is reflected by three indicators, (i) the first is the venue, equipment, and facilities, (ii) the second is the correlation among teachers and students, and (iii) the third is the association among the students [23, 24].

A big data mining model of the significance of integrating classical sports into institution physical education is constructed, a mathematical model according to the expected evaluation indexes is established. The fuzzy association rule feature quantity adopts the distribution of the significance reliability indexes of integrating classical sports into institution physical education, and combines the fuzzy decision-making method to build an optimized decision-making model of the significance evaluation of integrating classical sports into institution physical education, and obtains the important parameter set of integrating classical sports into institution physical education as follows in the following (6) and (7):

$$\widehat{q}_{k+1} = (1-d_k)\widehat{q}_k + d_k\left[\widehat{x}_{k+1|k+1} - m^{-1}\sum_{i=1}^{m} f_{k+1}\left(X_{i,k|k}, u_k\right)\right], \quad (6)$$

$$\widehat{Q}_{k+1} = (1-d_k)\widehat{Q}_k + d_k\left[G_{k+1}\widetilde{z}_{k+1}\widetilde{z}^T_{k+1}G^T_{k+1} + P_{k+1|k+1} - m^{-1}\sum_{i=1}^{m}\left(X^*_{i,k+1|k} - \widehat{x}_{k+1|k}\right)\left(X^*_{i,k+1|k} - \widehat{x}_{k+1|k}\right)^T\right]. \quad (7)$$

According to the data of classical sports integration into institution physical schooling instruction resources, rendering to various evaluation systems, and the identification prototype of the significance assessment of classical sports integration into institution physical schooling instruction is constructed. Furthermore, the information entropy of the significance evaluation of classical sports integration into institution physical schooling instruction is obtained conferring to the parameter adjustment method of the influencing factors. This relationship is mathematically illustrated as given in (8):

$$H_2 = -\sum_{i=0}^{N} (1 - p_i)\ln(1 - p_i), \tag{8}$$

wherein, p_i is the sample parameter of the influencing factors of teaching quality, and N is the sample data size. According to the big data mining results of information entropy, the fuzzy function of the comprehensive decision of the significance of integrating classical sports into institution physical schooling is analyzed by arithmetical examination approach, and the spreading of the significance characteristics of integrating classical sports into institution physical education meets $\|C(l) - C(l-1)\| < \xi$. The membership degree of evaluating the significance of integrating classical sports into institution physical education is as follows:

$$A_j(L+1) = \frac{1}{n_j}\sum_{i=1}^{k} X_i^j \, (j = 1, 2, \cdots, k), \tag{9}$$

wherein, X_i^j is the function of fuzzy closeness to characterize the significance evaluation of classical sports integration into institution physical education, and k is the effective questionnaire size [22, 25]. According to the j characteristic factor, the joint characteristic parameters of the significance distribution of classical sports integration into institution physical education are $\{w_k\}$ and $\{v_k\}$, and the likelihood estimation parameter values of the significance evaluation of classical sports integration into institution physical education are given in (10):

$$\begin{cases} E[w_k] = q_k, & E\left[w_k w_j^T\right] = Q_k \delta_{kj}, E[v_k] = r_k, \\ E\left[v_k v_j^T\right] = R_k \delta_{kj}, & E\left[w_k v_j^T\right] = 0 \end{cases}, \tag{10}$$

where, δ_{kj} is the segmented detection coefficient of big data mining on the significance of integrating classical sports into institution physical education [24, 26]. A fuzzy constraint parameter model for evaluating the significance of integrating classical sports into institution physical education is established, and a constraint state feature distribution set for evaluating the significance of integrating classical sports into institution physical education is obtained, which is described as follows in equations (11) to (15):

$$\max Z = \sum_{=1}^{m}\sum_{j=1}^{m} x_{ij} c_{ij}, \tag{11}$$

$$st = \sum_{j=1}^{m} x_{ij}, \tag{12}$$

$$st = \sum_{i=1}^{m} x_{ij}, \tag{13}$$

$$x_{ij} = 1, \tag{14}$$

$$st = 0, \text{or}, 1. \tag{15}$$

In the above equations, $x_{ij} = 1$ exemplifies the regression parameter of classical sports integration into institution physical education quality evaluation, designs the quantitative regression distribution set of the significance of classical sports integration into institution physical education, $x_{ij} = 0$ represents the significance of classical sports integration into institution physical education, patent achievements transform the training set of the significance evaluation of classical sports integration into institution physical education, and $x_{ij} = -1$ represents the statistics of the significance evaluation of classical sports integration into institution physical education under the autoregressive examination model, and therefore, building the index exploration model and technique of the significance for classical and traditional sports integration into institution physical education [25].

4.2. Hierarchical Analysis of the Significance Evaluation of Integrating Classical Physical Education into Institution Physical Education. Through combining with the questionnaire analysis method of influencing factors of institution physical education teaching quality, this paper realizes the piecewise linear estimation of the significance of classical physical education in institution physical education, adopts the joint feature analysis method of quantitative rules, and combines the quantitative analysis of indicators and confidence test results of the significance of classical physical education in institution physical education, establishes an expert system model for the significance evaluation of classical physical education in institution physical education, and obtains the joint distribution threshold H_0. When $H_2 < H_0$, then it means that the statistical information feature quantity of widespread assessment of the significance of classical physical schooling in institution physical learning is described as follows in (16):

$$\begin{aligned} &\max 1 - \sum_i \sum_j \alpha_i \alpha_j K\left(x_i, x_j\right) \\ &\text{s.t: } \sum_i \alpha_i = 1 \text{an d} 0 \le \alpha_i \le A, i = 1, 2, \cdots \end{aligned}, \tag{16}$$

wherein, $K(x_i, x_j) = e^{-\|x_i - x_j\|^2/2\sigma^2}$, the smaller of σ values, the improved the convergence of the widespread assessment of the significance of integrating old-fashioned physical education into school physical education. For that reason, the hierarchical exploration technique of the significance evaluation of the integration of classical physical education into institution physical education is constructed, and the TTD function of the significance evaluation of the integration of classical physical education into institution physical education is obtained by using the maximum likelihood estimation and piecewise sample regression analysis is expressed in (17):

$$TTD = a_1 x_1 + a_2 x_2 + \cdots + a_k x_k + \delta. \tag{17}$$

In the above (17), the parameter TTD indicates the relevant features of the significance evaluation of classical sports integration into institution physical education,

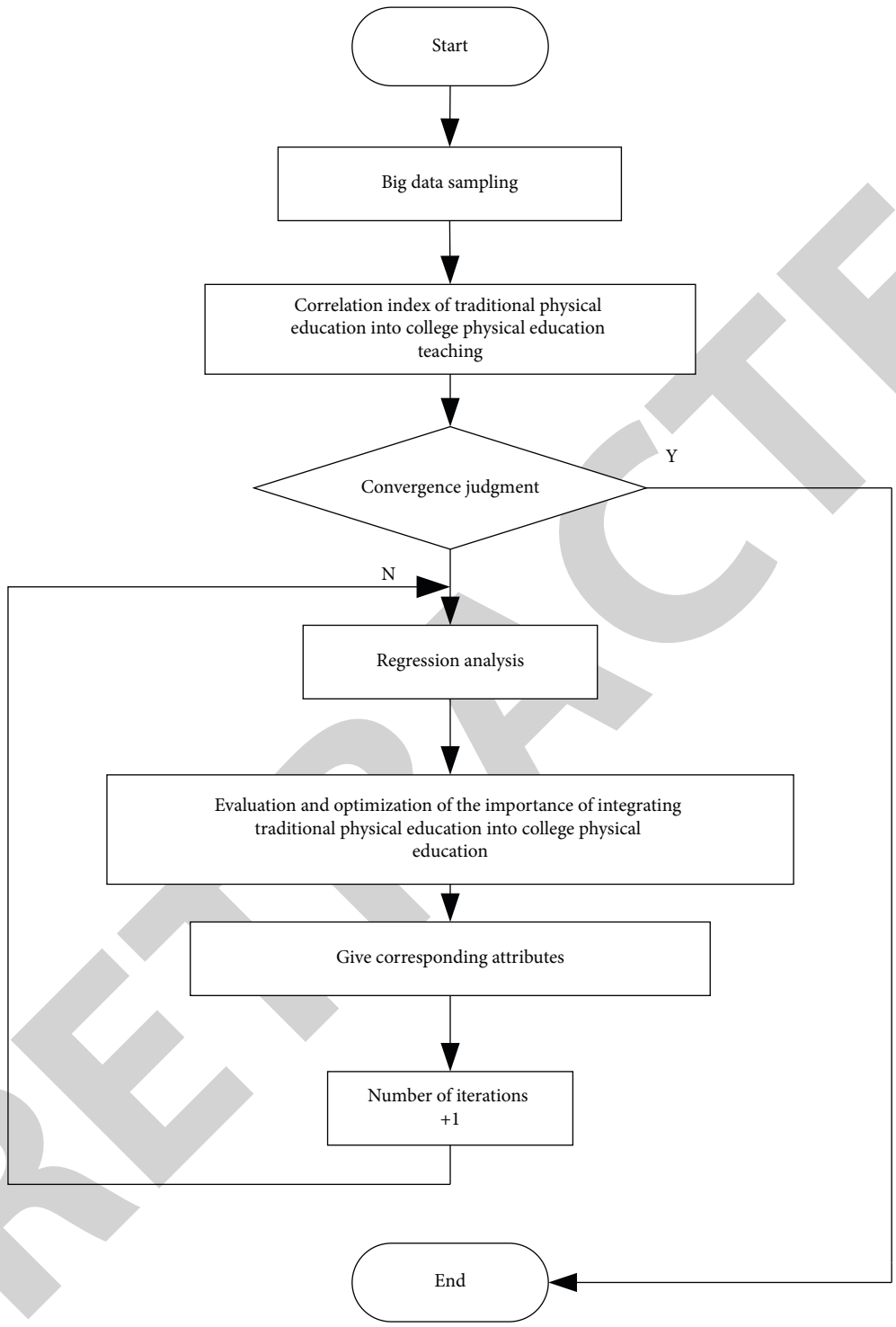

Figure 2: The optimization process of the significance evaluation algorithm of classical physical education into institution physical education.

namely, a_1, a_2, $\ldots a_k$. Using the weighting coefficient and expert evaluation system, the arithmetical characteristic measure of the significance assessment for classical sports integration into institution physical schooling is given by M^{β}, and the joint characteristic quantity of the significance distribution of classical sports integration into institution physical education is illustrated in (18):

$$M^{\beta} = \left\{ x \,\middle|\, x \in M, \frac{|f(x) \cap Y|}{|Y|} \geq \beta, 0 \leq \alpha \leq \beta \leq 1 \right\}. \tag{18}$$

The rough set algorithm with limited factors is used, $U(t) = \sum_{M \in E} P[M]$ represents the prior distribution function, $A_{st} \subseteq P \times T$, and a particular rule set for fuzzy association of the significance evaluation of the integration of classical

Table 3: The list of conditional attributes for the evaluation of the significance of integrating old-fashioned physical education into school physical education.

	Conditional attribute					
Evaluating indicator	MH1	MH2	MH3	MH4	MH5	MH6
Significance	0.040	0.839	0.749	0.987	0.829	0.040
Weight index	0.704	0.712	0.294	0.781	0.021	0.704

Table 4: The outcomes of the optimization process for the constraint parameters of the significance of integrating old-fashioned physical education into school physical education.

Explanatory variable	Contribution index	Normalized error	Covariance
Teacher	0.153	0.751	0.740
Student	0.263	0.942	0.644
Academic goal	0.071	0.661	0.794
Course	0.201	0.861	0.900
Teaching method	0.347	0.996	0.242
Teaching environment and feedback	0.293	0.236	0.916
Student factor	0.951	0.417	0.423
Teaching method	0.703	0.416	0.120
Communication ability	0.098	0.910	0.702
Know-how	0.403	0.476	0.837
Political caliber	0.259	0.102	0.461
Academic degree	0.367	0.832	0.202
Business experience	0.413	0.532	0.171
Teacher's age	0.415	0.471	0.225
Health level	0.096	0.753	0.677
Teachers' gender	0.200	0.419	0.594
Performance	0.924	0.508	0.413
Professional technology	0.129	0.608	0.584
Degree of education	0.917	0.934	0.370

physical education into institution physical education is constructed. Based on fuzzy decision-making method, the fuzzy evaluation of the significance evaluation of the integration of classical physical education into institution physical education is realized, and the comprehensive evaluation decision of the significance of the integration of classical physical education into institution physical education is achieved. The decision model is expressed as given in (19) and (20):

$$\begin{aligned} &\min F = R^2 + A\sum_i \xi_i \\ &\text{s.t: } \left\|\phi\left(x_i\right) - o\right\|^2 \le R^2 + \xi_i \text{an d} \xi_i \ge 0, i = 1, 2, \cdots \end{aligned}, \tag{19}$$

$$\begin{aligned} &\max \sum_i \alpha_i K\left(x_i, x_i\right) - \sum_i \sum_j \alpha_i \alpha_j K\left(x_i, x_j\right) \\ &\text{s.t: } \sum_i \alpha_i = 1 \text{an d} 0 \le \alpha_i \le A, i = 1, 2, \cdots \end{aligned}, \tag{20}$$

wherein $\sum_i \alpha_i = 1$, $K\left(x_i, x_i\right) = 1$, therefore, the hierarchical investigation technique and model of the significance assessment of the integration of classical physical schooling into institution physical education is established to comprehend the significance assessment of the integration of classical physical schooling into institution physical education, and the optimized realization process is shown in Figure 2.

5. Simulation and Empirical Analysis

The SPSS empirical analysis method is taken, and the significance of integrating old-fashioned physical education into school physical education is evaluated. The main purpose of descriptive statistics on the data is to understand the basic characteristics of the data and see if the data follow to the law of normal distribution mainly through a few simple statistical values to see the concentration and dispersion of a set of data [21]. Generally, the central position of the data is judged by the maximum, minimum, and average values. The standard deviation, kurtosis, and skewness are mainly used to judge the dispersion degree of a group of data. In this paper, the software of SPSs 25.0 is implemented to process the statistics, and the list of conditional attributes for the evaluation of the significance of integrating old-fashioned physical education into school physical education is shown in Table 3.

The result means that the answers of the people who fill out the questionnaire are different, indicating that the data have a considerable degree of discrimination. Judging from the degree of data distribution, the statistical deviation of the maximum dignified variables is a smaller amount than 1, which describes that the data are moderately focused. Kline RB (1998) mainly uses skewness and kurtosis to judge whether a group of data imitates to the law of normal distribution or not. The author thinks and claims that if the

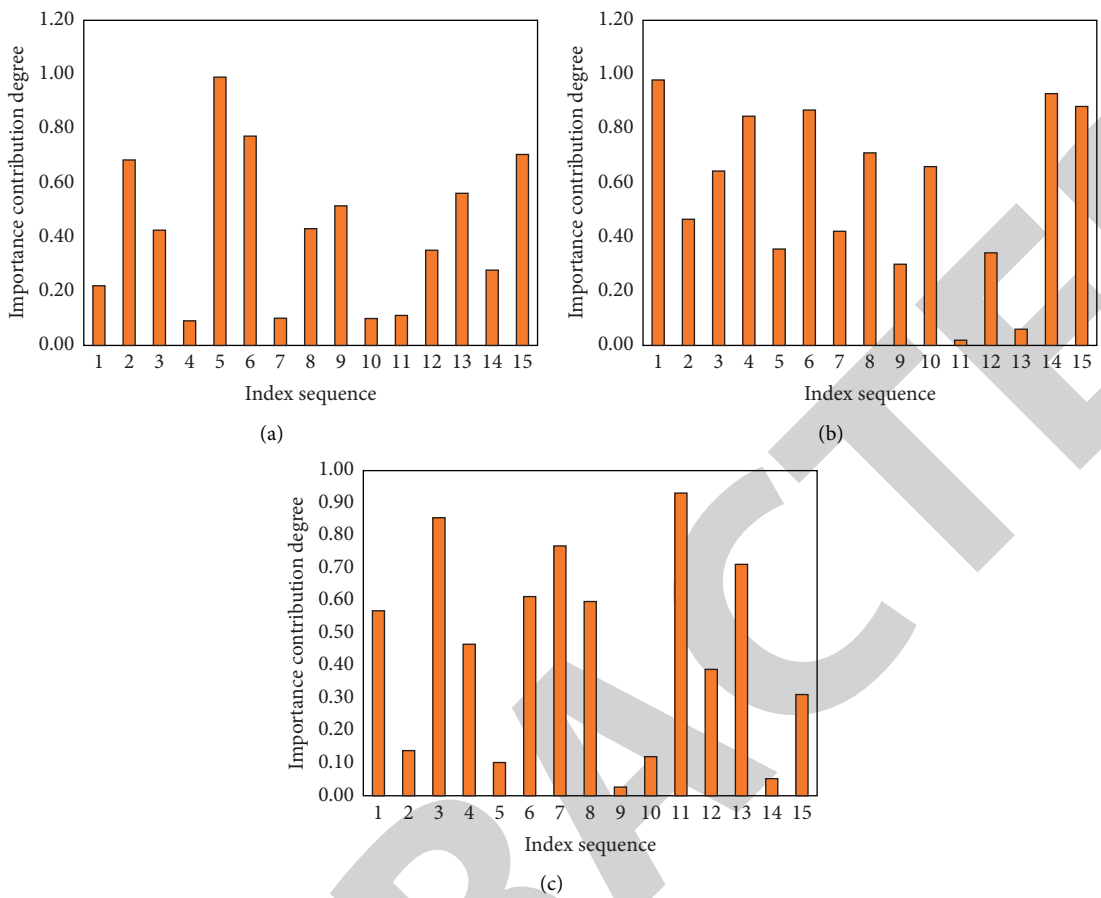

Figure 3: Histogram of significance distribution of classical physical education integrated into institution physical education. (a) Sample 1. (b) Sample 2. (c) Sample 3.

absolute worth of skewness is a smaller amount than 3 and the absolute worth of kurtosis is a smaller amount than 8 hours, then the data basically conforms to the law of normal distribution. Therefore, very easily it can be understood and realized that the data conform to the normal distribution characteristics. According to the distribution of conditional attributes, the constraint parameters of the significance of integrating old-fashioned physical education into school physical education are optimized, and the optimized solution results are made known in Table 4.

Analysis from Table 4 shows that this method is castoff to appraise the significance of integrating old-fashioned physical education into school physical schooling, and the calculation results of contribution level of related indicators are accurate and reliable, with high confidence level and small error. The distribution histogram of the significance evaluation of integrating classical physical education into institution physical education is tested, as shown in Figure 3, and the error distribution is shown in Figure 4.

Based on the analysis and exploration of outcomes in Figures 3 and 4, it can be easily understood that the evaluation of the significance of integrating old-fashioned physical education into school physical education by this method shows that the distribution of the evaluation of the significance of integrating old-fashioned physical education into school physical education is well balanced. The test accuracy is evaluated, and the comparison results are given away in Figure 5. In fact, the examination and exploration of Figure 5 confirms that the evaluation correctness of this approach is greater than other approaches, i.e., BP and PID.

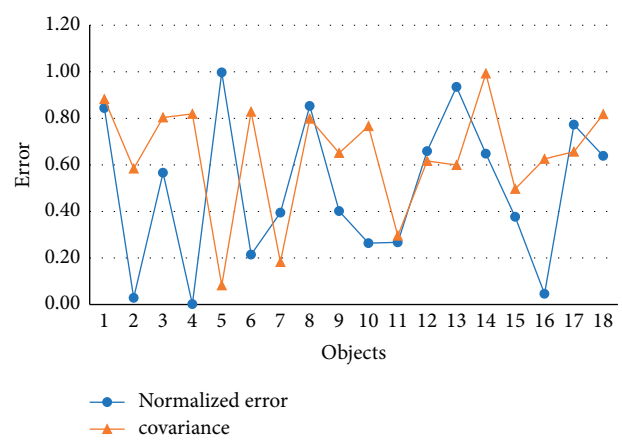

Figure 4: Error distribution curve.

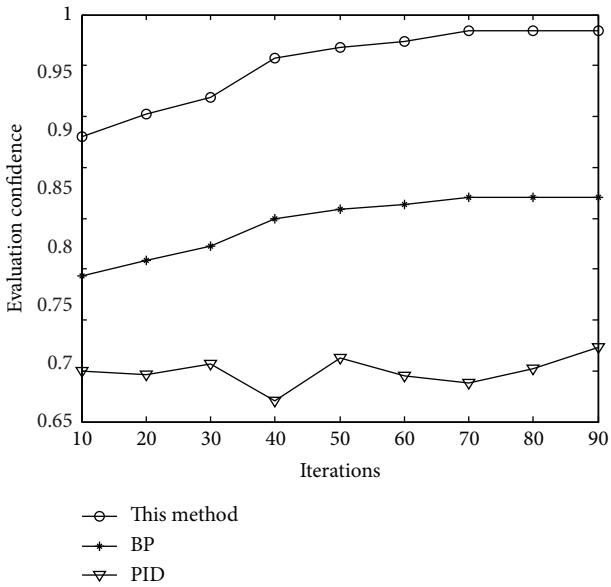

Figure 5: Comparison of evaluation accuracy.

6. Conclusions and Future Work

In this paper, it is of prodigious importance to explore the assessment model of the significance of integrating classical sports into institution physical teaching, which is of prodigious implication to optimizing labor dispatch and enterprise employment management. In this paper, we aim to put forward an evaluation model of the significance of integrating classical sports into institution physical schooling which is founded on the big data investigation of influencing factors of physical schooling excellence. Moreover, the constraint parameter approach of the significance assessment of the integration of classical physical teaching into institution physical schooling is performed through using the method of objective elements of physical schooling coaching effect, and, thus, the significance parameter investigation model of the integration of classical physical schooling into institution physical learning is realized through conjoining the quantitative statistical analysis method of structural parameters of physical education system. It is found that the evaluation of the significance of integrating old-fashioned physical education into school physical education by this method has a high accuracy and a good convergence level.

The relationship among the four influencing factors is clarified as: teaching environment, teachers, teaching methods, and students. Therefore, to progress the superiority and eminence of the P.E. teaching in academies and institutions of higher education, it is necessary to regulate the whole, coordinate the relationship among various elements, and link them together. However, due to factors such as time and self-ability, there are still some inadequacies in the research process of this paper, which are predominantly replicated in the subsequent two characteristics: (1) The selection of influencing factors of physical education teaching quality has certain limitations. There is a lack of some objective arguments in the process of determining the influencing factors. Therefore, in the future research, besides theoretical analysis, objective demonstration should be strengthened to improve the scientific and rigorous research results. (2) The selection of samples also has certain limitations. Due to the limited personal ability, the subjects of this questionnaire are mainly from nine universities in Hubei Province, but students from other universities are not investigated. Therefore, in order to make the research more universal, the scope of investigation can be further expanded in the future research process.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: Influencing Factors of Students' Ideological and Political Education, Identity, and Practice Concept Based on Double-Hurdle Model

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] K. Zhao, "Influencing Factors of Students' Ideological and Political Education, Identity, and Practice Concept Based on Double-Hurdle Model," *Mobile Information Systems*, vol. 2022, Article ID 8312092, 6 pages, 2022.

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Research Article

Influencing Factors of Students' Ideological and Political Education, Identity, and Practice Concept Based on Double-Hurdle Model

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With the further growth of the China's socialist market economy and the influence of decadent western ideas, in the context of diverse cultural choices and diversified value orientations, social hot issues have become increasingly prominent. Under the background of multicultural choice and multivalue orientation, social hot issues are becoming increasingly prominent. In order to accurately grasp the specific situation of college students' identification and training of socialist fundamental ideals and put forward targeted countermeasures and suggestions, by referring to economic research methods, this study builds a double-hurdle model, summarizes the significant factors that affect college students' identification and training of socialist fundamental values, and analyzes the causes of significant factors and irrelevant factors. In this paper, we explore the status quo, optimization countermeasures, and certain influencing factors for students' identification and practice of socialist core values. Furthermore, this study also puts forward the optimization countermeasures to enhance college students' identification and training of socialist fundamental values.

1. Introduction

With the deepening growth of economic globalization and China's economy for the socialist market, the application and popularization of the Internet and smart phones, a variety of thoughts, including the mainstream of Chinese socialism, the decadent western thoughts, and China's traditional feudal thoughts, interweave and stir each other [1]. Chen believed that college students because most of them are in the stage of gradually maturing physically and psychologically, their thoughts are extremely susceptible to the influence of external bad thoughts [2]. Zhang believed that some college students are at a loss as to what to do in value orientation and cannot find the correct standard for value judgment, which makes them more likely to doubt or reject the mainstream socialist values and weaken the guiding function of mainstream values [3]. She and Yi hold that any social consciousness will become an abstraction if it only concentrates on the rational cognition of its connotation, and this social consciousness will be fundamentally removed from the society in which it exists [4]. Therefore, practice is the essence of social life, and the conscious practice of socialist core values is a higher level of identification and internalization [5].

Through sorting out the statements of many scholars, the process of internalization and externalization of thoughts mainly covers four links: systematic cognition, emotional identification, thought transformation, and precipitation consolidation. From the perspective of the existing research, most of the research on the identity of ideological, along with, the political education of school students stays at the level of purely theoretical research. This study tries to apply the statistical analysis method of sociology to the research on the identity of ideological, along with, the political education of school students. From the perception of practice, this paper analyzes the present circumstances of school students'

identity and practice of ideological, along with, the political education and finds out the issues and causes of the ideological, along with, the political education of school students according to the status quo. Furthermore, this study can provide suggestions and countermeasures for strengthening the practice of institutional students' identity of ideological, along with, the political education.

With the further growth of the China's socialist market economy and the influence of decadent western ideas, in the context of diverse cultural choices and diversified value orientations, social hot issues have become increasingly prominent. Under the background of multicultural choice and multivalue orientation, social hot issues are becoming increasingly prominent. In order to accurately grasp the specific situation of college students' identification and training of socialist fundamental ideals and put forward targeted countermeasures and suggestions, by referring to economic research methods, this study builds a double-hurdle model, summarizes the significant factors that affect college students' identification and training of socialist fundamental values, and analyzes the causes of significant factors and irrelevant factors. In this paper, we explore the status quo, optimization countermeasures, and certain influencing factors for students' identification and practice of socialist core values. Furthermore, this study also puts forward the optimization countermeasures to enhance college students' identification and training of socialist fundamental ideals and values [6, 7].

The improvement of college students' identification degree of ideological, along with, the political education is an imperative topic and key problem in the implementation of ideological, along with, the political education, particularly, in the Republic of China. In order to increase the degree of identity in essence, it is compulsory to study the degree of identity of ideological, along with, the political education among university students from the perception of identity theory, so as to analyze the prevailing issues and put forward solutions and recommendations. The fundamental contributions of this paper are as follows: (1) this study uses the empirical model to analyze the results and summarizes the status quo of college students' identification and training of socialist fundamental standards. (2) Based on the research on the causes, it puts forward the path and countermeasures to strengthen the systematic cognition, improve the emotional identification, and deepen the practice consciousness, which is the innovation point of this study.

The left behind portion of the manuscript is organized in the subsequent fashion. The construction of the double-hurdle model is deliberated in Section 2. The influence factors of ideological, along with, the political education identity and practice concept is suggested in Section 3. The empirical process is demonstrated in Section 4. The identification and practical guidance of ideological, along with, the political education for university students is discussed in Section 5. To summarize the paper, Section 5 completes this paper and delivers some fundamental research directions for further consideration.

2. Construction of the Double-Hurdle Model

The double-hurdle classical model was first anticipated by the economist Cragg in the research of household durables consumption. The fundamental idea of the classical double-hurdle model is that consumer purchase behavior must span two "hurdles" of participation and payment, hence the name "double-hurdle model" [8]. Double-hurdle model is commonly used to process survey data containing a large number of zero observations and has been widely used in economics, ecology, tourism, and other fields [9]. For the content of this study, this model can be applied to this research in order to realize the aspects and elements that affect college students' cognition of socialist core values and their willingness to practice them. The double-hurdle model relaxes the assumptions of the Tobit model and is suitable for analyzing the factors that influence individuals' identification and practice of a certain value concept in these two different stages. Its essence is a Probit model and the combination of four truncated models [10, 11].

3. Influence Factors of Ideological, along with, the Political Education Identity and Practice Concept

In this study, approximately 15 explanatory variables (influencing factors) and 2 dependent variables (identification degree and willingness to practice) were selected. The influence factors of ideological, along with, the political education identity and practice concept are shown in Table 1.

4. Empirical Process

4.1. Results of Statistical. The empirical model results statistics are given away in Table 2.

According to Table 2, Empirical model results statistics, in probit model, ideological and political theory class teaching (C7), predominantly classroom, network media (C11), education courses, teachers, parents, and other groups (C15), to the social environment and family environment as the main form of the ring body (C14), mainly on theoretical education and practical exercise methods of education on college students' identity of socialist core values (C13) at 1% level Positive influence. In truncated model, the social practice activities organized by the students' school are significant at the level of 10% for college students' training of socialist fundamental ideals (C8), and the classroom, network-based media (C11), ideological and political teachers, parents, and other groups are significant at the level of 5% for college students' practice of socialist core values (C11) [22, 23].

4.2. Analysis of Nonsignificant Influencing Factors. According to the statistical results of the empirical model, your parents' emphasis on students' education (C6), the school's operation status of relevant systems on cultivating and practicing socialist core values (C9), and other courses

Table 1: Influence factors of ideological, along with, the political education identity and practice concept.

Items	Code	Source	Item set	Mean value	Standard deviation
Degree of identity	A1	Du [12] (2014)	Strongly disagree = 1, moderately disagree = 2, generally agree = 3, moderately agree = 4, strongly disagree = 5	4.12	0.91
Practice concept	B1	Jin and Hu [13] (2013)	Very unwilling = 1, relatively unwilling = 2, generally willing = 3, relatively willing = 4, very unwilling = 5	3.58	1.17
Grade	C1		Freshman = 1, sophomore = 2, junior = 3, senior = 4, graduate = 5	2.59	0.71
Major	C2	Wu [14] (2017)	Humanities and social sciences = 1, natural sciences = 2	1.89	1.12
Categories of colleges and universities	C3	Zhao and Lu [15] (2019)	Finance = 1, science and technology = 2, comprehensive = 3, agriculture and forestry = 4	1.31	0.50
Origin of student	C4		Village = 1, town = 2, county = 3, prefecture-level city = 4, provincial capital city = 5	1.68	0.61
Political landscape	C5	Liu [16] (2015)	Active party members = 1, probationary party members = 2, full party members = 3, ordinary people = 4, communist Youth League members = 5	1.53	0.82
The importance parents attach to education	C6		Very little attention = 1, relatively little attention = 2, general attention = 3, relatively much attention = 4, very much attention = 5	0.99	0.17
The impact of ideological along with the political theory teaching on the formation of socialist fundamental ideals	C7	Qin [17] (2018)	Very ineffective = 1, relatively ineffective = 2, generally ineffective = 3, relatively effective = 4, very effective = 5	1.62	0.69
The stimulus of social practice on the formation of socialist core standards	C8		Very ineffective = 1, relatively ineffective = 2, generally ineffective = 3, relatively effective = 4, very effective = 5	1.72	0.73
The practice of core socialist values is based on relevant systems	C9	Yongqiang and Zheng [18] (2014)	Very ineffective = 1, relatively ineffective = 2, generally ineffective = 3, relatively effective = 4, very effective = 5	1.55	0.96
Other courses propaganda and education of socialist core values	C10	Zhang [19] (2013)	Very little effect = 1, relatively little effect = 2, generally little effect = 3, relatively little effect = 4, very much effect = 5	1.86	0.71
A medium to understand socialist core values	C11		Books = 1, TV = 2, class = 3, internet = 4	3.08	0.94
The role of school rules, school motto and school discipline in identifying and practicing socialist core values	C12		Very ineffective = 1, relatively ineffective = 2, generally ineffective = 3, relatively effective = 4, very effective = 5	1.37	0.89
Which social practices affect core values	C13	Kang [20] (2016)	Blood donation = 1, social research = 2, social volunteer = 3, campus volunteer = 4, party activities = 5	4.09	1.34
Which environment affects core values	C14		Political environment = 1, economic environment = 2, social environment = 3, cultural environment = 4, family environment = 5	4.46	0.69
Which group influences core values	C15	Pan [21] (2015)	Classmates and friends = 1, counselors/head teachers = 2, professional teachers = 3, parents = 4, ideological teachers = 5	4.49	0.78

except for ideological and political courses (C10), school rules, school motto, school spirit, school discipline (C12), and other factors, there is no significant correlation between them and college students' identity and practice of core values.

(1) In terms of the prominence parents' residence on their youngsters' schooling, approximately 55.658% of the college students choose "Very much attention" and 25.69% choose "Relatively much attention," but there is still no correlation in the model analysis. The main reason is that parents focus more on their children's academic performance, pay more attention to intellectual education than moral education, and attach importance to success. The prominence parents' residence on their kids' schooling is shown in Figure 1.

Table 2: The empirical model outcomes statistics.

Index code	Coefficient	Significance	Coefficient	Significance
	Probit model		Truncated model	
C1	−0.12	−2.13	−0.05	−0.33
C2	0.29	2.78	−0.03	−0.36
C3	−0.07	−0.72	0.08	0.69
C4	0.46	0.82	0.07	−0.86
C5	0.08	1.59	0.03	3.07
C6	0.22	1.05	−0.36	−1.07
C7	0.18	3.36	0.18	0.92
C8	0.01	0.26	0.15	1.58
C9	−0.55	−1.62	−0.02	−0.22
C10	0.05	0.86	−0.08	0.13
C11	0.24	6.58	0.14	2.30
C12	0.04	−0.92	0.03	−0.64
C13	0.06	2.14	0.29	6.27
C14	0.47	7.56	0.29	3.44
C15	0.49	8.76	0.17	2.00

(2) In terms of the establishment and operation of relevant school systems, 24.10% of college students choose "Very effective," while 11.41% choose "Relatively ineffective" and 14.3% choose "Very ineffective." It holds that although colleges and universities have generally established relevant institutional systems, the effect of institutional education is not ideal, because the vitality of institutional construction lies in the firm implementation and strong feasibility. The relevant system operation circumstances are presented in Figure 2.

(3) There is no correlation between school rules, school motto, and school discipline, which indicates that the value of education function has not been given full play. The role of school rules, school motto, and school discipline in identifying and practicing socialist core values is shown in Figure 3.

4.3. Analysis of Influencing Factors of Significance. In terms of institution students' identification with the socialist fundamental standards, ideological and political theory class (C7), classroom, network-based media (C11), ideological and political teachers and parents (C15), social environment and family environment as the main composition of the loop (C14), students' grade (C1) and students' major category (C2) and other factors have a significant impact [24].

In terms of college students' practice of socialist fundamental ideals, in university students' political landscape (C5), (C8), various activities organized by the school classroom, the network of all kinds of media (C11), education courses, teachers, parents and counselors group (C15), is given priority to with the social environment and family environment play in the composition of various environment (C14) as well as education relying mainly on theoretical education and practical exercise methods (C13) has a positive effect.

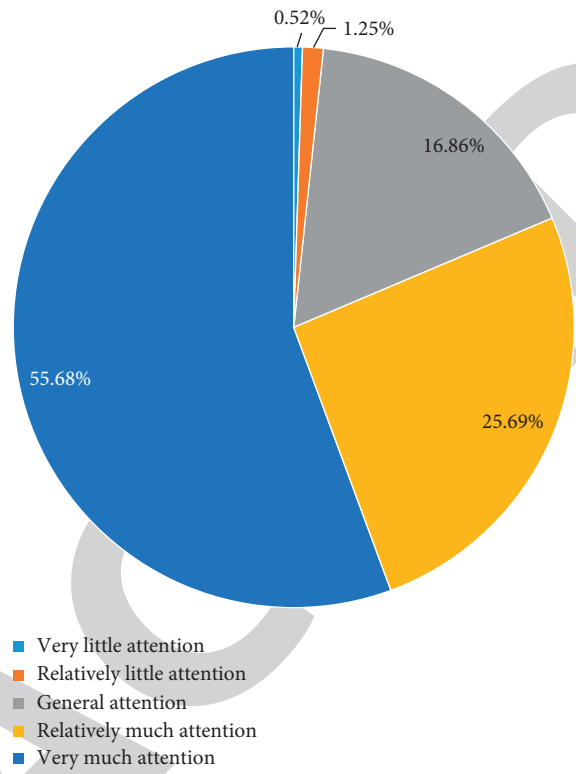

Figure 1: The prominence parents' residence on their kids' schooling.

5. Identification and Practical Guidance of Ideological, along with, The Political Education for School Students

5.1. Strengthen System Cognition. Strengthening systematic cognition aims to further enhance college students' theoretical cognition of socialist fundamental standards. The diversification of instruction sections is absolute, and the conditions of use are relative, which must change with the change of objective objects. Many times, the concerns of science and arts students on the same subjects are unmatched, and so occur to address the characteristics or common interests of students from different disciplines and incorporate them into the instructional context [25]. The ideological, along with, the political education of the course is reflected in the whole staff education and all-round education. In the process of enriching things silently, the integration of value and knowledge is strengthened. Therefore, educational style is of great importance. Style of study is an important content of campus culture construction. A good style of the educational study can affect students to consciously form a correct learning attitude, which can greatly promote college students to systematically understand the true meaning of socialist core values and implement them in their study and daily life.

5.2. Enhance Emotional Identity. Teachers should enhance their role awareness, control and relieve the fluctuation of their own emotions, communicate with the main body of the

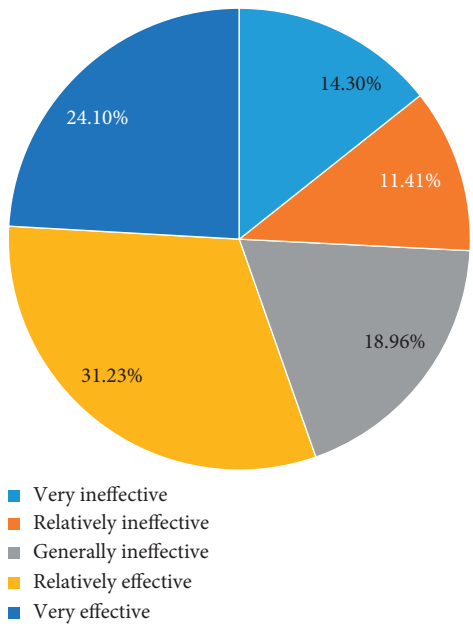

Figure 2: The relevant system operation situation.

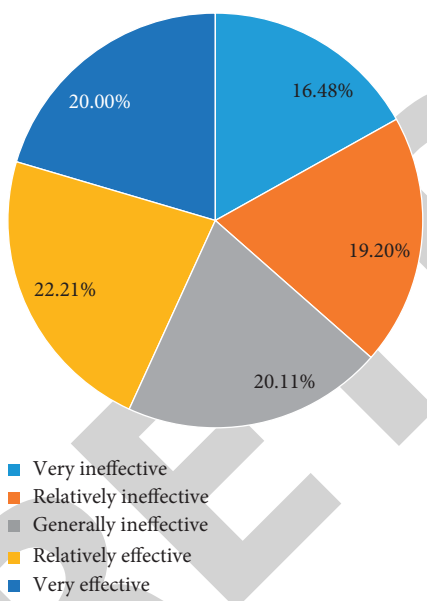

Figure 3: The role of school rules, school motto and school discipline in identifying and practicing socialist core values.

teacher and the main body of the students, deeply understand the ideas of students, and accurately educate students. In the completion of their own work and scientific research tasks, while strengthening theoretical learning and self-cultivation, promote professional development and education art synchronized improvement. The original intention of counselors is ideological education, and their role is inevitably political. In practice, counselors integrate the roles of management, service and education into the daily life of college students, so they should make contributions in promoting college students' identification and practice of core values. This requires counselors to set an example, always highlight the theme, advance and promote positive energy in the multiple values, correctly understand the core values and take the lead in setting an example, guide college students to understand and accept the socialist core values, and improve the spirit of college students into specific work.

5.3. Deepen Practical Consciousness. Socialist core values are not rigid framework theory, it is people for their own norms of conduct and guidance. Only by truly internalizing the socialist core values in the heart and then externalizing them in the form can they really play their role and manifest their strong vitality. All kinds of associations on campus are important channels and ways for college students to cultivate socialist core values. College students can participate in various associations to improve their abilities. Schools should attribute prominence to the building of social organizations in campus life, guide college students to enthusiastically contribute to the social organization accomplishments, and combine the theoretical study of socialist fundamental standards with practical activities. This should be noted that schools and institutions of higher education should encourage students to take the initiative to participate in public welfare activities and volunteer activities. It is necessary to improve the social practice system, such as social research and social practice platform in winter and summer vacation, which can provide a certain way for college students to practice socialist core values. In the study activities, class meetings with the theme of "socialist core values" are often organized to improve school students' intelligence of national crisis and social responsibility.

6. Conclusions and Future Research

Colleges and universities can actively develop and run-through the socialist fundamental standards, which is the basic project to encourage the production of socialist essential value structure. Furthermore, the urgent need to maintain the China's ideological security, and the internal prerequisite to accomplish the objective of constructing an abstemiously successful civilization in an all-round way and to observe to and advance socialism with the Chinese appearances is mandatory. It is about cementing the ideological foundation and forging the spiritual bond for comprehending and understanding the Chinese vision of national rejuvenation. The improvement of college students' identification degree of ideological, along with, the political education is an imperative topic and key problem in the implementation of ideological, along with, the political education, particularly, in the Republic of China. In order to advance the degree of identity in essence, it is compulsory to study the degree of identity of ideological, along with, the political education among school students from the viewpoint of an identity theory, so as to analyze the prevailing issues and put forward solutions and recommendations.

This study uses the empirical model to analyze the results and summarizes the status quo of college students' identification and training of socialist fundamental standards. Based on the research on the causes, it puts forward the path

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Research Article

The Prediction Model of Dance Talent Training in Fuzzy Neural Network Algorithm

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In view of the existing problems in the training of dance talents, particularly in China, the focal and key goal of this investigation is to examine and train a predictive model using the fuzzy neural network algorithm. In order to enhance the training, improve the quality of dance talents, and further promote the development of dance professional education, this paper implements the fuzzy neural network procedure to train prediction models for dance talents. Moreover, we carry out research and, then, establish a prediction model, through the fuzzy neural network algorithm, to predict the quality and effect of dance talent training. The model can be, then, used to deliver a fundamental and a key reference for the training of dance talents in the social sectors across the world. The experimental setup and obtained outcomes show that the suggested algorithm has good usability for the training and prediction of dance talents in terms of accuracy. We observed that the fuzzy-based technique is approximately 17.6% more precise than the classical scheme. Moreover, the prediction correctness was observed more than 98.5%.

1. Introduction

Before it was deemed beautiful, dance already existed as a cultural form. As time goes on, productivity increases, class distinctions become more clear, and the transition from cultural to aesthetic dancing has become a historical necessity. Moreover, dance becomes an art in the strictest sense when it develops aesthetic importance. In fact, the dance also progressively develops a discipline for the dance art, which leads to the creation of a new discipline called dance aesthetics. The creative quest for dance beauty is embodied in dance art, which acerbically and dynamically seeks out goodness, truth, and beauty in the social life of humans, as well as, spreading these qualities. Moreover, it creates different dance pictures, connects with the hearers, uses different action forms to represent the aesthetic consciousness and aesthetic emotion of dance, and satisfies their aesthetic demands.

Many academics have started using the BF and fuzzy approximation model for engineering design for the reason that the fuzzy neural network model, as demonstrated in [1], is effective at approximating functions. The fuzzy neural network is a particular kind of the feedforward neural network with a single, or more than one, hidden layer(s) that is capable of realizing both the nonlinear and linear mappings for the hidden layers, as well as, and the output network layer. A local response to the input signal is produced by the action function of the hidden layer node of the fuzzy neural network. When the input signal of the network model is near the central assortment of the neural network model, then the buried layer node generates a significant and considerable output. This should be noted that the fuzzy neural network's training algorithm is examined in the light of the fuzzy neural network model.

Lin and Lee [2] suggested an RNN-FLCS, or reinforcement neural-network-based fuzzy logic control system, to address a variety of reinforcement learning issues. For the implementation of a fuzzy logic control system, a general connectionist model known as the neural fuzzy control network (NFCN) is suggested [3–6]. Similarly, a developing fuzzy neural network (termed as EFuNN) along with an artificial neural network (ANN) model which is trained by means of the scaled conjugate gradient procedure (CGA) and the well-known backpropagation (BP) procedure is

presented, and these are the widespread soft computing techniques taken into consideration in the research conducted in [7]. The extrapolation of many benchmark chaotic structures and the time series is evaluated using a variety of neural and neuro-fuzzy models with various learning techniques in [1]. Lin et al. [8–10] proposed the SANFN-GSE technique, which stands for the self-adaptive neural fuzzy network with group-based symbiotic evolution. Moreover, Barbounis et al.[27] projected the LF-DFNN model (termed as locally feedback dynamic fuzzy neural network) for simulating the temporal processes. Yilmaz et al.[3] introduced the FWNN model (termed as fuzzy wavelet neural network) and other similar forecasting models for nonlinear dynamical systems, their identification along with prediction. Chang et al.[4] offered a novel technique that uses evolving partly connected neural networks (EPCNNs) as inputs to forecast stock price trend. In order to create models with greater accuracy and parsimony, Alexandridis et al.[5] introduced a unique technique for training the radial basis function (RBF) networks. Other noteworthy works is the work demonstrated by Micheli-Tzanakou et al.[1].

In order to enhance the training of dance talents, advance the quality of dance aptitudes, and further promote the development of dance professional education, this paper uses a fuzzy neural network algorithm to train dance talents. Carry out research and establish a prediction model, through the algorithm to predict the quality and effect of dance talent training [16–19]. This study builds the fuzzy function neural network model diagram. In fact, using the reiterated learning of the sample data, the fuzzy neural network (FNN) model depicts the nonlinear growth correlation of the complete structure in order to forecast the unknown data. As a result, the sample data used in the training are crucial for the neural network's capacity to generalize and fit accurately [20, 21].

The remaining five parts of this manuscript make up its general structure as follows. The background and importance of dance aesthetic traits are discussed in Section 1 before the primary topic of this article is introduced. Section 2 mostly introduces the state of dance aesthetic study both domestically and internationally. The fuzzy neural network model is introduced in Section 3. Section 4 introduces dance's artistic qualities and examines the experimental portion. The complete material is summarized in Section 5. Also, some prominent directions for future research are also listed in this section [22].

2. Fuzzy Neural Network (FNN)

2.1. The Basic Structure of Fuzzy Neural Network. The basic structure diagram of the classical fuzzy neural network is revealed in Figure 1.

Among them, every node that belongs to the input layer contains a synthesis function and an activation function, which are used to process information from linked nodes and to output the corresponding active value. The quantity of A_1 neurons is numerically equivalent to the amount of input variables or nodes, and the function is mathematically illustrated in the following equation:

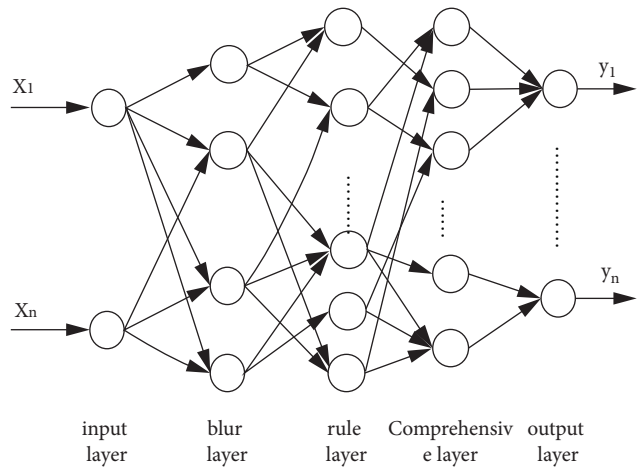

Figure 1: The basic organization of the fuzzy neural network.

$$\begin{aligned} f_k &= u_k^{(1)}, \\ \alpha_k &= f_k\left(1 \le k \le A_1\right). \end{aligned} \tag{1}$$

The second obscure layer represents the number of neurons A_2, which depends on the number of obscure subsets A_1 and the corresponding obscure subset. If all input variables $A_2 = A_1 \times a_2$ have the same number of obscure subsets, then $(|T(X_i)| = a_2, \quad i = 1, 2, \ldots, A_1)$ is satisfied. Each neuron represents an ambiguous subset, the member function assumes a Gaussian function, and then, the relationship is given by the following equation:

$$\begin{aligned} f_k &= \frac{\left(u_i^{(2)} - m_{ij}^{(2)}\right)^2}{\left(\sigma_{ij}^{(2)}\right)^2}, \\ \alpha_k &= e^{f_k}\left(1 \le k \le A_2\right), \end{aligned} \tag{2}$$

where $m_{ij}^{(2)}$ and $\sigma_{ij}^{(2)}$ are the center and width of the member function of the jth obscure subset that corresponds to the ith input variable, respectively.

The third layer is the rule layer, which implements the logical operation between fuzzy logic and fuzzy rules. In this layer, the value of A_3 is identical to the amount of fuzzy rules, and then, the relationship is given by the following equation:

$$\begin{aligned} f_k &= \min_{1 \le j \le A_1}\left(u_{kj}^{(3)}\right), \\ \alpha_k &= f_k\left(1 \le k \le A_3\right). \end{aligned} \tag{3}$$

In formula (3), $u_{kj}^{(3)}$ is numerically equal to the jth input value, in particular, corresponding to the kth node.

The fourth layer is the synthesis layer, which primarily executes the logic or functionality between nodes to obtain ambiguous rules. Its expression is mathematically illustrated in the following equation:

$$f_k = \sum_{j=1}^{A_{4k}} u_{kj}^{(4)}, \alpha_k = \min\left(1, f_k\right)\left(1 \le k \le A_4\right). \tag{4}$$

In formula (4), A_{4k} represents the number of inputs connected to the kth node, and $u_{kj}^{(4)}$ is numerically equal to

the jth input value corresponding to the kth node. Furthermore, all the connected loads in this layer are equal to 1.

The fifth layer is the output layer, which derives the result through the functionality of the function and expresses its value using the following equations:

$$f_k = \sum_{j=1}^{a_5} m_{kj}^{(5)} * \sigma_{kj}^{(5)} * u_{kj}^{(4)}, \tag{5}$$

$$\alpha_k = \frac{f_k}{\sum_{j=1}^{a_5} \sigma_{kj}^{(5)} * u_{kj}^{(5)}}, \quad (1 \le k \le A_5). \tag{6}$$

2.2. Learning Algorithm of the Fuzzy Neural Network. In this paper, it is necessary to determine the training prediction model of dance skills, network connection load $\omega_{ij}\,(i = 1, 2, \ldots, n; j = 1, 2, \ldots, n)$, mean value of membership function m_{ij}, and variance $h_{ij}\,(i = 1, 2, \ldots, n; j = 1, 2, \ldots, n)$. The erroneous active expression of the dance skills training prediction in this paper is given by the following equation:

$$\text{err} = \frac{1}{2} \sum \left(f_k - f_i\right)^2. \tag{7}$$

In formula (7), f_k is the expected output value of the network, and f_i is the actual output value of the network.

Once the connection load, mean, and variance of the network parameters have been trained by the suggested neural network algorithm, then their mathematical expressions are illustrated in the following equations:

$$\begin{aligned} \omega_{ij}(k+1) &= \omega_{ij}(k) - \beta \frac{\partial E}{\partial \omega_{ij}}, \\ m_{ij}(k+1) &= m_{ij}(k) - \beta \frac{\partial E}{\partial m_{ij}}, \\ h_{ij}(k+1) &= h_{ij}(k) - \beta \frac{\partial E}{\partial h_{ij}}. \end{aligned} \tag{8}$$

3. Establishment of Dance Talent Training Model

For dance skills training quality coefficient S_i, it is available through several years of continuous training quality, and its structure is built across the $S^0 = (S_{i1}^0, S_{i2}^0, \ldots, S_{im}^0)$ time grade. The steps to build the model are as follows:

Step (1): after accumulating the initial time series $S^0 = (S_{i1}^0, S_{i2}^0, \ldots, S_{im}^0)$, the value for $S^1 = (S_{i1}^1, S_{i2}^1, \ldots, S_{im}^1)$ can be obtained, where the specific expression of the accumulated time series is given by the following equation:

$$S_{ij}^1 \sum_{k=1}^{j} S_{ik}^0, \quad j = 1, 2, \ldots, m. \tag{9}$$

Step (2): then, the accumulated first-order differential equation is established, and its expression is given by the following equation:

$$\begin{bmatrix} a \\ b \end{bmatrix} = \left(B^T \;\; B\right)^{-1} B^T Y_M. \tag{10}$$

In formula (10), a and b represent coefficient terms and constant terms, respectively.

In addition, it is given that $z_k^1 = 1/2\,(S_{ik}^1 + S_{i,k-1}^1)$ $k = 1, 2, 3, \ldots m$, and thus, using the following formula (11), we obtain the value for B:

$$\begin{aligned} B &= \begin{bmatrix} -z_2^1 \\ \vdots \\ z_m^1 \end{bmatrix}, \\ Y_m &= \begin{bmatrix} S_{i2}^0 \\ \vdots \\ S_{im}^0 \end{bmatrix}. \end{aligned} \tag{11}$$

Step (3): the obtained fitting value $\widehat{S}_i^1$ is illustrated using the following equation:

$$S_{i,k-1}^1 = \left(S_{i1}^0 - \frac{b}{a}\right) e^{-k} + \frac{b}{a}, \quad k = 1, 2, \ldots m. \tag{12}$$

Step (4): restore the fitted value $\widehat{S}_i^1$, and then mathematically, it is expressed as given in the following equation:

$$\widehat{S}_{i,k+1}^0 = \widehat{S}_{i,k+1}^1 - \widehat{S}_{i,k}^0, \quad K = 1, 2, \ldots, m. \tag{13}$$

Subject to the availability of the following constraint given by the following equation:

$$S_{i,k+1}^0 = \left(1 - e^a\right)\left(S_{i1}^0 - \frac{b}{a}\right) e^{-ak}, \quad k = 1, 2, \ldots, m. \tag{14}$$

From this, it is possible to predict the training of dance talents in the coming years using the proposed fuzzy neural network algorithm.

4. Simulation Analysis and Results

This paper practices the MATLAB software tool to model and evaluate the fuzzy neural network. Furthermore, we make predictions through the network training from the aspects of dance performance, choreography, and dance teaching in the training process. In fact, the evaluation will help us so as to understand the professional qualities along with dance teaching abilities of the dance students.

After the fuzzy neural network model automatically learns and trains the data matrix of the input sample, it obtains the actual prediction data of the input sample data. As shown in Figure 2, five years of dance performance sample data are input, and the output results obtained after network training are compared with the actual results. It can be easily understood from the investigation in the figure that

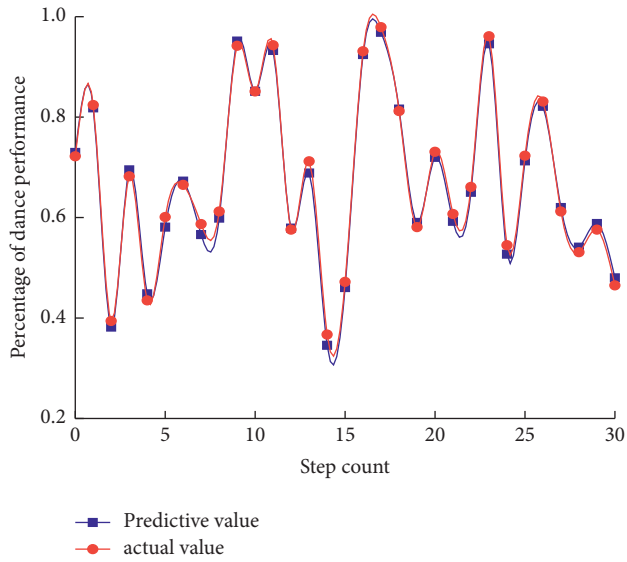

Figure 2: The effect of network training results and actual output.

the actual dance performance training effect is basically consistent with the training effect of the fuzzy neural network.

The errors between the proposed model prediction and the actual values are shown in Table 1. This could be understood from the reported values in Table 1 that the error range amongst the anticipated values and the actual values is significantly small, and the predicted trend of the dance performance effect is basically consistent with the actual situation.

In addition, this paper inputs the data samples of choreography to the network training, and the output effect after the network training is revealed in Figure 3. This is very clearly observed from the exploration of the above figure, and it can be comprehended that the output value of the choreographer after the network training is roughly consistent with the actual value. Except for a small part of the training value that has a certain error, the rest of the training data results are close to the actual ideal value.

The errors amongst the model anticipated values and the actual values of the choreographer are given away in Table 2. We can easily observe from the outcomes reported in Table 2 that the error range amongst the anticipated values and the real values is significantly small. Furthermore, the predicted trend of the choreography effect tends to be consistent with the actual value, and the results are relatively similar.

Finally, this paper inputs the sample data of the dance teaching into the suggested fuzzy neural network, and the training output outcomes and actual values are shown in Figure 4. The training outcomes show that the fuzzy neural network has a noble application impact in the prediction of dance teaching, with exact applicability.

The errors amongst the model forecasted values and the actual values of the dance teaching are given away in Table 3. From looking at the figure and reported values in Table 3, this could be comprehended from the table's outcomes that the error range amongst the expected values and the real values is significantly small. Furthermore, we observed that

Table 1: Fuzzy neural network error of dance performance.

Actual value	Predictive value	Relative error
0.722	0.73	0.011
0.824	0.82	−0.007
0.394	0.38	−0.031
0.682	0.69	0.019
0.435	0.45	0.030
0.601	0.58	−0.033
0.665	0.67	0.011
0.587	0.57	−0.036
0.612	0.60	−0.021
0.942	0.95	0.010
0.851	0.858	−0.008
0.943	0.93	−0.011
0.576	0.58	0.005
0.712	0.69	−0.033
0.367	0.35	−0.058
0.472	0.46	−0.024

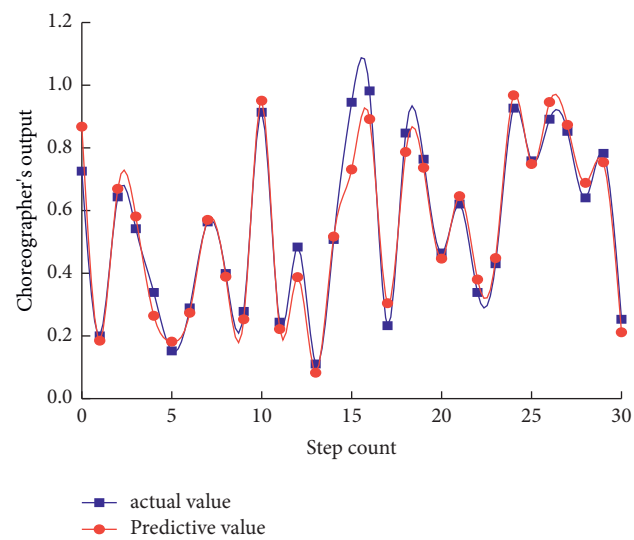

Figure 3: The network training results and actual output effects of the choreographer.

Table 2: Fuzzy neural network error of choreographer.

Actual value	Predictive value	Error
0.73	0.87	0.195
0.20	0.18	−0.077
0.64	0.67	0.040
0.54	0.58	0.072
0.34	0.26	−0.219
0.15	0.18	0.192
0.29	0.27	−0.054
0.56	0.57	0.012
0.40	0.39	−0.026
0.28	0.25	−0.091
0.91	0.95	0.044
0.24	0.22	−0.090
0.48	0.39	−0.199
0.11	0.08	−0.250
0.51	0.52	0.018
0.95	0.87	−0.079

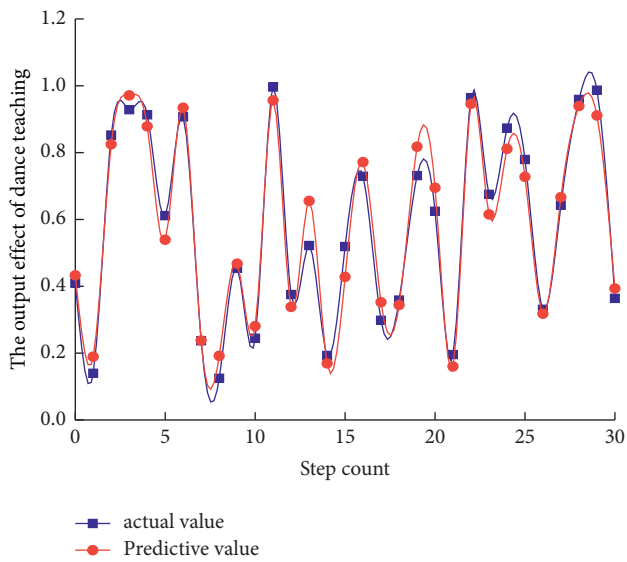

Figure 4: The network training results and actual output effects of the choreographer.

Table 3: Fuzzy neural network error in dance teaching.

Actual value	Predictive value	Error
0.409	0.433	−0.057
0.139	0.189	−0.356
0.852	0.825	0.032
0.928	0.971	−0.046
0.913	0.879	0.038
0.611	0.539	0.118
0.907	0.934	−0.030
0.237	0.238	−0.003
0.125	0.192	−0.542
0.454	0.468	−0.029
0.245	0.281	−0.147
0.996	0.956	0.040
0.375	0.338	0.098
0.522	0.655	−0.256
0.193	0.169	0.122
0.519	0.428	0.176

the predicted trend of the dance teaching effect is basically the same, that is, almost similar, as the actual values, and subsequently, the results are also similar.

5. Conclusions and Future Work

In this paper, depending on the characteristics of the dance skills training, we determined the functional characteristics of the model input layer along with the hidden layer(s) and the output layer neurons, including the configuration of the obscure neural network. Furthermore, we applied the obscure control theory to optimize the network training process. The network models improve neuronal connection load and the training performance. In the process of predicting dance skills training, network predictions can be obtained by comparing the error between the predictive result data and the actual operational data, in order to improve the precision and performance (real-time) of the prediction and bring the obtained predictive data closer to the reality. In fact, this bears a good resemblance to the actual values and confirms the high accuracy of the model data obtained.

In the future, we will account for larger data sets of the dance skill while taking additional parameters into account. Furthermore, we will investigate how deep learning models will perform against the proposed fuzzy neural network architecture. We will use big data technologies so that they can be integrated into the training process that usually is computationally intensive. We believe that using big data is essential to improve the runtime of the training and prediction phase. In future work, we will look into the computational complexities and how they can be significantly reduced using the edge and cloud computational schemes.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Mobile Information Systems
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Retraction

Retracted: A Self-Adaptive Recommendation Method for Online Ideological and Political Teaching Resources Based on Deep Reinforcement Learning

Mobile Information Systems

Received 25 July 2023; Accepted 25 July 2023; Published 26 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Y. Jin, "A Self-Adaptive Recommendation Method for Online Ideological and Political Teaching Resources Based on Deep Reinforcement Learning," *Mobile Information Systems*, vol. 2022, Article ID 1702657, 11 pages, 2022.

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Research Article

A Self-Adaptive Recommendation Method for Online Ideological and Political Teaching Resources Based on Deep Reinforcement Learning

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The online ideological as well as the political teaching resource management system structure is established in the view of information management in colleges and universities. Furthermore, the online ideological as well as the political teaching information level is improved by combining the optimized design of resource recommendation model. In this paper, an online ideological as well as political teaching resource adaptive recommendation system and algorithm, which is designed on deep reinforcement learning, is suggested. The cost relationship model between online ideological as well as the political teaching resources and learning profitability is constructed. Similarly, the multidimensional constraint index parameter analysis method is adopted, and the adaptive matching model of online ideological as well as the political teaching resources is established. According to online ideological as well as the political teaching norms, combined with the analysis of high-quality educational resources of audience groups, the dynamic evaluation of online ideological as well as the political teaching resources and the adaptive matching model of interest preferences are established. Finally, the deep reinforcement learning method is adopted. By analyzing the characteristics of the resource structure model of online ideological as well as the political teaching resources, through benefit evaluation, resource supply and demand balance management analysis and balanced game control, the online ideological as well as the political teaching resources management system can be improved and self-adaptive recommended. The simulation outcomes indicate that this approach has noble adaptability and high correctness in recommending online ideological as well as the political teaching resources.

1. Introduction

In the new era, the ideological as well as the political theory course bears the central job of moral education, and its role is irreplaceable. However, at the existing period, there are some complications in the teaching of ideological as well as the political theory course, such as "breaking," "repetition" and lack of pertinence, which to some extent affects the integration construction process of ideological as well as the political course in universities, primary, and secondary schools and the whole process of educating people. The fundamental reason is that the supply structure of ideological as well as the political education resources in the teaching content is unreasonable, such as the lag of the teaching content of ideological as well as the political theory course caused by the untimely updating of ideological as well as the political education resources in teaching [1]; the supply of ideological as well as the political education resources does not match the demand of students for teaching content; The irrational structure of ideological as well as the political education resources leads to the lack of effective connection between teaching contents of different classes, and so on. As a result, the teaching content lacks novelty, consistency, and hierarchy in different paragraphs, and then students lose interest in repeated content, and even generate resistance [2]. Therefore, the allocation of ideological as well as the political education resources needs to suit the remedy to the case.

According to the needs of different students' teaching contents, we should scientifically allocate ideological as well as

the political education resources by stages and levels, optimize the resource structure, establish a three-dimensional ideological as well as the political education resource system, form a systematic and hierarchical ideological as well as the political theory course teaching content, and realize the internal balance between ideological as well as the political education resource supply and students' needs in various sections. For example, "the postgraduate stage focuses on inquiry learning, this stage focuses on theoretical study, common sense study in senior high school, experiential study in junior high school and enlightening study in primary school, in order to effectively improve the pertinence of Ideological and political theory teaching content and promote the integration of ideological and political theory teaching content in primary and secondary schools [3].

The supply of ideological as well as the political education resources in the teaching content of ideological as well as the political theory course is the result of a series of comprehensive functions such as development, utilization, allocation, and combination, and has its own uniqueness. From the analysis of the resources in the teaching content of ideological as well as the political theory courses in various sections of colleges, primary and secondary schools, we can find that there are the following structural contradictions in the supply and allocation of ideological as well as the political education resources [4]. Therefore, it is necessary to study the adaptive recommendation model of online ideological as well as the political teaching resources.

According to the distribution of high online ideological as well as the political teaching resources, combined with independent learning of personal preferences, a distributed integration model of online ideological as well as the political teaching resources is assembled, and the scheduling for information of online ideological as well as the political teaching resources is carried out by combining multisource distributed design method [5]. Among the traditional methods, the self-adaptive recommendation methods of online ideological as well as the political teaching resources mainly include particle swarm recommendation method, K-means clustering analysis approach and fuzzy information fusion technique, etc. The relevance analysis model of self-adaptive recommendation of online ideological as well as the political teaching resources is established. Through fuzzy information scheduling [6], the self-learning and automatic matching of online ideological as well as the political teaching resources can be realized. However, the traditional method of online ideological as well as the political teaching resources recommendation has poor adaptability. To answer the aforementioned complications, this paper improves the informatization level of online ideological as well as the political teaching, and proposes an adaptive recommendation system and algorithm of online ideological as well as the political teaching resources based on deep reinforcement learning.

This paper constructs the cost relationship model between online ideological as well as the political teaching resources and learning profitability, adopts multidimensional constraint index parameter analysis method, establishes an adaptive matching model of online ideological as well as the political teaching resources, establishes a dynamic evaluation model of online ideological as well as the political teaching resources and an adaptive matching model of interest preferences according to online ideological as well as the political teaching norms and the analysis of high-quality educational resources of audience groups, and adopts deep reinforcement learning method to analyze the characteristics of resource structure model of online ideological as well as the political teaching resources and realize adaptive recommendation of online ideological as well as the political teaching resources. The fundamental ideas covered in this article are as follows:

(i) To improve the informatization level of online ideological as well as the political teaching, an adaptive recommendation algorithm of online ideological as well as the political teaching resources constructed on deep reinforcement learning is offered.

(ii) To construct the cost relationship model between online ideological as well as the political teaching resources and learning profitability.

(iii) To adopt the multidimensional constraint index parameter analysis method to establish the usage model of online ideological as well as the political teaching resources adaptive recommendation, so as to realize online ideological as well as the political teaching resources adaptive recommendation.

The remaining part of the article is systematized in the following manner. First of all, we discuss the basics of deep learning theory and methods in Section 2. In Section 3, analysis of data distribution and characteristics of adaptive recommendation of online ideological as well as the political teaching resources is deliberated. In Section 4, optimization of adaptive recommendation algorithm for online ideological as well as the political teaching resources is discussed. In Section 5, reliability analysis of online ideological as well as the political teaching resource recommendation is completed. Simulations and tests are conducted in Section 6. Lastly, Section 7 summarizes this article and provides several fundamental and key guidelines for future investigation.

2. Deep Learning Theory and Method

The input images can be used to directly control reinforcement learning, which combines the decision-making capacity of reinforcement learning with the perceptual skills of the deep learning technology. It is an artificial intelligence technique that is more similar to how people think. A complete perception and control system with a high degree of universality is reinforcement learning. The agent interacts with the environment at every second to obtain a high-dimensional observation, and it then utilizes deep reinforcement learning to interpret the observation in order to obtain a representation of a particular state characteristic. The cost function of each action should be assessed based on the anticipated return, and a technique should be used to

link the present state with the appropriate action. Get the following observation by responding to this environmental activity. We can eventually determine the best plan of action to reach the objective by repeating the aforementioned procedures. The principle framework of the reinforcement learning is shown in Figure 1.

3. Analysis of Data Distribution and Characteristics of Adaptive Recommendation of Online Ideological as well as Political Teaching Resources

3.1. Data Distribution of Adaptive Recommendation of Online Ideological as well as Political Teaching Resources. To fully understand and comprehend the personalized recommendation systems of distributed online ideological as well as the political teaching resources in the recent advanced arena of big data and learning environment, it is necessary to combine the preference information of online ideological as well as the political teaching audience, and conduct feature mining and clustering processing in the process of online ideological as well as the political teaching resources recommendation. Furthermore, it is also essential to build an adaptive recommendation model of online ideological as well as the political teaching resources, and adopt the methods of information fusion and big data clustering analysis [7]. Build a mining model of online ideological as well as the political teaching resources' interest preference characteristics of online ideological as well as the political teaching audience [8]. Under the heterogeneous storage structure mode, adopt regional fusion method to carry out dynamic structure reorganization in the process of online ideological as well as the political teaching resources' self-adaptive recommendation, and adopt personalized information fusion method to build the recommendation model. The overall structure model of the online ideological as well as the political teaching resources' self-adaptive recommendation is obtained as shown in Figure 2.

The tag identification method is adopted for the information sampling of online ideological as well as the political teaching resources adaptive recommendation, and the state feature $x_j = \{x_{1j}, x_{2j}, \ldots, x_{mj}\}^T$ of online ideological as well as the political teaching resources adaptive recommendation is output. The online ideological as well as the political teaching audience behavior information is sampled at more than twice the baud rate, and the fusion feature $p(x_0)$ of online ideological as well as the political teaching resources adaptive recommendation audience behavior information is obtained. The collected online ideological as well as the political teaching resources adaptive recommendation audience behavior information is mined with joint features, and the personalized recommendation and joint feature sampling model are outputted as follows:

$$P_{ij}(k) = \frac{\left(l_j(k) - l_i(k)\right)\eta_{ij}(k)}{\sum_{j\in N_i(k)}\left(l_j(k) - l_i(k)\eta_{ij}\right)(k)}. \tag{1}$$

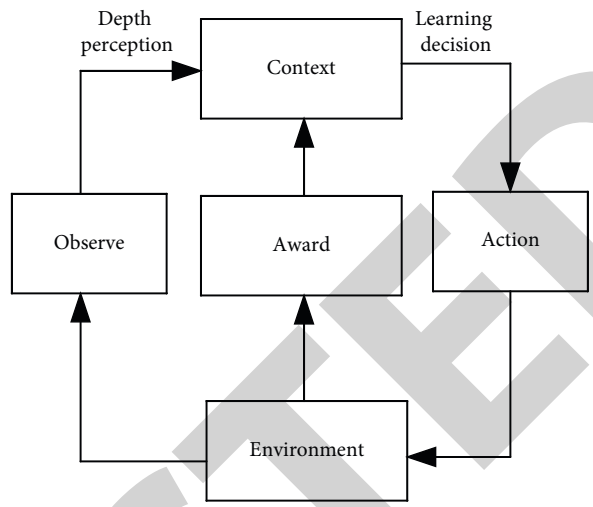

Figure 1: The framework of deep reinforcement learning (DRL) and basic principles.

The correlation detection method is used to jointly identify the characteristic information of online ideological as well as the political teaching resources adaptive recommendation. According to the association rule scheduling model, the sample set of personalized information sampling of online ideological as well as the political teaching resources is $s(t)$. The process of online ideological as well as the political teaching resources adaptive recommendation is controlled under the Internet of Things technology, and the sample set of online ideological as well as the political teaching audience preference characteristics is as follows:

$$\begin{aligned} s(v) &= \int_0^v \sin\left(\frac{\pi}{2}x^2\right)\mathrm{d}x, \\ y(t) &= u(s(t-\tau))\exp\left(j\omega_C s(t-\tau)\right), \end{aligned} \tag{2}$$

wherein, v represents the correlation directivity coefficient of online ideological as well as the political teaching resources adaptive recommendation, and $u(t)$ is the effective information feature component of online ideological as well as the political teaching audience preference characteristics. Under the platform of heterogeneous distributed networking system, the attribute dimensions of online ideological as well as the political teaching audience preference characteristics distribution are n, $N_1, \ldots, N_n$. Within L time slices, data will be gathered to v_s, and the standard quantitative set of online ideological as well as the political teaching resources adaptive recommendation information is:

$$\begin{aligned} E_{Tx}(l,d) &= E_{(Tx-\mathrm{elec})}(l) + E_{(Tx-\mathrm{amp})}(l,d) = lE_{\mathrm{elec}} + l\varepsilon d^{\alpha}, \\ &= \begin{cases} lE_{\mathrm{elec}} + l\varepsilon_{fs}d^2, d < d_0, \\ lE_{\mathrm{elec}} + l\varepsilon_{mp}d^4, d \geq d_0. \end{cases} \end{aligned} \tag{3}$$

The fuzzy adaptive scheduling scheme is implemented, and the big data information fusion model of online ideological as well as the political teaching resources adaptive

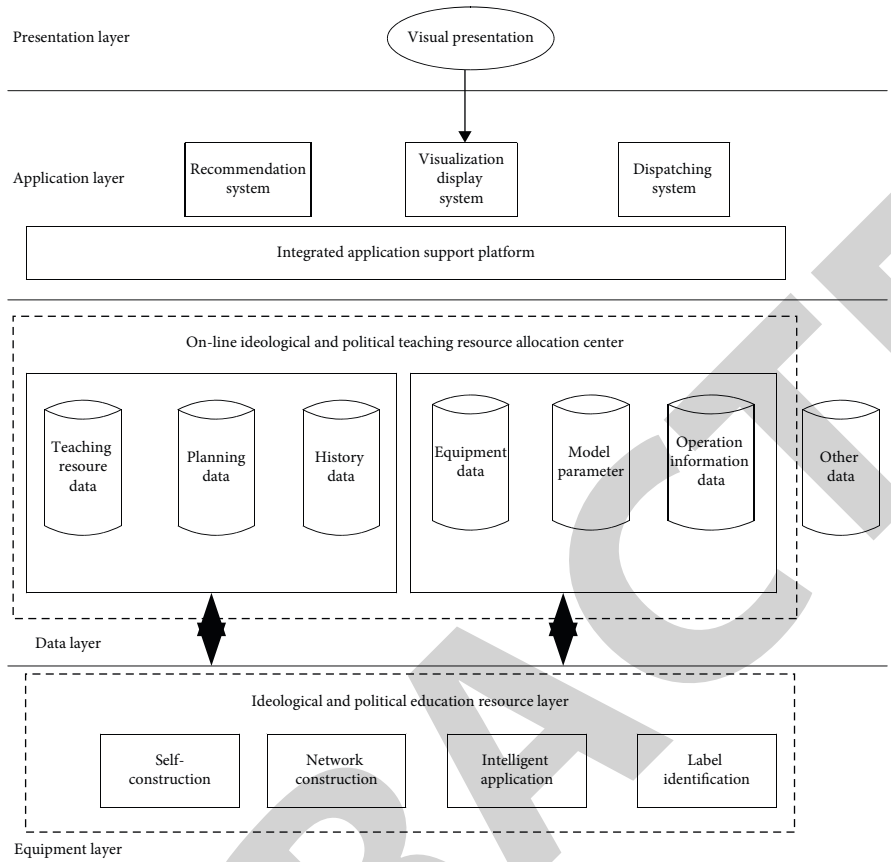

Figure 2: Overall structure model of adaptive recommendation of online ideological as well as political teaching resources.

recommendation is constructed. According to the data distribution characteristics of online ideological as well as the political teaching resources adaptive recommendation, the personalized recommendation algorithm is designed [9].

3.2. Online Ideological as Well as Political Teaching Audience Behavior Characteristics Analysis. On the basis of constructing the online ideological as well as the political teaching audience behavior information mining model, the online ideological as well as the political teaching resources online ideological as well as the political teaching audience behavior information fusion processing is performed by using the big data fusion scheduling technique [10], and the resource scheduling function of online ideological as well as the political teaching resources adaptive recommendation is acquired as follows:

$$\widehat{f}_i(n) = \frac{1}{2\pi}\sum_{i=0}^{p} i a_i n^{i-1}. \tag{4}$$

Information fusion is performed on the extracted statistical data of online ideological as well as the political teaching resources adaptive recommendation [13]. In the resource dispatching center, multi-dimensional feature reconstruction is carried out according to the preference features of online ideological as well as the political teaching audience groups. By adopting multiblock fusion matching method, the association rules of online ideological as well as the political teaching resources adaptive recommendation are obtained as follows:

$$\begin{aligned} c_k &= \frac{1}{j_k}\left[\frac{d^k}{d\omega^k}\ln(\Phi(\omega))\right]_{\omega=0} \\ &= (-j)^k\left[\frac{d^k}{d\omega^k}\Psi(\omega)\right]_{\omega=0} \\ &= (-j)^k\Psi^k(0). \end{aligned} \tag{5}$$

The collected information of online ideological as well as the political teaching resources self-adaptively recommended resources is processed by self-adaptive information fusion, and the fundamental database is assembled. Note that, the supreme distribution intermission of data fusion clustering approach is given by $r_{\max} = (P(N_0\beta)^{-1})^{1/\alpha}$, and the sample space distribution distance of online ideological as well as the political teaching resources self-adaptively recommended is $d \le r_{\max}$. The information fusion results of online ideological as well as the political teaching resources self-adaptively recommended are as follows:

$$\begin{aligned} X_\alpha(m) &= A_\alpha . e^{(j/2)\cot a.m^2\Delta u^2} \\ &\times \sum_{m=0}^{N-1} e^{(j/2)\cot a.n^2\Delta t^2} e^{-j.\frac{\operatorname{sgn}(\sin\alpha).2\pi nm}{M}}. \end{aligned} \tag{6}$$

ZigBee data acquisition node is designed as the information sampling center of online ideological as well as the political teaching resources adaptive recommendation, and the statistical features of online ideological as well as the political teaching resources adaptive recommendation are extracted by joint association rule mining technology, so as to obtain the association rule set of network personalized recommendation. The fuzzy correlation detection technology is implemented to perform the information fusion and deduplication processing in the process of online ideological as well as the political teaching resources adaptive recommendation [11], and the structural reorganization output of online ideological as well as the political teaching audience preference features is as follows:

$$S_p(u) = \{F^p[s(t)]\}(u) = \int_{-\infty}^{\infty} K_p(t,u)s(t)\mathrm{d}t. \tag{7}$$

The RFID tag identification technique is used, the information of online ideological as well as the political teaching resources adaptive recommendation is sampled, and the discrete feature distribution sequence $x_1, x_2, \ldots, x_{m+1}$ is obtained [14]. The window function of the recommendation information output is illustrated using equation:

$$x_1 + x_2 + \cdots + x_{m+1} = T + t - m \times t. \tag{8}$$

Moreover, the adaptive learning scheme is implemented to optimize the distribution in the process of recommendation, and the optimal distribution model of audience behavior characteristics of online ideological as well as the political teaching is obtained as follows:

$$H_i(x) = \sum_{k=1}^{K} p_k \ln \frac{1}{p_k} = -\sum_{k=1}^{K} p_k \ln\ p_k, \tag{9}$$

wherein, K exemplifies the node of the label attribute distribution for online ideological as well as the political teaching resources adaptive recommendation, and p_k is the spatial state feature amount and measure of the data link layer [15]. According to the above analysis, an audience behavior feature extraction model of online ideological as well as the political teaching resources adaptive recommendation is constructed, and the online ideological as well as the political teaching resources adaptive recommendation is optimized while agreeing to the feature extraction outcomes and results [12].

4. Optimization of Adaptive Recommendation Algorithm for Online Ideological as Well as Political Teaching Resources

4.1. Online Ideological as well as Political Teaching Audience Interest Preference Characteristics Mining. On the basis of the above-mentioned construction of the online ideological as well as the political teaching audience behavior information mining model, the online ideological as well as the political teaching resources online ideological as well as the political teaching audience behavior information fusion processing is performed by using the big data fusion scheduling technique, and the personalized recommendation of online ideological as well as the political teaching resources is realized. This paper proposes an online ideological as well as the political teaching resources adaptive recommendation system and algorithm established on deep reinforcement learning [16]. In the driving module of online ideological as well as the political teaching resources, the self-adaptive recommendation information scheduling model of online ideological as well as the political teaching resources is articulated as follows in equation:

$$\begin{cases} x = (x_1, x_2, \ldots, x_n), \\ y = F(x) = (f_1(x), f_1(x), \ldots, f_m(x))^T, \end{cases} \tag{10}$$

wherein, $x = (x_1, x_2, \ldots, x_n)$ is the distribution set of audience behavior characteristics recommended by online ideological as well as the political teaching resources adaptively; $y = F(x)$ characterizes the distribution node set of storage space, and features of related characteristics and features in different fields are aligned to obtain the distribution set $P(n_i) = \{p_k | pr_{kj} = 1, k = 1, 2, \ldots, m\}$ of audience behavior features of online ideological as well as the political teaching. This should be noted that the structural as well as consistent learning algorithm is used, the distribution set of spatial links is obtained as follows:

$$RTT_s = (1 - \alpha) \times RTT_s + \alpha \times RTT. \tag{11}$$

According to the tag information and part of speech of online ideological as well as the political teaching audience, the optimized value of personalized recommended spatial clustering ambiguity function is as follows:

$$\begin{aligned} \text{Opti} &= \sum_{k=1}^{m} \alpha_i^{-1} \alpha_k t_{i,k} \alpha_k^{-1} \alpha_j t_{k,j} \\ &= \sum_{k=1}^{m} t_{i,k} t_{k,j} = \begin{cases} 1 & i = j, \\ 0 & i \neq j, \end{cases} \end{aligned} \tag{12}$$

wherein, α_k is the semantic alignment binary feature group, α_j is the fuzzy correction vector and $t_{k,j}$ is the sampling time interval of interest preference information of online ideological as well as the political teaching audience. The nonhub features are aligned, and a mining model of interest preference features of online ideological as well as the political teaching audience is built. The output is:

$$\begin{aligned} P(U|\alpha_U) &= \prod_{i=1}^{M} N\left(U_i|0, \alpha_U^{-1} I\right), \\ P(V|\alpha_V) &= \prod_{j=1}^{N} N\left(V_j|0, \alpha_V^{-1} I\right), \end{aligned} \tag{13}$$

wherein, U, V is the clustering feature vector. Based on the above analysis, the semantic information feature quantity reflecting the online ideological as well as the political teaching audience's preference is pulled out, and the fuzzy information perception knowledge is used to schedule the information in the adaptive recommendation process of

online Ideological and political education resources, as well as the interest preference characteristics of online ideological and political education audiences [17].

4.2. Personalized Joint Recommendation of Online Ideological as well as Political Teaching Resources. Founded on the analysis of high-quality educational resources of the audience, a dynamic evaluation model of online ideological as well as the political teaching resources and an adaptive matching model of interest preferences are established, and the deep reinforcement learning method is adopted to comprehend the feature analysis of the resource structure model of online ideological as well as the political teaching resources [18]. Through the benefit evaluation and resource supply-demand balance management analysis, it is assumed that the attribute set of the nodes storing the preference feature information of online ideological as well as the political teaching audience in distributed online ideological as well as the political teaching resources is $X = \{x_1, x_2, \ldots, x_n\}$, and the calculation method of the overall weight influence is:

$$W_k(U) = g\left(\frac{1}{M}\sum_{i=1}^{M}\frac{\sum_{j\in \mathrm{Item}_i} r_{i,j,c_k}}{\sum_{j\in \mathrm{Item}_i} s\times \hat{r}_{i,j} + O}\right),$$
$$W_k(V) = g\left(\frac{1}{M}\sum_{i=1}^{N}\frac{\sum_{j\in \mathrm{User}_i} r_{i,j,c_k}}{\sum_{j\in \mathrm{User}_i} s\times \hat{r}_{i,j} + O}\right). \tag{14}$$

According to the influence joint distribution of online ideological as well as the political teaching audience groups and projects, the preference characteristics of online ideological as well as the political teaching resources are mined. The process of feature mining is shown in Figure 3.

A matrix decomposition model is constructed to obtain the personalized joint characteristic distribution of online ideological as well as the political teaching resources:

$$\max_{x_{a,b,d,p}} \sum_{a\in A}\sum_{b\in B}\sum_{d\in D}\sum_{p\in P} x_{a,b,d,p} V_p,$$
$$s.t. \sum_{a\in A}\sum_{d\in D}\sum_{p\in P} x_{a,b,d,p} R_p^{bw} \le K_b^{bw}(S), b\in B. \tag{15}$$

From the aspects of emotion, keywords, and structure, according to the behavior characteristics of online ideological as well as the political teaching audience, the dynamic reconstruction of the preference characteristics of distributed online ideological as well as the political teaching audience is carried out. According to the attribute characteristics of the data, the information identification probability of online ideological as well as the political teaching audience behavior characteristics is obtained by fuzzy clustering is $P(1) = [1 - L^{-1}]^{m-1}$. The complete set of clustering units is determined, the clustering criteria according to the clustering criteria and clustering factors of online ideological as well as the political teaching are set, and meta-dimensional processing on statistical data is conducted [19]. The deep learning method is adopted to mine online

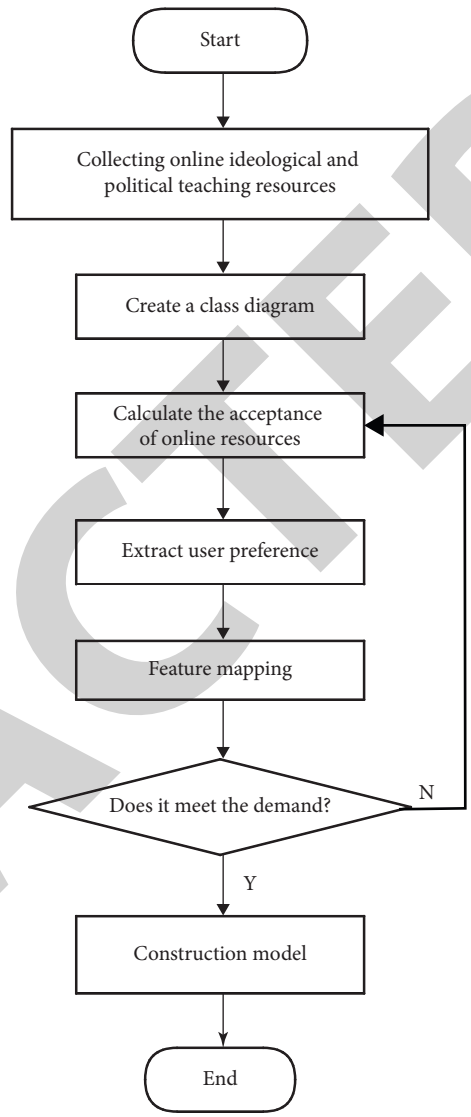

Figure 3: The flow chart of preference feature mining.

ideological as well as the political teaching audience behavior characteristics in the personalized recommendation process, and the output is as follows:

$$P(k) = P(1)[1 - p(1)]^{k-1}. \tag{16}$$

The domain-dependent features are projected into the fuzzy domain of adaptive recommendation of online ideological as well as the political teaching resources, and the fuzzy search mean function of personalized features is obtained as follows:

$$E(k) = \sum_{k=0}^{\infty}[1 - P(1)]^k = \frac{1}{1 - [1 - P(1)]} = \frac{1}{P(1)}$$
$$= \frac{1}{(1 - (1/L))^{m-1}}. \tag{17}$$

The average number of time slots for personalized recommendation of online ideological as well as the political teaching is:

$$T_{l-\text{ary}} = E(k)L = \frac{L}{(1-(1/L))^{m-1}}. \tag{18}$$

Calculate the joint information entropy of online ideological as well as the political teaching audience's behavior, and get personalized evolution features. According to the mining results of online ideological as well as the political teaching audience's preference features, the joint distribution density function of online ideological as well as the political teaching resources self-adaptive recommendation is obtained, which is described as:

$$\begin{aligned} &f_{T_1,T_2,\ldots,T_n}(t_1,t_2,\ldots,t_n) \\ &= c\left(F_{T_1}(t_1),F_{T_2}(t_2),\ldots,F_{T_n}(t_n)\right)\prod_{i=1}^{n} f_{T_i}(t_i) \\ &= (2\pi)^{-(n/2)}\left|\sum\right|^{-(1/2)}\exp\left[-\frac{1}{2}(F_T(t)-\mu)'\sum^{-1}(F_T(t)-\mu)\right]\prod_{i=1}^{n} f_{T_i}(t_i). \end{aligned} \tag{19}$$

To sum up, taking the common words in the field of online ideological as well as the political teaching audience preference as the pivotal feature, the personalized recommendation algorithm optimization design of online ideological as well as the political teaching resources is realized.

5. Reliability Analysis of Online Ideological as well as Political Teaching Resource Recommendation

In order to fully understand and comprehend the personalized recommendation of online ideological as well as the political teaching resources, this paper combines data analysis and collaborative control filtering technology, it adopts the sparse and expandable parameter identification method, establishes the online learning and feature identification model of online ideological as well as the political teaching resources, adopts parallel recommendation algorithm to mine online ideological as well as the political teaching resources, constructs a hybrid kernel function, and realizes the statistical feature analysis of online ideological as well as the political teaching resources [20]. Under the constraint of global kernel function, the distribution set of association rules recommended by online ideological as well as the political teaching resources is obtained. Through autocorrelation mapping, the online detection model of online ideological as well as the political teaching resources is established, and the distribution set of online ideological as well as the political teaching resources fusion parameters is constructed, and the correlation mapping Φ: $x \in R^n \longrightarrow F$ is obtained, which represents the transmission subspace of online ideological as well as the political teaching resources.

Using the method of hot-item weight factor analysis, the recommended learning model of online ideological as well as the political teaching resources is obtained, and the learning sample set is, in which the self-adaptive recommended gray-scale quantization feature $\{(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)\}$ of online ideological as well as the political teaching resources represents the input vector of the recommended model, $x_i \in R^n$ is the target parameter measurement value of the recommendation system, and n is the amount of samples. Similarly, introducing the popularity di and the average $d$avg, and combining the similar degree factor analysis method, the fitness function of online ideological as well as the political teaching resources recommendation is as follows:

$$\text{minimize}, \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n}(\xi_i + \xi_i^*), \tag{20}$$

wherein, ξ_i and ξ_i^* represent the ontological feature amount and evolutionary feature quantity, respectively, of the semantic distribution of online ideological as well as the political teaching resources, and w represents the weighted weight.

Under the control of significant correlation constraint, the cost relationship model between online ideological as well as the political teaching resources and learning profitability is constructed, and the high-order difference function of personalized recommendation of online ideological as well as the political teaching resources is obtained by using the multidimensional constraint index parameter analysis method:

$$f(x) = \sum_{i=1}^{n}(\alpha_i - \alpha_i^*)K\left(x_i, x_j\right) + b, \tag{21}$$

wherein, α_i and α_i^* are attribute values and template parameters that indicate the recommendation of online ideological as well as the political teaching resources, $K(x_i, x_j)$ is the core function of cooperative relationship in the view of information management in colleges and universities, and b indicates the recommendation threshold. According to the above analysis, the usage model of adaptive recommendation of online ideological as well as the political teaching resources is established.

Using the method of dimension analysis and the deep reinforcement learning technology, the Logistic mapping analysis model of online ideological as well as the political teaching resources is established [21]. Based on the similarity measurement method, the fitness function of online ideological as well as the political teaching resources adaptive recommendation is expressed as follows:

$$F_{\text{fitness}} = \frac{1}{m}\sum_{i=1}^{m}(f_i - y_i)^2, \tag{22}$$

wherein, f_i symbolizes the value for combination prediction of online ideological as well as the political teaching resources adaptive recommendation, y_i is the correlation distribution value of online ideological as well as the political teaching resources adaptive recommendation output, and m is the sample number of online ideological as well as the political teaching resources adaptive recommendation applicable articles [22]. Calculate the fitness distribution set of online ideological as well as the political teaching resources, expressed as δ^2, and judge whether $\delta^2 < H$ is established, and

Table 1: Distribution of characteristic data of online ideological as well as political teaching audience's interest preference.

Data set	Statistical values		Regression analysis value	
	Test set	Training set	Test set	Training set
Ideological as well as political data set	4031	46	4017	536
Cultural data set	4005	209	4207	350
Values data set	4262	303	4319	168
Teaching innovation ability data set	4040	11	4120	292
New media data set	4218	111	4012	81
Book data set	4011	284	4024	451

Table 2: Sample collection of online ideological as well as political teaching resources information collection.

Sample set	Number of data groups	Resource distribution dimension	Detection threshold	Correlation dimension	Statistical t value
Sample 1	4058	334	0.388	0.414	0.886
Sample 2	4314	531	0.332	0.479	0.729
Sample 3	4090	485	0.372	0.423	0.850
Sample 4	4255	139	0.381	0.464	0.900
Sample 5	4237	337	0.382	0.459	0.418
Sample 6	4025	442	0.337	0.406	0.879
Sample 7	4157	372	0.374	0.439	0.611
Sample 8	4271	468	0.332	0.468	0.799
Sample 9	4323	507	0.361	0.481	0.596
Sample 10	4100	224	0.331	0.425	0.426
Sample 11	4115	84	0.365	0.429	0.721
Sample 12	4277	24	0.344	0.469	0.876
Sample 13	4248	19	0.349	0.462	0.757
Sample 14	4050	449	0.338	0.413	0.701
Sample 15	4083	113	0.351	0.421	0.677
Sample 16	4320	235	0.368	0.480	0.878
Sample 17	4281	43	0.371	0.470	0.810
Sample 18	4053	69	0.353	0.413	0.439
Sample 19	4084	59	0.367	0.421	0.450
Sample 20	4330	152	0.355	0.482	0.805

get the spatial distribution basis function of online ideological as well as the political teaching resources mining as follows:

$$I_{i,j}(t) = \frac{\sum D''_{i,k}(t) D''_{k,j}(t)}{\sum D''_{i,k}(t)}, \tag{23}$$

wherein, $D''_{i,k}(t)$ is the difference characteristic quantity of online ideological as well as the political teaching resources measurement, and $D''_{k,j}(t)$ is the joint characteristic parameter of online ideological as well as the political teaching resources distribution. By introducing constraint function punishment, the spatial distribution weight C^*_{uv} satisfying the clustering center condition is obtained [23]. Combined with FCM clustering, the sensitivity characteristic quantity is as follows:

$$\omega(e) = \frac{\omega(e_s)}{\mathrm{OutDeg}(u, e_s)}, \tag{24}$$

wherein, $e_s \in E_s$, in the fuzzy control variable set, the learning effect distribution function of online ideological as well as the political teaching resource manager v_j and management object u_i is:

$$p\left(R|U, V, \sigma_R^2\right) = \prod_{i=1}^{n} \prod_{j=1}^{m} \left[N\left(R_{ij}|g\left(U_i^T V_j\right), \sigma_R^2\right)\right]^{I_{ij}^R}, \tag{25}$$

wherein, $N(x|\mu, \sigma^2)$ represents the confidence function of online ideological as well as the political teaching resource management effect evaluation in the view of university information management, and a normal distribution function with mathematical expectation μ and standard variance σ^2 is constructed to represent the constraint variables of online ideological as well as the political teaching resource management in view of university information management. To sum up, grounded on the analysis of the high-quality educational resources of the audience, a dynamic evaluation model of online ideological as well as the political teaching resources and an adaptive matching model of interests and preferences are established, so as to analyze the characteristics of the resource structure model of online ideological as well as the political teaching resources and recommend them adaptively, and improve the reliability of the recommendation model.

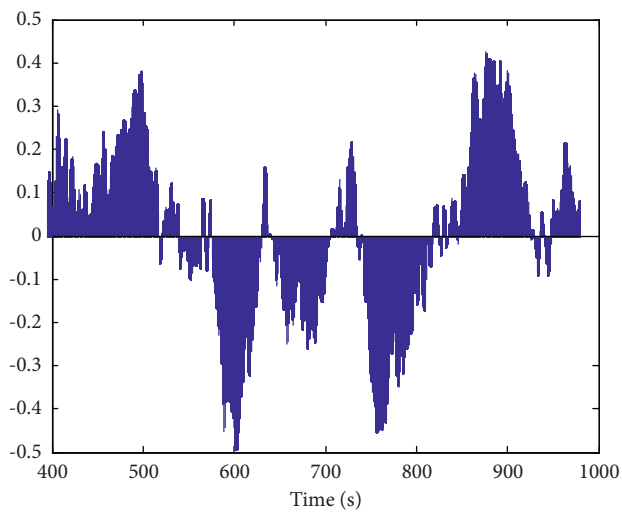

Figure 4: Raw data sampling of online ideological as well as political teaching resources adaptive recommendation.

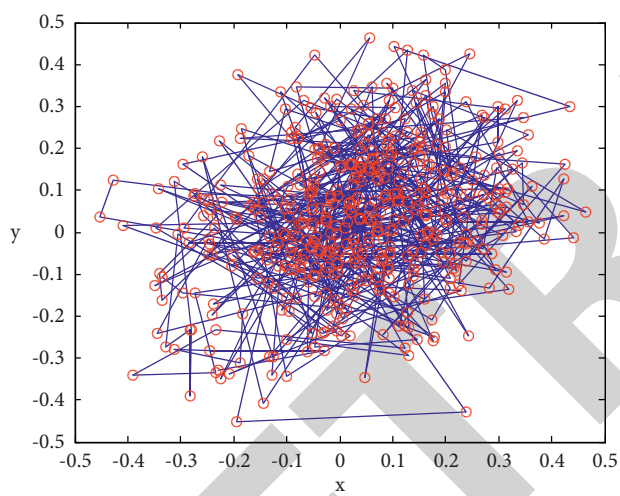

Figure 5: The feature extraction output.

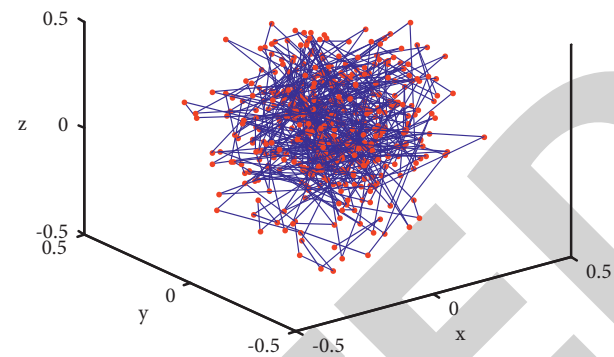

Figure 6: Classified output of adaptive recommendation of online ideological as well as political teaching resources.

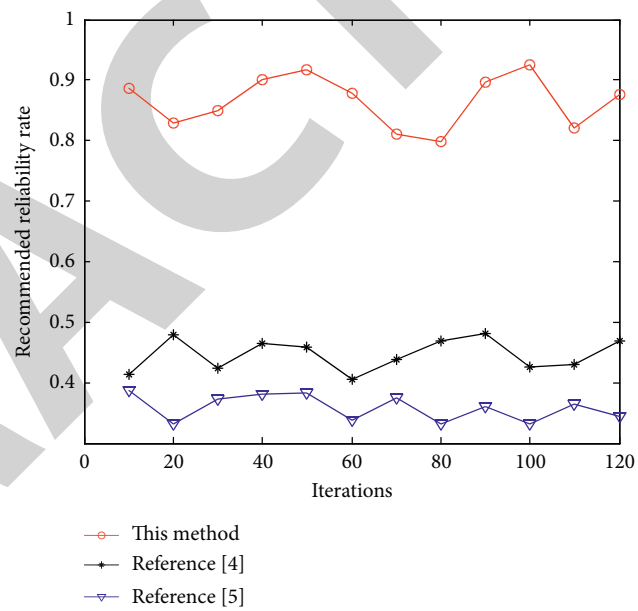

Figure 7: Confidence comparison of adaptive recommendation of online ideological as well as political teaching resources.

6. Simulations and Tests

The Matlab programming-based simulation is used to authenticate the performance of this technique in implementing the adaptive recommendation of online ideological as well as the political teaching resources. Online ideological as well as the political teaching resources are distributed in the school information management center, and the data of online ideological as well as the political teaching resources push model comes from the cloud database Pearson Database [24]. The length of test sample for online ideological as well as the political teaching audience preference features mining is 1024, and the size of test set is 2000. The dimension of online ideological as well as the political teaching audience behavior features distribution attribute is 4, the training sample size of online ideological as well as the political teaching resources self-adaptively recommended is 100, and the information sampling frequency is 80 kHz. The distribution of characteristic data of online ideological as well as the political teaching audience interest preferences is displayed in Table 1. See Table 2 for the sample set of online ideological as well as the political teaching resource information collection.

Conferring to the aforementioned simulation settings and parameters, online ideological as well as the political teaching resources are recommended adaptively, and the distribution of raw data obtained is shown in Figure 4.

The graph data are taken as the test object, the semantic information feature quantity that reflects the online ideological as well as the political teaching audience's preference is extracted, and the behavior feature group according to the online ideological as well as the political teaching audience from the aspects of emotion, keywords, and structure is conducted, and the feature extraction output is obtained as shown in Figure 5.

According to the analysis of Figure 5, the adaptive recommendation of online ideological as well as the political teaching resources by this method has a good fusion

performance of online ideological as well as the political teaching audience's behavior characteristics. On this basis, a mixed recommendation model of online ideological as well as the political teaching resources' online ideological as well as the political teaching audience's preference characteristics is constructed to mine online ideological as well as the political teaching audience's preference characteristics, and the classified output of personalized recommendation is shown in Figure 6.

According to the investigation of Figure 6, the recommendation technique in this paper has a strong ability to accurately identify the behavior characteristics of online ideological as well as the political teaching audience. The confidence level of self-adaptive recommendation of online ideological as well as the political teaching resources is tested by different methods, and the outcomes acquired are shown in Figure 6. After analyzing Figure 7, it is known that the self-adaptive recommendation of online ideological as well as the political teaching resources by this method has good confidence and recommendation accuracy.

7. Conclusions and Future Work

In order to increase the informatization level of online ideological as well as the political teaching, an adaptive recommendation algorithm of online ideological as well as the political teaching resources founded on deep reinforcement learning is suggested. Under the control of significant correlation constraint, this paper constructs the cost relationship model between online ideological as well as the political teaching resources and learning profitability, and adopts the multidimensional constraint index parameter analysis method to establish the usage model of online ideological as well as the political teaching resources adaptive recommendation, so as to realize online ideological as well as the political teaching resources adaptive recommendation. The test shows that the accuracy of online ideological as well as the political teaching resources recommendation by this method is high. Through the design of the recommended model in this paper, scientific division of ideological as well as the political education resources are the basis of rational allocation of resources, and an important prerequisite for ideological as well as the political course participants to correctly understand and make innovative use of ideological as well as the political education resources. Therefore, we must implement it as the primary project of ideological as well as the political education resource integration, and give full play to its positive role and promote the innovative utilization and rational allocation of Ideological and political education resources.

On the foundation of describing the content and stage division of ideological as well as the political education resources, we must constantly develop new and richer ideological as well as the political education resources while fully grasping the connotation of ideological as well as the political education resources, so as to realize the innovative utilization of ideological as well as the political education resources. By making innovative use of ideological as well as the political education resources, we can further deepen our understanding of the connotation and extension of ideological as well as the political education resources, increase our understanding of the system and mechanism of joint efforts of ideological as well as the political education resources, and enhance our ability to optimize the resource structure of ideological as well as the political courses on the supply side. Therefore, we must fully tap the educational elements contained in ideological as well as the political education resources, reasonably match and comprehensively utilize various ideological as well as the political education resources, and then improve the comprehensive utilization rate of ideological as well as the political education resources on the basis of grasping the relationship between resources.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Retraction

Retracted: An Evaluation Approach for Physical Education Teaching Practice Quality Using Stochastic Simulation Algorithm

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] C. Zhou and T. Ma, "An Evaluation Approach for Physical Education Teaching Practice Quality Using Stochastic Simulation Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 3103609, 9 pages, 2022.

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Research Article

An Evaluation Approach for Physical Education Teaching Practice Quality Using Stochastic Simulation Algorithm

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In order to increase the precision of the quality assessment of institution physical education, as well as teaching practice, the assessment system of institution physical education, as well as teaching practice quality, based on stochastic simulation algorithm, is put forward. Then, we construct the constraint parameter model of institution physical education, as well as teaching practice quality assessment, and analyze the hierarchical structure characteristics of institution physical education, as well as teaching practice quality. Subsequently we standardize the data fusion through the developmental characteristic analysis approach of teaching quality assessment and analyze the confidence level of institution physical education, as well as teaching practice quality, in order to construct frequent item set parameters. Moreover, we adopted the combination analysis approach of support and confidence level to analyze the correlation pattern and identify the characteristics, so as to recognize the characteristic analysis of institution physical education, as well as teaching practice quality level. The random simulation and association rule decision-making approaches are implemented to assess the quality level of institution physical education, as well as teaching practice, and the random simulation dynamic detection and the maximum matching degree analysis approach are implemented to assess the quality level of institution physical education, as well as teaching practice. The simulation outcomes confirm that the precision of this approach in evaluating the quality of institution physical education, as well as teaching practice, is considerably high, and the quality level of institution physical education, as well as teaching practice, is significantly increased.

1. Introduction

The quality assessment system of college sports practice teaching tries to combine students' teaching assessment data and data mining knowledge with computer technology and establish a complete set of data analysis model of school sports practice teaching. By analyzing the characteristics of college sports practice teaching data and combining data mining algorithm, it can comprehend the assessment and decision-making of institution sports practice teaching, which has a good application value, in particular, in the reform of college sports practice teaching. In the assessment of institution physical education, as well as teaching practice, the original knowledge parameter analysis is adopted to obtain the original knowledge related to the assessment system of classroom teaching quality, and a new assessment system of institution physical education, as well as teaching practice, with new rules is produced, so that the assessment outcomes are more scientific and systematic, and the decisive factors that affect the classroom teaching quality are really found, which can react on teaching in practice, promote the development of institution physical education, as well as teaching practice activities, and increase the management level and decision-making level of institution physical education, as well as teaching practice [1].

With the development of the transformation in institution physical education, as well as teaching practice, sophisticated requests are made known for the quality level of institution physical education, as well as teaching practice

[2–4]. Combining with the quantitative analysis approaches, in this paper, we (i) appraise the quality of institution physical education, as well as teaching practice, and (ii) build a quantitative regression analysis prototype for the quality of classroom and its assessment of institution physical education, as well as teaching practice, and make quantitative analysis on the quality of institution physical education, as well as teaching practice, through the early big data sampling outcomes. The main purpose is to increase the ability of accurate assessment of institution physical education, as well as teaching practice quality [5]. The research on the assessment approach of physical education practice teaching quality in schools and institutions of higher education has engrossed prodigious consideration. The assessment of institution physical education, as well as teaching practice quality, is based on the analysis of the constraint parameters of institution physical education, as well as teaching practice quality level; through fuzzy identification and statistical information analysis approaches, the integration of institution physical education, as well as teaching practice quality level is processed, and the correlation characteristic detection model of institution physical education, as well as teaching practice quality, assessment is constructed to increase the ability of institution physical education, as well as teaching practice quality assessment [6].

The determination of classroom teaching assessment index system, which is the key factor affecting classroom teaching quality in institution physical education, as well as teaching practice assessment, is a very important aspect. It can ensure the objectivity and fairness of institution physical education, as well as teaching practice quality assessment, more fully discover the problems existing in institution physical education, as well as teaching practice, and increase the quality of institution physical education, as well as teaching practice [7]. How to reasonably determine an effective assessment and computation index system of institution physical education, as well as teaching practice, and how to express, analyze, explain, publish, and use the teaching assessment outcomes can stimulate the interest of teachers and pupils, pay attention to and participate in institution physical education, as well as teaching practice assessment, and make institution physical education, as well as teaching practice assessment, play a greater role, which is a new subject worth studying at present. The traditional assessment approach of institution physical education, as well as teaching practice, has indeed played a certain role in teaching reform and classroom teaching quality enhancement. However, due to students' randomness in the process of grading, students of different majors have different inclinations to different courses, and some human factors interfere; the assessment outcomes of institution physical education, as well as teaching practice, cannot truly replicate the actual teaching effect of college physical education practice [8].

Therefore, combining with the actual situation of classroom teaching quality assessment organized by colleges and institutions of higher education, this paper uses the association rules approach of data mining to design the database of the college sports practice teaching assessment and discover the key elements that might potentially disturb the assessment outcomes of college sports practice teaching, so as to deliver a foundation for teachers to upsurge teaching level and classroom teaching quality. Simultaneously, the data mining technology is implemented in the administration system of institution physical education, as well as teaching practice, combined with the big data and fast information processing, to realize the optimization decision of institution physical education, as well as teaching practice assessment [9].

This paper puts forward an assessment based index system of institution physical education, as well as teaching practice quality, based on stochastic simulation algorithm. The constraint parameter model of institution physical education, as well as teaching practice quality assessment, is constructed, the hierarchical structure characteristics of institution physical education, as well as teaching practice quality, and integrating the data standardization by the approach of developing characteristic analysis of teaching quality assessment are analyzed, and the level of institution physical education, as well as teaching practice quality, by combining random simulation dynamic detection and maximum matching degree analysis is assessed. To end with, the simulation test analysis and outcomes express the greater performance of this approach in cultivating the assessment ability of institution physical education, as well as teaching practice quality. The major contributions of our research are as given below:

(1) We constructed the constraint parameter model of institution physical education, as well as teaching practice quality assessment, and analyze the hierarchical structure characteristics of institution physical education, as well as teaching practice quality.

(2) We standardized the data fusion through the developmental characteristic analysis approach of teaching quality assessment.

(3) We analyzed the confidence level of institution physical education, as well as teaching practice quality, and constructed frequent item set parameters and adopted the combination analysis approach of support and confidence level to analyze the correlation pattern and identify the characteristics, so as to comprehend the characteristic analysis of institution physical education, as well as teaching practice quality level.

The remaining part of this manuscript is systematized in the subsequent manner. In Section 2, we deliberate the constrained parameters and model construction of physical education practice teaching quality assessment in schools, academies, and institutions of higher education. In Section 3, an optimization model of the assessment model of institution physical education, as well as teaching practice quality, is suggested. Simulations study and the obtained outcomes are elaborated in Section 4. To finish with, Section 5 completes this article and recommends possible directions for future work.

2. Constrained Parameters and Model Design of Physical Education Practice Teaching Quality Assessment in Schools and Institutions of Higher Education

2.1. Principles for Selecting Assessment Indexes of Institution Physical Education, as well as Teaching Practice Quality. In order to realize the excellence assessment of institution physical education, as well as teaching practice, the constraint parameter system of institution physical education, as well as teaching practice quality assessment, is constructed by combining adaptive learning algorithm, and the quantitative characteristics of institution physical education, as well as teaching practice quality, are analyzed. The assessment approach and scale of institution physical education, as well as teaching practice quality, are obtained, and the structural expression parameters of bilingual translation are constructed by structure. Through the quantitative index characteristics analysis of institution physical education, as well as teaching practice quality assessment, the big data evolution cluster analysis approach is adopted. To realize the process integration of institution physical education, as well as teaching practice quality assessment, according to certain institution physical education, as well as teaching practice quality objectives, it is a necessary condition for teaching assessment to establish a scientific assessment index or index system [10]. Without proper index or index system, we believe that institution physical education, as well as teaching practice quality assessment, cannot be carried out.

The index or index system of physical education practice teaching excellence assessment in schools and institutions of higher education is one or a series of variable names that reflect the quantitative individualities and features of the whole teaching practice. In fact, the assessment index system for physical education practice teaching quality in colleges and institutions of higher education replicates the quantitative features of the whole teaching process, and in fact it has homogeneous measurability and comprehensive quantity.

When reflecting the quantitative characteristics of the whole teaching process, the assessment indexes of physical practice teaching quality in colleges and institutions of higher education can be divided into quantitative indexes and quality indexes, which are also called extension indexes and connotation indexes.

The establishment of the assessment index system of teaching must meet the following constraints and conditions:

(a) Clarity: the objectives of each index are clear and clearly expressed, which can reflect the overall assessment objectives.

(b) Completeness: under the condition of fully considering each part of the overall assessment goal, each index can partially reflect the overall assessment goal of institution physical education, as well as teaching practice quality, making the whole index system comprehensive and systematic.

(c) Independence: the indexes in the index system are closely linked, both complementary and independent, which makes the index system more suitable for physical education practice teaching quality in colleges and institutions of higher education constitute an organic whole.

(d) Feasibility: each index is practical, and the calculation approach is scientific, clear and standard, completely testable, and as simple and operable as possible [11].

2.2. Selection Approach of Assessment Index. An important aspect of the scientificity of the assessment index system, in particular, designed for physical education practice teaching quality in colleges and institutions of higher education is its completeness. In other words, we can say that the assessment index system which is established for the physical education practice teaching in colleges and institutions of higher education must be able to reflect the teaching quality comprehensively and without omission. The selection of assessment index is divided into two stages: (i) the creation of initial index system and (ii) the selection of index system.

The first stage is the formation of the initial index system for the education quality. In order to find a comprehensive initial index system, the "affinity diagram" approach in institution physical education, as well as teaching practice management technology, is advisable. First of all, please ask experienced teaching management experts, teachers, and students at the front line of teaching to put forward assessment indicators, and record all the indicators that everyone thinks of one by one. Then, the indicators put forward by students, experts, and teachers are classified into two categories and classified according to the content, so as to reach the initial useable level; that is, they are quite systematic, measurable, comparable, complete, and concise. Finally, the opinions of the three parties are deeply investigated, and therefore the initial index systems for teachers and students are settled up, respectively.

The second stage is the selected initial index system. The initial index system questionnaire is distributed to the corresponding experts, teachers, and students, so that they can independently select important indexes as the final assessment indexes of institution physical education, as well as teaching practice.

2.3. Constraint Parameters of Physical Education Practice Teaching Quality Assessment in Colleges and Institutions of Higher Education. Using data mining approach, the data set of institution physical education, as well as teaching practice quality, is constructed. According to the data storage format of institution physical education, as well as teaching practice quality distribution database, the objects implemented for mining include transaction, relational, multimedia, and some object-oriented databases, a data warehouse, text data source, and a working World Wide Web [12]. At present, the data sources implemented for data mining are mainly transactional databases, relational databases, data

warehouses, and the World Wide Web. By combining and sorting the sample level distribution sequence of the assessment index of institution physical education, as well as teaching practice quality level, and through quantitative regression analysis, the mathematical description of the constraint optimization target of institution physical education, as well as teaching practice quality level assessment, is obtained as follows in the objective function:

$$\begin{aligned} &\min F(x) = [f_1(x), f_2(x), ..., f_n(x)] \\ &\text{s.t. } g_i(x) \le 0 \,(\text{or} \ge 0), \quad i = 1, 2, \ldots, n, \\ &h_j(x) = 0, \; j = 1, 2, \ldots, m, \end{aligned} \tag{1}$$

where $f_i(x)(i = 1, 2, \ldots, n)$ characterizes the objective function, while $g_i(x)$ represents the inequality constraint condition. Similarly, $h_j(x)$ is the correlation statistical constraint condition that formulates the objective. It should be noted that in this paper we introduce the fuzzy detection technology of characteristics distribution of institution physical education, as well as teaching practice, and appraise the quality level of institution physical education, as well as teaching practice.

Definition 1. The dominating set of institution physical education, as well as teaching practice quality assessment, x^* dominates x, the decision variable of institution physical education, as well as teaching practice quality assessment, which satisfies the following: all $f_i(x^*) \le f_i(x)$, and there is at least one and only one $f_i(x^*) < f_j(x)$, where $i, j = 1,2, \ldots, n$; at this time, the self-correlated fuzzy state dominating set of institution physical education, as well as teaching practice quality assessment, satisfies local convergence.

Definition 2. The Pareto optimal solution is given as follows. For the discriminant statistic $X^* \in S$ of institution physical education, as well as teaching practice quality level assessment, if and only if there exists a boundary constraint explanation $X \in S$, entire inequalities $f_i(X^*) \le f_i(X)$ are recognized, such that $i = 1, 2, \ldots, n$; within the distribution range of institution physical education, as well as teaching practice quality level, there is one i, which makes the characteristic distribution of institution physical education, as well as teaching practice quality assessment, satisfy the strict inequality $f_i(X^*) < f_i(X)$. At this time, the statistic X^* of institution physical education, as well as teaching practice quality level assessment, is a multiobjective optimization problem. By obtaining the Pareto optimal solution of the objective function of institution physical education, as well as teaching practice quality level assessment, the convergence of the assessment model can be satisfied [13].

According to the above definition, the constraint function of institution physical education, as well as teaching practice quality assessment, based on stochastic simulation algorithm model is given. Initialize the characteristic parameters of institution physical education, as well as teaching practice quality level assessment, and revise the redundant vector set in the conclusion, and get the optimal constraint index parameter of institution physical education, as well as teaching practice quality level assessment, as Pbest, and the ambiguity function of institution physical education, as well as teaching practice quality level assessment, is determined using

$$\begin{aligned} V_{ij}(g+1) = V_{ij}(g) &+ c_1 r_{1ij}(g)\left[P\text{best}_{ij}(g) - x_{ij}(g)\right] \\ &+ c_2 r_{2ij}(g)\left[\text{Gbest}_j(g) - x_{ij}(g)\right]. \end{aligned} \tag{2}$$

Setting up a learning model for the assessment of the quality level of institution physical education, as well as teaching practice, through the fuzzy mathematical model, the quantity of nodes N and the amount of vector elements in the distribution of the quality level of institution physical education, as well as teaching practice, and the autocorrelation characteristic distribution vector of the assessment of the quality level of institution physical education, as well as teaching practice, are obtained:

$$x(t) = \left(x_0(t), x_1(t), \ldots, x_{k-1}(t)\right)^T. \tag{3}$$

Combined with the association rule mining approach, the formal distribution feature set of the association rule mining problem is given, and the weighted vector of the assessment of institution physical education, as well as teaching practice quality level, is obtained using the velocity function of the PSO.

$$Gbest_i(g+1) = \arg^{\min}_{P\text{best}_{ij}} f\left(P\text{best}_{ij}(g+1)\right). \tag{4}$$

It should be noted that, based on load balancing scheduling, a constraint parameter model for appraising the excellence level of institution physical education, as well as teaching practice, is established [14, 15].

2.4. Big Data Mining of Institution Physical Education, as well as Teaching Practice Quality Assessment. Based on the analysis approach of developmental characteristics of teaching quality assessment, the hierarchical structure characteristics of institution physical education, as well as teaching practice quality, are analyzed and the data are standardized and fused. The correlation factor between X_i and X_j of institution physical education, as well as teaching practice quality level characteristics, is described as the similarity between the two characteristic quantities of institution physical education, as well as teaching practice quality level, which can be expressed mathematically as follows:

$$l\left(X_i, X_j\right) = \left\|X_i - X_j\right\|. \tag{5}$$

The distance similarity level indicates the degree of difference in the assessment of institution physical education, as well as teaching practice quality level. Through local convergence learning, the optimized weight subset $\{W_O\}_{i=1}^{N-m-a}$ and the fuzzy parameter distribution subset $\{W_{\text{final}}\} = \{\{W_H\}, \{W_C\}, \{W_O\}\}$ of institution physical education, as well as teaching practice quality level assessment, are obtained. After optimizing the distribution structure of institution physical education, as well as teaching practice quality, it is expressed as follows:

$$\{W_O\}_{i=1}^{N-m-a} = \left\{\left\{x_O^i\right\}_{i=1}^{N-m-a}\right\}. \tag{6}$$

Note that if $(N_f/N) < \delta$, then, by using big data mining technology, the sample attribute set of assessment index of institution physical education, as well as teaching practice quality, is recorded as follows:

$$\begin{aligned} &minimize \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n}(\xi_i + \xi_i^*) \\ &subject\ to\ y_i - (w'\Phi(x_i) + b) \le \varepsilon - \xi_i(w'\Phi(x_i) + b) \\ &-y_i \le \varepsilon - \xi_i^*\xi_i, \quad \xi_i^* \ge 0,\ i = 1, 2, \ldots, n;\ C > 0. \end{aligned} \tag{7}$$

On the basis of the collaborative optimization approach, the optimal solution of institution physical education, as well as teaching practice quality fusion, is obtained, and the adaptive weighted expression of institution physical education, as well as teaching practice quality level assessment, is as follows:

$$K_{\min} = \beta K_{\text{poly}} + (1-\beta)K_{rbf}, \quad \beta \in (0, 1), \tag{8}$$

where $K_{\text{poly}} = [(x \cdot x_i) + 1]^2$ is the kernel function of the quality control of institution physical education, as well as teaching practice, $K_{\text{RBF}} = \exp(-\gamma\|x - x_i\|^2)$ is the fitness kernel function of the initial assessment of institution physical education, as well as teaching practice quality, and β is the dynamic adjustment weight coefficient of institution physical education, as well as teaching practice quality. If the maximum number of iterations of institution physical education, as well as teaching practice quality assessment, is reached, the optimal value of institution physical education, as well as teaching practice quality level assessment, is expressed mathematically as follows:

$$\begin{aligned} &Swarm\ Behavior\text{: if}\left(\frac{N_f}{N} < \delta\ \&\ \&Y_c < Y_i\right), \\ &X_{i\longrightarrow\text{next}} = X_i + \text{rand}(\,) \cdot \text{step} \cdot \frac{X_c - X_i}{\|X_c - X_i\|}, \\ &else\ go\ to\ search. \end{aligned} \tag{9}$$

According to the above description, this paper analyzes the confidence level of institution physical education, as well as teaching practice quality level, constructs frequent item set parameters and samples features, and adopts the combination analysis approach of support and confidence level to analyze correlation patterns and identify features, such as to comprehend the feature analysis of institution physical education, as well as teaching practice quality level [14].

3. Optimization of the Assessment Model of Institution Physical Education, as well as Teaching Practice Quality

3.1. Quantitative Analysis of the Quality of Institution Physical Education, as well as Teaching Practice. The fuzzy correlation constraint approach is implemented to dynamically assess the quality of institution physical education, as well as teaching practice, and the fuzzy correlation constraint parameter model of institution physical education, as well as teaching practice quality, is extracted, and the descriptive statistical sequence between quality distribution states X_i and X_j is obtained as $\{x(t_0 + i\Delta t)\}$, $i = 0, 1, \ldots, N-1$, and the optimization model of dynamic assessment of institution physical education, as well as teaching practice quality, is as follows:

$$X = [s_1, s_2, \ldots s_K]_n = \left(x_n, x_{n-\tau}, \ldots, x_{n-(m-1)\tau}\right). \tag{10}$$

Conjoining the approaches that are used for parameter analysis and for panel parameter exploration, this paper identifies the fuzzy parameters of institution physical education, as well as teaching practice quality assessment, and optimizes the weight subset $\{W_O\}_{i=1}^{N-m-a}$, and the characteristic subset of institution physical education, as well as teaching practice quality distribution, is $\{W_{\text{final}}\} = \{\{W_H\}, \{W_C\}, \{W_O\}\}$. Bestowing to the fuzzy feature distribution set of institution physical education, as well as teaching practice quality assessment, the fuzzy state feature distribution subset can be expressed as follows:

$$\{W_O\}_{i=1}^{N-m-a} = \left\{\left\{x_O^i\right\}_{i=1}^{N-m-a}\right\}. \tag{11}$$

If $(N_f/N) < \delta$, x_O^i is implemented to indicate the perceived range of institution physical education, as well as teaching practice quality assessment, and visual indicates the maximum iteration number of institution physical education, as well as teaching practice quality assessment, so that $f(s_i) = (f(x_1), f(x_2), \ldots, f(x_n))$, the fuzzy subspace scheduling prototype for assembling and establishing an effective institution physical education, as well as teaching practice quality level distribution, is $P(n_i) = \left\{p_k | pr_{kj} = 1, k = 1, 2, \ldots, m\right\}$, and the index sample attribute set of institution physical education, as well as teaching practice quality assessment, is recorded as follows:

$$\begin{aligned} \lambda &= \frac{1}{1 + \alpha(\partial S/\partial t)^2}\widehat{k}_\mu(t+1) \\ &= \widehat{k}_\mu(t) + Q(t+1) \times \left[\frac{\left(\partial \widehat{F}_\mu / Mg\right)}{\partial t} - \frac{\partial S}{\partial t}\widehat{k}_\mu(t)\right]. \end{aligned} \tag{12}$$

Based on the two values of support and confidence, a fuzzy information fusion model is established to assess the quality of institution physical education, as well as teaching practice, and the adaptive weighted expression of institution physical education, as well as teaching practice quality assessment, is obtained using the two following calculation formulas:

$$f_{T_a}(t) = \begin{cases} \dfrac{1}{\sqrt{2\pi}\,\sigma\left(t - t_a^0\right)} e^{-\left(\ln\left(t - t_a^0\right) - \mu\right)^2/2\sigma^2}, & t > t_a^0 > 0, \\ 0, & \text{廉余.} \end{cases} \tag{13}$$

$$F_T(t) = \int_{t_a^0}^{t} \frac{1}{\sqrt{2\pi}\sigma\left(t - t_a^0\right)} e^{-\left(\ln\left(t - t_a^0\right) - \mu\right)^2 / 2\sigma^2} dt. \tag{14}$$

Let the membership degree of the first class of the current concept set of physical education practice teaching quality distribution in colleges and institutions of higher education be recorded as $CF = \langle F, Q, n, RT_1, RT_2, RW \rangle$. If it reaches the maximum iteration times of particle swarm optimization, the optimal value of physical education practice teaching excellence assessment in schools and institutions of higher education can be obtained, and the fuzzy scheduling function of physical education practice teaching excellence assessment in schools and institutions of higher education can be obtained using the three following equations, respectively:

$$p_j(t+1) = \frac{a_1 p_j(t) + a_2 p_g(t)}{a_1 + a_2}, \tag{15}$$

$$\mathbf{mbest}(t+1) = \frac{1}{n} \sum_{j=1}^{n} p_j(t), \tag{16}$$

$$\mathbf{X}_j(t+1) = \mathbf{p}_j(t+1) \pm \beta \times \left| \mathbf{mbest}(t+1) - \mathbf{X}_j(t) \right| \times \ln\left(\frac{1}{\mathbf{u}_j(t+1)} \right). \tag{17}$$

In the above equations, $\mathbf{X}_j(t)$ is the fuzzy rule set of institution physical education, as well as teaching practice quality assessment, after the $t$iteration [13, 16].

3.2. Quantitative Assessment of Physical Education Practice Teaching Quality in Schools and Institutions of Higher Education. The random simulation and association rule decision-making approaches are implemented to assess the quality level of institution physical education, as well as teaching practice [17]. Combined with random simulation dynamic detection and maximum matching analysis approach, the adaptive optimization model of institution physical education, as well as teaching practice quality level, is as follows [18, 19]:

$$M_v = w_1 \sum_{i=1}^{m \times n} (H_i - S_i) + M_h w_2 \sum_{i=1}^{m \times n} (S_i - V_i) + w_3 \sum_{i=1}^{m \times n} (V_i - H_i). \tag{18}$$

In (18), note that the distribution function of the association rules for institution physical education, as well as teaching practice quality assessment, is M_h, and the assessment model of institution physical education, as well as teaching practice quality, is given by

$$GD = \frac{\sqrt{\sum_{i=1}^{n} d_i^2}}{n}. \tag{19}$$

When $d_i = 0$, the convergence formula of institution physical education, as well as teaching practice quality assessment, is mathematically expressed as follows:

$$DM = \frac{d_e + d_b + \sum_{i=1}^{n-1} \left| d_i - \left(\sum_{i-1}^{n-1} d_i / n - 1 \right) \right|}{d_e + d_b + (n-1)\left(\sum_{i=1}^{n-1} d_i / n - 1 \right)}, \tag{20}$$

where d_e is the extreme point in the quality distribution set S_s of institution physical education, as well as teaching practice, and d_b is the edge dynamic optimization function. To sum up, combined with the random simulation dynamic detection and maximum matching analysis approach, the quality level of the institution physical education, as well as teaching practice, is appraised [20, 21].

4. Simulations, Tests, and Results

In order to study and examine the application performance of the suggested approach established for the assessment of institution physical education, as well as teaching practice quality, a simulation experiment is conducted. It is assumed that the sample number of statistical information of institution physical education, as well as teaching practice quality, is 3000, and the training sample number is 200 [22]. The minimum window distribution of fuzzy learning of institution physical education, as well as teaching practice quality, is $W_{\min} = 0.4$, the maximum window threshold $W_{\max} = 0.9$, the minimum similarity coefficient $C_{\min} = 1.5$, and the maximum similarity coefficient is $C_{\max} = 2.0$. The sample data of institution physical education, as well as teaching practice quality level, are normalized, and the probability of ambiguity cross distribution of college physical education practice courses is $0.1 \longrightarrow 0.3$. Rendering to the aforementioned parameter settings, the statistical study data of institution physical education, as well as teaching practice quality, are exposed in Table 1.

According to the above regression analysis and statistical analysis outcomes, in association rules, the rules generated underneath the background of support confidence can be distributed into four categories: (i) the first category is the operational association rules, that is, instructions that users are interested in; (ii) the second category is redundancy rules; (iii) the third category is weak correlation rules; and (iv) the fourth category is secondary correlation rules [23]. The support-confidence framework is implemented to generate association rules. Moreover, whether the support-matching structure can mine the operational rules and decrease the creation of weak association rules are compared with each other. There are 22 attributes in the database, and each attribute can take several attribute values. In this database, each record contains 23 values, of which the first 22 are attribute values, and the last one is judgment value, and the judgment values are comestible and venomous, respectively. The determination of the association rule mining is to discover which characteristic values will clue to the comestible or venomous appearance. The following parameters are set to run the experiments.

In the structure of support confidence, support = 0.4 and confidence = 0.7. Moreover, in the structure of support matching, support = 0.4 and matching = 0.6. Here, we take out two rules from the rules generated by the two approaches to make a comparison. First of all, look at this rule: (free,

Table 1: The statistical examination of physical education practice teaching quality in schools and institutions of higher education.

Age	Practical teaching input	Practical classroom teaching effect of physical education	Student satisfaction level	Regression analysis value
2011	0.619	0.888	0.635	0.094
2012	0.529	0.721	0.302	0.291
2013	0.171	0.790	0.695	0.550
2014	0.280	0.193	0.473	0.883
2015	0.636	0.415	0.268	0.212
2016	0.421	0.475	0.272	0.404
2017	0.663	0.104	0.299	0.998
2018	0.744	0.828	0.988	0.350
2019	0.376	0.189	0.729	0.615
2020	0.099	0.657	0.185	0.468
2021	0.159	0.492	0.714	0.169

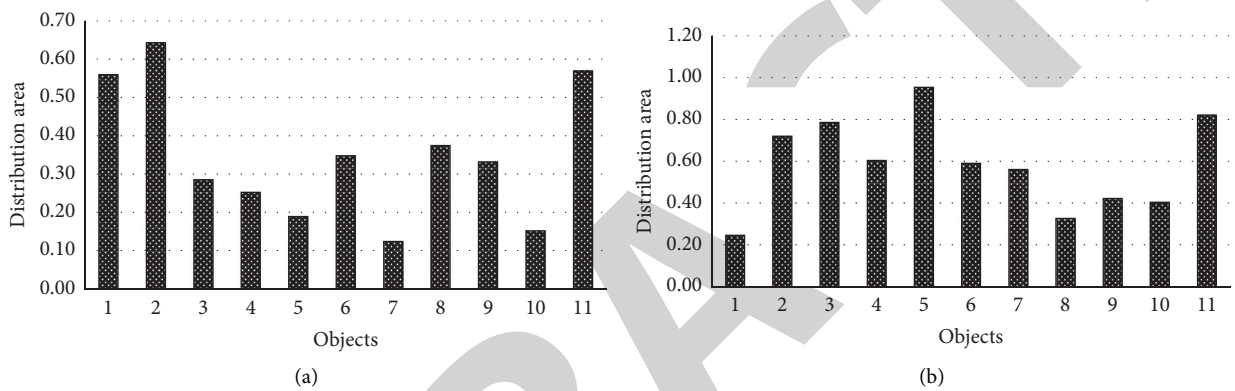

Figure 1: Sample data of teaching quality assessment of sports practice courses. (a) Test object 1. (b) Test object 2.

white, partial, one, no) = poisonous. The antecedents of the rule are the attribute value and judgment value. Confidence = 0.772 and sup = 0.401 in the framework of support confidence; match = 0.603 and sup = 0.401 in the framework of support matching, so the two approaches can also mine effective association rules. Look at the following rule: (white, partial, no) ⟶ toxic. Under the framework of support confidence, confidence = 0.723 and sup = 0.406. However, under the framework of support-matching degree, match = 0.726–0.175 = 0.551, which does not meet the minimum matching degree, so it is a weak correlation rule [24]. From a mathematical point of view, the correlation between the item sets is p (white, partial, no, toxic) − p (white, partial, no) × p (toxic). It can be seen that this rule is indeed a rule with poor correlation. Experimental outcomes confirm that the support-matching structure can not only mine the operational association rules but also diminish the generation of weak association instructions. In this way, it can be ensured that the instructions delivered to users have a great correlation, and thus the sample data output of institution physical education, as well as teaching practice quality assessment, is shown in Figure 1.

Observing the data, as revealed in Figure 1, as the input means merging the data from multiple data sources and normalizing the data, when mining the association analysis of students' assessment, logical data is needed, so the data of students' assessment form should be converted into Boolean representation, so as to assess the teaching quality of sports practice courses, and the assessment outcomes are shown in Figure 2.

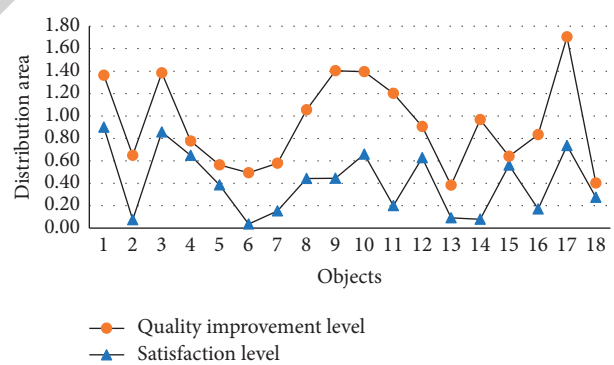

Figure 2: Assessment outcomes of teaching quality of sports practice courses.

According to the analysis of Figure 2, if the minimum confidence is set to 0.6 according to the assessment system of support and confidence, all the above association rules meet the conditions. However, if the assessment system of support and matching is implemented, the assessment of teaching quality is the best when the minimum matching degree min_match = 0.6. Test the reliability of teaching quality assessment by different approaches, and the association outcomes are given away in Figure 3. By closely analyzing the view of Figure 3, we know that the precision of college

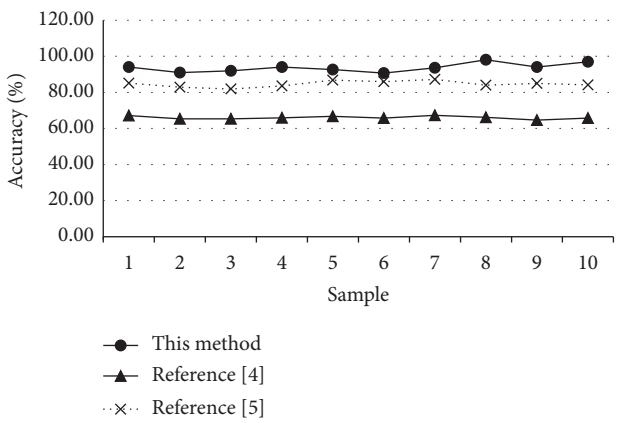

Figure 3: Comparison of reliability test of teaching quality assessment.

physical practice teaching quality assessment by this approach is high, and the quality level of college physical practice teaching is increased [25].

5. Conclusions and Future Work

In this paper, the assessment system of institution physical education, as well as teaching practice quality, based on stochastic simulation algorithm is put forward. A quantitative regression analysis prototype for the eminence assessment of institution physical education, as well as teaching practice, is constructed, a quantitative analysis of institution physical education, as well as teaching practice quality, is carried out, the ability of accurate assessment of institution physical education, as well as teaching practice quality, is increased, and the horizontal distribution sequence of assessment index samples of institution physical education, as well as teaching practice quality, is combined and sorted. On the basis of the fuzzy mathematical model, a constraint parameter prototype for appraising the excellence level of institution physical education, as well as teaching practice, is established. Through the collaborative optimization approach, the optimal solution of institution physical education, as well as teaching practice quality fusion, is obtained, and the fuzzy information fusion model is established to gauge the excellence of institution physical education, as well as teaching practice. The random simulation and association rule decision approach are adopted to measure the eminence level of institution physical education, as well as teaching practice. The analysis shows that this approach has high precision and convergence in evaluating the quality level of institution physical education, as well as teaching practice.

On the foundation of the research conducted in this paper, the assessment standard system of generating association rules and the algorithm of generating maximum frequent sets are basically realized to increase the assessment efficiency of institution physical education, as well as teaching practice quality. Furthermore, the application of data mining technology in college classroom for teaching quality and its appropriate assessment is preliminarily realized. However, there are still some open issues that need the researchers' consideration and need to be studied further in the continuing part of this work.

To begin with, in order to increase the mining quality of association rules in institution physical education, as well as teaching practice quality assessment, we should not only consider the efficiency of assessment system and association rule algorithm, because the usefulness of an assessment rule of institution physical education, as well as teaching practice quality, ultimately depends on the user's feeling, and only the user can decide the validity and feasibility of the rule. Therefore, we should increase the system factors and combine the needs of users at the same time. For example, when mining data, some constraints can be artificially added, which can reduce the amount of data implemented by data mining algorithms and increase the quality of data. Moreover, in the research on the mining outcomes of association rules of institution physical education, as well as teaching practice quality assessment, it is found that there are still errors in the generated rules. The reason is that the five-level classification of the assessment data has not been realized, and the data set implemented may not be the best data set, which needs further research and investigation that we should account for in the future.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Retraction

Retracted: 3D Human Pose Estimation Based on Transformer Algorithm

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] G. Chen, "3D Human Pose Estimation Based on Transformer Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 6858822, 9 pages, 2022.

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Research Article

3D Human Pose Estimation Based on Transformer Algorithm

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Human pose estimation (HPE) is a fundamental problem in computer vision, and it is also the basis of applied research in many fields, which can be used for virtual fitting, fashion analysis, behavior analysis, human-computer interaction, and auxiliary pedestrian detection. The purpose of HPE is to use image processing and machine learning methods to find out the positions and types of joints of people in pictures. There are two main difficulties in HPE. First, the complex human images make the model need to learn a highly nonlinear mapping relationship, and the learning of this mapping relationship is extremely difficult. Second, the highly nonlinear mapping relationship needs to be learned by using a model with high complexity, and a model with high complexity requires a lot of computational overhead. In this context, this paper studies the 3D HPE based on the transformer. We introduce the research status of HPE at home and abroad and provide a theoretical basis for designing the transformer 3D HPE model in this paper. We introduce the technical principle and optimization scheme of CNN and transformer and propose a 3D HPE model based on transformer. We used two datasets, COCO and the MPII datasets, and performed a number of experiments to find the best parameters for model development and then assess the model's performance. The experimental findings suggest that the strategy described in this study outperforms all other methods on both datasets. The average precision (AP) of our model reaches up to 79% on COCO dataset but a PCKh-0.5 score of 81.5% on the MPII dataset.

1. Introduction

When photos of human bodies are analyzed using HPE, computer vision-related technologies are used to extract the body's important features and link them together. Image sensors capture human body images, which are subsequently analyzed by computer vision algorithms to extract important points and the relationships among those points. Finally, analysis extracts the human body's key points and relationships among them. HPE technology has also made significant strides and has been better developed and implemented in recent years with the advancement of software and hardware [1]. Including algorithm improvement and optimization, the new algorithm can analyze the relevant structure of the human body more comprehensively and intelligently and use less resource occupancy to obtain more accurate key point positioning. The improved image quality of the image sensor and the more detailed images can make the human torso and limbs clearer, so as to achieve better analysis results. The improvement of the processor, faster clock frequency, and better performance can improve the processing speed of the algorithm, shorten the execution time of the algorithm, and perform more complex algorithm analysis in the same time [2]. For human pose analysis, traditional artificial methods first need to perform preprocessing methods such as illumination normalization, histogram equalization, and grayscale correction on the image to obtain relatively clear and stable images, then use HOG, SIFT, or morphological processing to obtain human-related features, then normalize these features by visual word bag and other methods, and finally use the processed features to use the HPE algorithm to determine whether there is a human body and the location of key points of the human body, so as to achieve HPE [3]. The traditional manual feature extraction steps are cumbersome and lack high-level semantic information, which makes the HPE under the traditional method limited by the scene, resulting in low accuracy and generalization. It is even more difficult for the occlusion of human key points and the recognition of complex poses. Compared with traditional methods for

HPE, deep learning methods represented by DNNs have been favored by algorithm researchers in recent years. Compared with manual feature extraction, DNN methods have better robustness [4]. Unlike statistical learning methods, machine learning methods require algorithm researchers to have prior knowledge of the corresponding domain and then model the domain according to the prior knowledge and rules. Feature engineering plays an important role in machine learning methods. The construction of simple and effective features is an important basis for judging whether the model is good or bad. At the same time, the feature dimension will also greatly affect the performance of the model. Too few features will make the model unable to fit. If the target problem is met, too many features will make the model overfit. The advantages of automatic feature extraction by deep learning can well deal with feature extraction problems. By designing a model structure based on convolution and nonlinear operations, a large number of effective features can be automatically extracted. At the same time, features are continuously combined and abstracted in the model. It makes the features have more high-level semantic information and global features [5]. The model updates and corrects the parameters through the gradient-based backpropagation algorithm and finally converges to the local optimum point to complete the parameter learning [6]. At the same time, the overparameterized model has an implicit regularization effect, which can alleviate the overfitting problem caused by too many parameters [7]. In short, with the excellent characteristics of DNN algorithms, one of the most popular algorithms in business and academics is deep learning, which has many applications in computer vision, natural language processing, and voice recognition. HPE belongs to the field of computer vision with great research value and challenging direction and has a wide range of applications in military, security, industry, and entertainment, mainly in intelligent video surveillance, patient rehabilitation systems, human-computer interaction, human body animation capture, and virtual reality and more. The HPE algorithm can realize automatic human behavior analysis and action recognition. Compared with traditional manual analysis algorithms, deep learning algorithms greatly improve efficiency and liberate productivity, thereby enabling the automation of the above industries and other related scenarios, reducing the consumption of human resources, and enabling more new scenarios. [8].

The main work of this paper is to study 3D HPE based on transformer, develop a HPE software library, provide convenience for researchers of HPE algorithms and application software developers, and simplify the research and development process of algorithm researchers and related application developers. Reducing the development difficulty of related practitioners can also make more college students and other entry-level developers pay attention to the field of HPE and jointly promote the development and application of this field. We study the 3D HPE based on the transformer and provide a theoretical basis for designing the transformer 3D HPE model in this paper. We introduce the technical principle and optimization scheme of CNN and transformer and propose a 3D HPE model. We take images of human pose and use various data enhancement techniques such as rotation, scaling, and saturation adjustments and use this data to train the HPE model. We used two datasets, COCO and the MPII datasets, and performed a number of experiments to find the best parameters for model development and then assess the model's performance. The experimental results prove the efficiency of the proposed approach.

2. Related Work

Computer vision has a long history of using 3D models to identify objects. 3D models may be used to identify a restricted number of categories, such as vehicles and motorbikes. Design unique characteristics that match the synthetic 3D model with genuine photographs in [9–12]. Some academics have started to use neural networks for 3D object identification because of their great parallel processing capacity and the success they have had in object recognition. For 3D objects, Mehta D et al. [13] developed a Hopfield network, although it is only appropriate for smooth surfaces. Wang et al. [14] specified an energy loss function that has a minimal value when the identification result is accurate, and this approach may identify several items in a single scene. The 3D ShapeNets proposed by Peng et al. [15] use a 3D CNN architecture to learn features from voxel grids for recognition purposes. The first three layers of 3D ShapeNets are convolutional layers, and the fourth layer is a fully connected layer. Considering the impact of object outlines on recognition and classification, no pooling operation is used in the network. This approach is actually a process of simulating a two-dimensional depth convolution, but the input source is changed from a picture to a voxel grid, and the two-dimensional convolution operation is changed to a three-dimensional convolution, which has achieved good results in recognition and classification. In contrast to PoseNet, which returns the 6D posture directly from RGB photos via the network, the authors [16, 17] propose to transform the 3D pose estimation issue into a classification problem by discretizing the continuous pose space. Because of its regression displacement and rotation vectors, these two quantities require hyperparameters to reconcile in the loss function. Another approach is to not directly predict the pose of the object, but to predict the pixel coordinates of the key points of the object, similar to the method proposed by Lowe D G. [3], because all the predicted values are in the 2D image, so there is no need to reconcile in the loss function. With different loss terms, the entire training process will also become more stable. Using a denoising autoencoder that employs domain randomization to train on simulated views of the 3D model, Fischler M A and Bolles R C [18] convert objects in the input picture to a vector and then determine the nearest pretrained vector that returns the proper position from the training data. Ren et al. [19] proposed a new DNN to estimate the 6D pose of an object. The paper pointed out that the method of directly returning the object pose to the image has limited accuracy, and by matching the rendered image of the object, it can be further improved. Improve accuracy, that is, given an initial pose estimate, render the

synthetic RGB image to match the target input image, and then calculate a more accurate pose. Compared with traditional pose estimation methods, deep learning-based methods have better performance, which mainly relies on the powerful feature extraction capability of deep learning, which makes it suitable for pose estimation tasks. The method of global registration does not depend on the initial pose, and a commonly used method is the RANSAC algorithm proposed by Badrinarayanan et al. [20]. In each iteration of the method, the two point sets that need to be registered are first sampled, then calculated, and evaluated until the difference between the two is below a certain threshold and the iteration process terminates. This method has high requirements on the quality and accuracy of the 3D model of the object and the input point cloud and requires more expensive computing resources. References [21, 22] proposed to generate 3D bounding box candidates, first extract the point cloud of the target object, and then use a 3D convolutional network to learn voxelized features for pose estimation. Although voxel representations can efficiently encode geometric spaces, they are computationally expensive. In addition, some deep learning framework methods based on 3D point cloud can directly estimate 6D pose on 3D point cloud. The VoxelNet proposed by Gujjar H S. [23] uses 3D convolutions for feature learning on the voxelized grid of point clouds, which achieves very good results so far on the KITTI dataset. RGB-D based methods are commonly used for tasks such as indoor robot 3D object recognition, pose estimation, and grasping. The most representative of this type of methods is the LINEMOD algorithm proposed by Du et al. [24], which extracts RGB images and depth images from different perspectives to generate templates for 3D models of objects. Then use these templates to match the actual image, get the initial pose estimation, and then use the ICP algorithm to optimize. Busari et al. [25] fuse the features of the depth image on this basis, and the convolutional neural network processes the RGB image and the depth image at the same time. After obtaining the initial pose information, it is also necessary to perform postprocessing optimization on the 3D input data to obtain the final pose.

3. Method

3.1. Convolutional Neural Network Composition. Modern CNNs are mainly composed of convolutional layers, pooling layers, fully connected layers, activation functions, normalization layers, input, and output. The convolution pooling part at the front end of the network is the feature extractor, including activation function and normalization layer. The part of the backend close to the output can select active network layers according to different task types, including fully connected layers, global pooling layers, and convolutional layers. A completely connected layer is linked to the feature extractor's backend in the early stages of classification or regression, and the fully connected layer reduces the feature's dimension. However, overfitting may occur if too many parameters are included in the fully linked layer. Various components of CNN are described as follows:

(1) The convolutional layer is the core component of the CNN, which is composed of convolution kernels, and its purpose is to extract local features in the image. There is a significant reduction in the number of parameters when the convolution kernel glides across an image or feature map. Even though the receptive field of each individual convolutional kernel is modest, by stacking many convolutional layers, the receptive field of the total network may be much larger. Convolution kernels slide over an image or feature map and produce activation values based on the dot product of the convolution kernel and the current region when the CNN is forwarded. After the sliding is over, the convolutional layer outputs a new feature map.

(2) Another important component in CNNs is the pooling layer, which is a form of nonlinear downsampling. Common pooling layers are max pooling layer, average pooling layer, global max pooling layer, etc. Among them, the maximum pooling layer is the most commonly used pooling layer which divides the input into a set of nonoverlapping subregions and takes the maximum value in each subregion to represent this subregion. The purpose of using pooling layers is to obtain translation invariance, making the model focus on the presence of a feature rather than the location of the feature. In addition, the pooling layer can also reduce the resolution of the feature map, which can reduce the computational cost of the network while avoiding overfitting.

(3) Fully connected layer: high-level semantic features will be extracted after the CNN has used many layers of convolution and pooling to extract features. In the old technique, the completely linked layer serves as a "classifier." Each neuron in this layer is connected to the preceding layer. The position information in the feature map is discarded by the fully connected layer, which reduces the model learning process's parameter sensitivity.

(4) The activation function is an indispensable component in the neural network and is often used in conjunction with the convolutional layer. In order to understand complicated mapping relationships, nonlinear transformations in activation functions are utilized instead of basic linear transformations. A linear regression model is a neural network with no activation function. The commonly used activation functions are Sigmoid function, Tanh function, ReLU function, Leaky ReLU function, etc.

(5) Normalization layer: the training of CNN is a very complex process, and as the depth of the network increases, the training of the network will become more and more difficult. It is due to a number of reasons. First, if there is a slight change in the first few layers in the network, this change will gradually accumulate as the number of layers increases, thus

having a large impact. Second, if the distribution of data in a certain layer of the network changes, then the backend network of this layer needs to be relearned. During the training process, the network needs to continuously adapt to changes in the distribution of input data, and the convergence speed is affected. Third, if the distribution of the input data changes, the distribution of features at each layer in the entire network changes, a phenomenon known as internal covariate shift. To solve this problem, researchers propose batch normalization layers. In addition to the batch normalization layer, the commonly used normalization layers are group normalization layer, instance normalization layer, etc.

3.2. Optimization Method. Common optimization methods in convolutional neural networks include stochastic gradient descent (SGD), AdaGrad, Adam, etc.

(1) *SGD Algorithm*. Update network parameters:

$$\theta = \theta - \alpha \frac{1}{m} \sum_{i=1}^{m} \nabla_\theta L\left(F\left(x^{(i)}; \theta\right), y^{(i)}\right), \tag{1}$$

where α is the learning rate and θ is the model parameter.

(2) *AdaGrad Algorithm*. Calculate the gradient:

$$g = \frac{1}{m} \sum_{i=1}^{m} \nabla_\theta L\left(F\left(x^{(i)}; \theta\right), y^{(i)}\right). \tag{2}$$

The square of the cumulative gradient:

$$r = r + g \odot g. \tag{3}$$

Update network parameters:

$$\theta = \theta - \frac{\alpha}{\mu + \sqrt{r}} \odot g, \tag{4}$$

where α is the global learning rate, θ is the model parameter, u is a constant, and the gradient squared cumulative variable $r = 0$.

(3) *Adam Algorithm*. Update the first moment estimate:

$$s = \rho_1 s + \left(1 - \rho_1\right) g. \tag{5}$$

Update the second moment estimate:

$$r = \rho_2 r + \left(1 - \rho_1\right) g \odot g. \tag{6}$$

Correct first moment deviation:

$$\hat{s} = \frac{s}{1 - \rho_1^t}. \tag{7}$$

Correct second moment bias:

$$\hat{r} = \frac{r}{1 - \rho_2^t}. \tag{8}$$

Update network parameters:

$$\theta = \theta - \frac{\alpha \hat{s}}{\mu + \sqrt{r}} \odot g, \tag{9}$$

where ρ_1 and ρ_2 are the exponential decay rates of the moment estimates, the first-order moment variable $s = 0$, the second-order moment variable $r = 0$, and the number of time steps $t = 0$.

3.3. 3D HPE Algorithm Based on the Improved Transformer. Transformer neural network aims to solve sequence-to-sequence tasks and handle long range dependencies with ease. It is a deep learning model that uses the mechanism of attention and is composed of many self-attention layers. It differentially weights the significance of parts of the input data and processes all the input data at once by allowing parallelization, thus greatly reducing the training time. It encodes the input data as features via the attention mechanism. The input images are divided into several local patches and the representation of their relationship is calculated [26]. Transformers can be applied to various data modalities, and recent research shows that they can achieve a higher accuracy, better parameter efficiency, and computational efficiency when applied in the domain of computer vision. In this subsection, we describe the training process of our transformer-based model in detail.

3.3.1. Training Process. The camera captures the human pose in a nonspecific scene at a certain frame rate, creates a human pose dataset, and performs data enhancement. The data enhancement methods include random rotation, random scaling, and random saturation adjustment. Then randomly rotate the picture from −45° to +45°, and randomly scale the picture to 0.7~1.3 times of the original image. The implementation method of random saturation adjustment is to first set a threshold value t. Then randomly select a number a within (0, 1). If so, the saturation adjustment is scaled by a. If it is not satisfied, a number b is randomly selected within (-a, a), and the ratio of saturation adjustment is b+1. The two-dimensional HPE model is trained, and the image after data processing is firstly subjected to two-dimensional HPE to obtain the two-dimensional coordinates of the joint points of the human body. It specifically includes the following:

(1) The Cascaded Pyramid Network (CPN) is used for 2D HPE, and Mask R-CNN is used for human bounding box detection, where Mask R-CNN uses ResNet-101 as the backbone

(2) On the basis of the completed model, CPN selects ResNet-50 as the backbone, and the input image size is 384×288

(3) Reinitialize the last layer of the network, so that the heat map of human joint points returns to the two-dimensional joint points corresponding to the data set

(4) After training the cascade pyramid network model, input the data-enhanced image into the cascade pyramid network for 2D HPE and obtain the 2D human body joint point coordinates

In the above training process, the model hyper-parameters are set to the following: iterate 10,000 times, select Adam optimizer, the number of training samples in a single batch is 16, and the learning rate uses a gradual decay strategy. The rate is 0.1. After training the improved transformer model, the two-dimensional coordinates of all human joint points are composed of a feature sequence and input into the improved transformer for 3D HPE, and the 3D coordinates of the human joint points are obtained.

3.3.2. Improved Transformer Model Training Process. Transformer is improved through switchable temporal hole network and pose graph convolution, and the improved transformer model is trained on the dataset, including the following:

(1) Switchable temporal hole network structure: the feature sequence size of the input switchable temporal hole network is (243, 34). The input feature sequence is subjected to a 1D convolution with a kernel size of 3, a dilation rate of 1, and an output channel number of 544. Then the feature goes through B blocks with residual structure. Each block first undergoes a 1-dimensional switchable time-domain hole convolution with a convolution kernel size of 3 and a hole rate of 3C. Afterwards, the feature sequence undergoes a 1D convolution with a kernel size of 1 and a dilation rate of 1. Each convolution is followed by a set of 1D batch normalization layers, ReLU activation functions, and dropout layers.

(2) Switchable temporal hole convolution: the feature sequence size of the input switchable temporal hole convolution is (H, 544). Among them, H represents the H frame image, 544 represents the number of channels, and the input feature sequence is firstly subjected to the time-domain convolution with the convolution kernel size of 3, the stride of 1, and the hole rate of 3C. The convolution kernel size is S, and the hole rate is standard convolution of 1 and self-attention. The size of the feature sequence after self-attention is $H \times H$, and then the average pooling feature size becomes (H, 1), and then the conversion factor M is obtained through 1D convolution with a convolution kernel size of 1 and SoftMax. The feature sequence K2 is obtained by multiplying M and the feature sequence after feature extraction by the time-domain hole convolution with a convolution kernel size of 3. The feature sequence K1 is obtained by multiplying (1-M) with the feature sequence obtained by feature extraction by standard convolution with a convolution kernel size of S.

(3) Self-attention mechanism: Q in the mechanism first aggregates the local feature information of joint points in the feature sequence through pose graph convolution and then performs matrix multiplication with K. Then, the weight matrix is obtained through SoftMax and finally multiplied by V to obtain the output of the graph self-attention mechanism.

(4) The relationship of the human body joint points includes the human body joint point adjacency relationship, the human body joint point symmetry relationship, and the human body joint point motion correlation relationship.

(5) There are four types of motion associations between the joints of the human body: the left wrist is connected to the right ankle, the left elbow is connected to the right knee, the right wrist is connected to the left ankle, and the right elbow is connected to the left knee.

(6) The model loss consists of two parts; one is the three-dimensional coordinate difference:

$$L_a = \sum_{i}^{M} \left\| \rho_i - \widehat{\rho}_i \right\|_2^2, \tag{10}$$

where $M = 16$, ρ_i is the three-dimensional coordinate of the i-th joint point predicted by the model, and $\widehat{\rho}_i$ represents the real value of the 3D coordinate of the i-th joint point.

The other part is the difference in the length of the bones in the symmetrical part of the human body:

$$L_b = \sum_{C} \left\| D_C - \widehat{D}_C \right\|_2^2, \tag{11}$$

where D_C represents the length of the C-th bone on the left, $\widehat{D}_C$ represents the length of the C-th bone on the right, and $C \in [1, 6]$.

The six symmetrical parts are the bone length difference between the neck and the left and right shoulders, the left and right shoulders and the left and right elbows, the left and right elbows and the left and right wrists, the bone length difference between the spine and the left and right buttocks, the bone length difference between the left and right hips and the left and right knees, and the left and right knees. The asymmetrical part of the human body is the difference in length between the left and right ankles. The meaning of the skeletal difference in the symmetrical part of the human body is that the length of the right wrist and the right elbow of the human body is the same as the length of the left wrist and the left elbow of the human body; that is, the ideal difference between the two should be 0, and the loss function expression is as follows:

$$L = \beta_1 L_a + \beta_2 L_b, \tag{12}$$

where β_1 and β_2 are their respective coefficients.

Finally, the transformer model designed in this paper is shown in Figure 1.

4. Experiment and Analysis

4.1. Dataset Source and Parameter Selection. A custom dataset could be used by collecting relevant images or

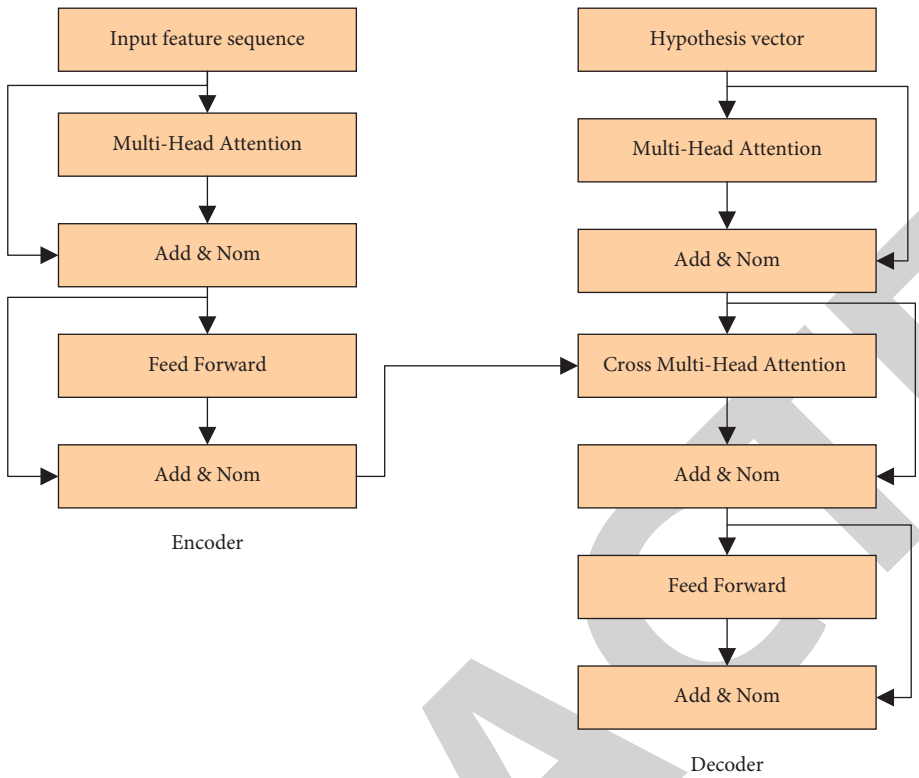

Figure 1: The transformer model designed in this paper.

using an automated tool such as that presented by [27] to create a dataset of relevant images. In our experiment, we used two state-of-the-art datasets, COCO [28] and MPII [29–31]. COCO is a large dataset provided by the Microsoft team for computer vision tasks such as HPE. COCO2017 is divided into training set, validation set, and test set. It has 200,000 images and 25,000 human labels, and each human label sentence contains 17 joints. When solving the pose estimation problem, COCO first detects the target and locates the joint points. Secondly, the evaluation criteria of pose estimation refer to the target detection criteria in this dataset. It uses object keypoint similarity (OKS) to evaluate the similarity between the ground-truth and predicted values of joints. In this paper, the overall network calculates AP (average precision) and AR (average recall) based on the OKS results. MPII is another dataset for evaluating HPE results. It contains more than 28,000 training samples and is evaluated using the PCK metric. In the data preparation stage, this paper uses DETR to detect human bounding boxes. The original image of COCO is 384×288, which is cut into blocks according to the human body bounding box and then expanded into a single-person image of the same size. Data enhancement includes the following ways: Random rotation [-45°, 45°], random scale [0.7, 1.3], and flip. The MPII data preprocessing procedure is consistent with COCO except that the image resolution is set to 384×384.

The number of encoder layers in the transformer hyperparameters has a certain influence on the experiment. Therefore, in this paper, the number of encoder layers is selected to be 6, 8, and 10 for experimental comparison. The results are shown in Figures 2–4. The selected evaluation indicators are as follows. In this classification metric, the accuracy (ACC) is used to evaluate the model when the sample distribution is balanced, which refers to the proportion of correct results in the sample.

$$ACC = \frac{TP + TN}{TP + FP + FN}, \tag{13}$$

$$PPV = \frac{TP}{TP + FP}, \tag{14}$$

where PPV is the ratio of predicted positive samples to actual positive samples.

According to the trend of the curve in the figure, among the 6-layer, 8-layer, and 10-layer encoders, the 8-layer encoder performs the best. Also under 500-epoch training, the 8-layer encoder has the highest accuracy. Under 500-epoch training, 8 layers achieve more than 90% in the ACC metric. This shows that the multihead attention mechanism used in the encoder encoding of the transformer model can better learn the relationship between pose estimates.

4.2. Model Performance Testing Experiment. We conducted model performance experiments on the two datasets and compared the results of our model with other methods. Tables 1 and 2 summarize the results.

Table 1 shows the comparison between the prediction results of this paper and other methods on the COCO test

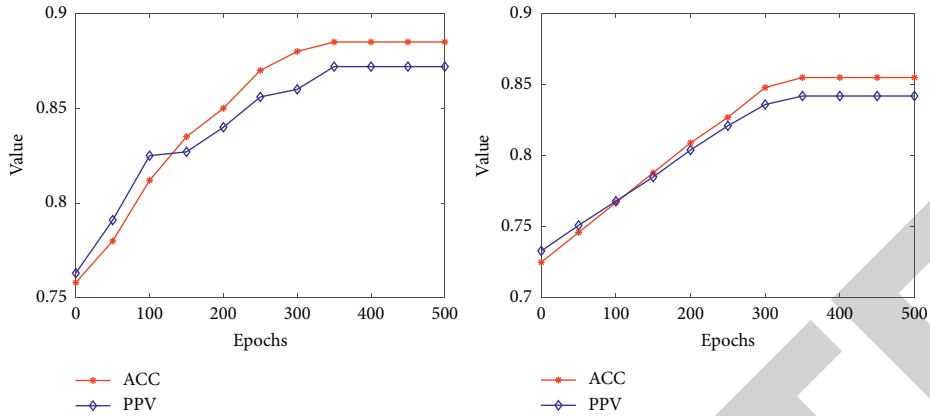

Figure 2: Indicators comparison of the model on the COCO and MPII datasets when $N = 6$.

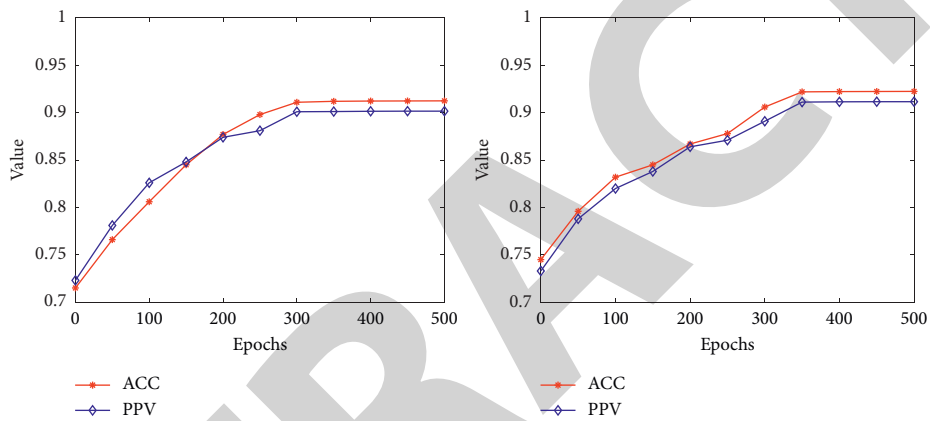

Figure 3: Indicators comparison of the model on the COCO and MPII datasets when $N = 8$.

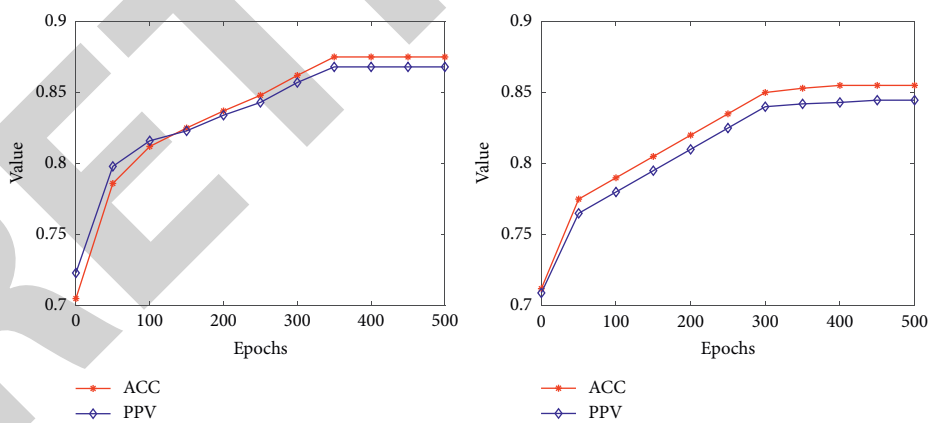

Figure 4: Indicators comparison of the model on the COCO and MPII datasets when $N = 10$.

Table 1: Prediction results of this paper and other methods on the COCO test set.

Method	Backbone	AP	AP_{50}	AP_{75}	AP_M	AP_L	AR
CVPR	ResNet-101	62.5	83.9	71.3	55.8	73.8	68.5
ECCV	ResNet-101	65.8	85.8	75.9	61.9	75.6	68.9
ICCV	ResNet-101	67.3	89.2	77.2	62.6	76.7	76.1
PRTR	ResNet-101	68.2	89.2	77.5	62.8	77.2	76.0
Our model	ResNet-101	71.9	90.5	79.8	65.5	78.8	78.1

Table 2: Prediction results of this paper and other methods on the MPII test set.

Method	Backbone	Hea	Sho	Elb	Wri	Hip	Kne	Ank
CVPR	ResNet-50	93.5	91.2	86.5	80.1	85.8	82.9	76.2
PRTR	ResNet-50	95.2	93.9	87.2	81.5	87.2	84.5	78.5
PRTR	ResNet-101	95.3	93.8	87.3	81.7	87.7	85.2	79.5
Our model	ResNet-50	95.8	93.8	88.4	82.4	88.2	86.6	80.2
Our model	ResNet-101	95.6	94.0	88.4	83.1	88.5	85.7	81.0

set. It can be seen that the AP of our method on the COCO test set is 71.9%, which is still 3.7% higher than the PRTR ratio of the same backbone network. The APs for CVPR and ECCV were only 62.5% and 65.8%, respectively. In addition, the AR of our method is 78.1%, which is 2.1% higher than PRTR.

The results on the MPII validation set are shown in Table 2 where Hea refers to head, similarly Sho refers to shoulder joint, Elb refers to elbow joint, Wri refers to wrist joint, Kne refers to knee joint, and Ank refers to ankle joint. When using ResNet-50 as the backbone network, PRTR achieved a PCKh-0.5 score of 81.5% for the wrist joint and 78.5% for the ankle joint. The scores of our method under the same conditions are 82.4% and 80.2%, respectively. When the backbone network is replaced with ResNet-101, the PCKh-0.5 scores of PRTR for wrist and ankle PRTR are 81.7% and 79.5%, respectively. The scores of our method under the same conditions are 83.1% and 81.0%, respectively. Compared with other joints, the method proposed in this paper has more advantages in the prediction results of terminal joints.

5. Conclusion

HPE is a hot research direction in computer vision. Because the image is affected by factors such as shooting angle, illumination, and surrounding environment, early HPE methods based on handcrafted features have not been able to obtain satisfactory performance. Using convolutional neural networks (CNN) to learn feature representation instead of traditional handcrafted features can achieve end-to-end optimization. Although the HPE method based on CNN has made great progress, in practical applications, it still faces some problems. On the one hand, most HPE research focuses on increasing accuracy, but it neglects the crucial balance between model speed and accuracy that is essential to HPE efficiency. Previous methods did not realize the importance of quantization error and optimization contradiction in HPE, which is a key issue to achieve high-precision HPE. These two major issues are addressed in this study by conducting research from three different angles, efficient network architecture design, model training approach, and high-precision placement. We introduce the research status of HPE at home and abroad, which provides a theoretical basis for the design of the transformer 3D HPE model. Secondly, the technical principle and optimization scheme of CNN and transformer are introduced, and a 3D HPE model based on transformer is proposed. Two well-known datasets are used to perform experiments to find the best parameters for model development. Various data enhancement techniques such as rotation, scaling, and saturation adjustments are applied and the model is trained. The experimental results show that the proposed model's prediction results are better than other methods we compared our work with.

Data Availability

The datasets used during the current study are available from the author on reasonable request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Research Article

An Evaluation Approach for English Teaching Quality Using DEA Fusion Algorithm

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The Data Envelope Analysis (DEA) is a technique that has been implemented in order to assess the effectiveness of various entities, including programs, organizations, and so on. They are accountable for making use of the available resources in order to obtain outputs that are of interest. It has been applied to the task of analyzing a variety of activities. The DEA is a fractional programming model that can contain multiple outputs and inputs without having to resort to prior weights or explicitly stating the functional relationship between inputs and outputs. This is because DEA is a model that is based on dynamic programming. It computes a scalar measure of efficiency and establishes the level of efficiency at both the organization's inputs and outputs that are being evaluated. The assessment of the excellence of English instruction in universities and colleges is primarily plagued by two issues: first, the evaluation index system is lacking in its coverage, and second, the evaluation model struggles when confronted with highly nuanced signs. In order to find solutions to these issues, in this work, we delve deeply into the topic of assessing the quality of English instruction in colleges and universities and develop a model for doing so that is based on the DEA fusion algorithm. To assess the quality of English instruction provided by colleges and universities, a model, that takes into account both quantitative and qualitative research findings, has been developed. The findings of the implementation suggest that the DEA fusion algorithm that was proposed is capable of successfully assessing the quality of English instructions and teaching provided in colleges and universities. The proposed algorithm outperformed the traditional Multilayer Perceptron (MLP) algorithm and the Decision Tree (DT) algorithm. The findings of this research have been very helpful in encouraging the enhancement of the quality of English instruction in colleges.

1. Introduction

The DEA is a method for calculating the product input-output ratio by finding solutions to linear programming models [1–6]. It is an evaluation method for data efficiency. Since the approach was first proposed in 1978, there has been an ever-increasing amount of studies conducted on DEA. The DEA in my nation is leaning more and more toward the field of economic management as the level of research here continues to gradually increase. In the modern age, there has been a paucity of research conducted on the specific evolution trend of this topic, as well as the most recent development trend of this topic both domestically and internationally. The DEA is a technique for determining how efficient something is. Some academics have only utilized efficiency as a keyword and conducted a visual examination of the efficiency of domestic and international knowledge graphs under the condition that they were only allowed to study a limited number of subjects. this research may be only the top of the iceberg. After conducting research, it was discovered that there is only one study that uses the term DEA as its primary keyword and focuses on the application of the DEA approach to the management sector. The DEA approach for performance evaluation is a non-parametric production frontier method that takes into account variable returns to scale assumptions. This allows for the acquisition of purely technical efficiencies that are unaffected by scale effects. Because of how effective it is, it has found widespread use in a variety of disciplines like medicine, sports, education, and finance, amongst others.

The DEA is capable of managing many inputs as well as several outputs simultaneously. Second, it takes into account the different inputs and outputs that are being considered. In addition, this nonparametric method does not employ any subjective weights, which demonstrates a great deal of flexibility in the process of designing algorithms for performance prediction. The vast majority of DEA models are built for ex-post efficiency analysis using data on inputs and outputs that have been pre-specified, and very small research has looked at the possibility of making predictions about future performance. The data-driven proposal highly evaluates the value of the data, and how to fully mine the available information hidden under the big data [7–10], which has gradually become a research hotspot. This evaluation takes into consideration everything from the large amount of data that is being considered to the knowledge and information that lies behind the data.

At this point in time, higher education places a significant emphasis on the all-encompassing and high-quality training of senior personnel [11–13]. In nations where English is not the native language, it is important to cultivate college students who not only have strong proficient knowledge and abilities, nevertheless, they also have good college English talent, in order to foster senior talent interchange and development. For this purpose, it is of the utmost importance to enhance the quality of English instruction offered in higher education institutions and to foster the development of high-level talent that is fluent in English. However, English instruction in secondary schools, colleges, and universities is frequently influenced by a variety of financial considerations, including English teachers, English instruction, scientific research, English teaching management systems, English teaching mechanisms, the teaching philosophy of English, the teaching methods for English, as well as, social factors, human factors, and material factors. The process of enhancing and evaluating the quality of English instruction at colleges and universities is made more challenging by the complexity of the situation. In light of this, a number of researchers have carried out complementary study and research on the enhancement and evaluation of the quality of basic English classroom instructions and teaching.

The quality of English instruction has been the topic of discussion amongst a few academics, who have considered novel instructional strategies for engineering English instruction [14]. A number of researchers have investigated the quality assessment of medical English instruction based on requirements analysis [15]. Several academics have investigated the building of a SPOC-based college English teaching quality evaluation index system and presented their findings. Some academics have presented a methodology for evaluating the quality of English instruction that is based on an RBF neural network that has been tuned using genetic algorithm. A fuzzy evaluation approach of English teaching quality based on the bat algorithm has been the subject of discussion amongst a few academics [16].

The digital English teaching mode is a novel style of instruction for use in the classroom that is being promoted by the Ministry of Education. It not only improves the resources available for teaching English and the methods used for teaching English, but it also reintegrates and makes full use of the advantages of teaching, provides an information-based teaching environment, and alters the conventional mode of teaching. It satisfies the needs of the ongoing building of the golden course for hardware facilities and encourages the balanced growth of the university's educational ecosystem. The term software building of golden courses refers to the enhancement of the quality of classroom instruction [17]. Among other things, the development of a scientific and efficient course quality evaluation system is essential in order to ensure that the course will be of a high standard. Currently, the majority of classroom teaching quality evaluations at domestic colleges and universities are coordinated by an educational administration agency. This coordination includes the construction of an evaluation system as well as the publication of evaluation data. Many colleges and universities do not differentiate the nature of the courses that they offer and instead use unified evaluation indicators that include not only the teaching attitude and content but also the teaching methods and effects. This is especially true when it comes to the setting of evaluation indicators. The advantage is that it guarantees the evaluation of common difficulties, but the downside is that it ignores the qualities that are unique to each course [18]. The flaws, lags, and limits of this teaching evaluation method become more apparent over time as a result of the introduction of a new notion in educational evaluation. As a consequence of this, the development of an evaluation system that is compatible with the new teaching reform model for the digital age and that conforms to the new teaching concept has emerged as one of the most essential tasks associated with the reform of college English instruction in universities and colleges.

Evaluation of the quality of teaching in the classroom is the foundational component of education quality evaluation. An efficient model for evaluating teaching needs to be supported by efficient evaluation indicators in order to generate results that are scientific in nature from the evaluation. Over the past few years, the academic community has made significant efforts to conduct research on the evaluation of digital classroom education. Planning and preparation, classroom instruction, second classroom extension, and teaching responsibility are the four components that have been suggested as the basis for the construction of an evaluation model for second language teachers by various academics [19]. Some academics have developed evaluation indicators to assess the teaching ability of online teachers, among other things. Nevertheless, the focus of these assessment model studies is on the study of the validity of evaluation indicators, whereas the research on evaluation methods still needs to be carried out in greater depth.

The evaluation of the quality of English instruction in colleges and universities is primarily plagued by two issues: first, the evaluation index system is lacking in its coverage, and second, the evaluation model struggles when confronted with highly nuanced signs. The key contributions can be listed as follows.

(i) In order to find solutions to these issues, in this work we delve deeply into the topic of evaluating the quality of English instruction in colleges and universities and develop a model for doing so that is based on the DEA fusion algorithm.

(ii) To evaluate the quality of English instruction provided by colleges and universities, a model, that takes into account both quantitative and qualitative research findings, has been developed. This model's primary focus is on the indicators.

(iii) The findings of the implementation suggest that the DEA fusion algorithm that was proposed is capable of successfully evaluating the quality of English instruction provided in colleges and universities.

As a result, we developed a system for determining the efficacy of English instruction at higher education institutions that is based on the DEA fusion algorithm. Following that, we will present our work by utilizing parts. The recent relevant work is covered in Section 2. The introductory discussion of the algorithm model makes up Section 3. The comparison and analysis of the results of our simulations is the topic of Section 4. Discussion over the obtained outcomes is covered in Section 5. The debate is contained within Section 6 of the whole text.

2. Related Work

The DEA is a strategy for making decisions based on multiple criteria by making use of objective facts. It is a research field that crosses the boundaries of management and operations research, and it is utilized extensively in the examination of efficiency in a variety of other fields. The DEA was initially conceived of by the well-known operations researchers Charmes et al. [20], and its primary function is to assess the comparative efficacy of decision-making units that are comparable to one another. Furthermore, it is necessary to compare the production efficiency of each decision-making unit objectively and efficiently to quantify the productivity of each decision-making unit in the production system with multiple inputs and multiple outputs. This is necessary in order to measure the productivity of each decision-making unit. It is not essential for the DEA to carry out dimensional processing on the data units that are input to and output from each decision-making unit. It is non-parameterized, therefore there is no need to specify any weights, and it does not require setting any parameters. This should be noted that DEA is one of a kind when it comes to multi-output and multi-input analysis for evaluating various complex systems because it takes into account every possible input and output combination for the decision-making unit itself, which allows it to more accurately replicate the information and features of the assessment and evaluation object itself. At present, DEA is being utilized in an extensive manner in the validity study of public utilities, banking, the service industry, transportation, and the evaluation of projects.

The DEA can be represented mathematically using a linear model, and the solution to the DEA problem can be solved using linear programming, which is also known as a conditional optimization problem. The linear programming method is currently the method that is considered to be the standard way of solving DEA problems. In this method, the DEA model that needs to be optimized is first structured as a typical linear programming problem, and then the problem is solved with the assistance of linear programming software and toolkits such as DEAP2.1, Lingo and Cplex among others. However, these programs require a high level of specialization, and the procedure as a whole is very complex. As a result, it is difficult for individuals who are not specialists to use them. In addition, Excel software can be used to solve DEA problems. However, the process of finding a solution is highly laborious, and it is essential to specify the limitations of input and output one at a time. The amount of work is substantial, and the current system is not suited to cope with increasingly intricate DEA issues.

Since the DEA problem is, at its core, an optimization problem with several constraints, it is possible to find a solution to it by using the concept of optimization. Optimization methods that are currently in widespread use include heuristic algorithms like the particle swarm optimization algorithm [21, 22], the genetic algorithm [23–25], the simulated annealing algorithm [26–28], and other optimization algorithms. In order to find solutions for a wide variety of optimization issues, many people turn to the usage of these heuristic algorithms, which are not only straightforward but also efficient and straightforward to comprehend. However, these conventional optimization methods do not have a strict mathematical theoretical basis, and the effect of solving optimization issues depends on the parameters being specified reasonably and effectively. Since different optimization problems require the setting of parameters with varied values and the selection of parameters depends on the user's expertise, it cannot be broadly utilized to solve a variety of optimization problems at once.

College English classes are particularly vital to the functioning of the nation's higher education system because of the breadth and scope of their coverage. It is quite clear, in light of the effects that the pandemic has had, that the fast transition of traditional classes to online instruction did not make enough preparations for college-level English instruction. Obviously, this was a problem for a great deal of other courses as well. There are significant distinctions between teaching in a regular classroom and teaching in an online environment. The teaching and learning that take place in a traditional classroom setting are combined, however, in an online classroom, these two components are kept distinct. The way in which one teaches does not necessarily have an effect on the way in which one learns, and there are numerous elements that cannot be controlled. There is no way to ensure the high quality of the instruction, and the activities associated with teaching are challenging. At this point, it appears that online teaching has evolved into a kind of solo dance for instructors. Traditional educators are used to employing a variety of strategies for maintaining order in the classroom, instructing students, and motivating them to do better. These strategies are less useful in the online context. The force that binds. How can this tendency be reversed, the quality of course instruction be successfully

improved, and the level of satisfaction felt by teachers be increased? Because of this, the knowledge system needs to be reshaped according to the features of the field, teaching objects, and teaching content, and the design needs to be totally based on the peculiarities of the online environment. Teaching materials, using gamified examinations to encourage and test students, using scientific and technology ways to feedback on teaching impacts, and using team-based approaches to cope with online teaching are all important aspects of effective education today. At present, university teaching is limited by the teaching platform, large class size, outdated technical means, and other problems. However, it is entirely possible to gradually improve college English online teaching from the perspectives of course resources, interactive feedback, and improvement of tests, and it is also possible to gradually improve course satisfaction. The problem is that it is impossible to customize learning according to the needs of students.

The existing research on college English teaching primarily focuses on the current situation of college English teaching [29, 30] and teaching reform, the cultivation of autonomous learning ability and strategies, the application of flipped classrooms and MOOCs in college English, and the development of college English teachers. Few people concentrate on the development of online resources for college English classes and online instruction. Some academics, based on their experience in the construction of college English online courses, have pointed out that the construction of foreign language online courses must first understand eight issues. At the core of these issues are the questions of whether or not to understand the cognitive psychology of college students in the new era, how to solve the problem of homogenization construction, and how to grasp the pain points of English learning. Other issues that must be understood include whether or not to understand the cognitive psychology of college students in the new era. At the same time, it proposes eight principles for the construction of college English online courses, which are as follows: the design ought to be fresh, the navigation ought to be astute, the topic selection ought to be stringent, the excavation ought to be deep, the expansion ought to be wide and the interest ought to be robust, the application ought to be extensive, and the impact ought to be immediate. The researcher emphasized that the development of high-quality online classes ought to involve many academic institutions, multiple schools, multiple software platforms, co-creation and sharing, and mutual advantage.

3. Research Design

3.1. Data Processing

3.1.1. Data Sources. The data that we used to compile this report were taken from an evaluation of English instruction at a domestic university. In order to train our suggested DEA fusion model, we make use of 75 percent of the data as the training set, and we use the remaining 25 percent of the data as the test set. Figure 1 presents a block diagram of the DEA evaluation framework.

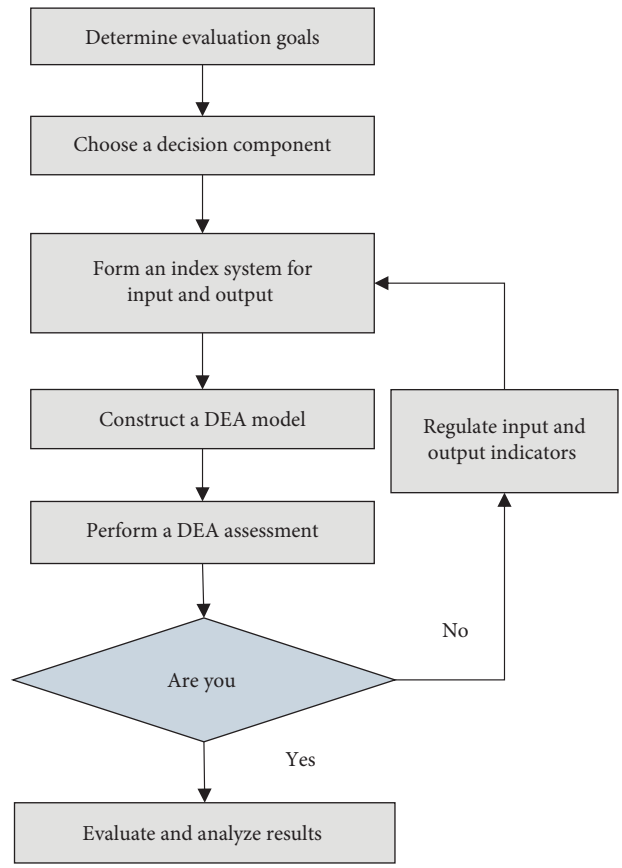

Figure 1: The DEA evaluation structure diagram and flowchart.

3.1.2. DEA-Based Data Preprocessing. The first thing that has to be done in order to begin the process of data preparation is to identify variable indicators. In this article, the input and output variables are figured out by picking out the pertinent variables. The comparative efficiency of the suggested DMU is deliberated and, subsequently, rated by the suggested DEA model based on the input and output data that is provided, and any data that is either incomplete or redundant is removed from the analysis. In this study, the efficiency value of DMU is determined using the time-honored CCR model as the basis for the calculation.

Let's now undertake that there are several DMUs of the same category, and that every DMU has N and R indicators that respectively correspond to input and output indicators. Furthermore, we also assume that the classical CCR approach is used to estimate the efficiencies of DMAs for these DMUs. Finally, we consider that the input indicator data of the decision-making unit can be represented by the matrix Q. Note that the matrix both for input and output indicators is given by $Q = q_{nm}\,(n = 1, 2, ..., N; m = 1, 2, ..., M)$, where q_{nm} represents the first entry in the matrix. The nth input metric for the mth DMU in the system. Similarly, the data for the output indicator are represented in the matrix $Z = z_{r\ d}\,(r = 1, 2, ..., R; m = 1, 2, ..., M)$. The regulation states that the effectiveness of DMU can be measured as the fraction of the linear weighted combination of input indicators to the linear weighted combination of output

indicators. In other words, the efficiency of the DMU is articulated as a ratio. The formula can be broken down as follows in:

$$\eta_p = \frac{\sum_{r=1}^{R} \alpha_r z_{rp}}{\sum_{n=1}^{N} \beta_n q_{np}}. \quad (1)$$

In (1), η_p stands for the efficiency evaluation index of the DMU, and is one of these components. Similarly, $\beta_n (n = 1, 2, ..., N)$, which stands for input indicator weight vector, and $\alpha_r (r = 1, 2, ..., R)$, which stands for output indicator weight vector, are the other components.

The standard CCR model determines the following problems for every DMU $(1 \leq P \leq n)$ in the following order, as illustrated in

$$\text{Max}\, \eta_p = \frac{\sum_{r=1}^{R} \alpha_r y_{rp}}{\sum_{n=1}^{N} \beta_n x_{np}}. \quad (2)$$

The frontier of the optimal decision-making unit is determined by the DEA, and the comparative efficiency of other decision-making units is determined by their proximity to this frontier. All of the DMUs that were tested produced efficiency values that were either less than or equal to 1, and the DMU that was used to determine the optimal frontier surface produced an efficiency value of 1. When calculating the efficiency value, the classic CCR model is used to do a comparison between the prevailing DMU and the current DMU on the frontier. This allows the model to effectively differentiate between valid and invalid DMU. Within the context of this article, all DMUs that have an efficiency value of 1 have been chosen and applied as the greatest efficient level for more training and testing.

3.2. The Building Process for the DEA Model. In order to build the RBF model, the DEA preprocessed dataset was put to use. RBF will pick at random an adequate quantity of data for the learning process, and the remaining data will be utilized to evaluate the RBF model's level of accuracy. If the accuracy does not meet the requirements, it is possible to perfect it by modifying the model parameters. In fact, RBF is a powerful technique for nonlinear modeling that has a high learning efficiency and is able to deal with datasets that have an ambiguous link between the variables that are input and those that are output. An interpolation method, which can process a vast quantity of discrete facts and generate a function over and done with the discrete sampling points, in order to anticipate all the unidentified points, is what the algorithm is, at its core. Its primary and fundamental role is to forecast unidentified points.

Assuming that there are L units in the sample, and that each unit contains u and v input and output variables, respectively. Then, the sample dataset can be characterized as a set denoted by $\{X_{Lu}, Y_{Lv}\}$ where $(L = 1, 2, \ldots, l; u = 1, 2, \ldots, U; v = 1, 2, \ldots, V)$. This is because each unit in the sample has u and v input and output variables. Among them, the input is denoted by the symbol $X = \{X_{11}, X_{12}, ...X_{Lu}\}$, the predicted output is denoted by the symbol $Y = \{Y_{11}, Y_{12}, ...Y_{Lu}\}$, and the actual output, $Y' = \{Y'_{11}, Y'_{12}, ...Y'_{Lu}\}$, is the appropriate representation. The following is a mathematical expression for the RBF model, which stands for radial basis function:

$$g(x) = \sum_{k=1}^{b} w_i \theta_i(x) \quad (i = 1, 2, \ldots, b). \quad (3)$$

This should be noted that the above model is being able to fulfill the interpolation condition given by

$$g(x) = G(x_i), \quad (4)$$

where w_i denotes the weight of the ith node, which is produced by the interpolation condition through the matrix solution. Furthermore, $\theta_i(x)$ is used as the foundation function, and the Gaussian function is frequently utilized. The expression for the Gaussian function is mathematically expressed as follows in

$$\theta_i(x) = e^{-\|x - a_i\|^2 / 2\mu_i^2}. \quad (5)$$

In the above formula (5), a_i characterizes the midpoint vector of the ith hidden node, while μ_i exemplifies the girth or the variance of the radial foundation function, which is implemented to alter the sensitivity of the model. Together, these two variables are used to find the ith hidden node's center vector.

In the next phase, we construct a set of equations simultaneously like follows:

$$H \times w_i = G(x_i). \quad (6)$$

This reveals the one and only solution to the problem:

$$\widehat{w}_i = H^{-1} \times G(x_i). \quad (7)$$

The RBEF uses the training data to determine the relevant weights, and then adjusts those weights in order to optimize the regression prediction of the data. Then, it implements a set of test data to the altered and adjusted model in order to obtain its anticipated value. And finally, it evaluates the model by calculating the error that exists between the true value and the predicted value. In case, the model correctness does not reach the standard threshold (predefined), then the model can be fixed by continuously altering its various parameters. This is the case regardless of whether or not the accuracy fulfills the requirement.

The DEA-RBF approach syndicates the benefits of the DEA and the RBF methodology into one, and it is able to handle large data sets whose variable properties are unknown. In most cases, the length of the RBF training process will be impacted by the amount of the data volume. The cost of storing the data and the cost of operating the data increases at an exponential rate with the increase in the data volume. An excessive data volume may even cause the system to fail due to the strain it places on its resources. Therefore, in order to reduce the amount of time required for RBF training and to increase its overall operational efficiency in the face of large amounts of data, the data set must be condensed, at least to some degree. Nevertheless, there is a

possibility that the accuracy of the RBF training will vary as a result of the reduction in the dataset. The traditional method of data sampling only involves simple sampling, and it, potentially, does not take into consideration the association amongst various variables that are located within the dataset. Additionally, it cannot assure that the reduced dataset (filtered) can still preserve the features of the original data (non-reduced), which may have certain effects on the experiments that use the data set for prediction. a damaging effect on. DEA is able to remove some unnecessary data as well as data that interferes with other data without altering the generality of the data, which allows it to filter out the data layer that is the most useful in the data collection.

This paper standardizes, among two predefined thresholds, the nominated valid dataset in order to avoid data distortion and, as well as, prevent small data from being swallowed up by the large data. As a result, the paper is able to achieve a more accurate prediction effect. This is because the sizes of the data sets that are represented by the various variables are not identical. The normalization formulation using the mode is given by

$$H = \frac{\delta - \delta_{\min}}{\delta_{\max} - \delta_{\min}}. \tag{8}$$

In (8), δ stands for the original data, while $\delta_{\max}$ and $\delta_{\min}$ refer to the highest and lowest values in the original data, correspondingly.

The reduced dataset (filtered) is then separated into a training dataset and a test dataset, and the efficiency of the hybrid technique is evaluated based on how well the multi-output RBF model is learned and tested. The model that is proposed in this study has the potential to increase the accuracy of model prediction while simultaneously reducing the amount of data, significantly reducing the amount of time needed for training, and improving the efficiency with which data is processed.

3.3. Evaluation Indicators. We introduce the confusion matrix, which is illustrated in Table 1. The following are the formulas for calculating precision and recall, respectively:

$$\text{precision} = \frac{\text{TP}}{\text{TP} + \text{FP}}, \tag{9}$$

$$\text{recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}, \tag{10}$$

where TP stands for true positive and FP represents the false positive ratio between the predicted and actual outcomes. Similarly, FN characterizes the false negative.

4. Results

The DEA method will hereafter be referred to by us as the OUR algorithm, and we will contrast it with the Multilayer Perceptron (MLP) algorithm and the Decision Tree (DT) algorithm. Comparison of the three algorithms demonstrates, from a variety of perspectives, that the OUR algorithm is superior to the other two.

Table 1: The confusion matrix.

	Actual value	Predictive value
Actual value	TP	FN
Predictive value	FP	TN

Figure 2 depicts the accuracy change trend diagram for the OUR method, the MLP algorithm, and the DT algorithm as the number of iterations is increased. It is plain to see that the precision of the OUR method, the MLP algorithm, and the DT algorithm gradually improves along with the number of iterations that are applied to the calculation. Even if the accuracy rate of the OUR algorithm is the lowest at the beginning of the process, it has the fastest increase rate in the early stage, according to the increasing trend. In addition to this, the overall accuracy rate is superior to that of the MLP algorithm and the DT method.

The evolution of the loss functions of the three algorithms is depicted in Figure 3, which is organized according to the number of iterations. It is clear to us that as the total number of iterations grows, the amount of data lost by each of the three algorithms steadily lessens, with the final amount of data lost by the OUR algorithm being the least. The second problem is the destruction of the MLP algorithm. However, the DT method has the most amount of loss when compared to the other two algorithms.

Figure 4 presents a comparison of the accuracy and recall rates achieved by each of the three methods. Even if the accuracy of the MLP algorithm is only 0.14 percent lower than that of the OUR method, it is clear that the OUR algorithm has the highest level of precision. The DT algorithm has the worst accuracy of all the ones we looked at. When it comes to recollection, the OUR algorithm is superior to the DT algorithm and achieves better results overall. In comparison to the MLP algorithm, the recall rate achieved by the DT method is significantly higher.

In terms of accuracy, precision, recall, and loss, we contrasted the OUR algorithm with the MLP method and the DT algorithm. It is evident from the attained outcomes that the generalization performance of the OUR model is exceptional because the OUR algorithm has the highest level of accuracy across the board.

5. Discussion

Although the Chinese government invests very little money in education, the country's education system is intended to be exceedingly comprehensive. School administrators should pay attention to the issue of school-running efficiency, seek to increase school-running efficiency, harness potential from inside the school, sensibly distribute limited educational resources, and make maximum use of those resources. ongoing development. Evaluation is something that needs to be paid attention to if we want to see improvements in how efficiently schools are operated. It combines the analytic hierarchy process, establishes a scientific model, and combines the reality of the widespread application of information technology in the digital age. This study uses the DEA fusion algorithm to evaluate the teaching quality of college English

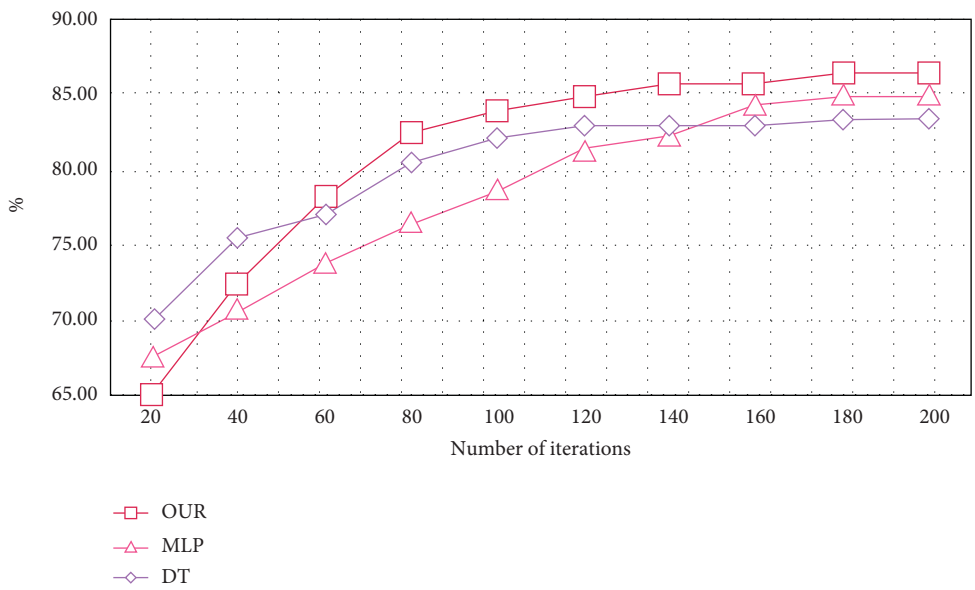

Figure 2: Accuracy of OUR algorithm, MLP, and DT algorithms (the higher the value the more accurate is the algorithm).

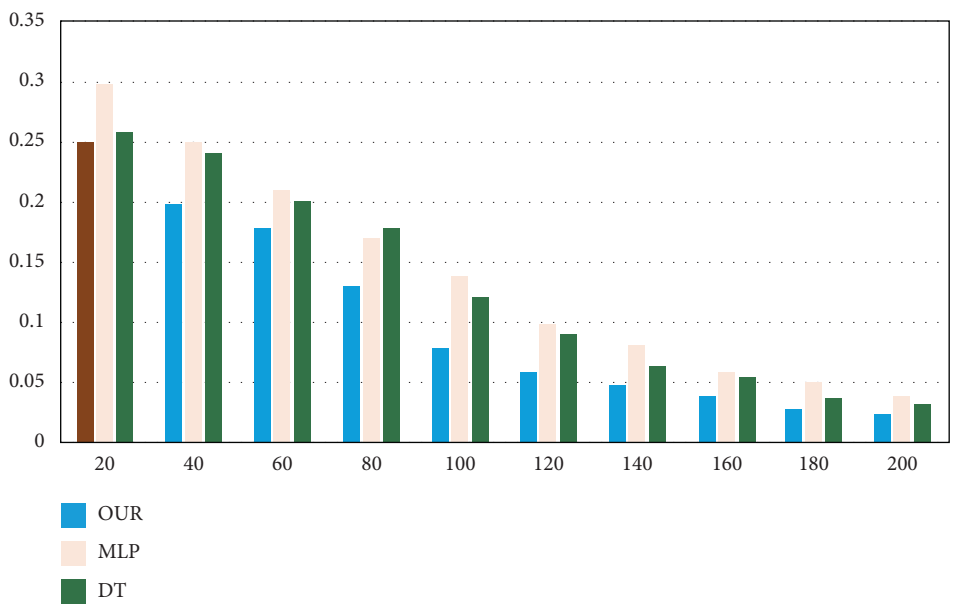

Figure 3: Change in loss (the lower the value, the lesser is the loss).

teachers. It comprehensively considers the characteristics of multi-index, multi-factor, and multi-objective evaluation. It is a better solution to the problem that a single assessment index cannot adequately reflect the comprehensive level of teaching that is being done by teachers since the multi-factor problem is incorporated into a single factor. At the same time, the grades are more precise, rigorous, and scientific, which eliminates the influence of the correlation of each evaluation index on the evaluation results to a certain extent. Additionally, this eliminates the inaccuracy of the evaluation results caused by errors caused by the subjective factors of a single evaluation model.

The findings demonstrate that the evaluation procedure is exhaustive and highly operable. The evaluation results are accurate and trustworthy. The calculating method and process are efficient. And they satisfy the software requirements for the Golden Course construction. In the future, we plan to conduct in-depth research on a greater number of universities, teachers, and courses. Promote and apply the quality evaluation model for English classroom teaching that was proposed in this study. And based on the results of the evaluation, solve the issues that are currently present in English classroom teaching in the digital environment in a manner that is targeted. In order to find a solution to the problem, you need to reframe it as an opportunity for educational reform. Stimulate college students to learn English in English with initiative and enthusiasm, and form the autonomous learning ability of English learning by deeply integrating advanced information

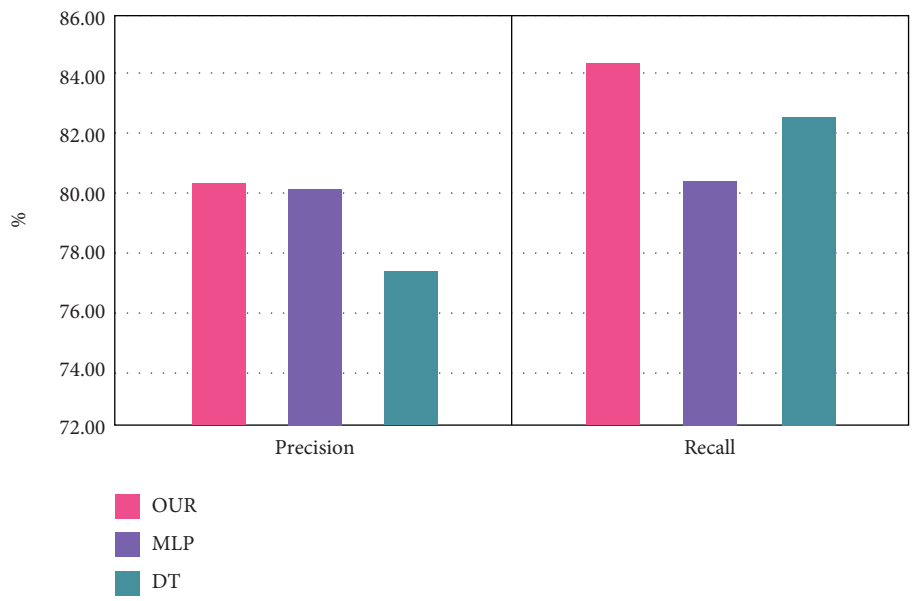

Figure 4: Comparison of precision and recall (the higher the value the more accurate is the algorithm).

technology and college English education, exploring diverse online and offline innovative teaching modes, forming more learning space, and forming the ability for college students to learn English on their own. In addition, we will continue to revise and improve the evaluation model in future course practice in accordance with the standards for the construction of golden courses. This is being done in order to improve the scientificity and effectiveness of the evaluation model of the quality of college English instruction. In terms of accuracy, precision, recall, and loss, we contrasted the OUR algorithm with the MLP method and the DT algorithm. It is evident that the generalization performance of the OUR model is exceptional because the OUR algorithm has the highest level of accuracy across the board.

6. Conclusions and Future Work

This study examines the evaluation index system used for English instruction in colleges and universities from the perspectives of teaching, learning, management, innovation factors, integration factors, and specific results in the process of college English instruction. Based on the findings of this investigation, a proposal is made to establish an environmental impact report system that is both more systematic and comprehensive. The newly developed comprehensive environmental impact approach for evaluating the quality of English instruction in colleges and universities has substantial implications for guiding students in the right direction. A fuzzy evaluation model of college English teaching quality evaluation has been established on the basis of the DEA method and the grey system theory. This model not only clarifies the physical meaning of college English teaching quality evaluation, but it also ensures that the calculation is both simple and reliable. The suggested algorithm outperformed MLP and DT algorithms.

The proposed system gives a means for quantitative analysis, as well as, a method for evaluating the quality of English instruction in colleges and universities. The relevant strategies to improve the quality of college English teaching are initially discussed based on the DEA fusion algorithm which is based on the evaluation method model of college English teaching quality. This has a certain reference value for improving the quality of college teaching as a whole. In the future, we will continue developing more sophisticated algorithms and will integrate deep learning and big data technology to improve the precision of the prediction and computational time. Similarly, the training model of the machine learning approach can be made fast enough to improve the system response time using big data technologies like cloud and edge computing. We intend to advise a framework that will improve the prediction durations of the proposed system. Finally, we will compare the proposed system with other closest rivals.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Research Article

Educational Evaluation of Piano Performance by the Deep Learning Neural Network Model

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In recent years, the piano education industry has occupied a huge market. However, the automatic evaluation function of piano performance has shortcomings in existing piano education products. Deep learning (DL) algorithm and the recurrent neural network (RNN) structure can help in automatics evaluation function of the piano performance. This paper proposes a Musical Instrument Digital Interface (MIDI) piano evaluation scheme based on the RNN structure and the Spark computing engine using the Deeplearning4J DL framework. The Deeplearning4J framework can run on the Java Virtual Machine; therefore, the entire system does not require cross-platform development. The Spark distributed computing engine realizes parallelization in music data preprocessing, feature extraction, and model training. Combined with the training user interface (UI) provided by the Deeplearning4J, it can improve developmental efficiency. Additionally, the RNN parameters are analyzed. The results demonstrate that the error value of the three-layer RNN structure is smaller than other closest rivals' techniques. In particular, few piano training institutions and MIDI website datasets are used as the basis, and the experimental samples are collected. The neural network is trained, and the performance of the evaluation model is tested. The results show that the evaluation outcomes of the designed performance evaluation model for the piano are fundamentally consistent with the real levels of the players with assured feasibility; after 3k times of the training periods, the error of the RNN model is close to 0.01 and the network converges.

1. Introduction

In the 10th year of reform and opening, the piano examination system was restored, and China ushered in the stage of the explosive development of piano education for the first time [1]. In recent years, with the improvement of material living standards, the awareness of spiritual needs has deepened in people's lives, and piano education has experienced a second explosive development. Whether entering an art school for collective study or asking a pianist to teach individual study, these teaching methods have high professional requirements for piano educators. There is a serious shortage of traditional Chinese piano educators, so the contradiction between supply and demand is difficult to solve in the short term [2]. Additionally, the commission of traditional educators is generally high, and the price of wooden pianos is high, which is unaffordable for ordinary families. High cost has become an important obstacle in the development of piano education. Therefore, reducing the cost of learning has become an inevitable trend in popularizing piano education. At present, piano teachers mainly rely on their own understanding to monitor, assess, and precise students' performances in the class. Teachers and students have different perspectives on what constitutes play and music. Not only the proper or wrong note but also significant aspects like rhythm and expressiveness have an impact on the performance [3]. As a result, the conventional approach to teaching piano music contains flaws like strong subjectivity, insufficient judgement, and high unpredictability [4].

The New Generation Artificial Intelligence Development Plan, which the State Council of the People's Republic of China formally released in July 2017, emphasised the use of intelligent technology to accelerate the reform of talent training models and teaching methods and to build a new education system that includes intelligent and interactive

learning [5]. The Artificial Intelligence Innovation Action Plan for Colleges and Universities, published in April 2018 by the Ministry of Education, promoted the advancement of intelligent education; explored a new teaching model based on artificial intelligence (AI); rebuilt the teaching process; and utilised AI to monitor the teaching process, analyse learning situations, and diagnose academic level [6]. In recent years, deep learning (DL) neural network, as one of the more important branches in the field of AI technology, has been fully developed, especially in computer vision, machine learning, and other directions, and education is increasingly integrated. The application of DL neural network structure in the field of education shows a trend of rapid growth [7]. Since 2015, various educational applications of AI have emerged, and a number of companies dedicated to empowering education with AI have also emerged. Under the background of the dual promotion of national policies and industry, a number of key technologies of DL neural networks are playing an increasingly important role in the field of education and are gradually being widely used [8].

Under the requirements of the times, the intelligent teaching evaluation mode has become a popular teaching evaluation method that the education community pays attention to. The DL neural network structure is integrated into the evaluation of piano performance education, which can help students obtain a more comprehensive and complete teaching evaluation [9]. This study mainly proposes a convolutional neural network (CNN)-based Musical Instrument Digital Interface (MIDI) piano performance education evaluation method based on the DL neural network structure. The evaluation grades are divided into five grades: excellent, good, medium, poor, and poor to help music teachers understand students' mastery. This study aims to provide important technical support for alleviating the inadequacy of piano coaches and reducing the work amount of piano instructors. Moreover, it can help in realizing automatic error amendment and evaluation of playing objectives and refining the productivity of music teaching for piano. The goal of this study is to offer crucial technical assistance for addressing the shortage of piano teachers, lowering the workload for piano teachers, achieving the objective assessment of piano performance education, and enhancing the effectiveness of piano music instruction. Following is a summary of our work's main contributions:

(I) The deep learning algorithm (DL) and the recurrent neural network (RNN) structure are analyzed;

(II) This study proposes a Musical Instrument Digital Interface (MIDI) piano evaluation scheme that is based on the RNN structure and the Spark computing engine and using the Deeplearning4J DL framework; and

(III) The Spark distributed computing engine realizes parallelization in music data preprocessing, feature extraction, and model training.

The remaining article is organized in the following manner: in section 2, we discuss various methods such as deep learning and neural networks. Besides, forward propagation and back propagation (BP) networks are also discussed. A deep network model construction of Piano performance evaluation based on RNN method is discussed and proposed in subsequent section 3. Discussion over the dataset is also included. Experimental outcomes and discussion are illustrated in section 4. Finally, we summarize the findings of our study in section 5 and offer ways for further research.

2. Methods

2.1. The DL Neural Network Analysis. Geoffrey Hinton first proposed DL in Science magazine, and it was studied by later generations and gradually emerged. The DL is an extension of the original basis of machine learning [10]. Compared with the machine learning network, the DL network optimizes the hierarchical data of the network structure; therefore, making the overall structure more complex. Furthermore, the internal operation algorithm has also undergone greater progress [11]. The most common algorithms are classified according to common machine learning algorithms and DL algorithms. The classification results are shown in Figure 1(a).

In Figure 1(b), DL learns the inherent laws and representation levels of sample data by analyzing the underlying laws and data structure levels within the sample data and uses the data obtained in the learning process to provide reference explanations for data in other fields [12]. The original research goal of the DL algorithm is to apply it in the field of AI, to help AI so that it can analyze and learn like humans, and to recognize various forms of data. The DL has achieved results in several fields. This should be noted that improving the analytical learning ability of AI through DL helps humans solve many complex data problems [13].

DL is a general term for data research patterns and methods. It is classified according to the specific research content. The classification results show that DL neural networks include (i) CNN is a neural network system based on convolution operation; (ii) deep belief network (DBN) performs pretraining in the form of a multilayer self-encoding neural network and further optimizes the neural network's weights by combining the discriminant information; and (iii) recurrent neural network (RNN) is a self-encoding neural network based on multilayer neurons, including autoencoder and sparse coding [14].

2.2. The RNN Structure Analysis. Currently, RNN is one of three types of neural networks that are most commonly used in the field of artificial intelligence. The characteristic of RNN is that the neurons in the hidden layer can communicate with each other. When the next input information is processed, the previous output information also affects it [15]. This memory capacity is beneficial for time series analysis. Therefore, RNN approach is extensively implemented for natural language processing (NLP), speech synthesis, speech recognition, and other fields of optimization. The structure of the basic RNN is shown in Figure 2.

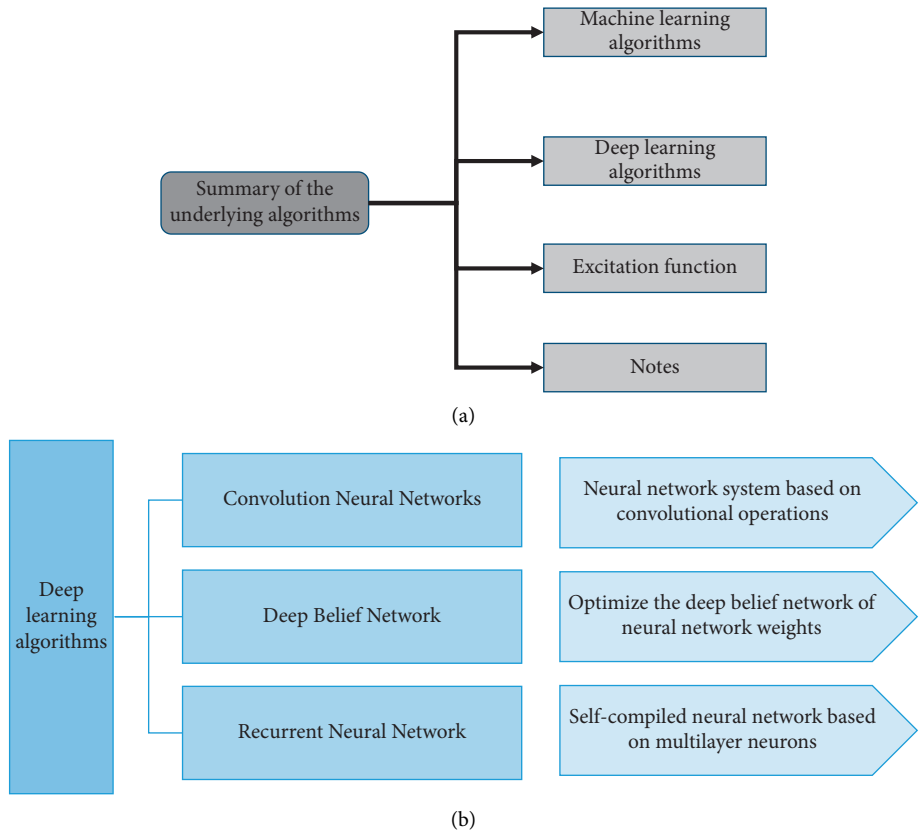


Figure 1: Algorithm classification results. (a) Algorithm basic classification. (b) Research content classification.

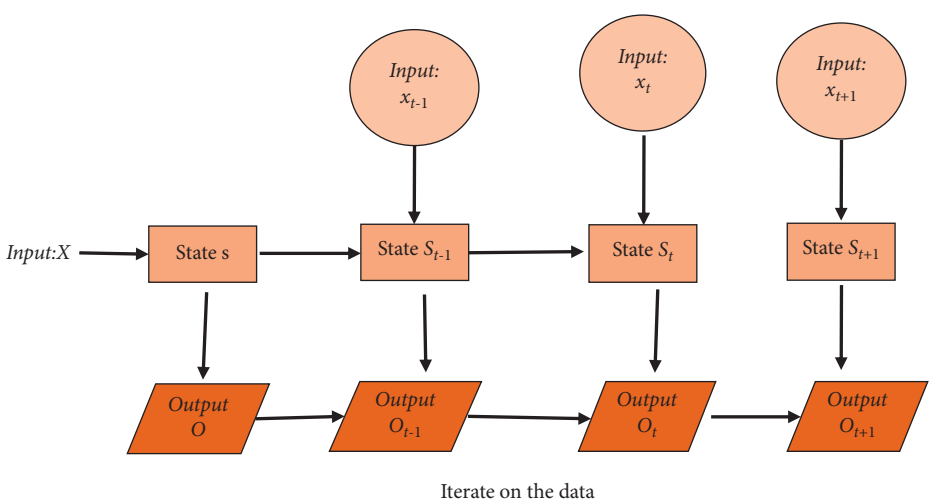


Figure 2: The structure of an RNN model.

In Figure 2, the RNN has an input x_t at every moment. Then, according to the state h_{t-1} of the RNN at the previous moment, the new state is denoted as h_t, and the output is denoted as O_t. The current state h_t of the RNN is jointly determined according to the state h_{t-1} at the previous moment and the current input x_t. At time t, the state h_{t-1} condenses the information of the previous sequence as a reference for the output. Since the length of the sequence can be extended indefinitely, however, the h state with a restricted dimension cannot store all statistics of the sequence. For that reason, the model needs to essentially learn and to retain only the utmost significant facts and statistics relevant to the subsequent jobs [16].

At time t, the expression of the output value O_t is shown as follows:

$$O_t = g(Vs_t). \tag{1}$$

In the above equation, g characterises the activation function, V represents the weight, and s_t symbolises the sum of the weights at time t.

The weight and s_t expression at time t is shown as follows:

$$s_t = f\left(Ux_t + Ws_{t-1}\right). \tag{2}$$

In the above equation, f symbolises the activation function, U represents the weight, W characterises the state transition weight matrix from the before the next moment, x_t represents the input at time t, s_{t-1} represents the weighted sum at time $t-1$. (2) is substituted into (1) to obtain the O_t expansion. RNN has a strong memory function for sequence information. The expansion is shownas follows:

$$O_t = Vf\left(Ux_t + Wf\left(Ux_{t-1} + Wf\left(Ux_{t-2} + Wf\left(Ux_{t-3} + \ldots\right)\right)\right)\right). \tag{3}$$

2.3. Forward Propagation Algorithm. The forward propagation algorithm, that is, the algorithm that realizes the function of data propagation along the forward direction, calculates the parameters of the forward propagation algorithm [17]. At time t, the hidden state s_t is shownas follows:

$$s_t = \sigma\left(Ux_t + Ws_{t-1} + b\right), \tag{4}$$

where σ represents the activation function, generally marked as tanh; and b represents the bias.

At time t, the output O_t is shown as follows:

$$O_t = Vs_t + c, \tag{5}$$

where c stands for bias.

At time t, the predicted output $\overline{y_t}$ is given by:

$$\overline{y_t} = \sigma\left(o_t\right). \tag{6}$$

At time t, the hidden state h_t is shownas follows:

$$h_t = f\left(s^{t-1}, x_t, \theta\right), \tag{7}$$

where s is the internal state, f is the excitation function, and θ is the weight coefficient inside the recurrent unit.

2.4. Backpropagation Algorithm. The RNN forward propagation algorithm is used as the basis, and the RNN backpropagation algorithm is calculated. The process of the RNN backpropagation algorithm is to calculate the gradient of each parameter of the model, that is, the gradients of U, W, V, b, and c through the transferred property of the gradient descent error [18]. The loss function is set to the cross-entropy loss function L, the output activation function is the softmax function, and the activation in the hidden layer is the tanh function.

The total loss function is shown as follows:

$$L = \sum_{t=1}^{T} L_t. \tag{8}$$

The gradients of V and c are given by the following equations, respectively:

$$\frac{\partial L}{\partial c} = \sum_{t=1}^{T} \frac{\partial L_t}{\partial L} = \sum_{t=1}^{T} \overline{y_t} - y_t, \tag{9}$$

$$\frac{\partial L}{\partial V} = \sum_{t=1}^{T} \frac{\partial L_t}{\partial V} = \sum_{t=1}^{T} \overline{y_t} - y_t\left(s_t\right)^T. \tag{10}$$

2.5. The Basic Framework of Spark. Spark is a fast, general-purpose, and scalable big data analysis computing engine based on memory. The following are the major features of the Spark framework.

(1) Rapidity: Spark supports memory-based computing, which can effectively save Input/Output (IO) resources compared to MapReduce's disk-based computing engine. In iterative operations, it runs nearly 100 times faster than MapReduce. Even, Spark is still nearly ten times faster than MapReduce on disk-based computing due to the superiority of Scala code for the functional language.

(2) Versatility: Spark provides standardized solutions to reduce enterprise development costs.

(3) Scalability: In addition to its own resource scheduler, Spark can replace Hadoop's Yarn or Mesos resource scheduler and can process all data supported by Hadoop [19]. The internal module structure of Spark is shown in Figure 3.

Figure 3: The Spark module is based on Spark Core. The Spark Structured Query Language (SQL) is built. Moreover, Spark Streaming, Mlib, Spark Gragh, and Spark SQL are mainly used for the interactive query. The Spark Streaming is mainly used for stream computing. The Mlib is used for machine learning and the Spark Gragh is a graph computing library.

2.5.1. Deeplearning4J Framework. The Deeplearning4J is a DL framework, open-sourced, and maintained by the Skymind. The Deeplearning4j is based on features developed by the Java Virtual Machine (JVM). Deeplearning4J natively supports distributed model training and making distributed modelling possible based on the theory of data parallelism. At present, the solutions for distributed modelling of deep neural networks are mainly divided into (i) model and (ii) data parallelization. The model parallelization can perform hierarchical training on multilayer neural networks; that is, the parameters of some network layers are concentrated on one node of the cluster for training. The update of parameters between each node is scheduled through the scheduler. The data parallelization saves a copy of the network model on each compute node and trains its own batch of data separately. Then, the global network parameters are updated according to a synchronous or asynchronous mechanism [20]. Deeplearning4J mainly uses data parallelization solutions. Currently, Deeplearning4J

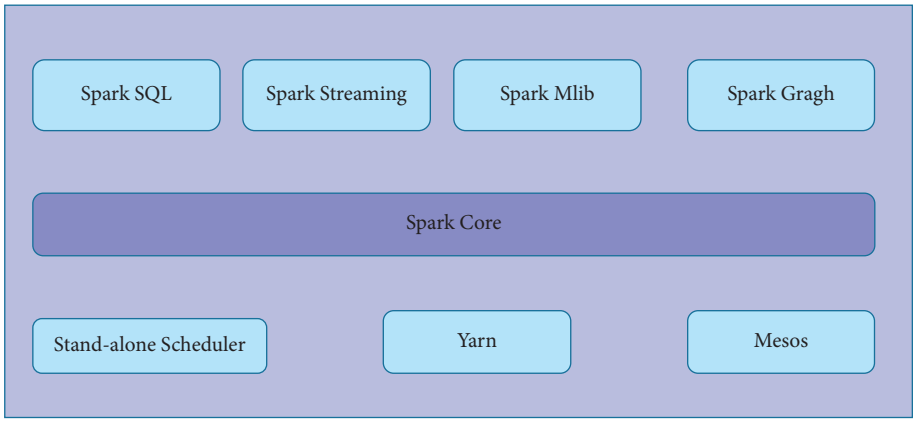


Figure 3: Structure of Spark's built-in modules.

supports two data parallelization strategies: a parameter synchronous averaging and a decentralized gradient sharing scheme [21]. The principle of data parallelization is shown in Figure 4.

In Figure 4, the principle of parameter synchronization and averaging is to define a parameter server, for instance, Parameter Server in the Driver. This example uses a weighted average algorithm to calculate the updated model parameters after collecting training parameters from multiple nodes. Then, the updated parameters are made into broadcast parameters and passed to each node [22]. The principle of decentralization is that multiple nodes are connected in pairs and can update parameters with each other. In order to solve the bottleneck problem in network transmission, the decentralized gradient sharing scheme defines a threshold for each gradient change. The gradient parameters can only be updated when a certain gradient change is greater than the threshold.

3. Model Construction of Piano Performance Evaluation Based on RNN

This study adopts the Deeplearning4J DL framework that trains and runs on the Spark-Yarn run mode cluster and Deeplearning4J cluster. The User Interface (UI) provided by the Deeplearning4J is used to monitor the training effect in real time and adjust the model parameters at any time. Additionally, the RNN model with attention mechanism can achieve efficient and accurate Musical Instrument Digital Interface (MIDI) piano performance evaluation. The framework of the evaluation model is shown in Figure 5.

In Figure 5, in the data acquisition module, the Sqoop tool is used to migrate data to the Hadoop Distributed File System (HDFS). In the data preprocessing module, raw data that are not suitable for training are filtered. The raw data are transformed into an input matrix form that is suitable for the RNN model training. The dataset is divided into training, validation, and test datasets. In the music evaluation classification module, the Spark-Yarn cluster is built. On the distributed framework, the RNN model is built. The preprocessed data are fed into the model training. The model parameters are adjusted in real time through the UI provided by Deeplearning4J, and the model parameters with better evaluation effects are obtained [23].

3.1. Data Preprocessing. Before training the model, the MIDI music data are predesigned. Timestamps in track chunks are unified to 1/16th notes, efficiently handling tedious preprocessing. The preprocessing content includes filtering music data synthesized by multitrack and MIDI software, extracting feature vectors, and designing a more reasonable model input format. There are two main types of characteristics of music. The first category is physical characteristics, including pitch and timbre. The second category is time-domain features, including short-term energy, short-term average zero-crossing rate, and short-term average amplitude. Since the MIDI music is digital music, the MIDI format can completely record the required physical characteristics, which is difficult to obtain compared to the time-domain characteristics [24]. Therefore, physical features are selected as the feature research direction. Because the timbre is only related to playing the instrument, the model only evaluates the piano music, so the timbre can directly get the default value. The ordinate of the input feature matrix is set as the time series; the abscissa is set as the key information; the matrix elements are set as the pitch information. Since the piano keyboard has 88 keys, the dimension of the abscissa is 88. The ordinate dimension is determined by the playing time of the music.

3.2. MIDI-based Piano Evaluation Neural Network Model. After obtaining a piece of piano playing audio, firstly, a data preprocessing algorithm is used to obtain the start and endpoints of each note. At this time, the time value information of the musical note is also determined. The functional requirement of this model module is to evaluate multiple pieces of MIDI music with high accuracy. The evaluation results are divided into five grades: excellent, good, medium, poor, and poor. This study uses the RNN structure and attention layer in DL for classification by *softmax* function. The complete model structure design is shown in Figure 6:

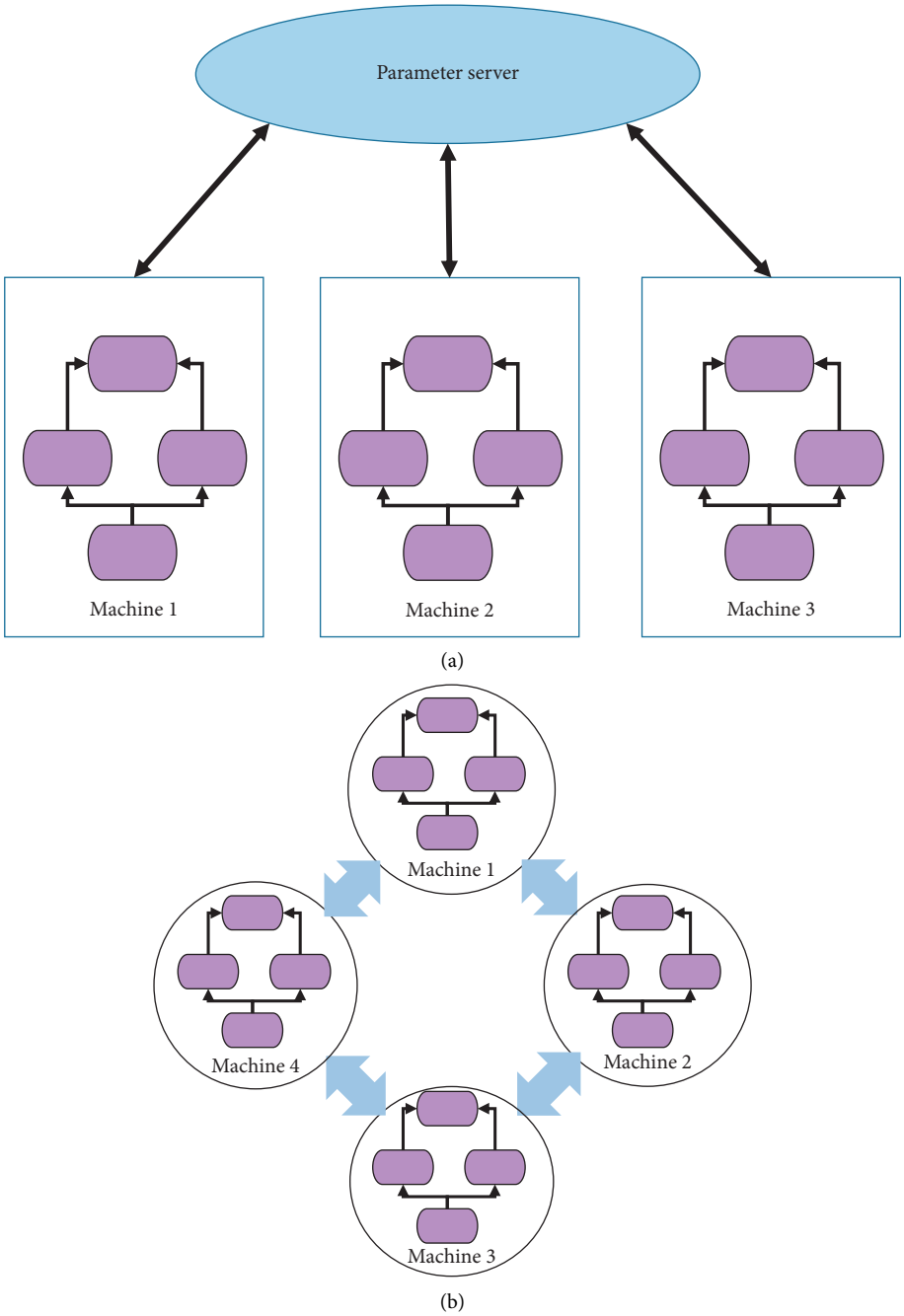


Figure 4: Principle of data parallelization; (a) principle of parameter synchronous averaging scheme; (b) principle of decentralized gradient sharing scheme.

In Figure 6, multiple subnet models are designed to realize the function of evaluating multiple pieces of piano music. Each subnet model needs to be trained separately. Multiple subnetwork models are evaluated separately for specific piano music. The evaluation subnet model obtains a feature matrix by training sample repertoires with differences in level. Then, a classification algorithm is used for evaluation. The main structures of the evaluation subnet model are input, bidirectional LSTM, attention mechanism, and output layer [25]. The input layer receives the difference sample repertoire, obtains the input feature matrix through data preprocessing, and then inputs it into the RNN structure. After the sample passes through the attention mechanism layer, the evaluation is obtained through the *softmax* function of the output layer.

3.3. Analytical Methods of Experiments

3.3.1. Data Acquisition. The data of this experiment mainly come from two parts. In fact, part of it comes from the database provided by five piano training courses in Guangxi, and the other part comes from the MIDI Show web page. The

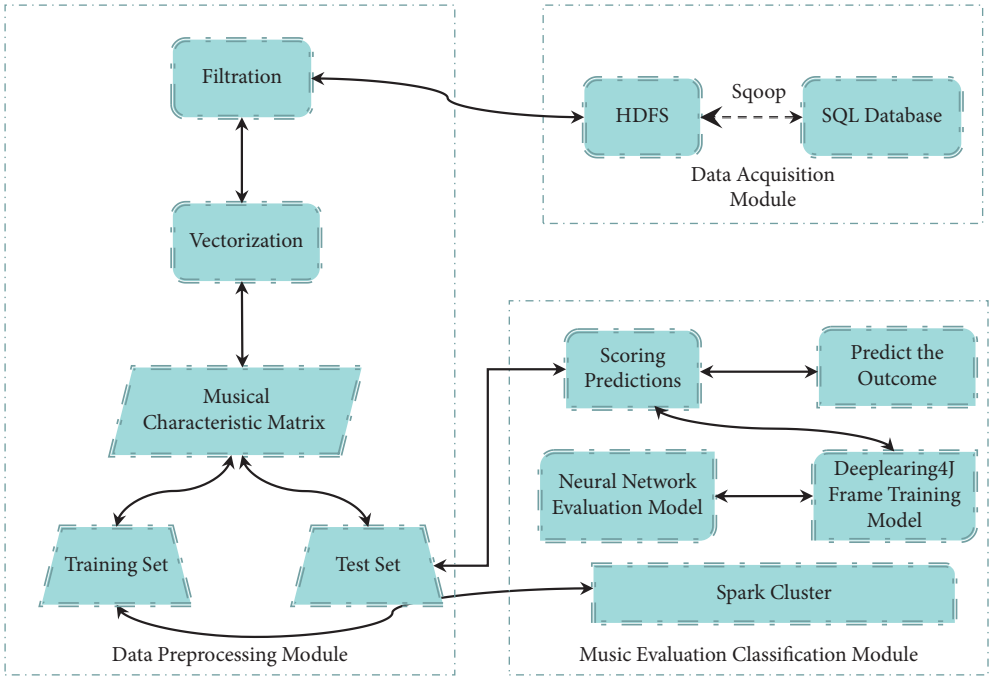


Figure 5: Framework of the piano evaluation model.

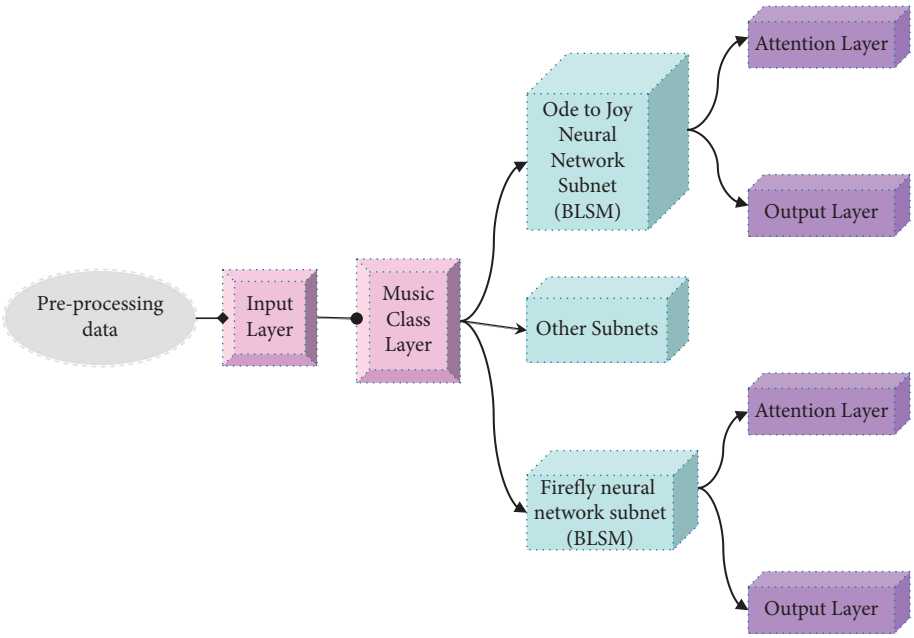


Figure 6: The structure of the piano neural network model.

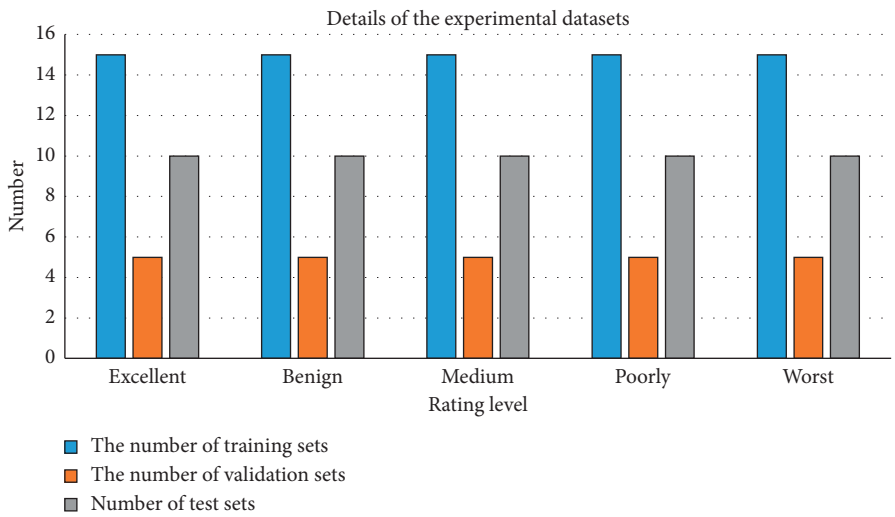


Figure 7: Details of the experimental datasets.

MIDI enthusiasts upload their works on this platform and score them. The scores are divided into five intervals, which correspond to the five evaluation levels of the system. In order to facilitate the implementation and analysis of the evaluation model, this study only selects piano music in 4/4 time [26]. The details of the experimental dataset are shown in Figure 7.

In Figure 7, 30 piano pieces are selected for each evaluation level, for a total of 150 pieces. For each evaluation level, 15 songs are selected as the training set, 5 as the validation set, and 10 as the test set.

In databases, the quality of music data is uneven. Neural network models cannot recognize raw data. Data are preprocessed. Preprocessing is divided into two Figure 8 steps:

(1) Music files synthesized by MIDI software are filtered. The filtering process is shown in Figure 8; this should be kept in mind that when the number of pitch values in the experimental dataset is less than 40 or the number of pitch values is greater 80 while is less than 20, then in that cases the MIDI music is filtered out.

(2) The filtered data are vectorized; that is, the data in the form of MIDI are converted into an input matrix that the RNN structure can read.

3.3.2. Analysis of RNN Parameters. The choice of the number of layers of the RNN structure and the corresponding number of nodes will directly affect the reliability and accuracy of the model. A reasonable number of layers of the RNN structure and the corresponding number of nodes are given so that the model is optimal, and the prediction error is minimized [27]. The value of the loss function L for different layers and different nodes of the RNN is analyzed separately, as shown in Figure 9.

In Figure 9, when the RNN structure is a single layer, the more node values, the smaller the L value. After the node value is greater than 352, the rate of decrease of the value slows down. The RNN structure is a double layer; the more node values, the smaller the L value. After the node value is greater than 176, the rate of decrease of the value slows down. When the RNN structure is three layers, the changing trend of node value and L value is not obvious. Therefore, a three-layer RNN structure is chosen [28]. Additionally, the number of nodes per layer is set to 352, 176, and 88.

3.3.3. The RNN Training. The mean square error (MSE) is used to assess the performance of the proposed RNN model. After the input of the parameters affecting the piano performance, education evaluation and the parameters and structure of the RNN are determined. Subsequently, the neural network is trained to attain the anticipated needs for precisions and accuracy. First, the standard information of each characteristic is obtained by playing and MIDI file by the piano teacher. Then, through different levels of piano performance, input features are extracted. The training method of RNN is mainly to obtain training samples by playing the *Minuet* piano piece several times by two piano teachers and three students. The input data to the RNN are derived for each play [29, 30]. The overall rhythmic feeling and level of playing expression are then assessed separately. The supplied data's range is 0–1. For this training, 10 samples were gathered. The parameters are as follows: learning rate of 0.76, momentum factor of 0.4, and error of 0.1.

4. Simulation Results

4.1. Analysis of the RNN Training Results. The RNN structure model is trained as shown in Figure 10.

In Figure 10, with the increase of training times of RNN, the resulting error value gradually decreases. After training 3000 times, the error value of the RNN structure is basically fitted with the standard error value, reaching the network convergence accuracy. Additionally, the correlation coefficient between the output of the RNN structure network and the target

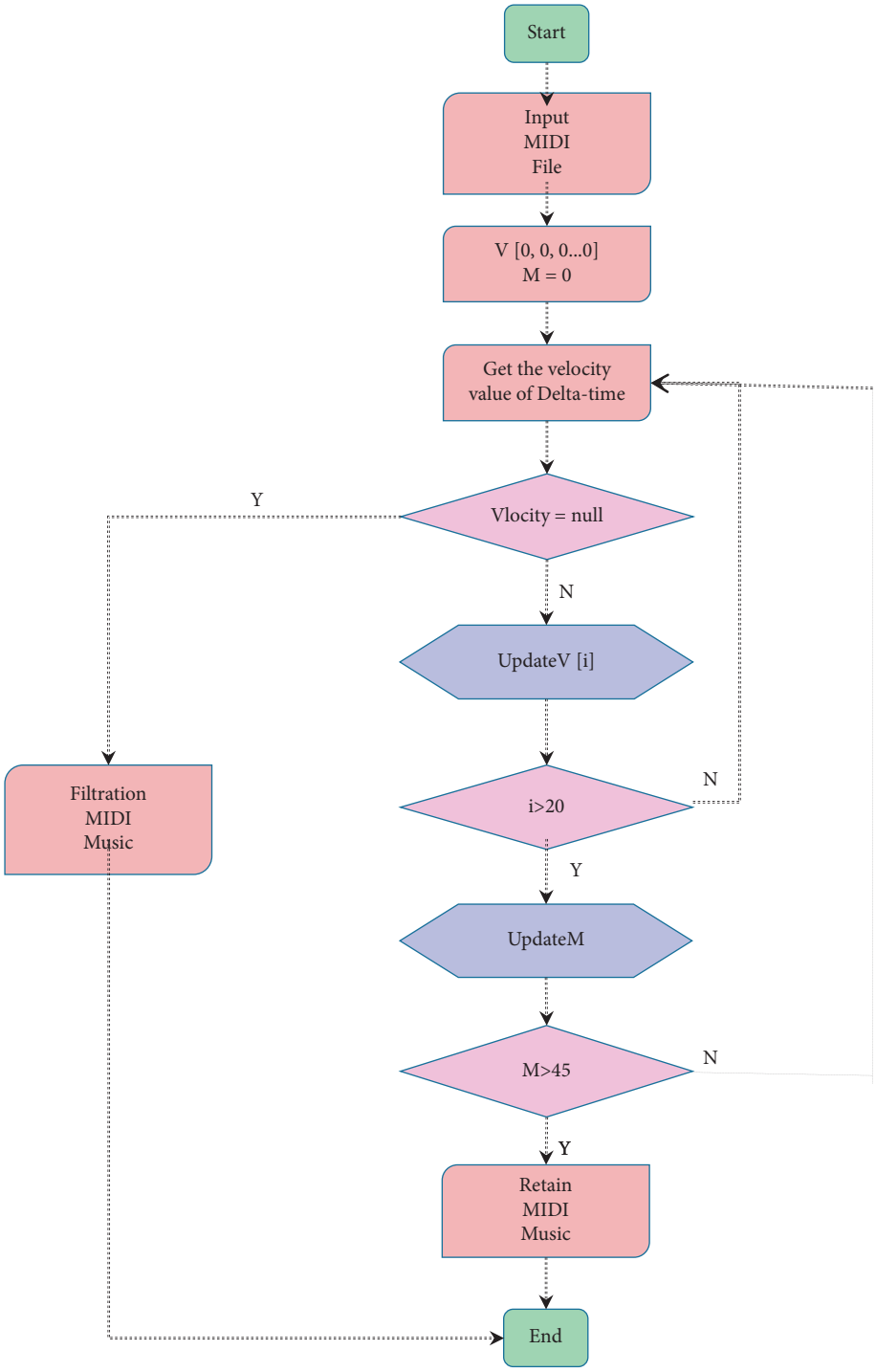


Figure 8: The data filtering process.

is as high as 0.99947, showing a high degree of fit. The designed RNN performance can meet the actual requirements.

The designed teaching evaluation model is used to evaluate the piano teacher, student A (piano level 6 level) and B (piano level 5 level), and the evaluation results are shown in Figure 11.

In Figure 11, the average value of the overall evaluation of the piano teachers is 0.92, the average value of the

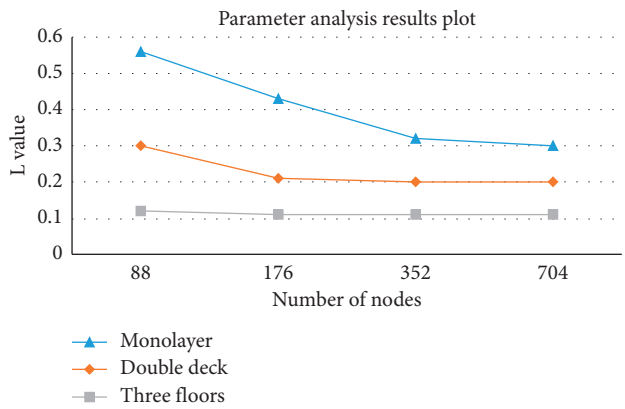
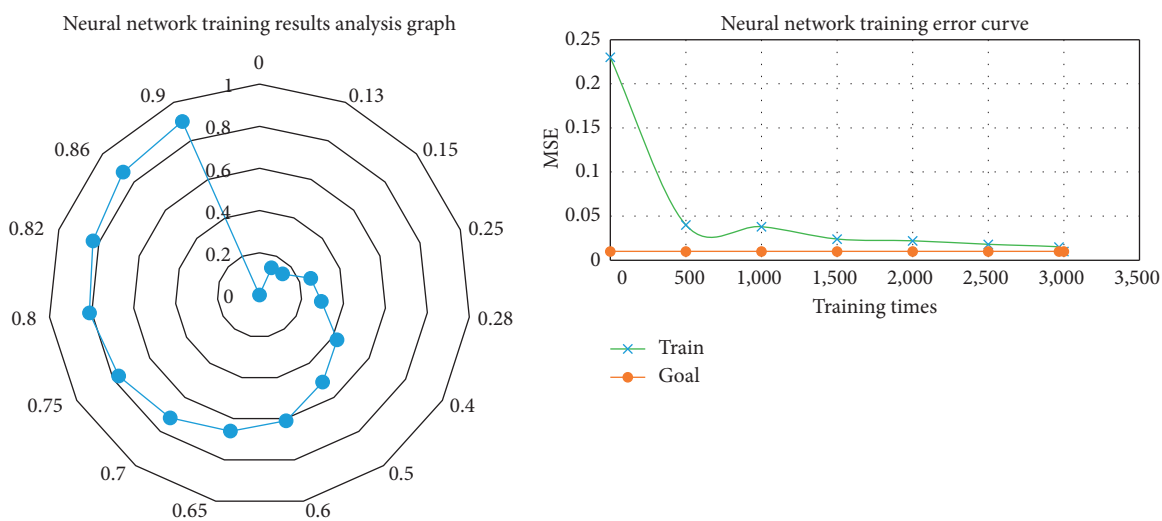
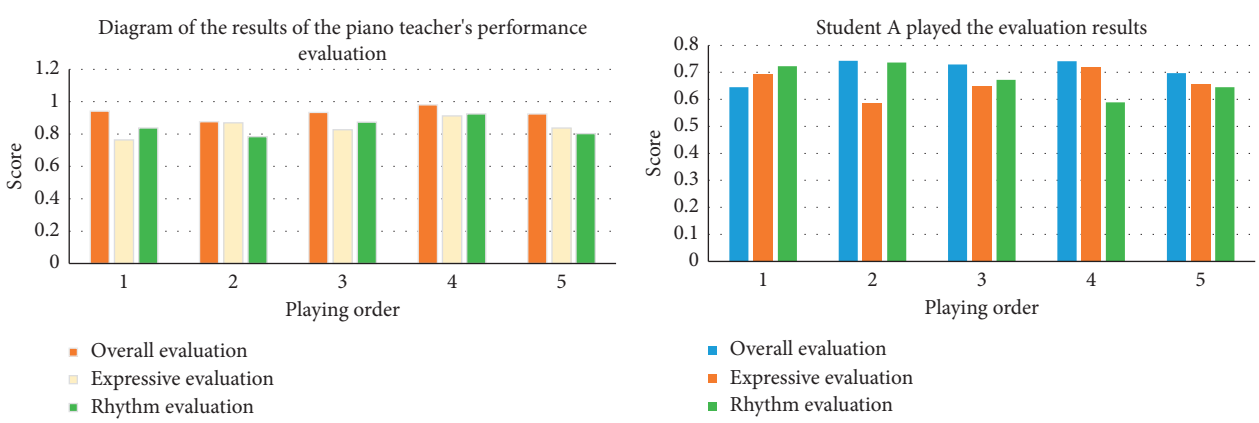


Figure 9: Results of parametric analysis.



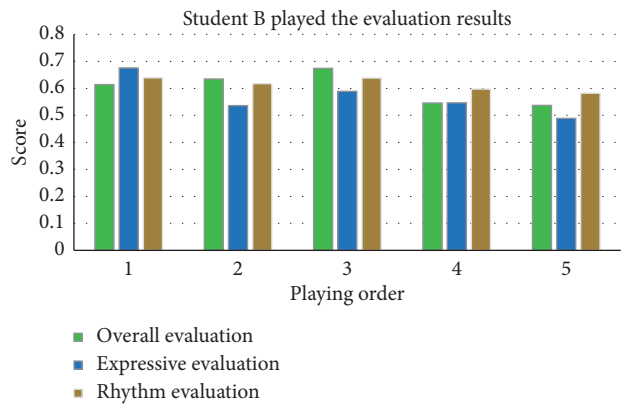
(a) (b)

Figure 10: RNN training results; (a) analysis of MSE training results; (b) the error curve of neural network training.



(a) (b)

Figure 11: Continued.



(c)

Figure 11: Model evaluation results; (a) results of piano teacher performance evaluation; (b) student A performance evaluation results; (c) student B performance evaluation results.

performance evaluation is 0.83, and the average value of the rhythm evaluation is 0.82. Student A's evaluation averages are 0.71, 0.65, and 0.67. Student B's averages are 0.6, 0.59, and 0.57, respectively. The piano instructor, student A, and student B are the evaluation values provided by the model, which are generally consistent with the actual level of the performers. The data evidence that the proposed model's results can encounter the necessities and can be applied to the evaluation of piano performance education.

5. Conclusions and Future Work

The proposed RNN-based MIDI piano performance education evaluation method makes up for the shortcomings of the rule-based evaluation method, which cannot consider the coherence and expressiveness of music. First, raw data are selected from the MIDI database and the educational data of a local piano training institution. Then, the raw data are preprocessed. Next, the three-layer bidirectional LSTM neural network and the attention mechanism make it easier for the model to capture useful information. Additionally, the Spark cluster is built using the Deeplearning4J DL framework to train the model. The work efficiency is improved by adjusting model parameters through UI dependencies provided by Deeplearning4J. Additionally, the RNN parameters are analyzed. The results show that the error value of the three-layer RNN structure is smaller. Local piano training institutions and MIDI website data are used as a basis. Experimental samples are collected. These samples are used to train the neural network and to test the performance of the evaluation model. The findings demonstrate that (1) the evaluation outcomes of the developed piano performance evaluation model are largely consistent with the actual skill level of the players and have some degree of viability; and (2) after 3000 training cycles, the RNN error is close to 0.01, and the network converges. The disadvantage is that the research stays at the theoretical level.

In order to test a large amount of data, the DL network is developmental, and it is necessary to update the evaluation model according to the latest development. The purpose is to provide important technical support to improve the efficiency of piano music teaching. Similarly, deep neural networks and the impacts of the model activation functions should be analyzed in subsequent research efforts. The Spark framework runs the deep learning algorithms in parallel; however, the computational time is still limited on a single online system. Therefore, big data technologies such as cloud and edge computing should be used to improve the training efficiency in terms of computational times.

Data Availability

The experimental data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding this work.

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Research Article

Study on the Distance Learners' Academic Emotions Using Online Learning Behavior Data

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In recent years, computer vision, artificial intelligence, machine learning, and other high-tech technologies have advanced rapidly. These strategies lay a new technical foundation for online learning and intelligent education by making it easier to promote the scientific, intelligent, and data-driven growth of learners' academic emotions. However, at present, online learning can better make up for the shortcomings of traditional learning and enable people to realize distance learning. However, as an important indicator, learners' learning emotion has a direct impact on learners' learning quality and effect. Therefore, this paper analyzes distance learners' academic emotions based on online learning behavior data. It extracts online learning behavior data by using a deep learning algorithm and multimodal weighted feature fusion based on DS (Dempster-Shafer) evidence theory, establishing distance learners' academic cognition motivation model, and constructs an online learning emotion measurement framework. Finally, it is determined through a correlation study of distance learners' academic emotions and learning impacts those learners' academic emotions in class. It will have a beneficial influence on learning since learners' academic emotion is favorably connected with instructors' emotion, and learners' addition, deletion, and modification behavior is positively correlated with learners' academic emotion.

1. Introduction

With the continuous reform of the educational concept, the problems of traditional classroom education have become increasingly prominent. In traditional classroom teaching, teachers and students communicate with each other in a variety of ways, such as students' facial expressions, body language, and answering questions in class. The online learning behavior of distance education learners needs to use technical means to capture sound, text, images, and other information, to realize indirect emotional communication with learners, thus increasing the difficulty of distance learners' academic emotion analysis [1]. Academic emotion is a major factor influencing the effect of online learning. Emotion permeates all aspects of people's life and works, showing the effects of perception and motivation, which can promote or inhibit people's learning motivation [2].

Chinese academic institutions have changed the education of big classes and in-person training in classrooms with insufficient ventilation to comply with the National Epidemic Control Center's requirements on social distance. These innovations have included teachers transitioning from traditional classrooms to online schools using computerized learning management systems, as well as providing synchronous instruction via distant courses. Yet, synchronous education has been criticized for its instructor-centric models, which prioritize educators above pupils [3]. As a result, several learners who were quarantined or unable to visit China during the COVID-19 epidemic preferred the small private courses online and massive online class's initially public and private colleges as means of distance learning. The MOE has established a statewide online learning framework that covers all educational sectors, especially higher education, to address the COVID-19

epidemic without interrupting lectures. This platform supports a collection of online educational programs and materials available throughout all systems for usage by all institutions [4]. The abovementioned system collaborates with telecommunication companies to provide special offers on online services, including free 4 G SIM cards and some other pupil discounted rates, to financially deprived students or students for whom the school systems have been stopped and are now attending courses online at home.

The idea of behavioral psychology states that analysis of behavioral data can provide information about students' psychodynamics and observable behaviors [5]. LMSs provide the ability to record a child's online operating habits, which are saved as part of a student record. To monitor a learner's learning behaviors, teachers might mine the student's biography for data. The operating actions of learners when participating in online learning are termed learning behaviors [6] and can indicate either explorative learning behavior or learning involvement behaviors. Various LMSs offer multiple data gathering limitations; therefore online operational behaviors vary. Investigators can collect recordings of various online operational activities to extrapolate information that is not readily visible in raw data. When a student clicks on a certain function in the LMS, the record and timing of that activity are saved in the database as part of the student biography. When appropriately evaluated, such online operational behaviors might mirror students' online learning practices. The majority of online learning activities are estimated using frequency and duration. These include the total frequency with which a class was accessible, the total time with which an instructional video was accessed, and the total amount of posts generated in online conversation [7, 8]. After researchers collect these online learning behaviors, data cleaning must be performed to avoid bias caused by aberrant outcomes, and the efficiency of the behavioral data collecting must be evaluated. This is done to mitigate the impact of determined online operational actions induced by user competition. This means that researchers must gather data about online learning behaviors properly to avoid things for which pupils are prone to be affected by the score, i.e., items from which students might gain higher scores by selecting more regularly or spending more time.

Based on the above, this research work focuses on the emotional problems of distance learners under the online learning behavior data. By collecting, identifying, and analyzing various emotional data formed by online learners, we can master the emotions of distance learners and mine the resources and values in educational data. In addition, we can establish an online learner emotion measurement model, which is conducive to better grasping the academic emotions of distance learners [9].

The main innovations in the research process of this paper are as follows: (1) this paper uses a deep learning algorithm to build a perception model and uses multimodal weighted feature fusion based on DS evidence theory to collect and analyze students' academic emotions [10]. (2) Summarize the connotation and different classifications of academic emotion, establish the academic cognition motivation model of distance learners, strengthen the learning effect and influence, and build the online learning emotion measurement framework [11].

The following sections are organized in the research process of this paper: Section 2 discusses the contributions of national and international researchers. Section 3 explains the material and approach for online learning behavior based on deep learning. Section 4 will give an analysis of the academic emotions of distant learners. Section 5 discusses in depth the results and simulation of distant learners' academic emotion analysis. Finally, this study is completed in areas such as Section 6.

2. Related Work

At present, scholars at home and abroad focus on the academic emotion analysis of distance learners and have achieved remarkable research results [12]. The work of [13] studied the influence of screen time on emotion regulation and student performance, studied the use of smartphones and tablets by more than 400 children in a four-year cycle, analyzed the relationship between these behaviors and emotion and academic performance, and evaluated students' ability and academic performance. Similar to the above scholar, the work of [14] studied the influence of early childhood emotion on academic preparation and social-emotional problems. Emotion regulation is the process of regulating emotional arousal and expression, which directly affects whether children can better adapt to the school environment. In this connection, the researcher of [15] introduced the connectionist learning theory to establish a new learning model of distance education and proposed the teaching content based on the emotional education objectives. They used the Mu class teaching mode to build a distance learning community, humanized network courses, and other new teaching modes for the problem of emotional deficiency in the stage of distance education. For effectiveness, the scholar of [16] builds a hybrid reality virtual intelligent classroom system. The system makes full use of television broadcasting technology and interactive space technology to form a network teaching environment. Teachers employ video, audio, text, and other techniques to realize contact between teachers and students and to increase communication between teachers and students in the network teaching stage.

Besides the above scholars, the early work of [17] proposed a sift emotion recognition algorithm based on facial expression scale invariant feature transformation. Based on emotion theory, this algorithm captures the facial expression of distance learners according to facial expression to realize SIFT feature extraction, recognize the expression of distance learners, and better compensate for the lack of emotion in the learning stage of distance learners, while the researcher of [18] established a learner emotion prediction model for an intelligent learning environment based on the fuzzy cognitive map. They used the model to extract and predict the learning emotion of distance learners, which is convenient for the teaching system to adjust the teaching scheme in real time according to the predicted emotion. The work of [19]

developed the distance learner emotion self-assessment scale, which can define the basic emotion variables of distance learners and complete the design and establishment of the distance learner emotion early warning model. Finally, based on the regression model, the work of [20] analyzed the online academic emotion of adults, analyzed various factors affecting it, and studied the environmental factor model of online learning community related to academic emotion tendency in an online learning community. Inspired by the contributions and findings of the aforementioned scholars, we attempt to study distance learners' academic emotions using online learning behavior data and obtain significant results.

3. Material and Methodology for Online Learning Behavior Based on Deep Learning

3.1. Online Learning Behaviors and Its Features. Online learning behavior refers to learning behaviors that occur in a network setting. We concentrate on extracting learner features from online learning behavior following analysis to comprehend the quality of teaching and learning. The functioning of online learning behaviors lies at the heart of learning behavior [21]. The features of online learning behavior can be explained in Figure 1.

3.1.1. Style of Learning. Style of learning is the characteristic of a person of learners when studying and trying to solve their academic tasks, which influences learners' cognitive load. As per the Felder-Silvermande study habit concept, we may examine learners' learning styles using the 4 aspects of information process, information interpretation, information intake, and information comprehending [22].

(1) Processing of Information. Students studying the processing of information are quite interested in the material on the online learning system, and they are responsive to the opinions made by the other online learners and the comments from professors in the course materials instructional video on the learning system. Motivated students obtain information by constantly doing much to share or explain concepts to others, and they like cooperation, whereas reflective learners prefer learning via deep concentration, either alone or with a daily study partner.

(2) Awareness of Information. Learners of information are supported and are habituated to comprehending information by individual interpretation, and they choose conceptual and fascinating learning content. They are particularly interested in video learning on the learning system, extensive learning materials, and student communication. Insightful students enjoy studying information and great attention to detail. However, they frequently avoid complicated topics, whereas perceptive students enjoy studying theoretical knowledge and have the guts to learn complex subjects but they are careless in their gaining.

(3) Input of Information. Learners of this system of learning are clever or responsive and are used to learning from the contributions of others. This sort of learner is more interested in reading or watching videos. Visual students, for example, are exceptional at recalling what they see, such as video pictures, but on either side, auditory learners have a strong memory for what they listen to or read.

(4) Understanding of Information. This type of learner often analyzes and comprehends knowledge on their own, which is expressed in studying to meet their requirements. Stepwise learning and knowledge acquisition in predetermined logical order are characteristics of orderly learners. While comprehensive learners want to think globally, their thought is more varied and leaping.

3.1.2. References of Learning. Various types of students have different learning preferences, which influence students' success in the online learning system. The preferences of students reflect their requirements. Main input learning preferences, including audiovisual and verbal learning, are reasonably straightforward to accommodate, and existing online training systems may be incorporated. Intermediate preference is mostly for communication activities between persons and others, such as student inquiries, instructor responses, and contact between online learners. Enhanced preference is the process of autonomous creativity that occurs after pupils integrate knowledge, such as spreading information individually.

3.1.3. Interactive Learning. Human-computer interaction and human-human interaction are the two types of interactions that take place throughout the online learning procedure. Registration, browsing, downloads, and other actions that proactively obtain platform resources are the most common human-computer interface behaviors. Person-to-person interaction mostly refers to learner publishing and answering data in BBS, which can construct a learning interaction network graph. The geographic closeness in the network may be computed based on the size of learner nodes to determine the interaction scenario and learning law of the learner, as well as the connection with other learners [23]. Learners' engagement and engagement depth can be utilized as markers to measure interactive behavior.

3.2. Data Acquisition of Online Learning Behavior Data. The data created by the interaction among students and the platforms throughout the process of learning is primarily recorded in real time by the system database and other technologies. Learning partners may gain a more complete understanding of the study processes and realize empirical forecasting, assessment, and management of the learning experience by evaluating online learning behavior data. On the other hand, the foundation of learning evaluation is the collecting of behavioral data. It may be split into server-side and client-side methods based on variations in data capture targets and rules, whereas sources of data can be classified into wireless connections, PC connectors, and client connectors based on terminal viewpoints. Multiterminal and all-aspect data collecting approaches can help in understanding learners' learning features. Figure 2 depicts the online learning behavioral data gathering architecture [24].

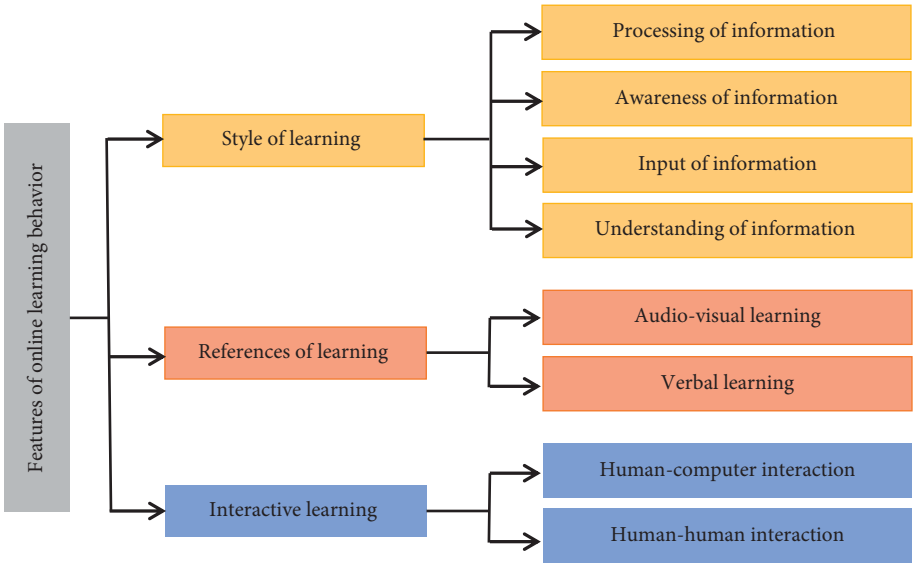

Figure 1: Features of online learning behavior.

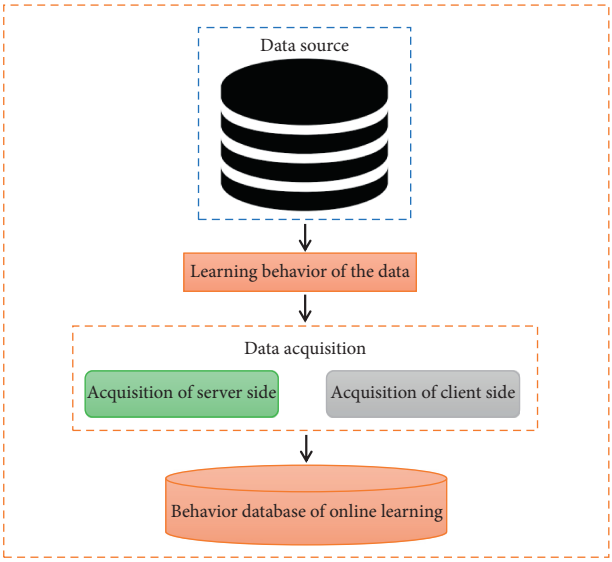

Figure 2: Architecture of online learning behavioral data gathering.

As per the above figure, Web services and Web-logging are two examples of server-side data collecting. A weblog is being used to record data from the learner's real-time operation, such as the user's demand moment, demand type, demand contents, request progress, the client's accessible location, the time of procedure completion, and the browser version used by the clients, among other things. A web application is a method of implementing data collecting using backend programming. Investigators may create the platform component database module based on the kind of learning behavior so that the target material can be gathered based on the demands, and learner behavior collected data could be more complete and adaptable, with a wide variety of services.

Furthermore, client-based collected data involves the collection of data created by learners when they are using the browser to study directly, which mostly employs the Java script Cookies to gather data to conveniently obtain information about the learner's browsing activity. This approach stores learner behavior data in a specified area and gets the data from the information stored as required, allowing for even more adaptable data collecting and recording of caching proxy server usage, as well as more precise tracking of visitor activity.

3.3. Deep Learning. Machine learning is to build statistical models based on data and use models to predict and analyze data. As the main branch of machine learning, deep learning is called "depth," which is a machine learning model compared with the traditional shallow feature learning. The essence of deep learning is to imitate the brain neurons of the human brain. The use of a multilayer neural network structure to simulate the way the human brain processes information is a deep-seated feature learning method. Deep learning can imitate many different data types such as images, texts, sounds, and videos analyzed by the human brain and build an analysis model that imitates the human brain. Its analysis ability is strong.

The learning method adopted by deep learning is similar to the neuron structure of the human brain. Its components include a hidden layer, input layer, and output layer. The nodes of the input layer are used on input data, and the nodes of the output layer are used on model output. The input layer is similar to neurons, the output layer is similar to decision-making neurons, and the weight coefficient is similar to the strength of connecting each neuron. The perceptron model is a basic artificial neural network. The architecture of the perceptron model is seen in Figure 3. To imitate the stimulation process of the human brain, the perceptron model employs the $f(x)$ activation function.

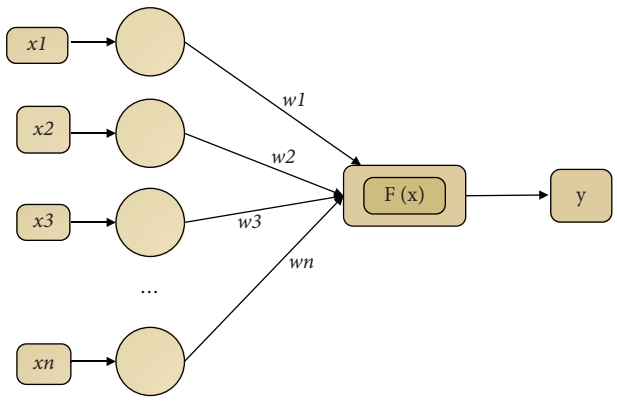

Figure 3: Perceptron model structure diagram.

According to the above, each perceptron is a function whose input is represented by x and which may be obtained by creating a function. Similarly, the output is represented by y as the function is processed. Equation (1) represents the function.

$$x = w_1x_1 + w_2x_2 + \cdots + w_nx_n + b \longrightarrow y = f(x). \quad (1)$$

Deep learning can generate a complex function and automatically learn the input features, so the model accuracy is higher than other learning methods. In Chinese text classification, the deep learning method can realize the automatic extraction of text features, reduce manual intervention problems, significantly improve the accuracy of the learning model, and greatly improve the classification degree. Therefore, using deep learning algorithm in emotion classification is feasible and more efficient [25].

3.4. Multimodal Weighted Feature Fusion Based on DS Evidence Theory. The core of learning emotion is to explain the differences in various model features. For example, human posture features describe the position of human joints from a global perspective, and facial expression features explain the apparent structure of local areas of the image, which are quite beneficial. Following a large number of trials, the accuracy of diverse emotion recognition on different particular characteristics differs, indicating that various aspects differ significantly in the recognition sensitivity of an emotion type [26]. The Dempster-Shafer probability concept, abbreviated as DS theory, is a popular method in the field of multisensor data fusion. It is an imprecise derivative of probability and statistics, and Bayesian thinking may work without previous information and random selection. As a result, this work provides a weighted feature fusion approach based on DS evidence theory that computes the weight vectors of all feature types based on the verification set samples determined by DS evidence theory.

DS evidence theory is mainly used to deal with the problem of multimodal information fusion represented by Θ. The identification framework and the concept of m trust assignment function explain uncertain information. To identify the framework, setting the mapping to [0, 1] represents the trust allocation function of M; if $AA \subseteq \Theta$, then it expresses any subset of the following equation:

$$\begin{cases} m(\varphi) = 0, \\ \sum_{A \subseteq \Theta} m(A) = 1. \end{cases} \quad (2)$$

In the above equation, $m(\varphi) = 0$ indicates that the empty proposition has no trust, and $m(A)$ indicates the trust allocation function of event a. In the light of Θ subset a must meet the requirement of $m(A) > 0$, which is called evidence focal element. The evidence body is represented by $(A, m(A))$ binary body composed of evidence focal elements and basic trust. The combination of multiple evidence bodies is called evidence. If $m_1, m_2, \ldots, m_n$ are the same multiple basic trust allocation functions in Θ, then A_i, $i = 1, 2, \ldots, N$, is the corresponding focal element, and equations (3) and (4) are DS evidence synthesis rules.

$$m(A) = (m_1 \oplus \ldots \oplus m_n) = \frac{1}{1-K} \sum_{\cap Ai=A} \prod_{1 \le i \le n} m_i(A_i),\ A \ne \varphi. \quad (3)$$

$$K = \sum_{\cap Ai=\varphi} \prod_{1 \le i \le n} m_i(A_i). \quad (4)$$

In the above equations, $E1$ and $E2$ represent the evidence under different recognition frameworks in the two synthesized pieces of evidence, while $m1$ and $m2$ are the corresponding mass functions. Similarly, the corresponding focal elements are represented by A_j and B_j, respectively. From simplification of equations (3) and (4), we obtained the following equation:

$$\begin{cases} m(A) = \dfrac{1}{1-K} \sum_{\cap Ai=A} m_1(A_i) m_2(B_j),\ A \ne \varphi, \\ K = \sum_{Ai \cap Bj=\varphi} m_1(A_i) m_2(B_j). \end{cases} \quad (5)$$

In the above equation, $1/1-K$ is the regularization factor. K represents the conflict coefficient between different evidence pieces. If K is larger than or equal to 1, the evidence cannot be synthesized since there is no orthogonal sum between $m1$ and $m2$.

4. Analysis of Distance Learners' Academic Emotion

4.1. Connotation and Classification of Academic Emotion. Academic emotion refers to various emotional responses associated with academic tasks such as learning or teaching. Academic emotion is often classified into two types: negative emotion and positive emotion. It has been determined via extensive study that both negative and positive academic emotions pay little regard to the arousal dimension and that the arousal value also has a direct impact on the complicated behavior of students' learning. Therefore, some scholars add arousal factors to the classification of academic emotions and further divide academic emotions into arousal emotions

with higher positivity than low positivity and arousal emotions with lower negativity and higher negativity.

The emotional types involved in the above four academic emotions are listed in Table 1. The first kind of arousal emotion with high enthusiasm is reflected in hope, happiness, pride, etc., which is formed after positive events, such as teacher encouragement, support, reward, etc. The second kind of arousal emotion with low enthusiasm is reflected by calm, relaxation, satisfaction, and other emotions because the learners' learning environment is stable, and their performance remains stable. The third kind of negative arousal emotion is anxiety, anger, and guilt. The fourth is the low negative arousal emotion, which is manifested as boredom, disappointment, depression, and so on.

4.2. Distance Learners' Academic Cognition Motivation Model. The cognitive effect of academic emotion is reflected in the extraction, preservation, processing, and attention to resources of academic emotion. This paper analyzes the effect of academic emotional motivation from two different perspectives: internal motivation and external motivation. Internal motivation is the motivation of task generation and completion influenced by personal factors. Positive emotions will form positive internal motivation; negative emotions will reduce internal positive motivation and even generate negative internal motivation. Usually, external motivation refers to the motivation that students take to implement a task. Therefore, the emotion related to the results will interfere with the external task motivation, including retrospective emotion and anticipatory emotion. Happiness and hope will form positive external motivation, while personal anxiety will lead to negative motivation. Strong disappointment will enhance learning helplessness and reduce external motivation. Academic emotion will also interfere with the motivation effect and cognitive effect, which will be enhanced by adding this effect. Figure 4 shows the impact model of academic emotion on learning achievement.

4.3. Online Learning Emotion Measurement Framework. Figure 5 shows the proposed system's architecture, which defines the technical, application, and data visualization layers of the developed framework that describe the academic feelings of distant learners. The layers communicate via an interface that allows for the replacement and upgrade of their components as needed. Big data is employed for processing in this case. Data collecting, data processing, and data set analysis application services are the major components of the process. A model for measuring emotions in online learning is developed based on this and other aspects of emotion assessment.

This section can be used to discuss each layer's specifics of the recommended model.

4.3.1. Data Layer. A data layer may transform the data on our model so that it can be used by many tools. It guarantees that a homepage and a label management system communicate. This layer is also used to process, read, and store data. Its primary role is to preprocess data supplied by learners during online learning, such as posture, voice, physiology, and text. The index function is preserved and created into the database during automated clustering based on the appropriate system results, and retrieval and query activities are accomplished using the index.

4.3.2. Technical Layer. The technology layer is used to analyze emotions and collect data. The parts of this layer can be utilized to describe our model's technological architecture, detailing the structure and behavior of our model. The node is the major component of the active structure for this layer. In this layer, the component can be used to represent architectural objects. It precisely represents a system's factors in the form: its behavior is represented by an explicit link to the behavior component. A technical interface is a location where other nodes or software modules from the application layer can utilize the technological services provided by a node. Nodes come in a variety of configurations, incorporating device and system programs. A device represents a physical computing capacity on which objects can be executed. Various technologies are involved in data collection and analysis and diagnosis. Therefore, this system uses a variety of data acquisition technologies such as wearable devices, video surveillance, and web crawlers to record and save the data formed during learners' online learning and transmit it to the data layer. Then the system extracts the information from the data layer and uses text mining, emotion recognition, and other analysis and diagnosis techniques to identify students' academic emotions.

4.3.3. Application Layer. End-user applications such as internet browser programs employ the application layer. It offers protocols that enable software to communicate and collect information while also presenting useful data to consumers. The application layer in our proposed model is responsible for realizing mutual interaction with users, strengthening academic emotional interaction using visualization techniques to feedback data processing results to users, and developing reverse intervention or reinforcement adjustment schemes for learners in conjunction with their actual learning emotions.

5. Results and Simulation of Distance Learners' Academic Emotion Analysis

5.1. Correlation Analysis of Distance Learners' Academic Emotion and Learning Effect. When studying the correlation between distance learners' academic emotions and learning effect, this paper selects 50 students who have published posts on the course and have homework scores for analysis. The average emotional value of students' postings on the course during distance course learning is the learner's emotional value provided to the course, which is considered as the learner's ultimate learning outcome as its learning impact. After completion, Pearson correlation analysis is carried out [27]. Finally, the correlation analysis result

Table 1: Classification and performance of academic emotion.

Academic emotion	Emotional enumeration
Highly motivated arousal emotion	Joy, hope, pride
Low arousal emotion	Relaxed, calm, satisfied
Negative high arousal emotion	Anger, anxiety, guilt
Negative low arousal emotion	Disappointment, boredom, frustration

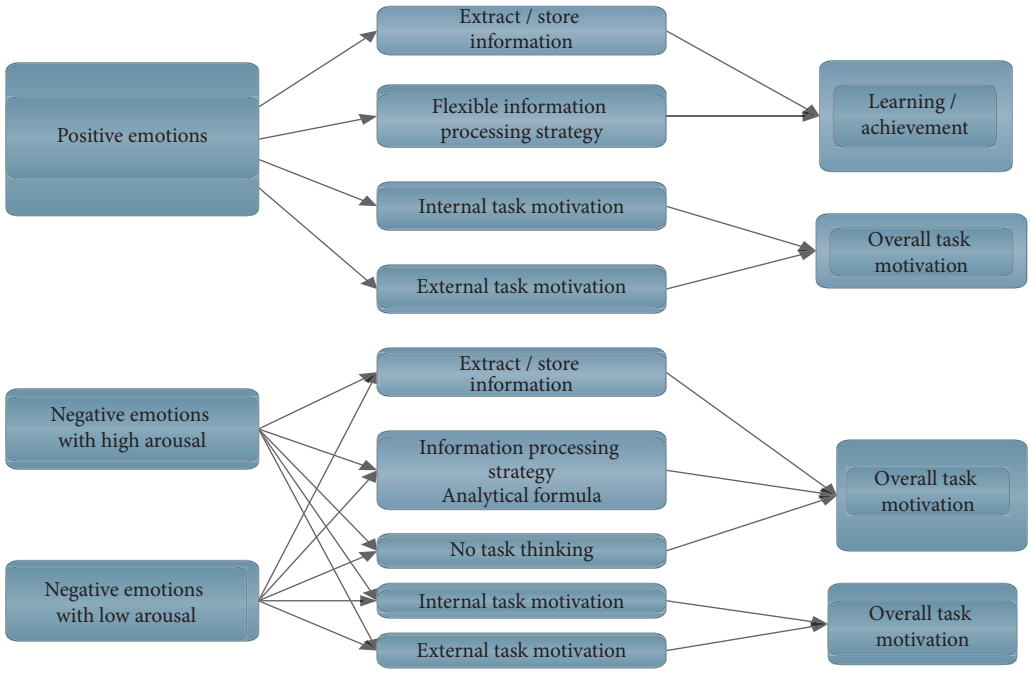

Figure 4: The influence model of emotion on learning achievement.

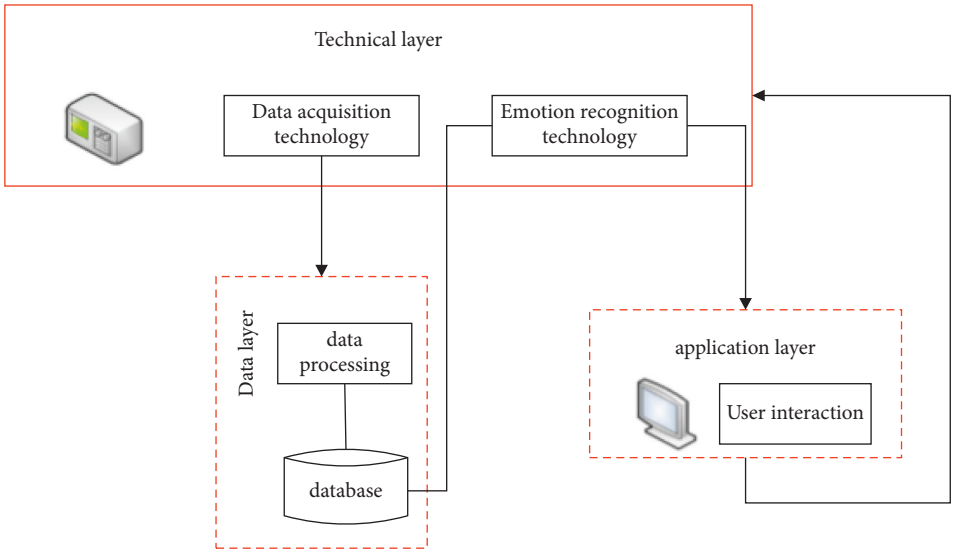

Figure 5: Online learning emotion measurement model.

obtained is $r = 0.537$, $p < 0.01$. Figure 6 shows the scattered distribution results between learners' academic emotions and achievements in class.

By analyzing the correlation analysis results and scatter diagram in Figure 4 above, students' academic emotions and learning effects in this course are significantly positively

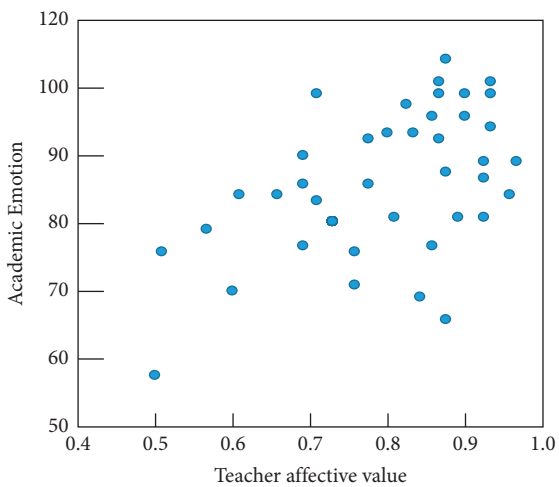

Figure 6: Scatter diagram of learners' academic emotion and achievement distribution.

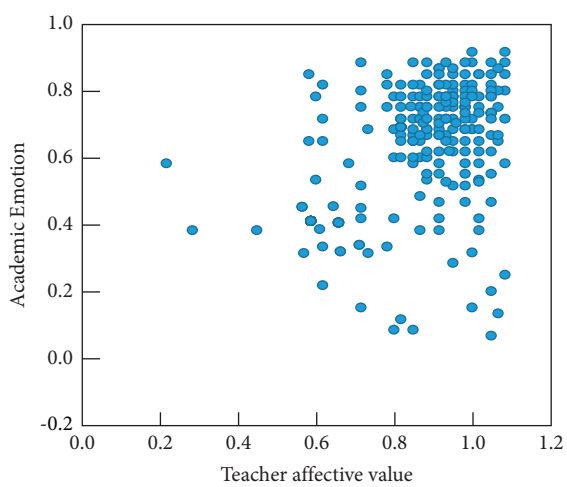

Figure 7: Scatter plot of learners' academic emotion and teachers' emotional value.

correlated at the level of 0.01, and the correlation coefficient result is 0.537. That is, learners' academic emotion in the classroom has a good impact on the learning effect, and the outcomes of learners' academic emotion in the classroom reveal that they are excited about students' learning. Furthermore, their impact and quality are higher, demonstrating the critical importance of analyzing distant learners' academic emotions [28].

5.2. Correlation Analysis between Distance Learners' Academic Emotion and Teachers' Emotional Tendency. This paper studies the positive correlation between distance learners' academic emotions and teachers' emotional tendencies based on the posting on student forums. By sorting out various topic posts under different course forums, it also conducts mining research on the evaluation results and data given by the courses in this topic post in one semester [29]. After analyzing the real content of the course post, it is concluded that most of the content of the course topic post is to arrange learning tasks, learning activities, etc., without significant emotional performance. Therefore, this paper only focuses on the course content of academic emotion analysis in the topic post replies. The selected research objects here are 100 teachers and learners of the residual course. The average value of teachers' post emotion in each topic post is calculated as teachers' emotion value, and the average value of learners' post emotion is calculated as learners' academic emotion. The correlation result of Pearson correlation analysis is 0.168, and $p < 0.01$. Figure 7 shows the scatter distribution results between teachers' emotional values and learners' academic emotional values.

By analyzing the learners' academic emotions on the topic post in Figure 5 above and the teachers' emotional values on this topic post, a significant correlation is shown. At the same time, the emotional distribution of students and teachers posted on the same topic in this course shows a triangular state, which is consistent with the above emotional calculation results. This demonstrates that there is a good association between students' academic emotions and instructors' emotions and those teachers have a favorable influence on students while teaching. The emotional tendencies of teachers have a direct influence on the academic inclinations of students.

5.3. Correlation Analysis between Real-Time Academic Emotion and Online Learning Behavior of Distance Learners. Based on the dynamic characteristics of distance learners' academic emotion, this paper proposes distance learners' learning emotion related to learning environment and learning tasks, and the emotion will not change in a certain period of time. The time period selected in the study is 2 days, 5 days, and 14 days. The online learning behavior indicators of learners before and 1 day, 2.5 days, and 7 days after posting are calculated according to the time point when learners post. Then Pearson correlation analysis is conducted between the online learning behavior indicators and the academic emotions of learners in corresponding posts [30]. The statistics ($^{*}p < 0.05$, $^{**}p < 0.01$) of the obtained results are shown in Table 2.

By analyzing the correlation results shown in Table 2 above, it is concluded that there are few online behaviors related to learners' real-time academic emotions, and some online behaviors have high significance and low correlation coefficients. In the above table, by analyzing the correlation analysis of the three groups in different time periods, only the addition, deletion, and modification behaviors of learners are significantly correlated with the real-time academic emotions of distance learners. The smaller the time period is, the higher the significance between academic emotions is, and the significance increases from 0.15 in 14 days to 0.004 in 2 days. Only the amount of forum and workshop participation and the addition, deletion, and

Table 2: Correlation between learners' academic emotion and real-time learning behavior.

Behavioral indicators	Relevance			Significance		
	14 days	5 days	2 days	14 days	5 days	2 days
Workshop participation	0.015	0.006	0.004	0.571	0.794	0.919
Page view	0.025	0.005	−0.011	−0.326	0.845	0.670
Number of access users	−0.032	−0.044	−0.041	0.201	0.079	0.098
Forum participation	0.048*	0.047	0.060*	0.044	0.053	0.016
Courseware visits	0.011	0.027	0.016	0.670	0.283	0.536
Browse course volume	0.036	0.027	0.033	0.16	0.286	0.195
Number of browsing behaviors	0.044	0.040	0.049*	0.081	0.113	0.051
Number of additions, deletions and modifications	0.062*	0.062*	0.071*	0.014	0.013	0.005

Table 3: Record form of learner's behavior indicators of adding, deleting, and correcting errors.

Functional module	Behavior action	Behavioral indicators	Number of records
Workshop	Increase	Increase the number of workshop activities	827
	To update	Update the number of behaviors in the workshop	193
Forum	Increase	Increase the number of actions in the forum	1886
	To update	Update the number of behaviors in the forum	93
	Delete	Delete the number of actions in the forum	21

modification of learners correspond. The number of online learning behaviors of learners is shown in Table 3.

In this paper, Pearson correlation analysis is conducted on the learning behavior indicators of learners within 2 days and the real-time academic emotions of corresponding learners. The correlation analysis results are shown in Table 4 below.

According to the correlation analysis results listed in the above table, the learners' behaviors of entering the forum to create new posts and the learners' academic mood are significantly high at the level of 0.01. In terms of correlation coefficient and significance, the number of learners' addition, deletion, and modification activities has greatly increased [29].

To improve the analysis of learners' online learning behavior data, thoroughly mine the students who have posted in this study and examine the link between their academic emotion law and their online learning behavior and academic emotion. If a learner has posted, it is necessary to calculate the emotional value of posting on this day and select the average value as the academic emotion value of the learner. After that, calculate the number of learning behaviors in the log when the learner posts. Figure 8 below shows the scatter distribution results between the academic emotion value of distance learners and the total number of online learning behaviors.

Figure 9 compares our eight behavioral indicators: workshop attendance, number of access users, forum involvement, courseware visits, browse course volume, number of browsing activities, and number of additions, deletions, and alterations. This data clearly shows that the indication number of additions, deletions, and alterations is more relevant than other indicators.

Figure 10 compares our eight behavioral indicators: workshop attendance, number of access users, forum involvement, courseware visits, browse course volume, number of browsing activities, and number of additions, deletions, and alterations. This data clearly shows that the indication workshop participation is more significant than other indicators.

Table 4: Results of correlation between learners' academic emotion and addition, deletion, and modification behavior.

Behavioral indicators	Relevance	Significance
Add number of behaviors to workshop	0.013	0.619
Number of update actions in workshop	−0.015	0.575
Number of behaviors added to the forum	0.074*	0.004
Number of updated behaviors in the forum	0.002	0.932
Number of deleted behaviors in the forum	0.001	0.954

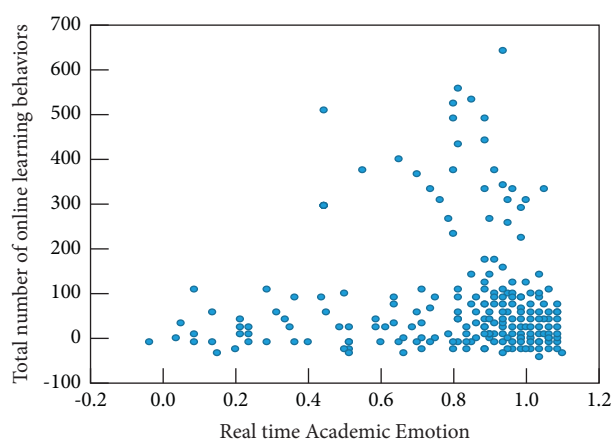

Figure 8: Scatter plot of learners' real-time academic emotion and total times of online learning behavior.

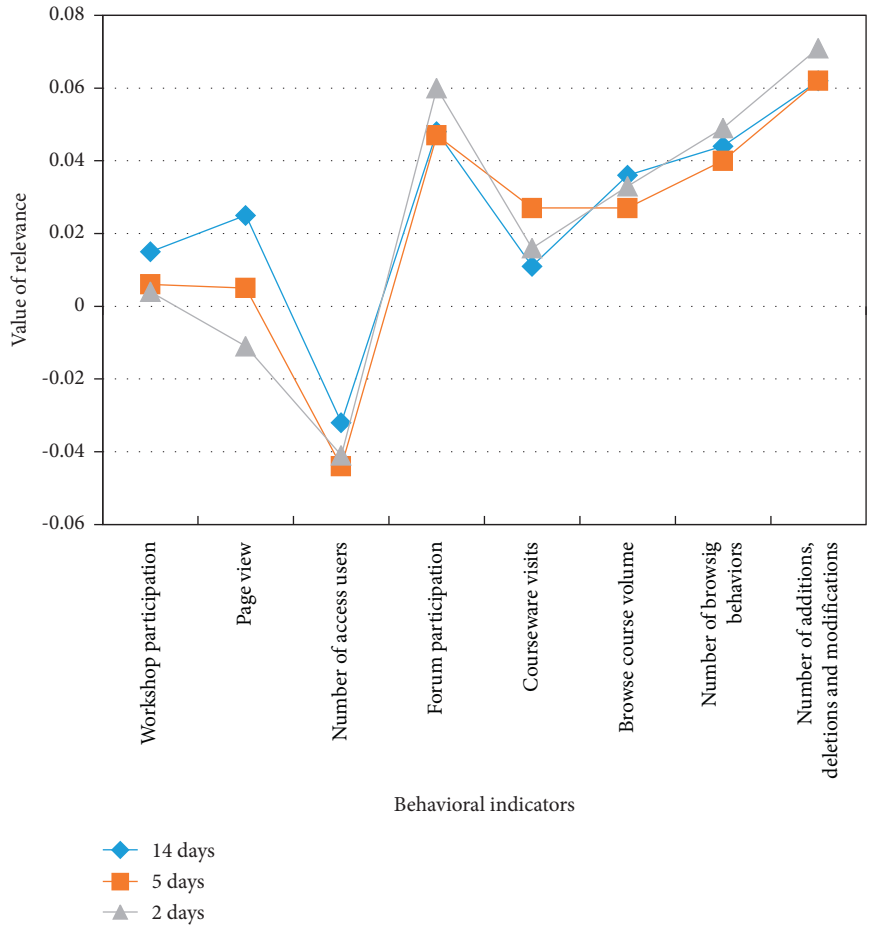

Figure 9: Comparison of relevancy.

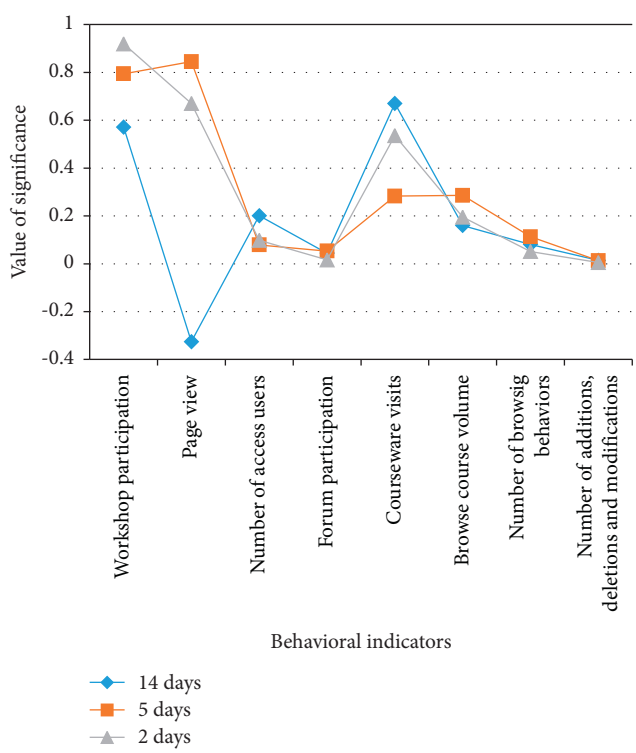

Figure 10: Comparison of significance.

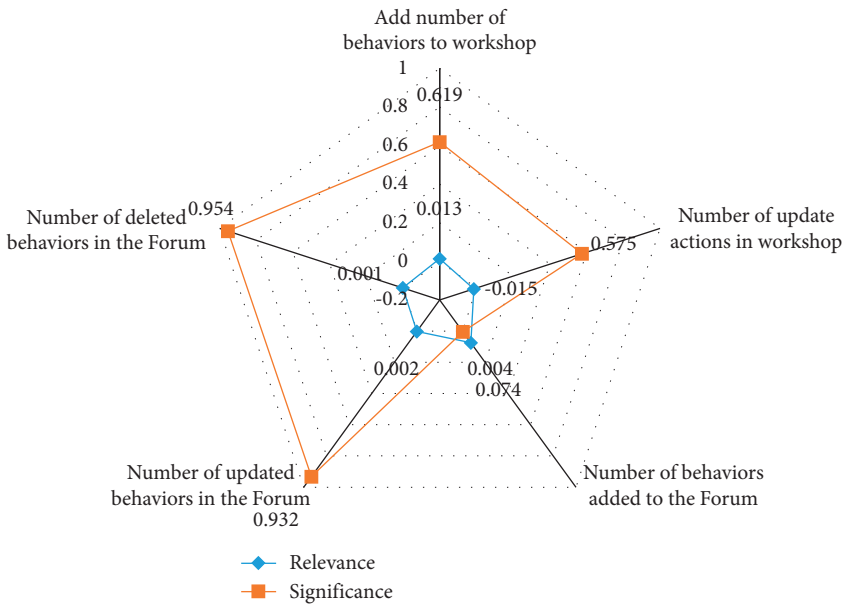

Figure 11: Comparison of relevancy and significance.

Figure 11 shows the comparison between relevancy and significance of our eight behavioral indicators: workshop attendance, number of access users, forum involvement, courseware visits, browse course volume, number of browsing activities, and number of additions, deletions, and alterations.

The distribution shape of dispersed points is a triangle, and the density in the lower right corner is high, indicating that this distribution state is associated with the strong intellectual emotion of some course participants. When more than 80% of learners' postings reflect the same emotional tendency, it suggests that the learners' academic emotions are heavily veiled and cannot be identified through an online learning activity.

6. Conclusions

With the fast growth of information technology, the online learning model is now extensively employed in the field of education and has evolved into a teaching mode with a broader range of applications. Online learning, which is based on information technology, disrupts traditional teaching techniques by connecting students, teachers, and online learning materials in a diverse interactive environment. Learners will experience a range of learning emotions throughout online learning, which will have a significant impact on the learning effect. Positive learning experiences can increase students' enjoyment and drive to study. When there are too many negative emotions, the learning effect suffers and the learning efficiency suffers. As a result, this article employs a deep learning system to assess distance learners' academic emotions based on data from online learning behavior. The multimodal weighted feature fusion algorithm based on DS evidence theory is used in this paper to extract online learning behavior data, and the academic cognition motivation model and online learning emotion measurement framework for distance learners are built. It is determined through a correlation study of distance learners' academic emotions and learning impacts that learners' academic emotions in class will have a favorable influence on learning, and there is a positive relationship between students' academic emotions and instructors' emotions. Furthermore, there is a favorable relationship between learners' addition, deletion, and modification activity with academic mood.

Data Availability

The data used to support the findings of the study can be obtained from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest for publication of this paper.

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Research Article

Simplified Algorithm of Geometric Model Region Segmentation Using Neural Network

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The simplification of three-dimensional (3D) models has always been a hot research topic for scholars. The researchers simplified different parts of the 3D point cloud data from both global and local information. Aiming at the need to retain detailed features in the simplification of 3D models, the neural network (NN) technology is firstly analyzed and studied, and a simplified algorithm for regional segmentation of geometric models based on Graph Convolutional Neural Network (GCNN) is proposed. Secondly, based on the idea of dense connection of DenseNet network structure, a symmetric segmentation model is established. The left part continuously performs Down-Sampling and local feature aggregation on the original geometric model through the Weighted Critical Points (WCPL) algorithm and edge convolution operation and performs compression encoding. At the same time, the right part uses the interpolation method for Up-Sampling the encoded data to increase the number of data points and feature dimensions, so as to restore the point cloud data to the dimensions before processing. Finally, it is restored to the dimension size of the original data to realize the end-to-end output of the segmentation model. Comparing the results with other segmentation models, it shows that (1) as the number of iterations increases, the regional accuracy of the training set increases; (2) after 1000 training rounds, from the perspective of the segmentation effect of a single category of objects, the model has good segmentation effect and has application prospects; and (3) compared with other models, the segmentation interaction ratio of the model is at a relatively mature level. The findings can provide a reference for the application of the segmentation technology of related geometric models and neural networks in the fields of similar models and image segmentation.

1. Introduction

In recent years, the three-dimensional (3D) image of the 3D model clearly describes the actual object due to the rapid progress of computer equipment and virtual reality technology. Therefore, 3D models are gradually widely used in scientific research and people's lives, such as in reverse engineering, 3D animation, professional medical field, design of the 3D game, and other fields [1]. The number of present 3D models is growing exponentially, and massive 3D models are created and published every day, which leads to a large amount of memory space for the number of these models [2]. Hence, separating the model's "sub-components" from the overall model to improve its reusability has become an important topic for researchers [3]. The data attributes of the 3D geometric model are completely different from those of audio, image, and video. Sound can be regarded as a one-dimensional linear function of time. The image can be regarded as a two-dimensional (2D) plane function in the left, right, up, and down directions. Video can be taken as a function of 3D space about time and space, in which time is one-dimensional and space is 2D. They are all sampled orderly and regularly in Euclidean space, and then converted into binary data [4].

The commonly used model in the field of graph segmentation is the supervised neural network model based on the information diffusion mechanism. Its principle is that different graph nodes exchange information through interconnected edges, and update their respective states until they reach overall stability. The state of each node is synthesized as the final output of the network model, and the

corresponding learning algorithm is introduced to estimate the model parameters [5]. At present, Graph Neural Networks (GNN) in neural networks are closely related to the segmentation of geometric models. However, due to the irregularity of 3D geometric model data, traditional convolutional neural networks (CNN) cannot directly process the data of geometric models [6]. Graph Convolutional Neural Network (GCNN) has received more and more attention recently, especially in the modeling of non-Euclidean domain data; some GCNN-based irregular data modeling methods have also achieved very mature results. Therefore, the geometric model data modeling based on GCNN is an effective and applicable method [7].

Gori et al. (2020) proposed a GNN model based on spectral methods. The model is guided by a solid mathematical theoretical foundation. It uses the overall structural information of graph data and processing methods such as Fourier transformation of graph signals. The state of the internal nodes of the graph data is calculated and updated recursively, and the expression output of the overall graph structure data is obtained. However, the spectral method-based GNN model has many limitations. First, when it processes graph data, the entire graph structure needs to be loaded into the memory for calculation at the same time, and cannot be calculated in batches. When the structure is very large, this method will be difficult to carry out; second, it can only calculate and process undirected graphs and graphs whose edges do not contain attribute features but cannot process directed graphs and other vector diagram structures. As a result, later researchers also proposed other structural forms of GNN models [8]. Scarselli et al. (2021) put forward a GNN model based on the spatiotemporal domain. The so-called GNN network structure takes a single graph node as the basic computing unit instead of the entire graph structure. The node contains the feature information of the graph data, and the edge denotes the dependencies between each node. The feature representation of each node is aggregated from the features of the node itself and the features of its adjacent nodes [9].

Looking at the relevant literature, it can be known that the previous research literature has proposed the relevant GCNN model and used the model to segment the image. However, there are few studies on 3D graphics segmentation, and most of the existing 3D segmentation models study single-image segmentation. Hence, on the basis of GCNN, it proposes a 3D geometric model segmentation algorithm based on GCN, uses the characteristics of GCNN to implement a segmentation model, and compares the segmentation effect and accuracy of the model to provide a reference for related geometric model segmentation research.

Firstly, the neural network technology is analyzed, and the specific network technology to be used in the research, namely, GNN technology is determined. Secondly, the GNN technology and GNN structure are further discussed, and the WCPL Down-Sampling algorithm is studied. Finally, a GCNN ensemble segmentation model is comprehensively proposed, and the designed GCNN segmentation model is tested using the ShapeNet parts dataset.

2. Methods

2.1. Analysis of Neural Network Technology. The Artificial Neural Network (ANN) is an intelligent model that classifies and processes information according to the structural characteristics of animal neural networks [10]. It has a complex structure, so it can process data in different ways according to the changes of internal nodes [11]. The core part of the biological neural network (BNN) is the human brain neural network, which is the basis of ANN. The research content of the human brain neural network is mainly the structure, application, and function of the human brain network [12].

ANN is the simplified technical model of BNN. Its main task is to rely on the theoretical basis of the human brain neural network, select the appropriate ANN model according to the actual needs, design the corresponding neural network algorithm, and simulate some intelligent activities of the human brain to achieve the target expectation and solve the problem [13]. Therefore, BNN mainly studies the mechanism of intelligence. ANN is the realization of intelligent mechanisms, and the two complement each other. Figure 1 shows the structure of neural network technology.

Figure 1 indicates that the structure of a neural network mainly includes three layers, and each layer is interconnected. Green is the input layer, blue is the output layer, and orange is the hidden layer. When constructing the structure of a neural network, the number of nodes in the input and output layers needs to be fixed, while the number of neural units in the hidden layer is not fixed, which can be any value. The meaning of the connected arrows in Figure 1 is the flow direction of data in the neural network operation. The data flow direction during operation is different from that during the test. Each arrow represents a diverse weight value. When calculating, the weight needs to be calculated according to the training situation. In addition to the structure expressed from left to right, another common expression is to represent a neural network from bottom to top. At this time, the input layer is at the bottom of the graph and the output layer is at the top [14].

The research of neural networks can be divided into two aspects: theoretical and applied research [15]. Theoretical research includes the following two categories. (1) It uses neurophysiology and human cognition to analyze human thinking and intelligence mechanisms. (2) It is to use the theoretical knowledge and existing theoretical literature on neural networks, and rely on mathematical methods to explore the neural network model with more complete function and better performance. The performance algorithms, such as network stability, convergence, fault tolerance, and robustness, as well as mathematical network theories, such as neural network dynamics and nonlinear neural fields, are further studied. Applied research can be divided into the following two categories [16]. (1) It is the research of software simulation and hardware implementation of neural networks. (2) It is the research on neural network application in various fields, such as pattern recognition, signal processing, knowledge engineering, expert

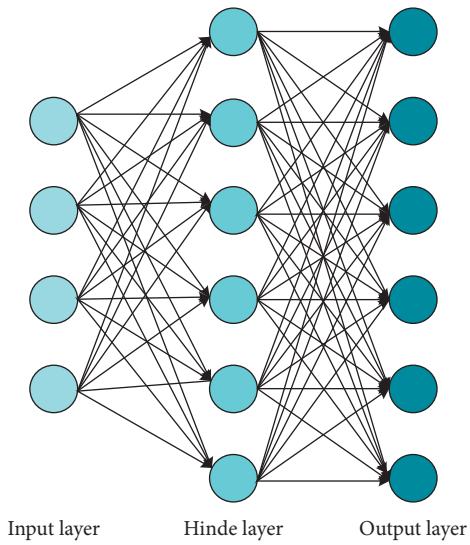

Figure 1: Structure of neural network.

system, optimal combination, and robot control. The application of neural networks will be more in-depth with the continuous progress of related theory itself and technologies. Figure 2 displays the detailed classification of the neural network model.

Figure 2 is to classify the neural network model from different perspectives of the internal structure of the neural network, which can be divided into the feedforward and feedback networks. Among them, the feedforward network is split into a single-layer feedforward network, a multi-layer feedforward network, and a linear neural network. Multi-layer neural networks include radial basis function neural networks, Back Propagation neural networks (BPNN), fully connected neural networks, and CNN. The application of single-layer feedforward neural network is mainly a single-layer perceptron, and the application of a linear neural network is mainly Madaline neural network. Feedback networks are divided into Recursive Neural Networks, Hopfield neural networks, and the brain-state-in-a-box model [17].

2.2. Analysis of GNN. When analyzing the data of the 3D geometric model, the traditional machine learning algorithm generally divides the model into simple parts and processes it through the segmentation of the geometric model. However, this processing method will destroy the overall structure relationship of 3D geometric model data, resulting in the lack of model structure data. These missing data will also lead to the loss of structural features of the geometric model. Therefore, the research on algorithms that can retain model data to the greatest extent is the focus in the field of data modeling and segmentation [18]. In 2009, scholars integrated the advantages of several previous neural network models and proposed a more practical GNN model [19]. The GNN model is based on the supervised neural network model of an information dispersion mechanism, and carries out data transmission and exchange through the connection edge between internal nodes to continuously update the internal state and maintain the stability of the structure. The output value of the model is obtained by calculating the state of each node, and the GNN model's parameter value is calculated according to the corresponding learning algorithm [20, 21]. GNN model regards the nodes connected inside the structure as a learning goal, and the connected edges between nodes represent the dependencies between nodes. Consequently, two nodes are connected, including the data characteristics expressed by each node and the common data characteristics between nodes. It means that the state vector x_v of each node is composed of its own state information and the state information of its adjacent nodes, that is,

$$\begin{aligned} x_v &= f_w\left(l_v, l_{co[v]}, l_{nc[v]}, x_{nc[v]}\right), \\ o_v &= g_w\left(x_v, l_v\right), \end{aligned} \tag{1}$$

x_v means the node state vector; o_v shows the output value of the node; and f_w refers to the local transformation function. g_w stands for a local output function, which describes the generation process of output value. l_v denotes label information.

According to GNN model theory, the 3D geometric model includes two parts of data. One is node information and the other is edge information. For nodes, each node can be regarded as a learning goal. This state is composed of the data characteristics represented by adjacent nodes and connecting edges and the common data characteristics between nodes. Moreover, it is learned through a corresponding learning algorithm. Hence, the most important content of GNN model research is to calculate the state of internal nodes. How to select and train an appropriate local transformation function f_w and local output function g_w is the key to the model establishment [22]. However, the nodes in the 3D geometric model are connected with each other to form a circular and discrete structure. Consequently, GNN uses iterative theory to calculate the state of nodes in the graph. Through continuous iteration, the attribute characteristics of nodes in the graph are recursively propagated until convergence. Finally, it can reach the equilibrium state of the whole graph. Therefore, the status and output of the node can be represented as follows:

$$\begin{aligned} x_v(t+1) &= f_w\left(l_v, l_{co[v]}, l_{nc[v]}, x_{nc[v]}(t)\right), \\ o_v(t+1) &= g_w\left(x_v(t), l_v\right), \end{aligned} \tag{2}$$

$x_v(t)$ represents the state vector of the t-th iteration of the graph node. Iterative state vector $x_v(t+1)$ of round $t+1$ is determined by the state vector and attribute label of the t-th round of the node, as well as the information of adjacent nodes and connecting edges. f_w and g_w represent the transformation function.

2.3. Structural Analysis of GCNN. CNN is the basis of image data processing by the deep learning (DL) method. However, the traditional convolution method can only be applied to the grid image data conforming to the "Euclidean domain," and cannot be directly applied to the geometric model. With

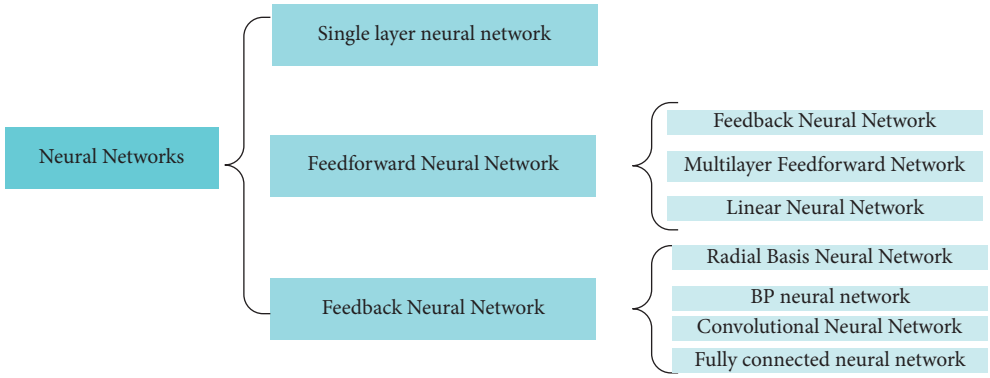

Figure 2: Classification of neural network models.

the increasing frequency of using the "non-Euclidean domain" in life, GCNN that can be applied to geometric model segmentation has gradually attracted the attention of researchers [23]. The GCNN model mainly applies the concept of convolution operation in the traditional CNN model to the geometric model data based on the GNN model. Unlike the mosaic learning method, the GCNN model does not need to convert the geometric model data into a low-dimensional continuous space vector in advance. It can directly input the whole geometric model into the structure. The graph convolution operation can retain the local feature data of the geometric model, ensuring its structure's overall invariance and integrity to extract the overall features of geometric model data more efficiently and output the feature expression accordingly [24]. The flow of the GCNN model is indicated in Figure 3:

Figure 3 refers that the operation of GCNN is divided into the forward propagation and back propagation. In the forward propagation process, the input vector and target output value are given after the initial value is input, the hidden layer is calculated according to the internal operation rules, and the output value of the output layer is calculated. The output value is compared with the target value to calculate the deviation between the target value and the actual output value. If the deviation value is within the allowable range, the training will end and the weight and threshold are fixed. If it is not within the allowable range, the error of neurons in the network layer will be calculated. Moreover, the error gradient is calculated to update the weight according to it. The output values of the hidden and output layers are retrained to continue comparing the error until the error value is within the allowable range [25].

Spectral Graph Convolution transforms node features into signals in the Fourier domain. Fourier transform is to convert the signal in the time domain into the signal in the frequency domain. The processing method is to integrate the signal in the time domain with the characteristic function of the Laplace operator. Based on Fourier transform, Spectral Graph Convolution integrates the signal in the time domain with the graph Laplace operator, aggregates the node features by Laplace transform, and finally calculates the output [26]. For the input image G, the Laplace operator matrix is

$$L = D - A. \tag{3}$$

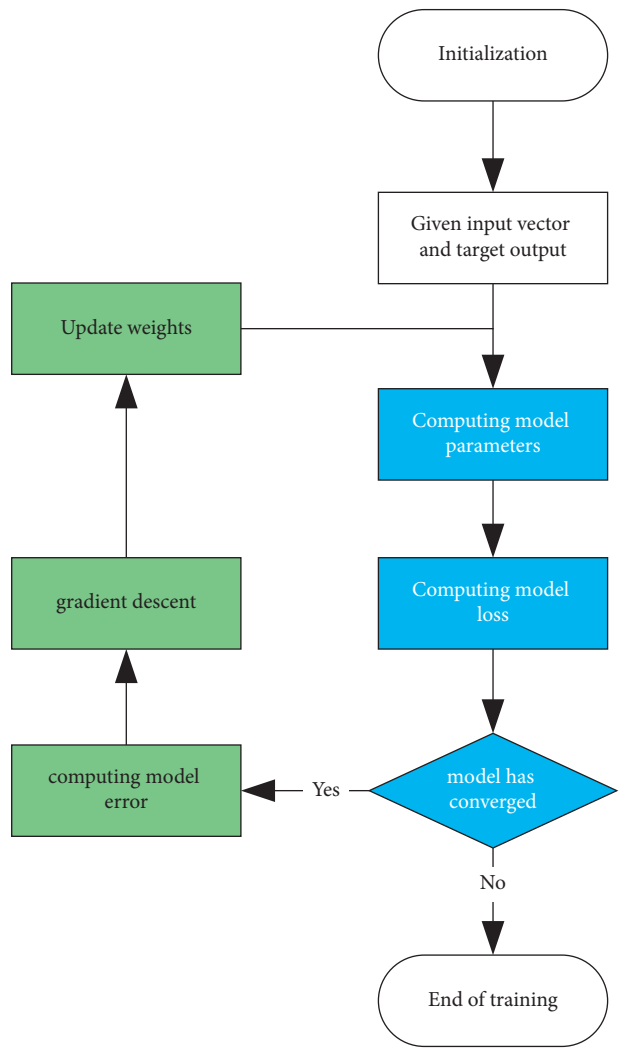

Figure 3: Flow of GCNN.

D is the diagonal matrix of nodes, and each element on the diagonal of the matrix is the degree of each node in turn. A is the adjacency matrix of graph nodes. Generally, the symmetric positive definite normalization of the Laplace matrix is indicated as follows:

$$L = I_N - D^{1/2} * A * D * D^{-1/2}, \tag{4}$$

I_N represents the identity matrix of graph nodes. The feature decomposition of L can be expressed as follows:

$$L = U \cap U^T. \tag{5}$$

$U = \{u_0, u_1, \ldots, u_n\}$ is the eigenvector matrix sorted by eigenvalue.

In the process of graph signal processing, the graph signal represents the eigenvector X of graph nodes, $X = \{x_i\}_{i \in N}$. The Fourier transform of X is as follows:

$$F(x) = U^T * x. \tag{6}$$

The inverse Fourier transform can be expressed as follows:

$$F^{-1}(\hat{x}) = U * \hat{x}, \tag{7}$$

$\hat{x}$ represents the converted signal obtained by the Fourier transform of graph signal x. According to Laplace transform principle, in image G, for the graph signal x, the convolution operation through the convolution kernel g can be written as follows:

$$x_G g = F^{-1}(F(x) \odot F(g)). \tag{8}$$

The mathematical expression of spectral graph convolution operation suggests that the convolution operation of spectral GNN is similar to that in traditional CNN. Through the inner product operation of the convolution kernel, the information expression of the previous layer is aggregated to the next layer as the network input, and the final spectral GCNN model is formed by stacking multiple convolution layers [27].

2.4. WCPL Down-Sampling Algorithm. In the process of processing point cloud data with a graph neural network, it is often necessary to Down-Sample the point cloud to calculate the high-level features of the point cloud. Common Down-Sampling algorithms include farthest point sampling (PointNet++ [28], ShellNet [29]), random sampling (RandLA-Net [30]), grid sampling (KPConv [31]), and so on. Although these algorithms can Down-Sample 3D point cloud data simply and clearly, one problem with these sampling algorithms is that they do not consider the importance of each point.

Based on the criterion that the more 3D point cloud data contributes to the feature after max-pooling, the higher the importance of the point, the WCPL Down-Sampling algorithm is proposed [32]. As shown in Figure 4, suppose there are n points, and the feature dimension of each point is m. The purpose of WCPL is to select the d most important points (Critical Points) from the n points. The algorithm operates as follows:

(1) Calculate a feature $1 \times d$ with max pooling. As can be seen from the above figure, the result is actually: the maximum value (*max*) of each column in the feature matrix, and the obtained points are called Critical Points. Here, the index of the maximum value (arg_max) in each column is additionally recorded, and an index array *idx* is obtained.

(2) In the obtained *idx*, a point may appear multiple times. Use a Set to remove duplicates, and the resulting index set *uidx* is called: Critical Set. At the same time, the items of the same index are accumulated to obtain a new feature *fs*, each of which corresponds to each item of *uidx* one-to-one, and *fr* represents the number of times each point contributes.

(3) For *uidx*, sort in descending order according to *fs*, and the index with the highest contribution comes first. Got a sorted list of indices: *suidx*.

(4) Then according to this number of times, a repeat operation is added later to get *midx*.

(5) To make the midx of different point cloud feature maps the same length, use the resize operation to adjust the midx.

(6) Use *rmidx* to generate a point set from the input gather to complete the Down-Sampling operation.

2.5. Construction of GCNN Set Segmentation Model. To accurately segment each point of the 3D point cloud data, the network model constructed in this paper should be able to identify deeper features of the point cloud data. The DenseNet [33] network proposes a dense connection mechanism that connects all layers with each other. Specifically, each layer of the neural network accepts all the previous layers as its additional input. In view of the great success of the DenseNet network in the field of image semantic segmentation, this paper proposes a 3D point cloud data segmentation network with a connection density similar to the DenseNet. The structure is shown in Figure 5.

The network proposed in this paper adopts the modes of Encoder and Decoder. The Encoder module can be divided into four parts. The first part consists of a k-NN Graph layer with $k = 40$ and an Edge Convolution Multilayer Perceptron (Edge Conv MLP) layer with 3 parameters in input and 64 parameters in output. The remaining three parts are composed of a WCLP layer, a k-NN Graph layer, and 2 Edge Conv MLP layers. The WCPL sampling method can dynamically adjust the number of data points calculated by each module of the model and reduce the computational complexity of the model. The WCPL sampling points of part 2, 3, and 4 are 2048, 1024, and 512, respectively. In the Encoder module, the point cloud data points are locally divided by using k-NN Graph layers of different scales, and local features are extracted and aggregated by using Edge Conv layers of different scales. The features output after the convolution of the last side and the features output by the previous layer of MLP together constitute the input of the modified MLP. After a series of nonlinear transformations of the MLP layer, the features are finally output to complete the extraction of 3D point cloud data information.

In the Decoder module of the model, corresponding to each module of the Encoder module, k-NN interpolation is used to interpolate the set of sampled data points and upsampling to expand the number of data points and the number of features in the dataset. Set the number of k-NN

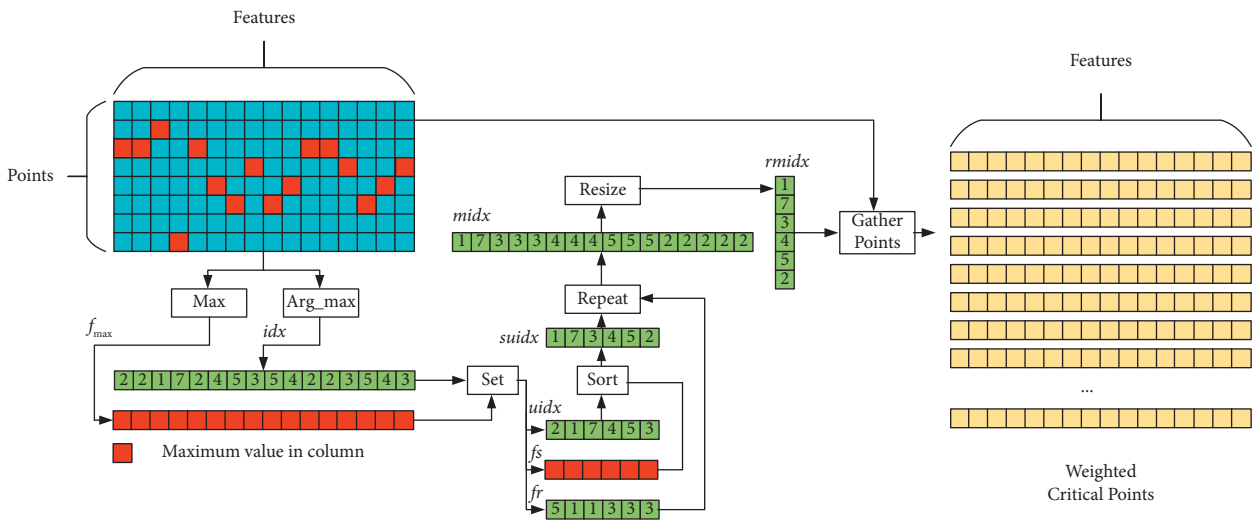

Figure 4: WCPL Down-Sampling flowchart.

interpolation in each stage to be the same as the current point cloud data, then double the number of point clouds through an Up-sampling layer, and then use.

K-NN Graph layers of different scales to complete the local division of point cloud data. After that, through the edge convolution layer and through a series of MLP layer nonlinear transformation finally output point cloud feature data. Through the Up-Sampling of the Decoder module, the Down-Sampling feature dimension in the Encoder module is restored to the original size.

In addition to the main Encoder and Decoder modules, we also add cross-layer horizontal connections at the deepest left and right ends of the model. The fusion of different scale features in the process of enhanced data segmentation improves the model's ability to obtain more local multi-scale features.

3. Experiments and Results

3.1. The Experiment of GCNN Set Segmentation Model. The computer configuration used in this experiment is Intel@CoreTMi7-7800X CPU, NVIDIA GeForce 3090 Ti(24G) GPU, and the operating system is Windows Professional Edition. The network model of this experiment is built based on Pytorch1.2. The segmentation experiments of the geometric model use the ShapeNet part dataset. The original data set is trained and cleaned by CNN. The specific data cleaning steps are exhibited in Figure 6:

In Figure 6, first, the data of the initial data set is reviewed to determine whether it is complete and whether there are errors in the data, screen the wrong data, and discard the unavailable data. Second, the preliminarily processed data is sorted and cleaned. Data cleaning mainly refers to "cleaning" the data by filling in missing values, smoothing noisy data, identifying or removing outliers, and resolving inconsistencies. It is mainly to achieve the following goals: format standardization, abnormal data removal, error correction, and removal of duplicate data. The step of data integration is further carried out. Data integration refers to the combination of data from multiple data sources and unified storage to establish a data warehouse. Meanwhile, the data are transformed into a form suitable for analysis. We uniformly sample 4096 data points for each 3D point cloud model to generate a point cloud dataset of a single object, which is used as the original input of the point cloud separation model, and each data point has a unique pre-label information label, which is used as a supervised Point 3D Cloud segmentation experiment test basis.

The segmentation model parameters include edge convolution layers, fully connected layers, activation functions, and other feature parameters. At the same time, each layer of the network uses standardized operations to standardize the input data, and adds a Dropout operation to the MLP layer at the end of the network to prevent the network from overfitting. The dropout rate of neurons is 0.6; the optimization process of the parameter uses the Adam optimization function, and the adjustment momentum is set to 0.85. The initial learning rate is set to 0.001, and it is set to dynamically decay, after every 20 training epochs, the learning rate decays to the original 0.8. For each Up-Sampling process, the number of interpolation data points of the KNN interpolation algorithm is $k = 1$, the dimension is the average of the feature dimensions of adjacent nodes, the batch size is16, and the total epochs is 1000.

3.2. Accuracy Analysis of the Segmented Region. The segmented geometric model area is more accurate and abstract. The training sample set is trained for 20 iterations, that is, the model after the previous training is used as the initial value of the model for the next training. Figure 7 exhibits the iterative training results of the segmentation model. Figure 7 reveals that as the number of training iterations increases, the region recognition accuracy of the model on the training set is higher. It means that the model's performance is better and better with the increase of training iterations, and The IoU performance of the model in the final training stage can be stabilized at around 0.91.

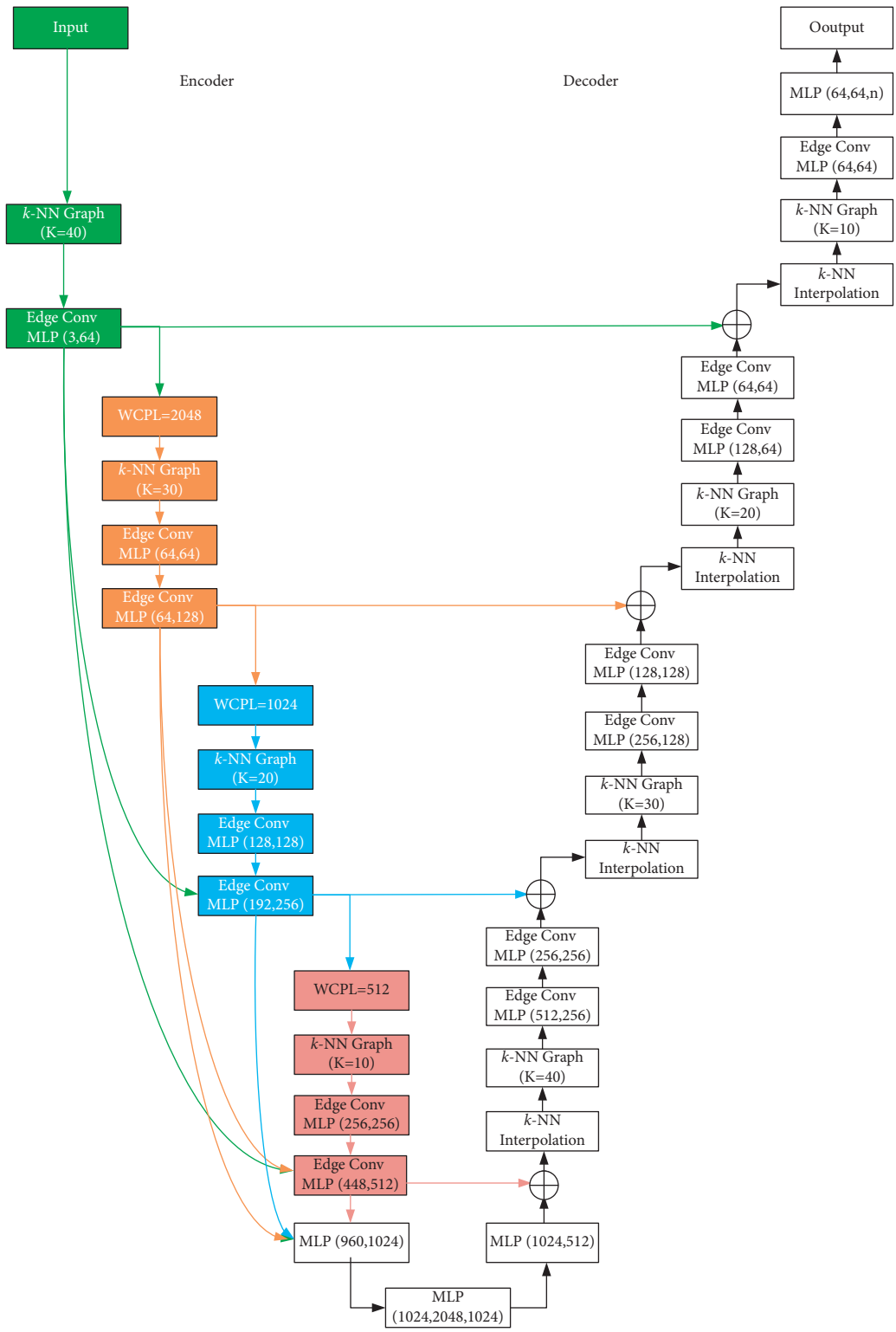

Figure 5: Structural diagram of the geometric segmentation model.

3.3. Intersection over Union (IoU) Analysis of Model Region Segmentation. The model area segmentation IoU is analyzed. IoU refers to the ratio of the intersection and union of "prediction frame" and "real frame," which is a performance's quantitative index at the pixel level. The larger the IoU is, the higher the overlap between the predicted value and the real value is, and the more accurate the predicted result is. This formula 9 is used to describe the degree of coincidence between two categories. The formula numerator is the intersection of the two classes, and the formula denominator is the union of the two classes, so their ratio represents the intersection ratio.

Figure 6: Steps for data cleaning.

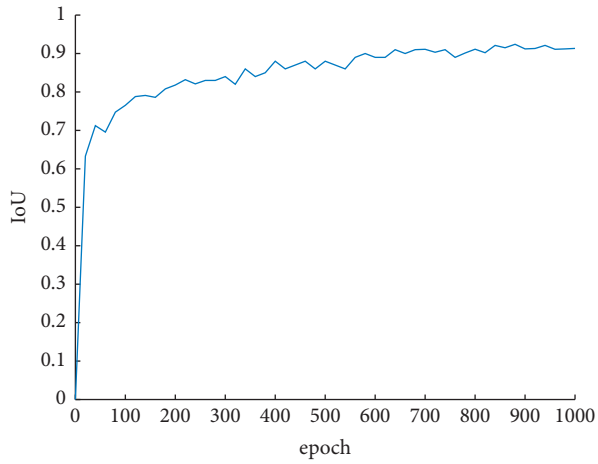

Figure 7: Test results of iterative training.

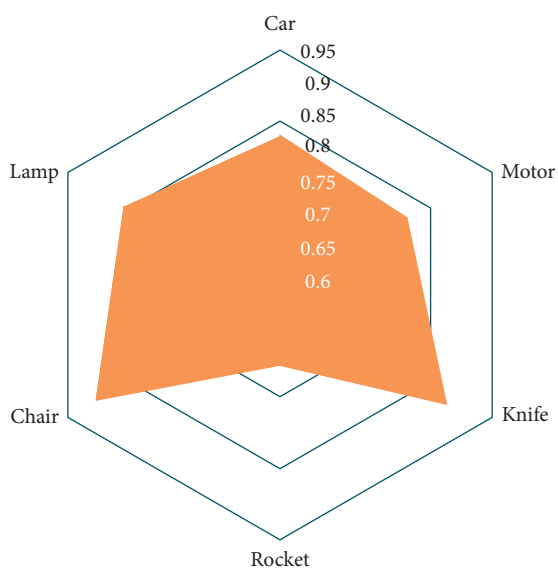

Figure 8: Schematic diagram of IoU and its analysis results.

$$\mathrm{IoU} = \frac{A \cap B}{A \cup B}. \tag{9}$$

Figure 8 indicates that from the segmentation effect of single category objects, the average IoU value of the segmentation model has reached more than 0.85, and the segmentation effect has reached a very mature level. The segmentation results of this model are compared with other existing geometric segmentation models for different objects. Figure 9 denotes the results.

In Figure 9, the proposed algorithm and mainstream point cloud data segmentation algorithms including PointNet [34], KD-Net [35], PCNN [36], and Point CNN [37] are used to segment Car, Lamp, Rocket, Knife, Chair, and Motor. PCNNs can connect and create highly flexible physiological filters. GCNN is a model based on CNN and a simple attention mechanism, which integrates the relatively new dilated convolution and gated convolution, and adds some artificial features. From the overall effect, the segmentation effect of the model proposed in this

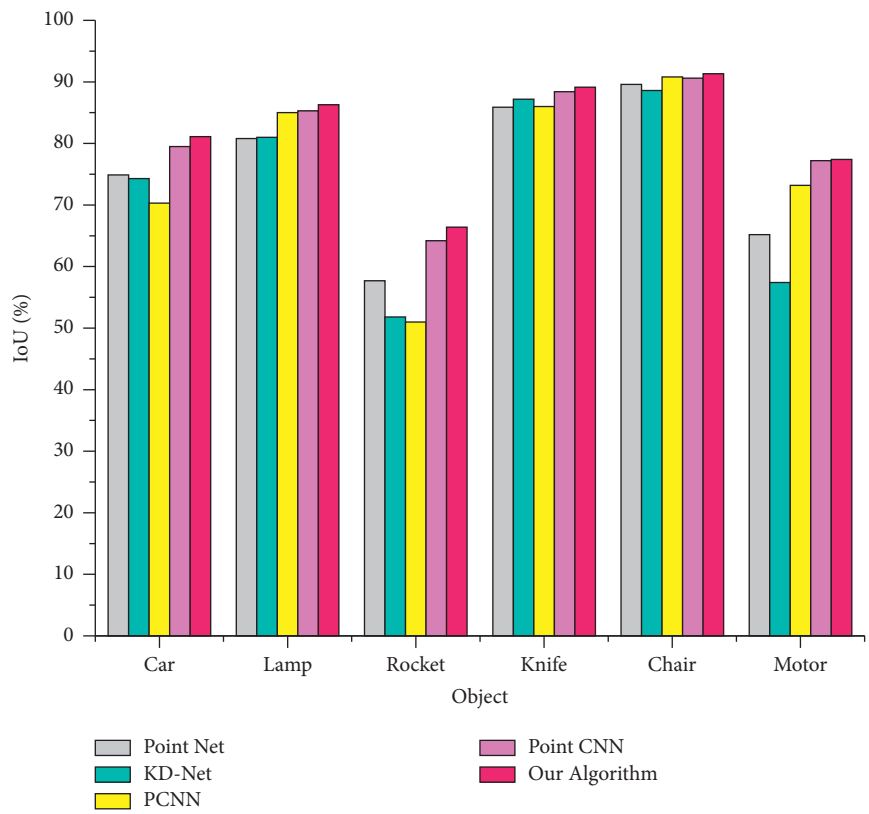

Figure 9: Comparison of segmentation effect.

paper is better than other 3D segmentation models, which proves the superiority of the algorithm proposed in this paper.

4. Conclusion

The 3D segmentation method based on the GNN model is a recent research hotspot and difficulty in the field of data modeling. Due to the irregularity of geometric model data, traditional DL algorithms cannot be directly and effectively applied to the modeling processing of geometric model data. GNN model is an emerging hotspot in the field of DL. In view of the need to retain detailed features in the simplification of 3D geometric model segmentation, a region segmentation algorithm based on GCNN 3D geometric model is proposed. The algorithm avoids the disadvantage that the traditional CNN cannot directly act on the data processing of the geometric model, and has strong anti-noise ability and robustness. Through the comparison experiments with other segmentation algorithms and the IoU of segmentation results, the findings manifest that this method is a convenient, practical, and effective region segmentation algorithm, and the segmentation model has a good segmentation effect, which can provide an auxiliary role for the segmentation of geometric models. The research results can provide a reference for the application of related geometric model segmentation technology and neural network in the field of geometric model and image segmentation. The disadvantage is that due to the short research time and the limited number of samples, the scope and depth of the investigation have certain deficiencies, and the sample size is small. In the future, the scope of the investigation will be expanded for further research. Meanwhile, neural network technology keeps pace with the times, and new technologies will be updated and used in the future. The theory and practice will be deeply combined, and follow-up in-depth research will be carried out.

Data Availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Point Cloud Key Point Extraction Algorithm Based on Feature Space Value Filtering

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With the rapid development of 3-dimensional (3D) acquisition technology, point clouds have a wide range of application prospects in the fields of computer vision, autonomous driving, and robotics. Point cloud data is widely used in many 3D scenes, and deep learning has become a mainstream research method for classification with the advantages of automatic feature extraction and strong generalization ability. In this paper, a hierarchical key point extraction framework is proposed to solve the problem of modeling the local geometric structure between points. Various point cloud models such as PointNet, PointNet++, and DGCNN are analyzed and their features in local key point are extracted. Based on these analyses, an indexed edge geometric feature spatial value screening neural network (IEGCNN) is proposed. This network extracts features from each point and its neighborhood, calculates the distance between the center point and the points within its neighborhood, and adds the point orientation information to the edge feature spatial value screening network. The relationship between points in the edge network architecture is projected onto a 3D coordinate system and decomposed into three orthogonal bases. The geometric structure between two points is modeled by feature aggregation based on the angle between the edge vector and the base vector and the distance between the center point and the neighboring points. The proposed method has the capability of fast processing of point cloud data by significantly reducing the training and recognition time. The experimental results show that this method achieved high classification accuracy value. This work also provides an idea to solve the problem of real-time target detection network, which has a broad applications prospect in the deployment of movable devices and real-time processing.

1. Introduction

Three-dimensional (3D) target recognition is a hot research topic nowadays, where the key to target recognition is target classification and segmentation [1–3]. With the development of data acquisition equipment, various means of data acquisition are becoming more and more abundant, from pictures to 3D models. Point cloud is the main expression line of 3D data; LIDAR, depth sensor, and other equipment can directly collect point cloud data [4–6]. Point clouds can be widely used in various fields of logistics, such as intelligent robots and unmanned vehicles. Intelligent robots use LIDAR to collect point cloud data. The traditional method uses video and other data, and its efficiency is low, while the point cloud data collected by intelligent robots has high efficiency, so the application of point cloud in the intelligent sorting system of logistics storage can improve the efficiency of sorting. Driverless cars use depth sensors to collect point cloud data in the environment, and the analysis and processing of point cloud data for obstacle avoidance and environment perception can improve the accuracy and time efficiency of environment perception [7–10]. Therefore, more and more scholars are focusing their efforts on the processing of point cloud data. Point cloud classification is like image classification, and the implementation principle is to correctly identify point cloud data according to the corresponding labels. Point cloud segmentation is to categorize point cloud data according to rules, and usually points with the same features are labeled into a class. Traditional methods generally extract features manually, and the key points are extracted to classify and segment the point clouds, but such methods rely on the professional level and

experience of human, and the process is more complicated and only applicable to specific tasks. Currently, in order to improve the automation of point cloud classification and segmentation, deep learning is used instead of traditional methods. Deep learning can extract high-dimensional features of the input data according to the learning objective. In recent years, many researchers have applied deep learning techniques from 2D domain to 3D unstructured point cloud data and can directly deal with disordered and sparse point cloud data. However, most methods only extract global features of point clouds, ignoring the local relationships existing between points and points, resulting in low accuracy and robustness of classification segmentation. In addition, deep learning is computationally complex and memory consuming and requires a large amount of training time, which is not conducive to transferring deep learning models to practical application scenarios. Therefore, it is of strong practical significance to improve the accuracy of point cloud classification segmentation, reduce memory loss, and improve the efficiency of training time [11–15].

Point cloud data is a set of vector collections in a 3D coordinate system, a 3D model representation, and each point is usually represented by 3D coordinates. Compared with 2D images and grid images, point cloud data contains RGB values, grayscale values, and other information, which can visually depict the real world. Point cloud data is the most primitive data, which does not need preprocessing and can be directly applied to deep learning methods for processing and analysis. Voxel data, on the other hand, generally has to be preprocessed before deep learning methods can be used. Example diagram of an unordered point cloud is shown in Figure 1.

As can be seen from Figure 1, the point cloud data consists of discrete points and does not contain structured information, which cannot be directly processed by traditional methods. Point cloud data is different from other data, it is disordered, and the same point may have many different manifestations, which leads to the traditional deep learning that cannot process the point cloud data, and the point cloud data has certain sparsity, and it is difficult to use the deep learning method to process the sparse point cloud when the collection device collects the point cloud data. As shown in the figure, the point cloud consists of four points, f_a, f_b, f_c, and f_d, and the point cloud data collected by different devices may have different orders, and the traditional methods will incorrectly identify the point clouds with different orders as different classes [16–19].

With the widespread use of many sensor devices and the increasing development of information technology, people's daily life and many fields such as engineering and technology generate various forms of massive image data, and the technology used to obtain "information" from the massive image data and guide machines to perceive and understand their surroundings is computer vision. Image alignment is an important step in many complex computer vision tasks, aiming to match multiple spatial data acquired by different sensors at different times and under different conditions, and is therefore one of the difficult and hot research areas in computer vision. Image alignment technology emerged in the 1970s and was early applied to military weapons and equipment. After rapid development, image alignment has been gradually applied to many civilian fields and widely used in different disciplines and different research tasks. Image alignment has been widely used in many fields and in imaging medicine, which produces multimodal data with a high degree of variability. Image alignment aligns multimodal organ data to the same coordinate system, and through image fusion, it can reflect the tissue shape and function of the organ at the same time, facilitating medical diagnosis. In mapping, image alignment technology aligns high-resolution serial images collected by UAVs to the same spatial coordinate system, and further stitching and fusion can generate a panoramic map of the target scene. Image alignment algorithms are also required as the basis for different tasks, such as 3D reconstruction, simultaneous visual localization and mapping, image stitching and fusion, image retrieval, target identification and tracking, and other complex computer vision tasks. 3D reconstruction restores the 3D structure of a static scene by recovering it from images with different viewpoints in three main steps, feature matching between images, camera pose estimation, and recovery of 3D structure using estimated motion and features. Image alignment is the first step of image processing, and the accuracy of its algorithm has a great impact on the 3D reconstruction results. Image stitching and fusion is the process of stitching and aligning two or more images with overlapping scenes obtained from different viewpoints, different times, or different sensors to produce a large field of view image, which is the most direct application of image alignment algorithms. The goal of the image retrieval task is to retrieve all images with similar scenes in each query image, where the image alignment algorithm compares the similarity between images by computing feature matching between images. In summary, the significance of image alignment is to establish the correspondence between the two or more images to be aligned, the image and the target object, or the image and the features extracted by the template. In recent years, image alignment techniques have achieved some results and have shown broad application prospects in many vision tasks. As a key technology in many fields, the evolving computer vision has put forward higher requirements on the alignment technology, so the alignment technology still has important research significance and practical value [20].

Point cloud data is widely used in many 3D scenes, and deep learning has become a mainstream research method for point cloud classification. According to the different ways of feature space value screening, the existing algorithms are categorized into traditional methods and deep learning algorithms. In this paper, based on the representative methods and the latest research of deep learning, the basic ideas are summarized with its advantages and disadvantages; compare and analyze the experimental results of the main methods; look forward to the future work and research development direction of deep learning in the field of point cloud key point extraction. There are still problems of excessive number of parameters and complex network size when the original point cloud is directly input to the classification

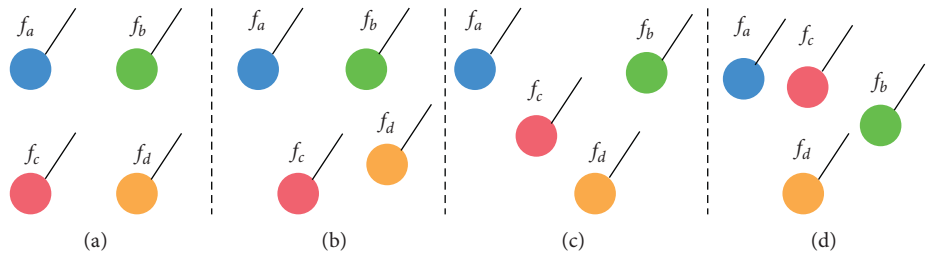

Figure 1: Diagram of a disordered point cloud.

network, and the real-time task processing still needs further optimization. The existing 3D point cloud key point extraction methods usually ignore the useful information in other neighborhood features, so this paper proposes a point cloud key point extraction algorithm based on feature space value screening. Firstly, the network structure and superparameters are trimmed and compressed to achieve a lightweight model; secondly, the k-nearest neighbor algorithm is used to determine a new local region on each feature space value screening layer, add the vector direction between neighboring points, map the output features of different layers, and make index jump connections to further reduce the local feature information loss. This will have a broad applications prospect in the deployment of movable devices and real-time processing.

2. Related Work

This section will elaborate point cloud key point extraction mechanisms and point cloud alignment techniques.

2.1. Point Cloud Key Point Extraction. In recent years, with the continuous development of science and technology and the rapid growth of life needs, the digital modeling of 3D objects in the objective world with point cloud data, i.e., 3D reconstruction technology, has been frequently used in various industries and has received good response. In the field of medicine, through the construction of three-dimensional model of human organs, there can be more intuitive response to the patient's lesions, to help doctors develop more effective treatment plan; in the field of public transportation, there is autonomous driving technology by real-time construction of the vehicle's surrounding environment, to help the vehicle in time to find and avoid obstacles; in the field of archaeology, through the construction of three-dimensional model of cultural relics, it can digitally repair the broken cultural relics and restore the historical appearance; in the field of archaeology, by constructing 3D models of cultural relics, it can digitally restore damaged relics and restore the historical appearance. The most basic and critical step in the realization of 3D reconstruction is the point cloud key point extraction [21–25]. When using 3D scanning equipment to scan an object, it is impossible to obtain complete 3D information of the surface of the object in a single scan due to object occlusion, limited field of view, and other factors in a fixed perspective. Therefore, the object needs to be scanned in multiple views, and then the results of multiple scans are stitched together and fused, and the fusion of point cloud data from two adjacent views uses the point cloud key point extraction technique. By solving the spatial transformation relationship between two coordinate systems, a rotation translation matrix can be obtained, and then the rotation translation matrix converts the two point clouds into the same coordinate system to realize the point cloud summary key point extraction, and so on to realize the 3D reconstruction of the object. However, in practice, due to the accuracy of 3D scanner measurement, human operation, or the influence of natural environment, the obtained point cloud data have errors, which will affect the key point extraction effect of two adjacent point clouds and thus affect the final 3D reconstruction effect. Therefore, this paper will start from the point cloud key point extraction algorithm, analyze several common point cloud key point extraction algorithms, and propose improvements, aiming to design a point cloud key point extraction algorithm that takes into account efficiency, accuracy, and robustness and provide a good technical support for the development of subsequent point cloud key point extraction technology and 3D reconstruction technology [26].

The point cloud key point extraction algorithm based on deep learning is based on inputting a point in the point cloud data and its neighborhood information into a neural network and describing the point using the output vector of a layer in the network. 3D ShapeNets lead deep learning to 3D modeling and extract global features by calculating deep key points of 3D data with good noise immunity, but poor extraction of key points for low overlap rate point cloud models. 2D feature space value screening neural network is used to generate descriptors for local feature matching, but it only connects image block feature vectors as training samples for the network, thus lacking spatial correlation. 3DMatch algorithm, a self-supervised learning method, uses millions of positive and negative labels in RGB-D reconstruction results to train robust descriptors by twin neural networks for point cloud key point extraction. Based on 3DMatch, KNN is used to find the corresponding points to improve the efficiency of the algorithm. Based on the 3DMatch network framework, more descriptive and distinguishable descriptors are trained by increasing the number of feature space value screening layers and eliminating pooling layers, but the training efficiency is low. Perfect-Match algorithm vowelizes the network input for

density values, reduces the voxel grid density, and saves the network capacity, and the algorithm has real-time performance. The binarized local feature descriptors can effectively reduce the computational effort. By increasing the negative sample weights, a multiedge-based loss function is proposed, which increases the gap between positive and negative samples. A 3D point cloud-based self-coding descriptor (Adaptive O-CNN) is proposed, which can retain more information of the original point cloud. Point cloud key point extraction plays a central role in 3D scene reconstruction, which is essentially to find the transformation relationship between the point cloud data to be matched. In early studies on point cloud key point extraction, key points with distinguishing and descriptive power are usually precalculated for point cloud data and then further processed. However, recent studies have shown that the existing key point detection methods are not only time-consuming but also ineffective in practical applications, while uniform sampling and random sampling methods are proved to be an effective method to replace the key point detection algorithm. Therefore, the research direction of feature-based point cloud key point extraction is mainly directed at feature description and feature matching. Table 1 collates the common point cloud feature description methods.

2.2. Point Cloud Alignment. In this section, point cloud alignment techniques are divided into two main categories: alignment based on traditional methods and alignment based on deep learning methods, and an overview of these two types of point cloud alignment methods is given. In traditional methods, traditional point cloud alignment calculates the spatial transformation relationship between two point clouds through spatial geometry theory or statistical principles, which can be divided into two categories: feature-based alignment algorithms and featureless-based alignment algorithms [27–29].

Feature-based alignment algorithms mainly use the feature points of point clouds to achieve point cloud alignment. The feature points are the rotation invariant points in the point cloud data, and the local space is constructed by taking the feature points as the center, extracting the information in the space to describe the feature points, judging whether they are the corresponding points by the similarity of the two point descriptions, and calculating the spatial transformation matrix between the two point clouds according to the corresponding point set to realize the point cloud alignment. The Harris algorithm is suitable for gridded point cloud data, which needs to be gridded before feature detection, so it is not real-time; the intrinsic shape signature algorithm defines a local coordinate system for each point in the point cloud and establishes the covariance matrix and solves it to determine the feature points according to the relationship between the magnitude of the feature values; the SIFT algorithm considers the extreme values of the adjacent scales of key points. The NARF algorithm only targets the edge feature points, so the detected feature points have limitations and are sensitive to noise and outliers. There are also many methods for feature descriptor construction. The concept of point signature, which generates a point signature for each point in the point cloud and finds the corresponding point pair by judging the similarity of the signature, is computationally intensive. The point feature histogram descriptor needs to calculate the distance and angle relationships of all points in the neighborhood of the feature points, and thus the algorithm is inefficient. Further, the fast point feature histogram descriptor, which simplifies some feature components in PFH, reduces the computational effort while maintaining the descriptiveness of the descriptor as much as possible [30]. By constructing a local reference system of feature points, dividing regions based on the interval and direction of points and feature points in the neighborhood of feature points, calculating the normal vectors of feature points in the regions and their angle cosines, and performing histogram statistics for each region, the histogram obtained by connecting each region is finally used as the SHOT descriptor. The matching of descriptors is accelerated by binarizing SHOT descriptors. Feature descriptors with scale invariance enable point cloud alignment at each scale. RIFT descriptors have rotation invariance. The residual angle in the adaptive domain is used as a feature descriptor of points for point cloud alignment at scaling scales. Various local features are combined such as normal and density as feature descriptions of points, which is computationally low and descriptive [38, 39].

Featureless-based alignment algorithm method refers to the direct manipulation of the original point cloud data to achieve alignment. The iterative nearest point algorithm has certain requirements on the initial positions of the two point clouds to be aligned, and when the initial positions of the two point clouds are far apart, the alignment is not effective or even cannot be achieved, and it is sensitive to extraneous factors such as noise. Using the point-to-point tangent plane distance instead of the point-to-point distance in the original ICP algorithm, the efficiency is improved by reducing the number of iterations. The ICP algorithm based on *K-D* tree accelerated search improves the efficiency of the algorithm. Point-to-point and point-to-surface feature definitions reduce the sensitivity of the ICP algorithm to the initial position of the model by estimating the curvature of all points in the point cloud but are not as efficient. Constrained ICP algorithm, by dividing the space and reducing the corresponding point search space, improves the efficiency of the algorithm. A search method based on PD-tree structure is robust to noise. The Pickey-ICP algorithm uses the idea of hierarchy to improve the efficiency of searching corresponding point pairs. The GO-ICP algorithm effectively solves the problem that the ICP algorithm easily falls into local optimal solutions. The ICP algorithm incorporating genetic algorithm takes the result of alignment using genetic algorithm as the initial position of the point cloud to improve the alignment accuracy. The ICP algorithm based on curvature extrema accelerates the convergence of the algorithm by constraining the curvature extrema. Hu improves the alignment accuracy of ICP algorithm by using dynamic angle factor. 4-point matching algorithm, however, generates incorrect alignment when the point cloud model has symmetry. Based on 4PCS, the Super4PCS algorithm is

Table 1: Point cloud key point extraction method.

Algorithm name	Algorithm categories
3DSC [31]	Point cloud descriptors based on local features
RoPS [32]	Point cloud descriptors based on local features
SHOT [33]	Local feature-based point cloud descriptor based on local features
PFH [34]	Local feature-based point cloud descriptor based on local features
FPFH [35]	Local feature-based point cloud descriptor
PointNet [36]	Convolutional neural network-based point cloud descriptor based on convolutional neural network
3DSmoothNet [37]	Convolutional neural network-based point cloud descriptor based on convolutional neural network

proposed to provide alignment efficiency while ensuring alignment accuracy. The chunked point cloud variance distribution similarity principle is used to extract the point cloud overlap region, which improves the accuracy of point cloud alignment with low overlap rate. The algorithm accuracy is improved by constructing an objective function to reduce the error accumulation.

The existing 3D point cloud key point extraction methods usually ignore the useful information in other neighborhood features, so this paper proposes a point cloud key point extraction algorithm based on feature space value screening. Firstly, the network structure and superparameters are trimmed and compressed to achieve a lightweight model; secondly, the k-nearest neighbor algorithm is used to determine a new local region on each feature space value screening layer, add the vector direction between neighboring points, map the output features of different layers, and make index jump connections to further reduce the local feature information loss. This will have a broad applications prospect in the deployment of movable devices and real-time processing.

3. Methods

In this section, the proposed system is discussed in detail. The proposed network structure is presented and the edge geometry feature space value filtering is discussed.

3.1. Model Architecture. Based on the principle of network light-weighting, a prototype network structure is proposed based on PointNet as shown in Figure 2. By simplifying the network structure, only the basic feature space value filtering layer, the pooling layer, and the fully connected layer are included in the network to achieve a lightweight network. In order to extract the global features of the point cloud, the maximum pooling layer is used to extract the key points, and the size of the feature space value filtering kernel is set to 1×1. Since each point in the fully connected layer is connected to all points in the previous layer, which integrates the features of the previous layers, the number of parameters in the fully connected layer is the largest in the whole network architecture, and the streamlining of the number of parameters and nodes in the fully connected layer is an important step to realize the network light-weighting. In the process of network optimization, the parameters of other layers can be kept consistent with the network prototype in order to investigate the impact of the parameters of one layer on the network performance.

3.2. Point Cloud Key Point Extraction. Traditional point cloud key point extraction methods are usually designed to solve domain-specific problems, and it is difficult to extend to new key point extraction tasks. Deep learning-based point cloud key point extraction can be divided into point-based extraction methods and tree-based extraction methods. The former directly uses the original point cloud as the input for deep learning; the latter first uses a k-dimensional tree structure to regularize the point cloud and then provides the processed data to the deep learning model. A class of feature space value filtering operation called Geo-Conv is applied to each point and its local neighborhood to extract the edge features of the central point and adjacent points by gradually expanding the acceptance domain of the feature space value filtering to extract features in layers and maintain the geometric structure of points along the hierarchy. Considering the directional information between points, the value of point projection to polar coordinates is calculated and then weighted and summed with the distance between two points to solve the problem of incomplete extraction of local key points.

3.3. Feature Space Value Filtering Based on Edge Feature Space Value Filtering. The key point extraction based on edge feature space value filtering uses the k-nearest neighbor method to define the k points closest to a point as the neighboring area. Firstly, the edge features between the center point and the neighboring points are extracted, and then the feature space value filtering operation is performed on the edge features. The set of nearest neighboring points to the centroid P_{xi} is $\{j{:}(i, j) \in \varepsilon\}$, and the set of directed edges associated with it is $\{(i,j_{i1}),\ldots,(i,j_{ik})\}$. The edge features are defined as e_{ij}, where h_θ is a nonlinear function composed using the learnable parameter θ. An asymmetric aggregation operation Ψ is added to the h_θ operation to obtain the feature output of the i-th vertex of the edge feature space value screening:

$$P_{xi'} = \Psi_{j:(i,j)\in\varepsilon} h_\theta\left(P_{xi}, P_{xj}\right). \tag{1}$$

For the features of the centroid, the feature difference between the centroid and the neighboring points are fed into the multilayer perceptron in series, so that the edge features fuse the local relationship between points and the global information of the points. After obtaining n edge features, maximum pooling is performed to obtain a single feature of this local region, and local information is extracted and integrated layer by layer by superimposing multiple layers of

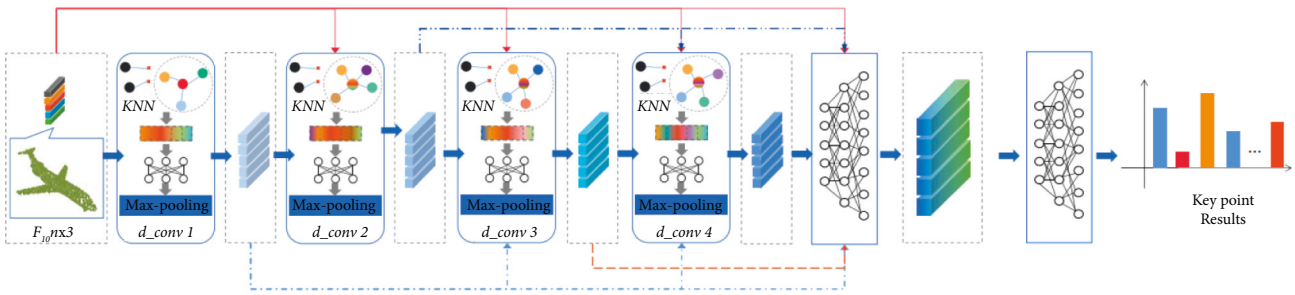

Figure 2: Proposed model structure.

feature space value screening in this way. The local neighborhood map of the edge feature space value filtering layer is constructed by a multilayer perceptron. When the edges of adjacent points are filtered by layer-by-layer eigenspace values, each layer outputs a new point cloud map structure and feature space, and a new local area is obtained. The method of interpoint difference is introduced to consider the geometric correlation information between points and solve the problem of incomplete extraction of local key points in PointNet and PointNet++ architectures; however, there is a problem of ignoring the directional information of points, so the indexed edge geometric feature space value screening neural network is proposed.

3.4. Key Point Extraction of Indexed Edge Geometry Feature Space. The edge geometry feature space value filtering is shown in Figure 3. Indexed edge geometry feature space value filtering neural network adds the orientation information of points to the edge feature space value filtering network, models the 3D point cloud with polar coordinate system, and projects the relationship between points in the edge network architecture to the 3D coordinate system. The values of polar coordinate projections to different axes are calculated and compared with two points

$$\begin{cases} P_{lj} = \sqrt{x^2 + y^2 + z^2}, \\ P_d = \left(\sqrt{x^2 + y^2}, \sqrt{y^2 + z^2}, \sqrt{z^2 + x^2}\right), \\ P_\theta = \arccos \dfrac{P_d}{P_{lj}}, \end{cases} \tag{2}$$

where P_{lj} denotes the mode length of vector, P_d denotes the projection length, and P_θ denotes the pinch angle. Suppose an F-dimensional point cloud contains n points; in the F-dimensional point cloud, n denotes the number of points and F denotes the number of channels. For each point, according to the k-nearest neighbor algorithm and the network superparameter r to construct a local spherical neighborhood, a spherical neighborhood $N(P_{xi})$ with P_{xi} as the center point can be constructed, and the feature output P_{xi} of the center point is calculated after obtaining several neighborhood points and then the center point, where the dimension of the weight matrix MF is $\varnothing_{\text{in}} \times \varnothing_{\text{out}}$.

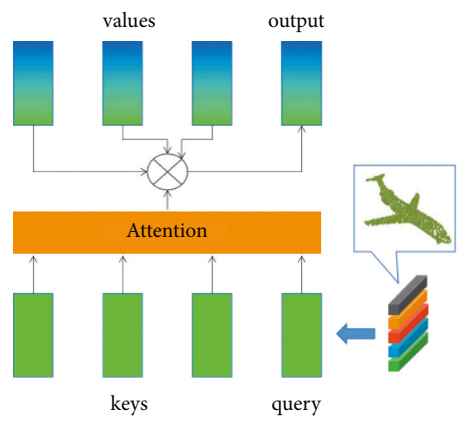

Figure 3: Edge geometry feature space value filtering.

$$N(P_{xi}) = \{P_{xj} | P_{xj} - P_{xi} \le r\},$$
$$f(p_i|(l)) = \mathbf{M}_F f(p_i|(l-1)) + \frac{\sum_{i=1,j=1\,(i\neq j)}^{n} w(P_{xi}, P_{xj}, r) h(P_{xi}, P_{xj})}{\sum_{i=1,j=1\,(i\neq j)}^{n} w(P_{xi}, P_{xj}, r)} P_{xi'}, \tag{3}$$

where $\mathbf{f}(p_i|(l))$ denotes the eigenvector of point p_i at layer l, $\mathbf{M}_F$ denotes the weight matrix used to extract the features of the centroid, and w denotes the distance weighting between the centroid P_{xi} and different neighboring points P_{xj}, which decreases monotonically with $\|P_{xj} - P_{xi}\|$. As the radius r increases, the perceptual field of the spherical neighborhood gradually increases and the difference with the weight function $w()$ of the center point decreases. $h(P_{xi}, P_{xj})$ denotes the edge feature, which is the most important feature extracted part of this network architecture. In the 3D Euclidean space, the vector can be expressed as the projection of three orthogonal bases, and the modulus of the projection represents the "energy" in the corresponding direction, so the edge features can be projected onto the three orthogonal bases, and the edge features in each direction are extracted using different weight matrices, and then the features in the three directions are regrouped to maintain the Euclidean geometry. The edge features based on polar coordinates are calculated as follows:

$$h(P_{xi}, P_{xj}) = \sum_{d\in D} \cos^2(P_\theta) M_d f(p_j(l-1)), \tag{4}$$

D denotes the set of three orthogonal bases in the quadrant where P_{xi} and P_{xj} are located; $\mathbf{M}_d$ denotes the direction-dependent weight matrix to extract edge features in different directions; $\cos^2(P_\theta)$ is the coefficient to ensure that the sum is 1 when the features are aggregated.

3.5. Extraction of Key Points for Graph Feature Space Value Screening. Graph feature space value filtering is shown in Figure 4. In this paper, a directed graph $G=(V, E)$ is constructed by using the K-nearest neighbor operator, V represents the input point cloud, which is the vertex of the graph model, $V\in[1, N]$, N is the number of point clouds, E is the edge composed of point pairs, and the structure of KNN model is shown in Figure 4. x_i is the node; e_{ij} represents K neighboring points and node. The output of the graph model is the feature aggregation of all directed edges of the node, which is expressed formally as

$$x_i = \sum_{j:(i,j)\in 1,\ldots,k} h(x_i, x_j), \tag{5}$$

where $h(x_i, x_j)$ denotes the edge function, to reduce the number of parameters to improve the efficiency of the deep network while taking into account the local information of the point cloud; the edge function is defined to consider only local features:

$$h(x_i, x_j) = h(x_j - x_i). \tag{6}$$

The feature vector e_{ij} of node x_i is defined as

$$e_{ij} = g\left(w \sum_{i=1} x\right), \tag{7}$$

where w is the weight assigned to the node; g is the max pooling symmetric function, which is used to aggregate the feature vectors of the neighboring points.

3.6. Point Cloud Key Point Extraction Steps. The specific steps of point cloud key point extraction are as follows:

(1) Input 7-dimensional point cloud with fused spectral and laser intensity information and solve the rotation invariance of the point cloud by aligning the input data with T-Net constructed by KNN.

(2) Use MLP (64, 64) abstraction to align the shallow features of the point cloud and map each point feature to 64 dimensions.

(3) Construct KNN for the 64-dimensional shallow features of each point. Expand the dimensionality of the point cloud (horizontal point cloud dimensionality, nonvertical feature dimensionality) with a directed graph, add the local information of K neighborhood points like the feature clustering, and then pool the most representative neighborhood information by MLP (64, 128) after mapping the point features with aggregated neighborhood information to 128 dimensions.

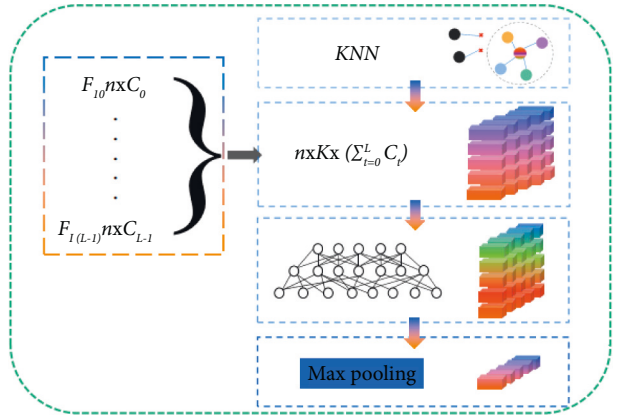

Figure 4: Graph feature space value filtering.

(4) Use the idea of residual network to connect the shallow features of the point cloud with the K-dimensional pooling by using a jump connection. After the graph model generates features that consider the local information, the original point cloud information is maintained in the deep network as the abstraction of features deepens to enhance the prediction capability of the network. In contrast to the edge function selection, which only considers local features, the information of nodes and neighboring points is considered while reducing the number of parameters to improve efficiency.

(5) The fused features are mapped to higher dimensions using MLP (1024), and fine-grained features at different scales are captured using spatial pyramid pooling to further enhance the feature abstraction capability of the network.

(6) The high-dimensional features of N points are connected with the fused features to improve the prediction accuracy of the network. Finally, the fully connected layer is entered for feature dimensionality reduction, and set the dropout layer to prevent model overfitting, and obtain the probability matrix of N points corresponding to M categories to achieve the key point extraction of the point cloud.

4. Experiments and Results

The experimental setup along with experiments conducted is discussed in this section. The results produced are also presented.

4.1. Experimental Setup. ModelNet is a standard dataset for classification of 3D models publicly available at Princeton University, with 12715 classification models in 662 classes, divided into two classes, ModelNet10 and ModelNet40. ModelNet10 contains 4899 models in 10 classes, with 3991 training samples and 908 testing samples; ModelNet40 contains 12311 models in 40 classes, including 9843 for training and 2468 for testing. The results of testing using this class division are called instance accuracy. If the first 20

models in each category test catalog are used as the test set and the first 80 models in the training catalog are used as the training set, the test results are called category accuracy. In this experiment, the example accuracy is selected as the test result.

The experimental hardware and software environment is shown in Table 2, and the model parameters are set as shown in Table 3. The training process loss convergence is shown in Figure 5.

Table 2: Experimental platform and configuration.

Operating systems	Linux Centos7
Operations acceleration library	RTX 2080Ti
Languages	CUDA 10. 1 + cuDNN7.5
GPU	Pytorch 1.3
Framework	Python 3. 5. 2

4.2. Experimental Results and Analysis. The comparison of accuracy and number of parameters in ModelNet40 and ModelNet10 are shown in Figures 6–8, respectively. The classification accuracy of the propose method is about 92.78% on ModelNet40 and 94.2% on ModelNet10 with 0.61 M parameters, which is the best result in the same number of parameters. It is higher than all multiview-based classification networks and most voxel and point cloud-based classification networks.

The experimental results are analyzed and discussed below:

(1) Comparison with multiview fusion-based network: The multiview fusion-based approach uses multiple projections of different fixed views to input the rendered image into the feature space value filtering neural network, which performs single-view key point extraction from the projected rendered image, and the input is required to be a continuous model. In contrast, the IEGCNN network model in this paper takes sparse and disordered point clouds as input, and the network model is more lightweight, with only about 0.4% of the parameters based on multiview, and the classification accuracy on ModelNet40 and ModelNet10 is improved by about 2.08% and 1.4%, respectively, compared with the pairwise network, which indicates that IEGCNN can well learn the essential features of the point cloud model.

(2) Comparison with voxel-based network: The voxel-based network can be built deeper and the network structure can be more complex due to the advantage of deep learning. The classification accuracy of the proposed method is only lower than that of VRNEnsemble, which is one of the many voxel-based methods, and the classification accuracy decreases by about 2.76% and 2.94% on the ModelNet40 and ModelNet10 datasets, respectively. VRNEnsemble trains voxel-based variable autoencoders, which are designed on the basis of ResNet, and the deep ResNet can be seen as an integration of shallow neural networks of different depths; ResNet enhances the flow of gradients by jumping connections. The voxel-based network takes full advantage of deep learning. The network is 45 layers' deep, the network architecture is complex, and as the depth increases, the network can better approximate the objective function through many nonlinear mappings and improved feature representations. For these reasons, the classification accuracy of VRNEnsemble-based network is higher than that of the method in the paper, but the training of this network requires encoding and decoding operations for the 3D voxel model, and the training time is the longest, which takes 6 days. At the same time, the voxel-based deep learning networks cannot be directly applied to the disordered and sparse point cloud model and require complicated voxelization operations. The designed network model contains only three feature space value filtering layers and one fully connected layer, which can quickly and directly process point clouds. The network parameters account for about 0.7% of the VRNEnsemble method. The eigenspace value filtering layer of the paper is 3 layers, while the eigenspace value filtering layer of the VRN architecture is 45 layers, which has advantages in terms of light weight and real-time.

(3) Comparison with PointNet: The designed network architecture has about 1% of the network parameters of PointNet. The classification accuracy is improved by about 3.58% and 1.12% using ModelNet40 and ModelNet10 datasets, respectively. The network parameters of IEGCNN are reduced by about 0.19 M compared to PointNet (Vanilla), but the classification performance is improved by about 5.58% on ModelNet40 and 2.24%. The experimental results show that the present network architecture can meet the requirements of classification accuracy and lightweight in the network with the original point cloud as input.

(4) Comparison with LDGCNN and DGCNN: The classification accuracy of IEGCNN is improved by about 0.58% compared with DGCNN, and the network parameters are about 30% of DGCNN. Although the classification accuracy on ModelNet40 is about 0.12% lower than that of LDGCNN model, the number of feature space value filtering layers is about 60% of that of LDGCNN and the training time is about 1/3 of that of LDGCNN model. Therefore, simply increasing the number of channels and the number of fully joined layers does not necessarily improve the overall performance of the network architecture.

(5) Comparison with 3DmFV and Point2Sequences networks: 3DmFV uses Fisher vectors as the input of the feature space value filtering neural network and voxels the point cloud into a standard 3D grid, which solves the problem of disorder of the point cloud.

Table 3: Experimental parameter setting.

Batch volume	Data set	Number of points	K-nearest neighbor points	Optimizer	Learning rate	Number of training sessions
ModelNet40	1024	20	SGD	0.001	32	250
ShapeNetPart	2048	40	SGD	0.001	14	200
S3DIS	4096	20	SGD	0.001	14	100

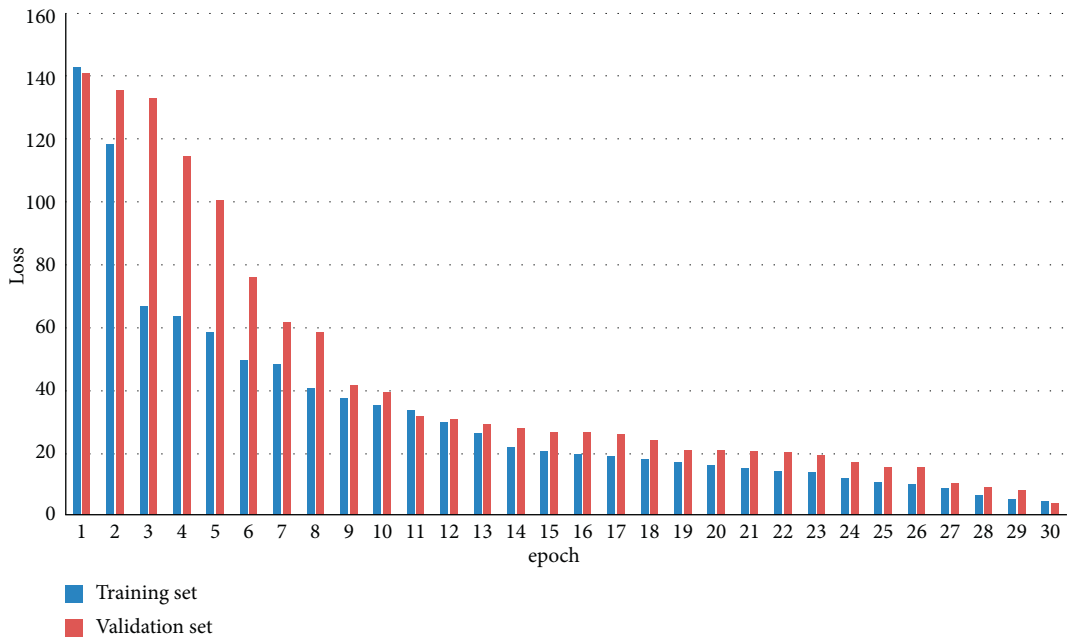

Figure 5: Schematic diagram of training process loss convergence.

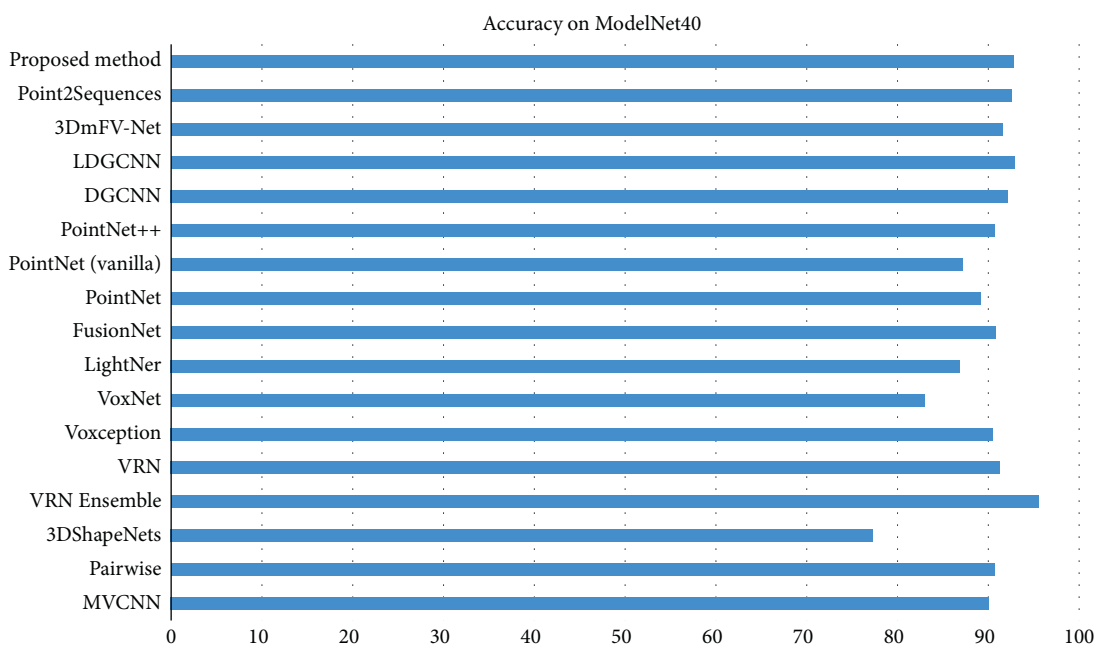

Figure 6: Accuracy comparison in ModelNet40.

Since Fisher vectors are computed using a vowelized grid, they are computationally intensive and memory consuming, which leads to information loss through manual key point extraction. Point2Sequences is a recurrent neural network-based model that uses a point cloud sequence learning model to capture the correlation between different regions within a local area of the point cloud by capturing the correlation

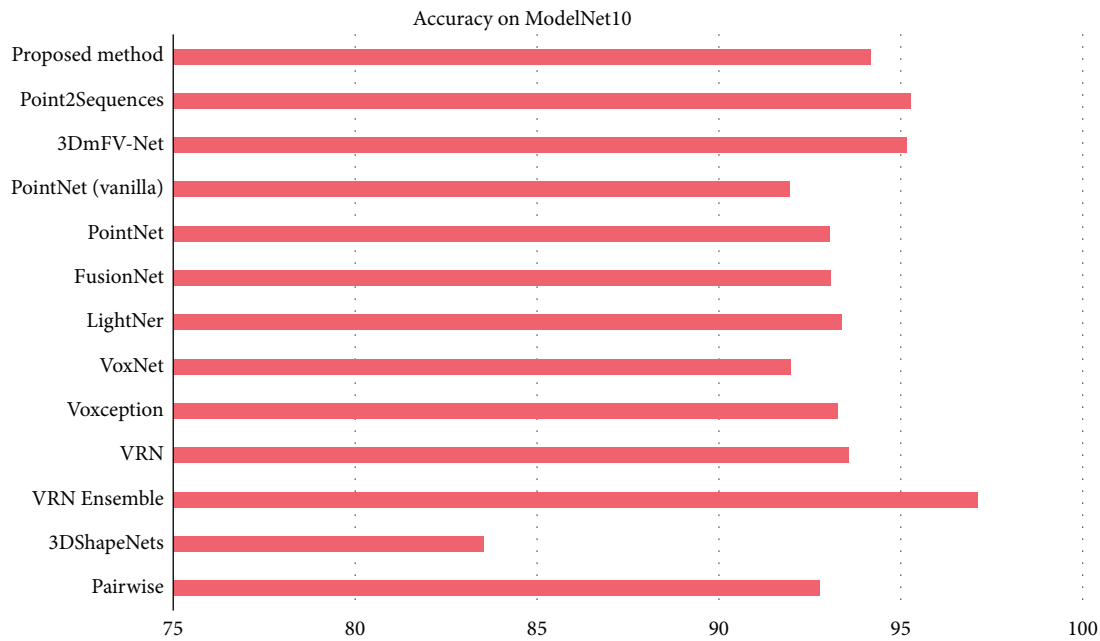

Figure 7: Accuracy comparison in ModelNet10.

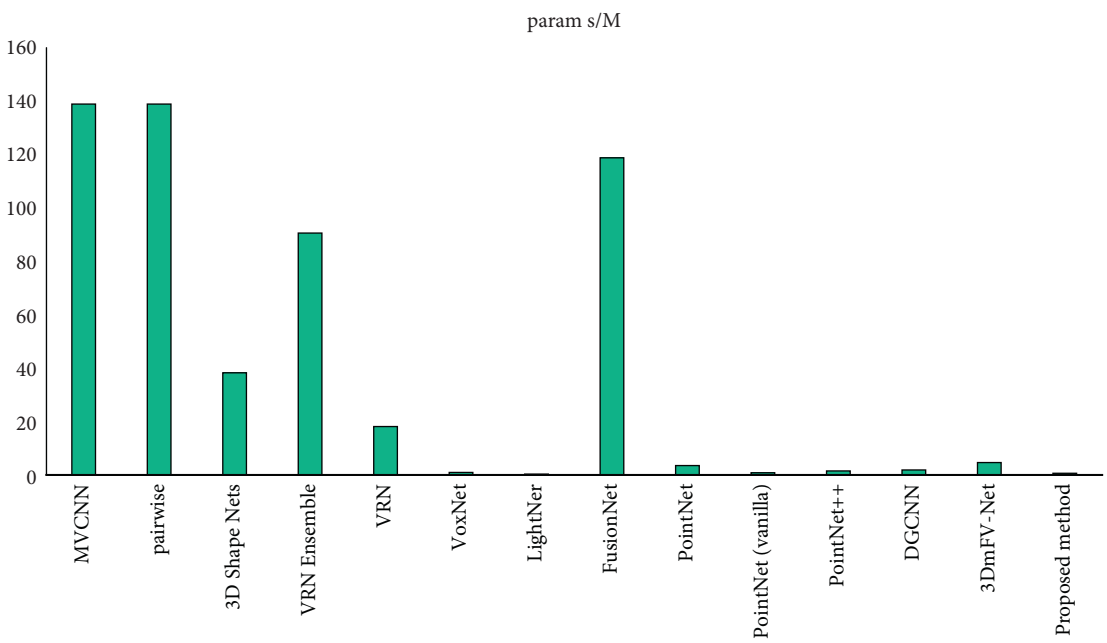

Figure 8: Comparison of number of parameters.

between different regions in the local area of the point cloud; the features of all the local areas are input into the coder-decoder of a recurrent neural network to achieve the aggregation of regional features. The proposed IEGCNN network improves the classification accuracy by about 1.68% over 3DmFV and 0.18% over Point2Sequences on ModelNet40 but decreases by about 1% and 1.1% over 3DmFV and Point2Sequences on ModelNet10, respectively, because the proposed architecture discards the number of feature space value filtering layers and the number of fully connected layers, and the number of nodes is significantly reduced because the traditional feature transformation layer is dropped. In the ModelNet10 dataset, due to the distribution pattern of training and testing samples and the limitation of the number of models, the features of the point cloud model are not fully extracted.

(6) Analysis of the generalizability of the streamlined model: The framework of the network model is

designed based on PointNet, and considering the problem of insufficient extraction of local key points in PointNet and PointNet++ network structures, a method of introducing the directional information of points is proposed combining edge index jump links, reducing the size of the network, reducing the number of feature space value screening layers in the model, and gradually changing the number of channels in each feature. The optimal model parameters are determined by gradually changing the number of channels in each spatial value filtering layer. Theoretically, the reduction of the network structure will cause a certain decrease in the classification accuracy. To compensate for the reduced accuracy caused by the reduction of the eigenspace value filtering network, the number of channels in the second eigenspace value filtering layer (Block2) was increased from 64 to 128 in the original model, and the key point extraction process was optimized by using indexed feature transfer to reduce feature loss and make the extraction more comprehensive. From the analysis of the experimental data, the streamlined network model can quickly process the whole point cloud model and improve the classification accuracy while reducing the number of parameters, which has strong universality.

5. Conclusion

With the continuous development of deep learning, the technology of 3D point cloud target recognition is more and more applied to the fields of unmanned driving and intelligent robotics. The unmanned vehicles and intelligent robots can be widely used in logistics sorting and transportation, and the data collected by unmanned vehicles and intelligent robots are mostly in the form of point clouds. Among them, the classification and segmentation of point clouds is the basis of 3D point cloud target recognition, and more and more research works are carried out around point cloud classification and segmentation.

A hierarchical key point extraction framework is proposed to solve the problem of modeling the local geometric structure between points. By analyzing point cloud models such as PointNet, PointNet++, and DGCNN and their features in local key point extraction, the indexed edge geometric feature spatial value screening neural network IEGCNN is proposed, which extracts features from each point and its neighborhood, calculates the distance between the center point and the points within its neighborhood, and adds the point orientation information to the edge feature spatial value screening network. The relationship between points in the edge network architecture is projected onto a 3D coordinate system and decomposed into three orthogonal bases, and the geometric structure between two points is modeled by feature aggregation based on the angle between the edge vector and the base vector and the distance between the center point and the neighboring points. It has the capability of fast processing of point cloud data by significantly reducing the training and recognition time. This work not only achieves better results in classification tasks, but also provides an idea to solve the problem of real-time target detection network, which has a broad application prospect in the deployment of removable devices and real-time processing.

Data Availability

The datasets used during the current study can be obtained from the author upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Location Selection of Digital Cultural Tourism Town Based on Improved Genetic Algorithm and BP Neural Network

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Due to the short development time of cultural and tourism towns in China, local governments and investors lack experience in building cultural and tourism towns and do not pay enough attention to the positioning of towns. Alternatively, this issue results in chaos in domestic cultural and tourism towns and even a large number of empty towns in some provinces. Therefore, how to accurately locate cultural tourism towns is a problem that must be studied in depth at present. This paper uses the regional economic theory to collect the influencing factors of cultural tourism town positioning. Based on the BP neural network and the improved genetic algorithm, a genetic neural network model is constructed to train and predict the samples of cultural tourism towns. Taking a small town in the East as a case, the data were collected and analyzed. Established on the prediction outcomes of the genetic neural network, the best location of a small town was selected according to the actual situation of the region. In terms of accuracy and training time, our experimental evaluation confirmed that the neural network enhanced by genetic algorithms outperforms the conventional BP neural network. Furthermore, we observed that besides the classification capabilities of the BP neural network-based model, the classical BP neural network improved by the genetic algorithm also exhibits great macrosearch capabilities and good global optimization performance.

1. Introduction

With China's economic development stepping into the new normal, the national consumption capacity is growing progressively, the spiritual and cultural demand is growing, and the proportion of the total tourism economy in GDP is also rising rapidly. The tourism industry has gradually become the pillar industry of the national economy. In March 2018, the State Council performed an innovative round of institutional reform, abolished the Ministry of Culture and the National Tourism Administration, integrated their original responsibilities, and established the Ministry of Culture and Tourism as an element Department of the State Council; by the end of 2019, the cultural and tourism departments of 31 provinces (cities and autonomous regions) have completed listing. This historic reform aims to encourage the assimilated growth of cultural endeavors, cultural engineering, and tourism. Similarly, it also aims to bring together the growth of cultural industries, engineering, and tourism resources. It is an important measure to fully affirm the necessity of cultural and tourism industry integration. It can be seen that the integration of culture and tourism is a strategic direction for the innovative growth of national tourism and the improvement of national cultural

soft power and the influence of Chinese culture in the future. Since the country initiated "culture + tourism," the development and construction of cultural and tourism towns across the country have entered a hot situation [1, 2].

When things reach extremes, they will turn against each other. In the process of development, cultural and tourism towns across the country are seriously homogenized and the "one town for one" phenomenon occurs, resulting in most cultural and tourism towns having no characteristics. Luo Shugang, Minister of Culture and Tourism of the People's Republic of China, clearly proposed to adhere to the principle of "integration when appropriate, integration when possible, promoting tourism with culture, and highlighting culture with tourism" [3]. This should be noted that compared with other industries, the tourism industry has stronger linkage and more prominent comprehensive driving ability. Especially under the promotion of the "tourism +" strategy, the tourism industry and the primary, secondary, and tertiary industries have had different degrees of linkage. In the context of supply-side structural reform, "tourism +" has been recognized by the public, which not only promotes the in-depth integration of tourism with the internet, industry, agriculture, aviation, science and technology, education, and other fields, but also promotes the emergence of "tourism + culture," that is, the integration of cultural and tourism industries [4, 5].

In 2016, the notice on developing characteristic towns jointly issued by relevant national departments called for the cultivation of 1000 characteristic towns, and characteristic towns have officially risen to the national level. In the past three years, cultural tourism featured towns have been the main force of featured towns. The first and second batches of national characteristic towns announced by the Ministry of Housing and Urban-Rural Development totaled 403, including 253 characteristic towns of cultural tourism type, accounting for 62.8% [6, 7]. By 2019, 31 provinces and cities in China have actively responded to the national call and established cultural and tourism departments; 25 provinces have formulated plans and relevant policies for the integrated development of cultural and tourism industries. With the strong advancement of national policies, the combination of cultural and tourism industries has been continuously and rapidly deepened; therefore, subsequently attracting a large amount of capital injection, and cultural and tourism featured town projects that have become a hot spot for investment have sprung up. Some research institutions predict that there will be more than 1200 cultural and tourism featured towns in China in 2020 [8–10].

In the past two years, in terms of the number and amount of investment and financing events, cultural and tourism featured towns and cultural and tourism complexes have steadily occupied the dominant position in the investment of cultural and tourism projects. It is shown that in 2018, there were 295 investment and financing events in the cultural tourism industry, with a total investment scale of 1.37 trillion yuan [11]. There were 129 Chinese tourism featured towns and cultural tourism complex projects, accounting for 43.7% of the total number of investment and financing events. The total investment scale reached 1.27 trillion yuan, accounting for 92.53% of the total amount. In the first half of 2019, there were 148 investment and financing events in the cultural tourism industry, and the total amount of proposed investment disclosed was 553.176 billion yuan, accounting for 61.5% of the total number of events and 96.3% of the total amount of investment and financing. Cultural and tourism featured towns account for the largest proportion in the whole investment process, which is significantly higher than the cultural and tourism complex, and much higher than the investment in scenic spots, theme parks, and other cultural and tourism projects. However, it should be noted that in the first half of 2019, compared with the same period in 2018, the number of cultural tourism featured town projects increased by 188%, but the total investment decreased by 20.61% [12, 13].

It is clear that the investment volume of tourism featured town projects is significantly declining, and the project development mode of seeking perfection has changed. From the perception of the business form of cultural and tourism featured towns, featured towns of natural resources, culture, health care, sports, and commerce are the mainstream development form. In the past two years, the development trend of cultural tourism industry investment has been consistent. Cultural tourism featured towns and cultural tourism complexes have overwhelming advantages in the number and amount of investment in cultural tourism projects [14]. The facts, as demonstrated in various research outcomes, show that the investment and development of the resource end of the destination have been upgraded from the main development mode of scenic spots to the main development mode of complexes, which is consistent with the trend that the consumption demand of tourists has been developed from sightseeing to leisure and vacation, which demonstrates that supply-side reform and innovative development are now a part of the cultural tourism industry's development.

It is evident that the market size and development trend of the cultural tourism town cannot be understated, particularly in light of the promotion of national policies and the fact that the cultural tourism sector is entering a high-quality development stage of transformation and upgrading to meet consumer needs. From the aspects of reception scale, tourist evaluation, and operating efficiency, the consumption market of tourism featured towns is hot, but at the same time, the competition is fierce, and the supply side needs to be transformed and upgraded. Under the macro background of economic transformation, consumption upgrading, and industrial structure adjustment, people's demand motivation, content, intention, and value demands for tourism are undergoing new changes. This should be noted that with the speedy and fast improvement of cultural tourism real estate, there are also some developers' crazy enclosures under the guise of "culture" and "tourism," resulting in low-level and homogeneous projects blooming everywhere [15].

Nowadays, most real estate enterprises have realized that the "low-level play" of selling houses and tickets is difficult to sustain. At present, the lack of supporting facilities is the main reason for the further development of small town products in the market. High-quality supporting facilities

are becoming a hard indicator of whether small town products are qualified or not. The development logic of the cultural tourism town is different from that of the traditional real estate. It first needs a rich "core" before it can leverage the surrounding markets. It is becoming a general trend of cultural tourism to turn from scenic spots to characteristic communities, from prosperous cities to ancient towns, and from shopping places to cultural and expo venues. In the next decade, operation oriented, resource integration, and fine management will become a new model of cultural tourism real estate. Therefore, from the future positioning, it can be seen that the cultural tourism town urgently needs to clarify its own positioning, so as to lay a good foundation for better tourism integration in the future [16]. The fundamental contributions of this research are as follows:

(i) We discuss how to accurately locate cultural tourism towns is a problem that must be studied in depth at present. This paper refines the influencing factors of cultural tourism town positioning, and considers selecting the policy support index to represent the national and local government-oriented factors;

(ii) We use the regional economic theory to collect the influencing factors of cultural tourism town positioning, and based on the traditional BP neural network and the improved genetic algorithm, a genetic neural network model is created to train and predict the samples of cultural tourism towns; and

(iii) Taking a small town in the East as a case, the data were collected and analyzed, and grounded on the prediction outcomes of the genetic neural network, the best location of a small town was selected according to the actual situation of the region.

The remaining part of this paper is structured as follows. We discuss the state-of-the-art related works in Section 2. In Section 3, the selection of evaluation model for cultural tourism town positioning is elaborated. In Section 4, test and result analysis are deliberated in detail. As a final point, Section 5 completes this paper and deliberates some future research guidelines.

2. Related Work

The case study is presented as an illustration of effective tourist growth within a region that is already undergoing economic and social diversification [1]. The primary goal of [3] is to investigate how Bishoftu town residents view the negative effects of urban tourism. The topic of locating the tourist sites in Karo Regency's shortest route is covered by Sembiring et al. [4]. The goal of [6] is to determine how to manage the Instagram account material in order to promote the Banyumas Regency's potential tourism promotion system. On the basis of the five tourist towns in northern Taiwan, [2] adopt the integrated MCDM approach to assess the SDI (sustainable development index) for urban and rural/town tourism. Reference [5] uses logical analysis and literature research to analyze the connotation creation and development path of sports tourism cities. Reference [9] offers a solution to the problem of cultural overtourism, which has serious adverse repercussions. Reference [8] aims to collect information from cultural managers to maintain in time the intangible culture of the oral traditions of the city of Otavalo in a digital magazine. The main idea put forth is how a business owner of tourism-related items in Tanah Karo can use and develop local wisdom as a strategy for the sustainability and steady growth of a particular enterprise in the tourism zone through utilizing scientific cleverness, specifically through the idea of encouraging the marketing of tourism goods founded on local understanding through the online media [10]. Other influential work includes [9].

Foreign cultural tourism towns are generally the product of local cultural and economic development to a certain extent after a long period of historical accumulation. Therefore, most foreign scholars take the successful towns as cases to analyze the influencing factors of project positioning. For example, when (Campeau and Claudia Nicoletta) studied the transformation of the small town of Sigishwara in Transylvania, they found that the successful positioning of the small town was due to the recognition of its unique resource advantage of rich historical and material cultural heritage. Furthermore, Hotten et al. found that the combination of the local characteristic mining material landscape and the unique mining cultural landscape had a qualitative improvement on the urban tourism economy when analyzing the mining towns in the western United States, and believed that the organic combination of the characteristic industry and the characteristic culture played a complementary role. In other research as demonstrated by (Zlatanovi ć, Sanja), the authors believe that the regional cultural heritage, the national and local administrative authorities, and the interests of investors will all affect the positioning and planning of regional cultural tourism [10, 12].

The authors (Heydari Chianeh *R* et al.) believe that for regions with a long history and cultural heritage, it is advisable to take cultural tourism as the leading industry [21]. Deng D. et al. established the regional tourism product framework of small towns on the basis of summarizing the tourism literature of small towns [22]. Taking Morden as an example, they believe that the positioning of small towns needs to consider a variety of factors, such as regional advantages, mature characteristic industries and cultural and creative industries, and local policy guidance. The authors (Vukovi ć Predrag, Č Avlin Gordana, and Č Avlin Miroslav) in various works proposed that the success of both rural tourism town in the UK benefits from natural hot spring resources, location conditions, and convenient transportation [16–19]. When studying the STP theory, (Daan Francois Toerien) found that the cultural and tourism towns have achieved good benefits in the innovative use of local characteristic resources [23, 24]. When (Tosun C) studied the towns of Urgup in Turkey, the authors found that political and economic policies and linear national planning methods had a great impact on the development direction of regional tourism [25].

3. Selection of Evaluation Model for Cultural Tourism Town Positioning

3.1. Basics of the BP Neural Network and the Improved Genetic Algorithm. This research suggests a genetic algorithm grounded on adaptive mutation probability to enhance the classical BP neural network as an alternative to the conventional genetic algorithm. An EM-AGA-BP positioning evaluation model, which is established on the entropy technique, the BP neural network (BPNN), and adaptive mutation genetic algorithm (GA), is constructed, according to the improved cultural tourism town positioning evaluation system, to give a method for the positioning evaluation of cultural tourism towns.

An adaptive mutation genetic algorithm (AGA) is suggested in this study. The algorithm's goal is to make the genetic algorithm's mutation process better. The genetic algorithm population's variety is increased by the mutation operation. The mutation probability is currently determined by ongoing experiments. Every living thing in nature is dynamically adaptable. The adaptive mutation probability should be used when using a genetic algorithm to identify the overall best solution. To upsurge the multiplicity of the population and the proportion of exceptional individuals, the mutation probability should be raised when the population fitness value is low. The mutation probability should be decreased when the fitness value is higher, or when it is close to the global optimal solution [20]. Formula (1) illustrates how the adaptive mutation probability P was calculated in this study as follows:

$$P = \frac{(P_1 + P_2)}{2} = \frac{\left(P_0 - (P_0 - P_{\min}) * m/M + P_0 * \max\limits_{X_K \in \Omega} F(X_K)/\overline{F}\right)}{2}, \tag{1}$$

where K is the supposed as the initial mutation probability, and $P_{\min}$ is the smallest value of the variation probability value range. Furthermore, F is the average or statistical mean fitness value of the present population, and $\max_{X_K \in \Omega} F(X_K)$ is the maximum fitness value of the current population. Furthermore, M characterizes the supreme evolutionary algebra, and, in fact, on the other hand, M is the contemporary evolutionary algebra. This should be noted that P1 is the wrong way round proportionate to the evolutionary algebra (M), while P2 is the wrong way round proportional to the statistical mean or average fitness value [21].

The initial weight and threshold are determined at random, although they have a momentous influence on the performance of the BP neural network. This should be noted that researchers frequently combine the neural network with various contemporary optimization strategies to improve it. For instance, the weight and threshold of neural networks are frequently optimized using evolutionary algorithms. Genetic algorithms are used in this technique, which is not dependent on the BP neural networks, to find the best answer throughout the entire domain. As a result, it can address some of the drawbacks of gradient descent-based neural networks, including their propensity to easily slip into local minima and their slow convergence rates. In this research, the BP neural network is enhanced using the adaptive mutation genetic method, which optimizes the BP neural network model. The BP neural network and the adaptive mutation genetic algorithm make up the bulk of the model [22]. Figure 1 depicts the BP neural network's flowchart:

The normalized data are calculated, and the initial evaluation findings are obtained, using the entropy approach [23]. The following are the steps involved in the entropy method's calculation:

(1) The first step is the process of standardization of the original evaluation data, using the equation as shown in formula (2) as follows:

$$\dot{x}'_{ij} = \frac{\left(x_{ij} - \overline{x}\right)}{s_j}, \tag{2}$$

where $\dot{x}'_{ij}$ is the normalized value, and x_{ij} is the score of the i-th sample in the j-th index. Furthermore, $\overline{x}$ and s_j are the average value and standard deviation of index j, correspondingly. In order to encounter the requirements of logarithm in the entropy technique, the standardized value shall be shifted, using the mathematical equation as shown in formula (3):

$$Z_{ij} = \dot{x}'_{ij} + A, \tag{3}$$

where A is the length of the translation, and Z_{ij} is the value, which is attained after the translation.

(2) The second step is to quantify the small town positioning evaluation indicators at the same level and subsequently estimate the percentage of the ith sample under the jth indicator in this indicator p_{ij}.

$$p_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{m} Z_{ij}} \ (i = 1, 2, \cdots, m;\ j = 1, 2, \cdots, n), \tag{4}$$

where Z_{ij} indicates the amount and town positioning evaluation data after the translation stage.

(3) The third step is to determine the entropy, symbolized by e, of the jth index E_j. This computation is shown in formula (5) as follows:

$$E_j = -k \sum_{i=1}^{m} p_{ij} \ln\left(p_{ij}\right). \tag{5}$$

(4) In the fourth step, we calculate the difference in the coefficient G_j of index j. This calculation is mathematically given as shown in formula (6) as follows:

$$G_j = 1 - E_j, \tag{6}$$

where E_j is the entropy of the index j.

(5) In the fifth step, we normalize the difference coefficient and estimate the weight w_j of the jth index. This estimation is carried out using equation as shown in formula (7) as follows:

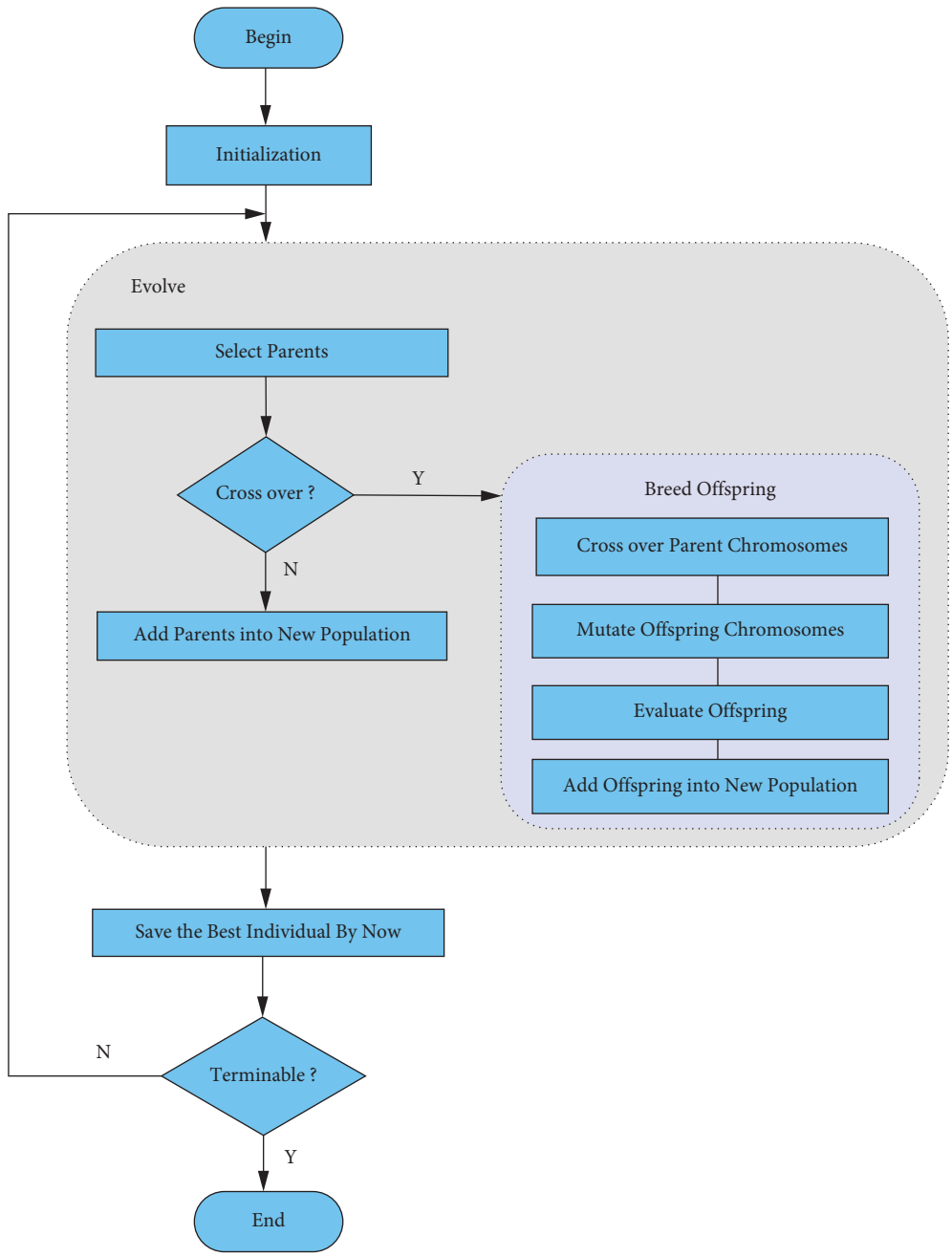

Figure 1: The BP neural network flowchart.

$$w_j = \frac{G_j}{\sum_{j=1}^{n} G_j}, \tag{7}$$

where G_j is the difference coefficient of index j.

(6) In the sixth step, we determine the town positioning evaluation F_i of the ith sample, and the process of this step is mathematically given as shown in formula (8) as follows:

$$F_i = \sum_{j=1}^{n} w_j p_{ij}, \tag{8}$$

where p_{ij} is the proportion of the ith sample in the jth index, and w_j is the weight of index j. The main modeling steps of the cultural tourism town positioning evaluation model are given as follows:

(1) we may make improvements and create a more accurate and useful index system by carefully examining the issues that currently exist in the positioning and evaluation of cultural tourism cities [24];

(2) bring together the sample data for the assessment of the positioning of a cultural tourism town, choose the evaluation indicators in accordance with the

positioning features of the cultural tourism towns, and distribute the sample data using some sort of percentages into the following: (i) training samples and (ii) test samples;

(3) we identify the BP neural network algorithm's parameters, such as the learning rate, the quantity of hidden layer neuron nodes, the extreme amount of iterations, the minimum error correctness, the transfer function, and the training duration;

(4) iterative training is accomplished while waiting for the trigger algorithm ends by feeding data into the assessment model;

(5) subsequently, we enter the test samples for the positioning evaluation of cultural tourism towns to see whether the improved genetic algorithm's training effect on the BP neural network model is sufficient. We continue to the next step if the forecast result satisfies the stop criteria; otherwise, reoccurrence to the preceding step, i.e., step (3), and reeducate the network model; and

(6) we enter the samples into the model used to evaluate the location of cultural tourism cities to get the evaluation results. The next two points primarily illustrate how the model uses the benefits of the entropy approach and the AGA-BP algorithm to make up for the drawbacks of the other methods.

(i) The AGA-BP algorithm model may overcome the drawback of the entropy technique, which lacks a horizontal comparison of indicators, by having the advantage of nonlinear mapping in any accuracy.

(ii) A way of weighting that is objective is the entropy method. The primary idea behind it is to calculate each index value's degree of volatility in order to estimate the index weight. This approach can lessen deviation brought on by human variables and offer a solid foundation for the neural network architecture. This method's initial evaluation result is used as a prior guidance sample for the AGA-BP algorithm model.

3.2. Source and Processing of Sample Data in Cultural Tourism Towns. By collecting the cases of cultural tourism towns that have been put into operation in China, and through careful screening, 50 town samples were selected as the training samples of the neural network for network training, and then, 5 samples were selected as the prediction samples to predict and verify the neural network after training. The basic data come from the statistical yearbook of provinces and cities, the network of characteristic towns, the public information of local government websites, etc., and then, the final data are calculated by formulas (8) and (9) and the evaluation system of historical and cultural tourism resources. In the table, $X1$ is the policy support index (P), $X2$ is the traffic accessibility index (g), $X3$ is the cultural and tourism industry influence index (a), $X4$ is the output scale index of characteristic industries (z), $X5$ is the ecological environment quality index (EI), $X6$ is the regional online tourism development index (T), and $X7$ is the human and historical resource index (H).

3.2.1. Policy Support Index (P). Whether the cultural tourism town project complies with the relevant local development policies or whether the local government gives relevant preferential policies: 1 is in conformity, 0 is not in conformity

3.2.2. Traffic Accessibility Index (G). The location conditions of the town are standardized and synthesized from the traffic (railway station, expressway, and airport) and location (distance from the adjacent urban area or scenic spot) to obtain the traffic accessibility index, which reflects the location and traffic convenience of the town.

$$G = \frac{\sum_{j\neq i}^{n_{ij}^{n}} \left(t_{ij}+t_i\right)\times P_j}{\sum_{j\neq i}^{n} P_j} \times k_i, \quad (9)$$

where G is the traffic accessibility index of the town; t_{ij} is the shortest time distance from small town i to the nearest urban area j; t_i is the resistance within the city; and P_j is the total population of the local area.

3.2.3. Cultural Tourism Industry Influence Index (A). This index is the influence of the cultural tourism industry in the region on all industries. The higher the impact index, the greater the impact of the tourism industry. In particular, it shall be calculated by constructing the Leontief inverse matrix as follows:

$$A = \frac{\sum_{j=1}^{n} \overline{z}_{lj}}{1/n \sum_{i=1}^{n} \sum_{j=1}^{n} \overline{z}_{lj}}, \ (i = 1, 2, \ldots, n). \quad (10)$$

3.2.4. Output Value Scale Index of Characteristic Industries (Z). The output value scale of characteristic industries refers to the proportion of the total output value created by the characteristic industries (except cultural and tourism industries) in a period of time in the comprehensive output value of all industries.

3.2.5. Eco-Environmental Quality Index (EI). The eco-environmental index refers to the index that reflects the quality of the eco-environment in a certain region.

3.2.6. Regional Online Tourism Development Index (T). Regional online tourism development refers to the tourism development level of each region, which can be queried through the big data report of China's online tourism development.

3.2.7. Human History Resource Index (H). The index of cultural and historical resources adopts the evaluation system of historical and cultural tourism resources, evaluates

Table 1: Normalized data of training samples.

No.	Name	$X1$	$X2$	$X3$	$X4$	$X5$	$X6$	$X7$
1	Town 1	1.0000	−0.4942	−0.8014	−0.6482	0.0206	0.8872	−0.4206
2	Town 2	1.0000	−0.9244	0.9778	−0.2349	0.6698	−0.5113	0.7658
3	Town 3	1.0000	−0.0717	−0.7387	−0.2391	−0.5797	−0.8496	−0.3975
4	Town 4	1.0000	−0.1796	−0.0780	1.0000	0.0844	−0.3609	0.0992
5	Town 5	1.0000	0.8551	−0.3049	−0.6400	0.0882	−0.3383	0.1575
6	Town 6	1.0000	0.4002	0.1159	0.8047	0.8874	1.0000	0.3011
7	Town 7	1.0000	−0.9630	0.9686	−0.8983	0.5910	−0.6541	0.6771
8	Town 8	1.0000	0.6715	−0.9534	−0.8396	−0.5385	0.2932	−0.9772
9	Town 9	1.0000	−0.0902	0.4665	0.4766	0.4484	−1.0000	0.0992
10	Town 10	1.0000	0.9877	−0.9094	−0.8056	−1.0000	1.0000	−1.0000
11	Town 11	1.0000	−0.6006	−0.8306	−0.7115	−0.2045	−0.8496	−0.1388
12	Town 12	1.0000	−0.7687	−0.3820	−0.8159	−0.8124	−0.6541	−0.9651
13	Town 13	1.0000	0.6808	−0.0405	−0.6529	−0.0131	−0.6541	0.1067
14	Town 14	1.0000	0.7394	−0.0832	−0.8501	0.5272	−0.5113	−0.0721
15	Town 15	1.0000	0.5451	−0.2130	−0.8044	0.2533	−0.3383	0.1307
16	Town 16	1.0000	0.0964	0.0422	−0.5341	−0.1632	−0.7744	0.2647
17	Town 17	1.0000	−0.3524	−0.2722	−0.5812	0.1220	−0.6541	−0.1639
18	Town 18	1.0000	−0.9306	0.9016	−0.6529	0.8274	−0.2857	0.4981
19	Town 19	1.0000	−0.9013	0.8798	−0.1237	0.1520	1.0000	0.4978
20	Town 20	1.0000	−0.9352	0.9386	−0.8409	0.6360	0.8872	0.5350
21	Town 21	1.0000	0.9013	0.6141	0.4753	0.3246	1.0000	0.0328
22	Town 22	1.0000	0.5035	0.3850	0.2289	0.2458	0.0451	0.0209
23	Town 23	1.0000	0.2768	0.1829	0.3709	0.3621	−0.3383	0.0068
24	Town 24	1.0000	−0.6931	−0.0958	0.9233	0.7561	1.0000	0.2014
25	Town 25	1.0000	−0.0625	0.7260	−0.1516	−0.0169	−0.5714	0.4475
26	Town 26	1.0000	−0.7687	0.8280	−0.8757	0.5910	−0.0752	0.7996
27	Town 27	1.0000	−0.8443	0.8885	−0.4925	0.3396	0.8872	0.4747
28	Town 28	1.0000	−0.8628	0.8558	−0.8774	0.6510	−0.0226	1.0000
29	Town 29	1.0000	−0.9291	0.8680	−0.4129	0.7974	0.8872	0.5495
30	Town 30	1.0000	−0.8504	1.0000	−0.2421	−0.0169	0.0827	0.5379
31	Town 31	1.0000	−0.8520	0.8127	−0.9338	−0.0469	−0.4737	0.5581
32	Town 32	1.0000	−0.0625	−0.0231	0.2288	0.3621	−0.3609	0.0752
33	Town 33	1.0000	0.3277	0.2657	0.3873	0.9625	1.0000	0.2061
34	Town 34	1.0000	0.2876	0.2861	0.4520	−0.2570	0.4361	0.1549
35	Town 35	1.0000	−0.9198	0.9199	−0.8819	0.4559	0.0451	0.8440
36	Town 36	1.0000	−0.8766	0.9525	−0.2954	−0.0094	−0.3609	0.5841
37	Town 37	1.0000	−0.9075	0.8558	−0.4235	0.3021	0.2180	0.4966
38	Town 38	1.0000	−0.9938	0.9003	−0.9513	0.6623	−0.0977	0.5073
39	Town 39	1.0000	−1.0000	0.9843	−0.4645	1.0000	−0.5113	0.7149
40	Town 40	1.0000	−0.8381	0.9037	−0.2522	−0.0131	0.0451	0.5396
41	Town 41	1.0000	−0.9861	0.9817	−0.2351	0.9475	−0.5113	0.6791
42	Town 42	1.0000	0.3894	0.1781	0.3685	0.1257	−1.0000	−0.0542
43	Town 43	1.0000	1.0000	−0.3685	−0.7740	0.3021	0.2180	−0.0120
44	Town 44	1.0000	0.8350	−1.0000	−0.2298	−0.3884	−0.2932	−0.3632
45	Town 45	1.0000	−0.5374	0.6485	−0.8856	−0.2120	0.3910	0.1275
46	Town 46	1.0000	−0.8134	0.8754	−0.6399	0.3471	−0.0226	0.8501
47	Town 47	1.0000	−0.5698	0.9159	−0.9996	0.6098	0.7970	0.0129
48	Town 48	1.0000	−0.9722	0.9961	−1.0000	0.3696	0.1278	0.7089
49	Town 49	1.0000	−0.8843	0.4268	−0.8773	0.4934	−1.0000	0.2092
50	Town 50	1.0000	−0.9553	0.9582	−0.8111	0.5985	−0.5113	0.6999

and calculates through AHP, and takes the regional historical and cultural resources as the object for the weighted calculation to obtain the final index.

The output range of the neural network in this research is (0, 1) since the transfer function employed in the output layer is an S-shaped function, and because of this, the output of training data must be normalized to fall within the [0, 1] interval. The preliminary assessment value range of cultural tourism town positioning determined by the entropy method is (0, 1). Therefore, Tables 1 and 2 can be obtained by data standardization again.

4. Test and Analysis

The evaluation outcomes for groups 1 through 50 are anticipated by the simulation experiment of the cultural tourist town placement evaluation based on the BP neural network, which is boosted by the enhanced genetic algorithm, and

Table 2: Predicted sample normalized data.

No.	Name	X1	X2	X3	X4	X5	X6	X7
1	Town 1	1.0000	−0.3348	0.8370	−1.0000	1.0000	−0.9762	−0.2947
2	Town 2	1.0000	−0.6319	0.0886	−0.7199	0.7029	−0.9762	−0.9240
3	Town 3	1.0000	−1.0000	0.8961	1.0000	−1.0000	−1.0000	0.1426
4	Town 4	1.0000	−0.0200	1.0000	−0.5814	0.2464	0.2857	1.0000
5	Town 5	1.0000	1.0000	−1.0000	−0.8284	−0.7754	1.0000	−1.0000

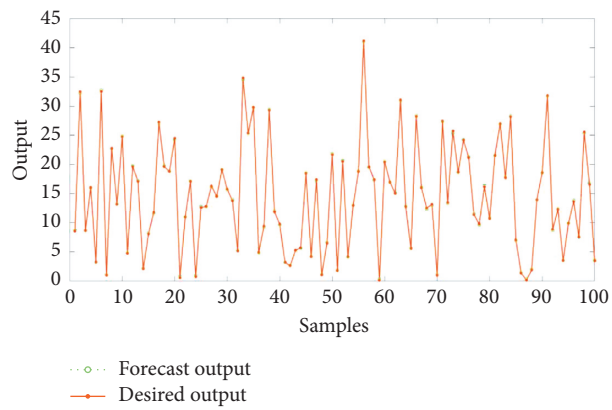

Figure 2: Improved genetic algorithm to boost the prediction results of the BP neural network model.

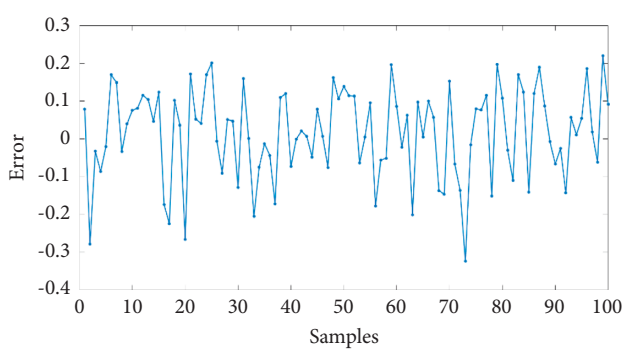

Figure 3: Improved genetic algorithm neural network prediction error percentage.

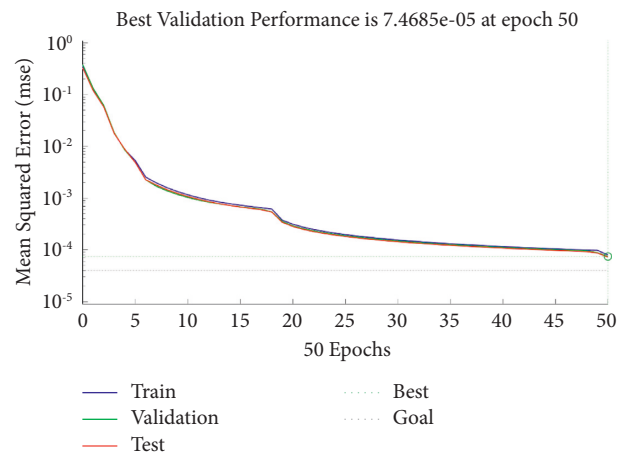

Figure 4: Mean square error convergence.

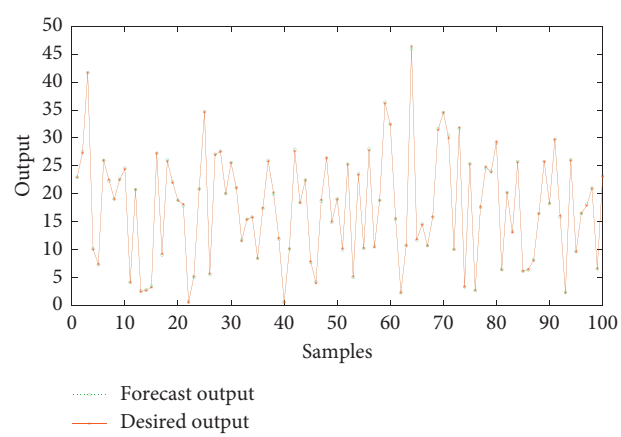

Figure 5: Prediction results of the AGA-BPNN model.

Figures 2–4 are generated. The mean square error (MSE) of the neural network model, which is enriched by the genetic algorithm, significantly drops during the first 10 iterations, nevertheless gradually over the subsequent 21 to 30 iterations, rendering to a comparison of the curve formed by the mean square error. In fact, we observed that the mean square error converges to 8.6066e-08 after 40 iterations. The neural network model is optimized by a genetic technique that practices adaptive mutation. The first generation iterates more quickly, whereas the second through eighth generations iterate more slowly. The ninth iteration is when convergence occurs, and the mean square error converges to 3.3839e-12, which somewhat increases the BP neural network's convergence speed and accuracy. The convergence accuracy is approximately twice as high, and the convergence rate is 82.13% greater than that of the neural network model optimized using the genetic algorithm. It demonstrates that applying adaptive mutation GA to optimize BPNN can increase the model's prediction accuracy while also speeding up the network's convergence rate.

We further compare the change in GA-BPNN error square sum with the AGA-BPNN error square sum of adaptive mutation. It can be seen from Figures 2 and 3 that the GA-BPNN average error square sum and minimum error square sum converge quickly before the 10th generation and slowly from the 10th to the 25th generation. When it finally reaches the 30th iteration, the sum of the squared errors is roughly 0.9. After just six cycles, the adaptive mutation GA-BPNN reaches convergence. The network's total error squares are stable, they converge to 0.19, the pace

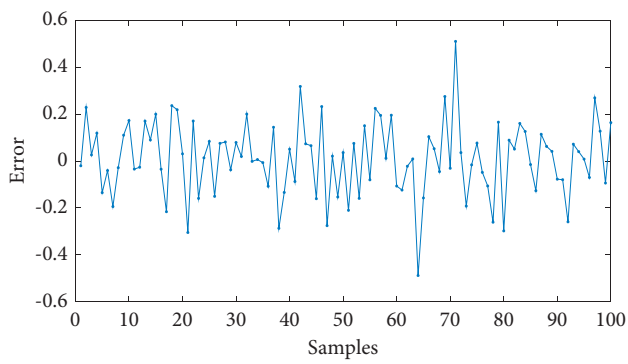

Figure 6: AGA-BPNN prediction error percentage.

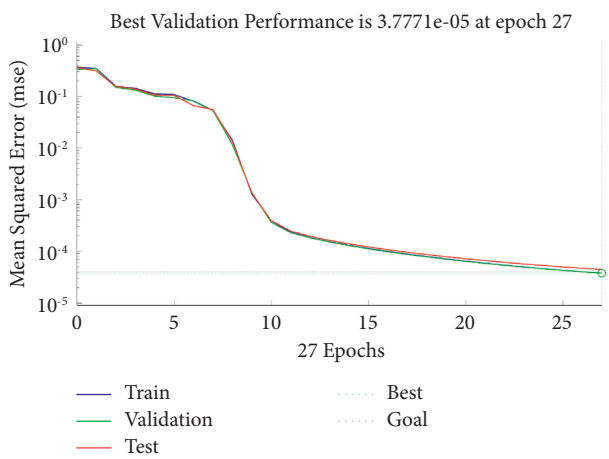

Figure 7: Mean square error convergence.

of convergence is raised by 84%, and the average total error square is decreased by 94%. It is clear from a comparison that the adaptive mutation GA-BPNN can efficiently carry out the entire bureau optimization. Both the BP neural network model and the enhanced model are applied to the latest 50 groups of test sample data in order to forecast the assessment results.

The outcomes of the predictions are displayed in Figures 4–7. It is evident that the evolutionary algorithm-optimized BP neural network model's prediction error is excessive, and the improved model's predictions essentially match the actual outcomes. The comparison of the three models' prediction accuracy is shown in Figure 8. As can be observed, the upgraded model has a much greater evaluation accuracy than both the BP neural network (BPNN) model and the BP neural network model improved by the genetic algorithm. As a result, the revised genetic algorithm-based BP neural network assessment model has better application value. The positioning of cultural tourist towns can be evaluated using the model in a fast, efficient, and scientific manner.

The average assessment correctness of the classical BP neural network model for approximately 50 collections of data is up to 84.23 percent, that of an optimized genetic algorithm is 91.84 percent, and that of an optimized genetic algorithm, which is founded on the adaptive mutation, is

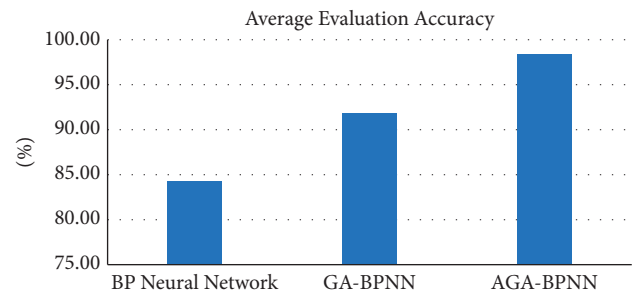

Figure 8: Average evaluation accuracy with different models.

approximately 98.37 percent, which is, respectively, 14.01 percent and 6.39 percent greater than the other two methods. The assessment outcome of the BP neural network approach that was improved by a genetic algorithm grounded on the adaptive mutation is superior, as can be observed.

5. Conclusions and Future Work

Based on the concept of sustainable development and regional economic theory, this paper refines the influencing factors of cultural tourism town positioning, and considers selecting the policy support index to represent the national and local government-oriented factors; using the traffic accessibility index to represent location and traffic factors; ecological environment index, regional online tourism development index, and human and historical resource index are used to represent the ecological environment and historical and cultural factors; the influence index of cultural and tourism industry and the output value scale index of characteristic industries are used to represent the industrial structure factors of the project area. It can be seen that the genetic algorithm can successfully address the drawback that the BP neural network may fall into the local lowest value by training and prediction of samples using the BP neural network and the BP neural network improved by the genetic algorithm. In terms of accuracy and training time, the neural network enhanced by genetic algorithms outperforms the conventional BP neural network. In addition to the classification capabilities of the BP neural network, the BP neural network improved by genetic algorithm also exhibits great macrosearch capabilities and good global optimization performance. The genetic neural network model trained by a sample database can quickly and accurately classify different cultural and tourism towns.

In the future, we will employ other PSO and machine learning method variations with the ability to adaptively modify different parameters in order to enhance algorithm convergence. Additionally, we will take into account the PSO's Markov jumping technique, which can split up the entire population into smaller stages and prevent the convergence of local optima. On the other hand, we will investigate alternative deep learning models in depth and raise prediction accuracy. The network's training and prediction times are directly impacted by the underlying problem of scarce resources. As a result, we will look into how big data

analysis and technologies like cloud and edge will assist to shorten the time needed for model training and prediction in the future.

Data Availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

A Comprehensive Evaluation of Environmental Quality for Health Ecotourism in Huangshan National Forest Park

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In recent years, people's life rhythm is fast due to which life pressure is increasing, and the ecological environment is seriously polluted. All these factors contribute to serious physical and mental health issues, posing a direct threat to people's health. Due to these factors, health tourism and recreational tourism of traditional Chinese medicine pay more attention. In this paper, Huangshan National Forest Park is selected as the actual research object, and the environmental quality of healthy ecotourism is analyzed according to the current situation of the forest park. It employs the analytic hierarchy process (AHP) to identify 12 different indicators of ecotourism's environmental quality. It establishes a comprehensive evaluation index system for the ecotourism environmental quality, as well as an evaluation model based on this system. Furthermore, a comprehensive evaluation model is established using the fuzzy math analysis method, and five levels of standards are established to judge the level of ecodevelopment of the Huangshan National Forest Health and Maintenance. By calculating the weight of each index in the evaluation system, the result of a comprehensive evaluation is 75.92 points, which is in the good grade. The experimental results show that the eco-environmental resources in Huangshan National Forest Park are of higher quality. The planned landscape is more attractive, the eco-environmental area is larger, the cleanliness of the air in the forest park is higher, and the service personnel have higher cultural literacy.

1. Introduction

Ecotourism is the representation of the principles of sustainable development inside the tourism sector, attempting to achieve stability between environmental, financial, and social elements [1]. Ecotourism, in particular, is well represented in developing economies owing to its special benefits of not only trying to promote environmental protection but also enhancing urban progress [2]. As of now, various organizations and researchers have described ecotourism from various perspectives. Whatever the description, the material has always been concerned with three aspects: ecotourism action, environmental preservation, and the maintainable promotion of local society [3]. One of the best early widely accepted ideas was suggested by Ceballos-Lascurain. It emphasizes the action of traveling to undisturbed natural or unpolluted nature reserves with the particular goal of learning, appreciating, and enjoying nature, as well as any current cultural elements discovered in these regions [4]. Ceballos-Lascurain offered this description from the point of view of the end user [5].

In reality, the definition of ecotourism reveals the interpretation of ecotourism development. Ecotourism is focused on nature-oriented and unique traditions, such as seeing wildlife, seeing wild plants, strolling on a forest path, mountain tribe hiking, and experiencing local customs [6]. Due to their all-centric trends, ecotourists, who tend to be more knowledgeable and have higher earnings, prefer staying, investing more each day than traditional tourists, and seeking out goods and services for their use. Ecotourists want a more environmentally responsible travel experience and are frequently concerned about conservation [7, 8]. Their age range and sex ratio vary depending on the type of ecotourism action they participate in and their preferences

[9]. Besides, the connotation of healthy ecotourism is health-oriented and health-preserving tourism, which is called healthcare tourism internationally. Therefore, it can be regarded as health-based tourism derived from health-oriented tourism to form healthy ecotourism [10, 11]. At present, people's quality of life has been greatly improved, the leisure economy has been developing rapidly, and the proportion of the tourism industry in the regional economy has been increasing year by year. This development promotes the rapid integration of tourism into other industries and further is subdivided into a variety of types of tourism, namely, health tourism and health ecotourism, which have become a new trend in tourism development [12, 13].

Ecotourism requires more planning and decision-making than other types of tourism [14]. To begin with, ecotourism is not uniform [3]. The same management can be applied to areas with varying characteristics and circumstances. Second, ecotourism's influence may not always be favorable [15]. In summary, the effect of ecotourism actions can be measured in terms of environmental, financial, and social outcomes. It will have several negative effects on local regions if unsuitable control mechanisms are used [16, 17]. Furthermore, ecotourism is complicated, reflecting the diversity of interested parties, including residents, local government, visitors, and related businesses [18]. As a result, the critical issue for ecotourism managers and executives is determining which technique should be used to successfully assess and manage the destination. The strategy analytic hierarchy process (AHP) method is suggested for ecotourism planning since it allows for the incorporation of clear statements of interested parties' preferences and the determination of relative weights of criteria [8]. Based on the aforementioned, the AHP is used in this paper to assess the environmental quality of Huangshan National Forest Park. It establishes a comprehensive evaluation index system for the ecotourism environmental quality of Huangshan National Forest Park and determines twelve ways to measure the quality of ecotourism. Furthermore, it establishes a comprehensive evaluation model based on this system, as well as a comprehensive evaluation model using the fuzzy math analysis method, and it establishes five levels of standards to judge the level of ecodevelopment of the Huangshan National Forest Health and Maintenance.

The innovations of this paper are as follows:

(1) To accurately pick the optimal action during health ecotourism, a multicriteria decision-making technique analytic hierarchy process (AHP) is used. Key influential characteristics known as criteria and subcriteria are recognized to assist in correct decision-making concerning the recommendation of best and suitable action in health ecotourism for tourists.

(2) The goal of creating a comprehensive assessment of Huangshan National Forest Park's ecotourism environmental quality is to accurately evaluate the ecotourism environmental quality in this area. It determines whether the region has the potential for tourism development and assists the region in identifying its weaknesses.

(3) By building a comprehensive evaluation model of the ecotourism environmental quality of Huangshan National Forest Park, 12 indicators are selected to evaluate the eco-environmental quality of the local health and maintenance, and the contribution degree of each indicator to the ecotourism environment is compared and analyzed, to provide a basis for the planning and development of the ecotourism of Huangshan National Forest Park.

The rest of this research work is listed as follows: Section 2 is based on the related work of national and international researchers; Section 3 highlights the methodology for the suggested model and the materials that employ for the model creation of this study; Section 4 is based on the comprehensive evaluation model of ecotourism environmental quality; Section 5 discusses the experimental work of the study and its results; and Section 6 concludes the work.

2. Related Work

Ecotourism is defined as a subset of sustainability that focuses on the natural surroundings [19]. A group of investigators has identified Ceballos-Lascurain's definition as among the most widely accepted [20]. Ecotourism is defined as traveling to relatively untouched or unpolluted natural areas with the specific goals of learning and appreciating the beautiful landscape and wildlife, as well as any traditional social representations found in these regions [21]. Forest recreation tourism originated from forest bathing and forest therapy. It is based on forest resources and the theoretical basis of Western medicine. It combines medical and recreational service facilities to carry out modern tourism activities such as forest recuperation, health care, old-age support, health maintenance, and vacation [22, 23]. It was the first forest bath base in the world founded in Germany in the 1940s. It started in Asia and developed in the construction of natural sanatorium forests in 1982, and in Korea. The booming development in the world was after the rise of Forest Recreation Tourism in European and American countries in the 21st century.

The healthy ecotourism develops rapidly, but the academic field is still in the preliminary research stage in the study of healthy ecotourism; especially, the content and results in the study of the environmental quality of the healthy ecotourism are relatively few. Foreign scholars started early on the study of forest recuperation tourism and related concepts, and theoretical basic research is mature. More research findings focus on the impact of forest recuperation tourism on human recovery. They mostly talk about how the forest environment affects human physiology and psychology. At the same time, a variety of health-preserving tourism modes have been developed, such as medical tourism and health-preserving leisure tourism [24, 25]. In 1998, some experts compared the types of hot springs and forest recreation from the perspective of recreation, pointing out that people walking in the woods and

soaking in hot springs play the same role. In 2007, the concept of forest therapy was put forward, and it was pointed out that the health attributes of forest health foods have higher development value. In 2009, experts analyzed all aspects of health maintenance and health maintenance from the perspective of the activity process, indicating that healthy ecotourism was formed by combining the modern leisure view with the health maintenance view [26, 27]. China has also started the wave of building a healthy tourism base. Each region should set up a characteristic health tourism industry based on its local advantages, of which the most complete supporting facilities are Shandong's healthy tourism base [28]. Starting from the current situation of health and well-being, Chinese scholars began to study and explore the mode of health and well-being ecotourism by fully drawing on the achievements of developed countries. In 2005, Chinese scholars initially defined the healthy ecology and pointed out that the future healthy ecotourism has broad prospects for development [29]. Ecotourism is a kind of tourism mode that plans the landscape according to the characteristic eco-environment of each region. Consequently, healthcare tourism depends strongly on their human and natural eco-environment [30]. The drawback in the above is that the landscape design is uniform and unable to reflect the local characteristics, and medical security facilities are difficult to meet the basic requirements of tourists. The purpose of this study is to provide a data basis for Huangshan National Forest to adjust the measures of healthy ecotourism and break the original solidification mode.

3. Material and Method

3.1. Ecological Value. Ecological value is the ability of the ecosystem to meet human direct or indirect needs. This capability derives from the functioning of ecosystems, such as the provision of products and services by natural processes and their components. When ecosystem function is endowed with the connotation of human value, it becomes the value of ecosystem products and services, that is, the ecological value [31].

The United Nations Millennium Assessment of ecological value refers to the benefits people derive from the ecosystem, which can be assessed and predicted based on real data. In further research, Fang K believes that ecological value can be divided into use value and nonuse value. Eco-use value refers to the value that humans can obtain economic benefits from this ecosystem service function in the current or future period. On the one hand, it includes the direct use value, that is, to directly meet the current production or consumption needs of human beings [32]. On the other hand, it includes the indirect use value, which provides necessary guarantee conditions for human production and consumption, such as water circulation, soil protection, and microclimate regulation. It also includes potential (alternative) value, which may be used in the future and provide economic benefits to humans. Water conservation, recreation, and entertainment are examples of future benefits realized by the direct or indirect application of value [33].

3.2. Ecosystem Functions. Since the 1990s, due to the dramatic increase in population and the exploitation and utilization of natural resources, the global ecological environment has changed dramatically. Based on classical biological individuals, populations, communities, and so on, the subjects of ecology are constantly upgrading their levels and expanding their space. With the natural-economic-social composite ecosystem as the research focus, ecology has become one of the most dynamic and fast-growing disciplines in the current disciplines.

Some scholars believe that the ecosystem has four main functions, namely, regulation function, carrying function, production function, and information function [34]. The scholars of [35] hold that the functions of the ecosystem are mainly manifested in the provision of life and product quality, the maintenance of a life support system, and the enjoyment of spiritual life. There are 17 main types of ecosystem functions, including gas regulation, climate regulation, disturbance regulation, water regulation, water supply, erosion control and sediment maintenance, soil formation, nutrient cycling, waste disposal, pollination, biological control, shelter, food production, raw materials, genetic resources, recreation, and culture. Researchers classify ecosystem functions as shown in Table 1.

3.3. Ecotourism. Ecotourism is a type of tourism that involves visiting vulnerable, pure, and largely unspoiled natural regions. It provides a low-impact, sometimes a small-scale, alternative to traditional economic mass tourism. It involves the protection of natural regions, environmental conservation, and increasing the local population. Its goals may be to educate the traveler, raise cash for environmental protection, directly help local economic growth and political empowerment, or promote respect for diverse civilizations and human rights. Ecotourism has been seen as an important undertaking by environmentalists ever since the 1980s, for coming generations to visit locations generally undisturbed by human involvement. A crucial factor in the ecotourism business is variety in terms of visitor kinds and actions. The typology nature of ecotourism may be seen in Figure 1.

The hardcore comprises scientific researchers or participants on tours created expressly for teaching, ecological sustainability, or similar goals. People who go deliberately to view protected places and learn about local natural and cultural heritage are among the devoted. Ordinary people are individuals who travel to the Amazon, Rwanda's gorilla park, or even other odd locations purely for the experience. Unplanned visitors are individuals that visit nature on the spur of the moment, such as on a day excursion or a longer vacation.

3.4. Ecotourism and Analytic Hierarchy Process (AHP). The AHP is a systematic procedure for organizing and analyzing complex decisions suggested by Thomas Saaty in 1980 for decision-making [36]. Even though AHP can define the main goal concerning a sequence of alternative solutions that are analyzed on the different criteria, it assists decision-

Table 1: Ecosystem function classification.

Service function		
Supply function	Adjustment function	Cultural function
Food	Climate regulation	Spiritual and religious
Freshwater	Disease control	Spiritual and religious
Fuelwood	Water regulation	Entertainment and ecotourism
Fibre	Water purification	Esthetics
Medicinal materials	Pollination	Inspiration
Genetic resources		Education
	Sense of place	
	Cultural inheritance	
Support functions		
Soil formation	Nutrient cycle	Primary production

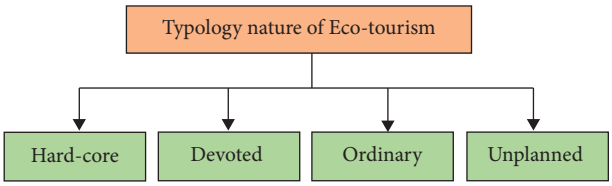

Figure 1: Typology nature of ecotourism.

making in finding the response that better serves their objective instead of the appropriate judgment. In other words, the results given by AHP will alter in line with changes in the criteria or the weight of the assessment criteria [37]. The multicriteria problem, according to AHP, is visually organized into a value tree of goals by building a hierarchy of characteristics [38].

The goal of this study is to use the analytic hierarchy process to pick the best ecotourism operation in Huangshan National Forest Park. To achieve this goal, it should first establish an alternate solution and criteria sets. Initially, the criteria and alternative solutions are developed with four aspects and twelve subcriteria based on previous theory evaluations and local real incidents. Following that, fuzzy mathematics is used to quantify the suggestions of the experts questioned, and the framework is eventually recognized with four criteria and twelve subcriteria. They are B1 healthy landscape environment (landscape ornamental C1, landscape diversity C2, and landscape uniqueness C3 to locals and tourists); B2 natural ecological environment (greening degree C4, air cleanliness C5, and negative oxygen ion concentration C6); B3 healthy social culture (healthy atmosphere C7, health culture C8, and construction of healthy talents C9); and B4 healthcare service facilities (accommodation and catering facilities C10, medical security facilities C11, and tourism public facilities C12 to locate the facilities of tourists).

4. Comprehensive Evaluation Model of Ecotourism Environmental Quality

4.1. Establishing a Comprehensive Evaluation Index System. This paper establishes the criterion layer when studying the comprehensive evaluation of the ecotourism environmental quality of Huangshan National Forest Park. The criterion layer is mainly used to evaluate the ecotourism environmental quality and ensures that the selected criterion layer index can cover all the factors of the ecotourism environmental quality of Huangshan National Forest Park and has a logical relationship between them. This paper uses the analytic hierarchy process (AHP) to divide the comprehensive evaluation model of the ecotourism environmental quality of Huangshan National Forest Park into three levels. The target layer is the comprehensive evaluation index system of the ecotourism environmental quality of Huangshan National Forest Park. The criterion layer is the landscape environment, the natural ecological environment, the social culture, and the health and maintenance service facilities. After subdividing the criterion layer, the content of the index layer is determined. Based on the data analysis and expert scoring method, 12 indexes were selected, including landscape ornamental, landscape diversity, landscape uniqueness, greenness, air cleanliness, negative oxygen ion concentration, recreational atmosphere, recreational cultural literacy, recreational personnel construction, accommodation and catering facilities, medical security facilities, and tourist public facilities. Figure 2 below is a comprehensive evaluation index system.

4.2. Fuzzy Mathematics. This paper uses the method of fuzzy math analysis, which uses the fuzzy principle and relationship based on fuzzy math, and evaluates the factors synthetically by quantifying the boundary, which is fuzzy and cannot be quantified. Based on each index of the evaluation object, a corresponding a hierarchical fuzzy subset is constructed, and the degree of superiority of the index is selected as the fuzzy hierarchical value, that is, the index membership. Fuzzy comprehensive evaluation quantifies the fuzzy indexes of evaluating things by using the method of constructing a hierarchical fuzzy subset, and then uses the principle of fuzzy transformation to comprehensively analyze each index. The flowchart of fuzzy mathematics adopted by this research for the environmental quality of health ecotourism in Huangshan National Forest Park can be seen in Figure 3.

The following are the specific steps of Figure 3:

Step 1: explicit factor scope of evaluation object: $X = \{X_1, X_2, \ldots X_n\}$, used to represent n different evaluation indexes.

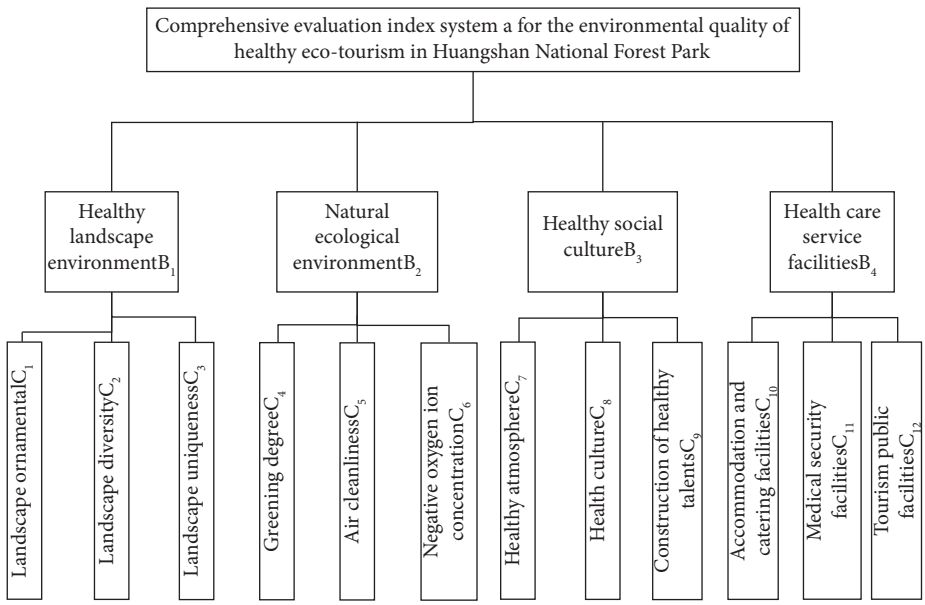

Figure 2: Comprehensive evaluation index system for environmental quality of health ecotourism in Huangshan National Forest Park.

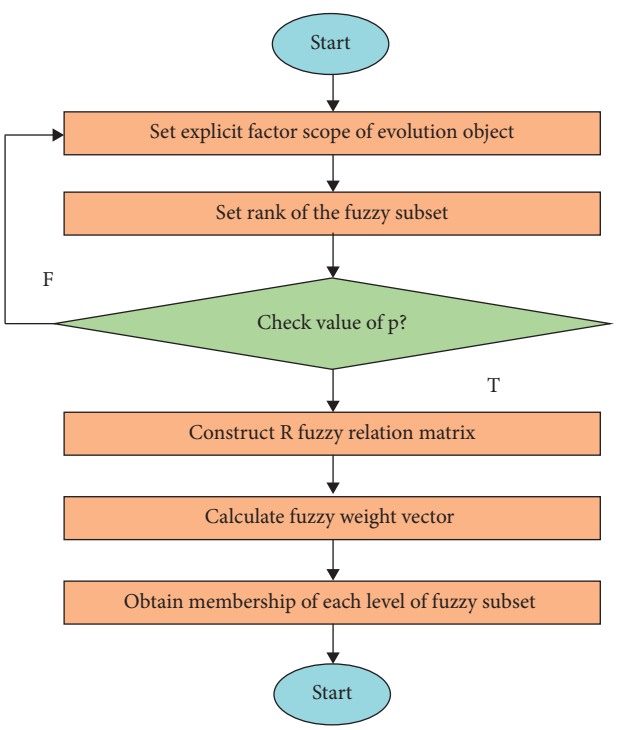

Figure 3: Flowchart of fuzzy mathematics adopted by this research for the environmental quality of health ecotourism.

Step 2: explicit comment-level field: $V = \{V1, V2,..., Vp\}$ rank set; each rank corresponds to a fuzzy subset; usually, the value interval of P evaluation level is [3, 7]; and its value is an integer. If the value of P is large, it indicates that the description is difficult and the attribution of its grade cannot be judged. If the P value is small, the quality requirement of fuzzy comprehensive evaluation cannot be met.

Step 3: the R fuzzy relation matrix is constructed by univariate evaluation. After the hierarchical fuzzy subset is established, the evaluated things are quantified on each factor X_i and the following fuzzy relation matrices can be obtained by analyzing the membership (R/X_i) of the evaluated things to different hierarchical subsets based on one-factor analysis:

$$R = \begin{bmatrix} \frac{R}{X_1} \\ \frac{R}{X_2} \\ \cdots \\ \frac{R}{X_n} \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1p} \\ r_{21} & r_{22} & \cdots & r_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ r_{x1} & r_{x2} & \cdots & r_{np} \end{bmatrix}_{n\times p}. \quad (1)$$

In the above matrix, r_{ij} is the jth column element in row i, that is, the membership of the fuzzy subset of the V_j rank of the transaction being evaluated by the Xi element analysis using $(R/X_i) = (r_{i1}, r_{i2}, \ldots, r_{ip})$ fuzzy vector to represent the evaluated thing in any factor X_i.

Step 4: the fuzzy weight vector $W = (\omega_1, \omega_2, \ldots, \omega_n)$, not all the evaluation factors, is of the same importance to the evaluated things, so the exact fuzzy weight vector should be calculated before synthesis. The weight vector in fuzzy comprehensive evaluation is represented by W, and ω_i is the membership of the X_i factor to the fuzzy subset, which can be calculated using the fuzzy method.

Step 5: by synthesizing all things based on fuzzy vector W, the membership of each level of fuzzy subset of the thing can be obtained. The following is a fuzzy comprehensive evaluation model:

$$W \circ R = (\omega_1, \omega_2, ..., \omega_n) \circ \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1p} \\ r_{21} & r_{22} & \cdots & r_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{np} \end{bmatrix} = (b_1, b_2, ..., b_p)B. \quad (2)$$

4.3. Establishing Comprehensive Evaluation Model of the Environmental Quality of Well-Being Ecotourism. The comprehensive evaluation of the environmental quality of ecotourism in Huangshan National Forest Park belongs to comprehensive evaluation work. For the established evaluation index system, any one of them must visually reflect the current situation of the ecotourism environment. This paper uses the weighted function method to fundamentally improve the quality of the ecohealth tourism environment. The basic formula can be shown in the following equation:

$$Y = \sum_{i=1}^{Nb} Bi \left(\sum_{j=1}^{Nc} Cj * Xk \right). \quad (3)$$

In the above equation, X is the standardized value of different single indicators. B and C are the weights of indicators at each level, Nb is the number of category B indicators, NC is the number of category C indicators to which category B indicators belong, Bi is the weight of the ith category B indicator, and CJ is the weight of the jth category C indicator.

According to the domestic and foreign ecotourism environmental classification methods, referring to this model, the ecotourism environmental quality of Huangshan National Forest Park is divided into five grades, and the score interval of each grade is described in detail in Table 2.

5. Experimental Results and Analysis

5.1. Current Situation of Tourism Resources in Huangshan National Forest Park. Huangshan National Forest Park is located in Huangshan District, Huangshan City, Anhui Province. It was officially established with the approval of China's forestry department in 1987. Its area is 12612.3 hm^2. Its components include the Yanghu National Forest Farm, the former Huangshan, Youshan, Lushan, and Xiancun. The detailed tourism resources of Huangshan National Forest Park are listed in Table 3.

5.2. Weight Calculation Results of the Comprehensive Evaluation Index System. The environmental quality evaluation criteria of healthcare ecotourism in Huangshan National Forest Park are classified into quantitative and qualitative components based on the nature of the various variables. The quantitative parameters may be tracked to identify the index level, whereas the qualitative factors must be evaluated by field investigation and analysis.

Based on the comments $V = \{V1, V2, V3, V4, V5\} =$ {preferably, good, commonly, difference, poor}, we establish the fuzzy mapping of Huangshan National Forest Park Health ecotourism environmental quality indicator layer, and then conduct a field investigation to clarify the membership of different indicators. We build a first-class judgment matrix R(Bi), further fuzzy operation R(Bi), and the response indicator layer weight set W(Bi). Based on these parameters, we obtain the first-class comprehensive evaluation such as Bi, shown in the following equation.

$$B_i = W(B_i) \times R(B_i). \quad (4)$$

This article examines the relevance of each criterion and determines the weight of the environmental quality evaluation index of healthcare ecotourism in Huangshan National Forest Park using the analytic hierarchy method and the Yaahp software, as shown in Table 4.

5.3. Analysis of the Comprehensive Evaluation Results of the Environmental Quality of Kangyang Ecotourism. Based on the constructed comprehensive evaluation model of healthcare ecotourism environmental quality and the above-calculated index weights, the weighted function method is used to evaluate the healthcare ecotourism environmental quality of Huangshan National Forest Park. The results of the first-order fuzzy evaluation on the environmental quality of the healthy ecotourism in Huangshan National Forest Park are as follows:

$B_1 =$ 0.273, 0.326, 0.184, 0.192, 0.035),
B2 = (0.000, 0.851, 0.123, 0.037, 0.000),
B3 = (0.133, 0.301, 0.352, 0.172, 0.054),
B4 = (0.098, 0.273, 0.275, 0.274, 0.112).

The first level of fuzzy comprehensive assessment outcomes is derived using the maximum membership degree of fuzzy comprehensive judgment. The data from each level are then standardized, and the assessment factors and grades are mapped one by one to provide the evaluation results for various variables, as shown in Table 5.

Based on the principle of membership, there are 7 good indicators, 2 average indicators, and 3 poor indicators in the indicator layer. Because no indications are rated good, there seem to be 7 indicators that are rated good, accounting for 0.583 of all indicators. It indicates that these indicators account for a significant proportion of the evaluation of the environmental quality of healthy ecotourism in Huangshan National Forest Park, which has a decisive impact on the final results. According to the data in Table 5, the comprehensive evaluation score of the environmental quality of the healthy ecotourism in Huangshan National Forest Park is 75.92, which belongs to the good grade.

By comparing the evaluation results of each index one by one, the histogram method is utilized to associate and examine the criteria-level indicators, and the actual evaluation outcomes are reflected from many aspects. These may be seen in Figure 4. According to this figure, the index weight is expressed by the height of the histogram. The higher the histogram is, the higher the importance of this index in the environmental quality of healthy ecotourism in Huangshan National Forest Park is. The advantages and disadvantages of indicators are depicted by using color blocks of varying

Table 2: Scoring standard for comprehensive evaluation of ecological health.

Score y	90–100	75–90	60–75	30–60	0–30
Healthy ecological development level	Preferably	Good	Commonly	Difference	Poor

Table 3: Current situation of tourism resources in Huangshan National Forest Park.

Type	Tourist resources
Geocultural landscape	Wushan Mountain, Youshan Mountain, Tianhu Mountain, Lushan Mountain, Luotuofeng Mountain, Toad Mountain, Xiangling Mountain, Ruoling Mountain, Longtan Canyon, Guangdong Canyon, etc.
Biological landscape	Deciduous broad-leaved forest, evergreen broad-leaved forest, alpine dwarf forest, Chinese fir forest, alpine meadow, Shili Bamboo Sea, nanmu forest, azalea sea
Hydrological landscape	Tianhu Lake, Taiping Lake, Dayang Lake, Xiaoyang Lake, Longtan, Wulong Waterfall, Pearl Lake
Celestial phenomena and climate landscape	Appreciating the moon in Tianhu lake, sunrise in Ruoling, misty rain in Pinghu Lake
Cultural activities	Huangshan mountaineering festival, closing the mountain with gongs, Huangshan tea ceremony
Tourism commodities	Bamboo carving, Huangshan Maofeng, Huangshan Shier, Huangshan Torreya grandis, bamboo shoots

Table 4: Evaluation index weight of ecological health tourism.

Target layer A	Criterion layer B	Weight	Index layer C	Weight
Comprehensive evaluation index system for the environmental quality of healthcare ecotourism in Huangshan National Forest Park A	Healthy landscape environment B_1	0.426	Landscape ornamental C_1	0.136
			Landscape diversity C_2	0.245
			Landscape uniqueness C_3	0.045
	Natural ecological environment B_2	0.157	Greening degree C_4	0.163
			Air cleanliness C_5	0.201
			Negative oxygen ion concentration C_6	0.216
	Healthy social culture B_3	0.262	Healthy atmosphere C_7	0.124
			Health culture C_8	0.257
			Construction of healthy talents C_9	0.158
	Healthcare service facilities B_4	0.155	Accommodation and catering facilities C_{10}	0.264
			Medical security facilities C_{11}	0.237
			Tourism public facilities C_{12}	0.198

intensities. However, if the lightness of each histogram changes less, the viewpoints are more congruent. If the color is darker, then the opinion will be better.

5.3.1. Healthy Landscape Environment B1. Figure 5 depicts the results of a comparison of healthcare landscape environment indicators. According to this figure, the most critical indicator in the healthcare ecotourism environmental quality of Huangshan National Forest Park is landscape ornamental, which is rated as good, indicating that tourists are very positive about the landscape designed and planned by Huangshan National Forest Park, and the layout meets people's esthetic requirements. The C2 index of landscape diversity has an evaluation grade of average, indicating that the number of healthcare landscapes built in the park is limited and cannot meet people's basic healthcare needs. The evaluation grade of the C3 indicator of landscape uniqueness is poor. When tourists evaluate Huangshan National Forest Park, they believe that its landscape is similar to that of other regions and does not reflect the characteristics of this region. It does not integrate the local cultural atmosphere into the landscape setting and lacks a healthy ecological environment with local characteristics.

5.3.2. Natural Ecological Environment B2. Figure 6 shows the comparison results of natural ecological environment indicators. The indicators of greening degree C_4, air cleanliness C_5, and negative oxygen ion concentration C_6 in this standard layer are good. The evaluation results show that the air cleanliness and negative oxygen ion concentration of Huangshan National Forest Park have been improved after years of management. At the same time, the natural ecological environment is good and the greening degree is high.

5.3.3. Healthy Social Culture B3. Figure 7 shows the comparison results of the indicators of the social and cultural environment of health care. According to the figure, both the

Table 5: Assessment results of the environmental quality of healthy ecotourism in Huangshan National Forest Park.

Target layer A	Total score	Criterion layer B	Evaluation results	Index layer C	Score	Evaluation results
Comprehensive evaluation index system for the environmental quality of healthcare ecotourism in Huangshan National Forest Park A	75.92	Healthy landscape environment B_1	Preferably	Landscape ornamental C_1	99	Preferably
				Landscape diversity C_2	73	Commonly
				Landscape uniqueness C_3	28	Poor
		Natural ecological environment B_2	Preferably	Greening degree C_4	97	Preferably
				Air cleanliness C_5	95	Preferably
				Negative oxygen ion concentration C_6	96	Preferably
		Healthy social culture B_3	Commonly	Healthy atmosphere C_7	98	Preferably
				Health culture C_8	97	Preferably
				Construction of healthy talents C_9	74	Commonly
		Healthcare service facilities B_4	Commonly	Accommodation and catering facilities C_{10}	27	Poor
				Medical security facilities C_{11}	29	Poor
				Tourism public facilities C_{12}	98	Preferably

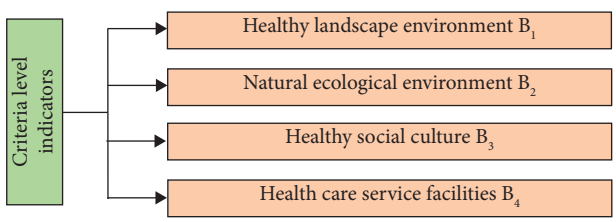

Figure 4: Comparison of criteria-level indicators.

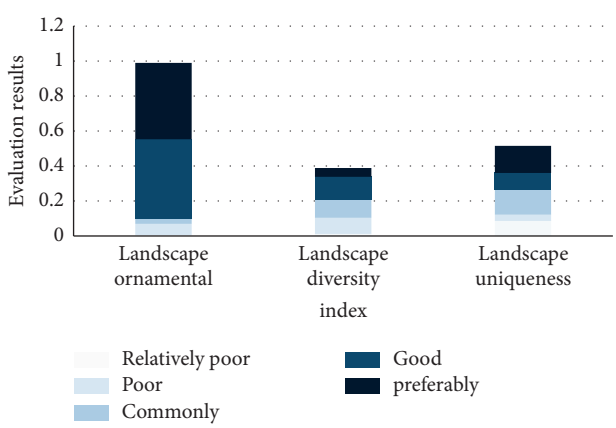

Figure 5: Comparison of landscape environmental indicators for health care.

indicators C7 and C8 are very important and are good, indicating that Huangshan National Forest Park has formed a mature healthcare system, which can create an ideal healthcare atmosphere for tourists. The personnel engaged in this work have high cultural literacy, have received

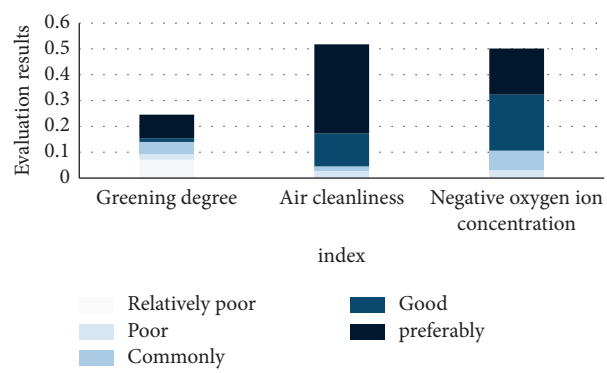

Figure 6: Comparison of natural ecological environment indicators.

relevant professional training, and have a strong sense of service. It can promote the development of tourism in this region. However, the C9 indicator level of healthcare talent construction is average; that is, the region lacks a complete talent construction system, and cannot continuously transport relevant talents. The publicity effect is not ideal. In the later stage, we should start from this aspect to set up relevant healthcare professional courses in universities to strengthen talent training.

5.3.4. Healthcare Service Facilities B4. Figure 8 shows the comparison results of indicators of healthcare service facilities. The indicator grade of tourism public facilities C_{12} is good, while the remaining indicators of accommodation and catering facilities C10 and medical security facilities C_{11} are poor. The tourist rest area built by Huangshan National Forest Park in terms of healthcare service and ecological environmental service facilities is relatively simple, so

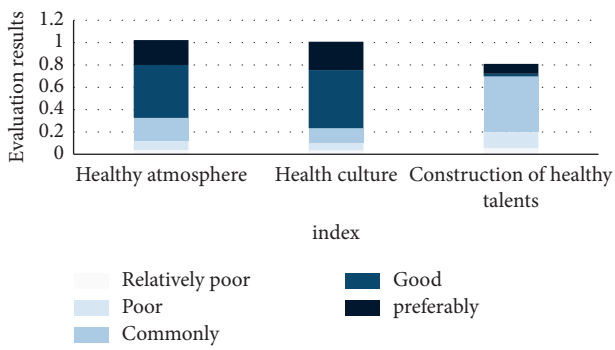

Figure 7: Comparison of indicators of social and cultural environment for health care.

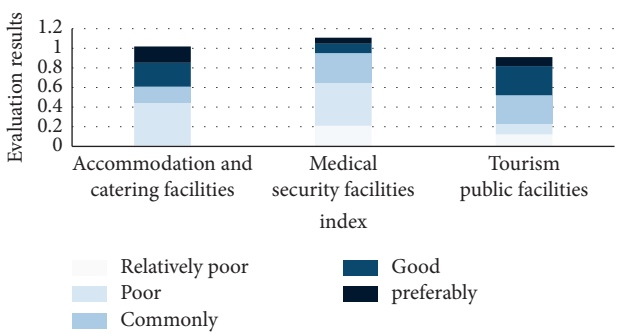

Figure 8: Comparison of environmental indicators of healthcare service facilities.

tourists cannot relax their pressure during their travel. Huangshan Forest Park has less investment in medical care, which makes it difficult for some tourists to meet their requirements when they need medical care services. The supporting catering and accommodation are also relatively simple. In the future, we should improve the service quality from this aspect.

According to the comprehensive analysis, the actual ecotourism situation of Huangshan National Forest Park is being investigated on the spot. Furthermore, the first-order evaluation matrix is constructed, and the weights of each index in the evaluation index system are calculated using the analytic hierarchy process and fuzzy mathematical analysis. The results show that the highest weight of healthy landscape environment B1 is 0.426, followed by healthy social culture B3, with a weight of 0.262. The proportion of these two weights is 68.8%, which has a decisive impact on the comprehensive evaluation results. The weights of other natural ecological environment B2 and healthcare service facilities B4 are 0.157 and 0.155.

6. Conclusions

In this paper, Huangshan National Forest Park is selected to make a comprehensive evaluation of the environmental quality of its healthcare ecotourism. After screening and determining 12 indicators that affect the environmental quality of healthcare ecotourism, the evaluation system of the environmental quality of healthcare ecotourism in Huangshan National Forest Park is established by using the analytic hierarchy process (AHP). The criterion layer indicators in the system include healthcare landscape environment B1, natural ecological environment B2, healthcare social culture B3, and healthcare service facilities B4. Combined with the fuzzy mathematical analysis method, a comprehensive evaluation model of the healthcare ecotourism environmental quality of Huangshan National Forest Park is constructed. Based on the comprehensive evaluation model of the environmental quality of healthcare ecotourism, the weights of each index are substituted, and the weighted function method is used to evaluate the environmental quality of healthcare ecotourism in Huangshan National Forest Park. After calculation, the comprehensive evaluation result is 75.92, and the grade is good, indicating that Huangshan National Forest Park has the environmental quality required for the development of healthcare ecotourism. The higher scores of each index such as landscape ornamental C1, greening C4, air cleanliness C5, negative oxygen ion concentration C6, healthcare atmosphere C7, healthcare cultural literacy C8, and tourism public facilities C12 are all good.

Data Availability

The data are available on reasonable request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Design of the Human Resource Optimization Allocation Model Based on Information Integration

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With the increasingly close integration of information technology and enterprise management, the human resource management (HRM) model is also changing in the direction of information integration. The new information-based human resource management has gradually become a common management model for all industries and enterprises. Information integration of management work achieves integration and resource sharing among HR departments, managers, and employees. Information integration also facilitates the management of big data and the query of information from the upper and lower levels of group companies. This research study focuses on how companies can solve their own problems, integrate valuable human resources, improve management, and face fierce external competition. This study addresses the above issues by targeting and optimizing the core of human resource management with a performance management system using fuzzy evaluation. Encouraging employees to stimulate motivation and autonomy on the basis of the original foundation has enriched the content of HR performance management, making the overall work more widespread, objective, and encouraging sustainable growth of the company. The experiment proves that this resource optimization allocation model has an important role for managers to make human resource management plans, improve the information technology content of management, and improve the information level of management, so as to improve management efficiency and promote enterprise development.

1. Introduction

Information integration and data mining are the products of the new era with strong technical characteristics, which bring significant opportunities for current social construction and unit development. In this context, it is necessary to strengthen the innovation and optimization of human resource management (HRM). In fact, HRM can comprehensively improve the authenticity and accuracy of performance information and promote the fair and unbiased development of performance management. As we all know, the technical functions and application trends of information integration and data mining in the new era are very important. Moreover, it has outstanding advantages in information collection, integration, dissemination, sharing, and intelligent statistics. At the same time, it also plays an important supporting role in promoting personnel management innovation and reform. In the implementation process of performance management, the carrier role of big data and machine learning can be given full play to comprehensively sort out and deeply analyze the relevant performance indicators [1]. On this basis, reasonable performance assessment standards are formulated to achieve clear objectives and efficient management.

Many companies prioritize operation over management. Poor HRM awareness and human resource management employees do daily tasks like payroll audits and workload records [2]. Even selection, employment, and assessment are lacking. Everywhere is sand. HRM is a strategy executor, not a decision-maker. It is hard to realize the benefits of management policymaking and design, and it is hard for an enterprise to thrive with internal management. It has been widely used in the organization and management of enterprises. It has shown great practical value in many aspects of human resource management, such as statistics, training, and

assessment, and enterprises have improved management efficiency and reduced management costs. The following are common problems in HRM models.

(i) Reverse HRM: Business management echoes the era of planned economy. Formal evaluation and light rewards and punishments limit employee motivation. Employees complain that the company lacks humanistic care.

(ii) Each functional department's management is weak: The enterprise's existing system is not perfect, it cannot be implemented effectively, and there is no mutual check mechanism between the organization and the employees, which leads to top leaders gaining more power. Other department heads know the latest enterprise trends, but they have little say and cannot correct wrong instructions.

(iii) Lack of communication and cooperation between departments: Complexity and variability of project activities strain information sharing and emergency response speed. In most companies, information transfer, performance assessment, and guidance are done within departments. Inconsistent command and unclear goals affect the enterprise's effectiveness.

(iv) Disconnection between enterprise and project management, and project confusion: As a company grows, economies of scale create multiple projects. Differences in time, location, and uniqueness of projects make enterprise management difficult. The management model of project manager responsibility has improved decision-making, but decentralization of authority has impacted project managers' ethical defenses, and black-box operations have begun to proliferate within the company's reach, weakening its profitability. Functional departments, as direct supervisors and directors of multiple projects, may shirk their responsibilities when meeting with project departments.

(v) Lack of long-term jobs and talent: Too much centralized staff training slows project progress. Existing training lacks relevance, mainly to meet certification and qualification requirements of construction companies, but ineffectively. Construction companies emphasize employees' contributions but ignore their own. They overuse talented workers but cannot use poor ones. Enterprises lack promotion paths and perfect reward and punishment mechanisms, causing employee dissatisfaction and job-hopping. Many low-capacity businesses must support the state, and talent is scarce.

Irrational internal organization, poor supervision and management, backward employment mechanisms, and talent loss highlight empty shell companies. Shrinking market share and difficult transformation make the company worse. Therefore, this research paper focuses on how various companies can solve their own problems, integrate valuable human resources, improve management, and face fierce external competition. This paper addresses the above issues by first, targeting and optimizing the core of human resource management a performance management system, as shown in Figure 1. The core of effective performance management is a continuous cyclic process of a series of joint activities, as shown in Figure 1, which usually and specifically includes four links: performance planning, performance implementation, horizontal effect assessment, and performance feedback [3]. The end of one management performance is the beginning of another performance management process. Through this cycle, individual and organizational performance can continue to evolve.

Based on this, we present our integrated HR optimization model based on the information from the integrated data, which we will present again in Section 3. In addition, this research area can benefit from the utilization of big data, the Internet of things, information technology, computer networks, and machine learning-based learning techniques. This research seeks to explore the informatization of developing human resource optimization allocation against the backdrop of big data in order to effectively integrate the current human resources and to increase efficiency of the HRM systems. We concentrate on how businesses can address internal issues, incorporate valuable people resources, enhance management, and deal with intense exterior competition. Finally, using a performance management system to target and optimize the human resource management system's fundamental functions, we address the aforementioned concerns. We think that the literature currently in print has relatively little to say about this particular field of study.

The first thing we do in this study is to construct the public service information platform for human resource allocation optimization using big data and quantitative assessment. Then, we thoroughly describe the platform's main elements before constructing the heterogeneous data model for the human benefit index. The information integration method is then used to optimize the target parameters in order to implement big data mining and feature analysis of human resources. The proposed solution may successfully integrate the current human resources and increase the effectiveness of HRM systems, as shown by our evaluation and testing results. The following are the study's main innovations:

(i) We build the public service information platform of human resources and optimization allocation using the fuzzy evaluation;

(ii) With the proposed method, different companies and organization can solve their own problems, integrate valuable human resources, improve their management, and face fierce external competition;

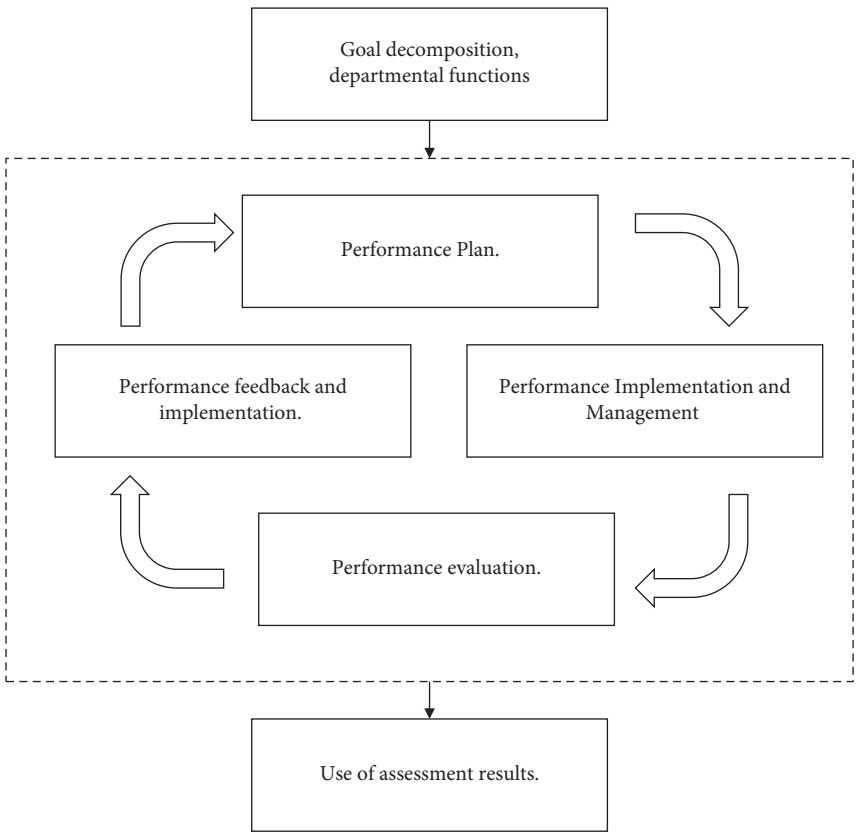


Figure 1: The performance management workflow.

(iii) We address the aforementioned problems, by focusing on and optimizing the core of human resource management with a performance management system; and

(iv) We demonstrate that the suggested strategy can efficiently distribute the available human resources and boost the effectiveness of the system for managing human resources.

The remainder of the manuscript is structured as follows. Modern related work is illustrated in Section 2. The information platform for optimizing human resource allocation is designed in Section 3 and is based on the widely accepted idea of fuzzy assessment. The model's mathematical justification is also demonstrated. Section 4 discusses the application and outcomes of the suggested approach based on fuzzy assessment. Finally, we wrap up this investigation and provide recommendations for future research in Section 5.

2. Related Work

2.1. Concepts and Background. During the evolution of HRM theory, many HRM experts have discussed in depth the definition of HRM, the practical activities of HRM, the responsibilities of HR managers, the value orientation of HRM, and the value orientation of HRM, and analyzed the challenges faced by HRM from their respective research perspectives. The definition of HRM traces and analyzes the development of HRM theory, and we summarize the definition of HRM into two categories.

The first category is the HRM concept was proposed by Peter Drucker and Barker et al. and introduced by Schuler et al. [4], and they consider human resource management as a broad general management function possessed by managers. Its goal is to effectively manage personnel in the workplace, which includes comprehending, maintaining, creating, using, and coordinating. This definition of HRM is based on a "humanistic" management philosophy. It views human resources and all employees in an organization as a valuable resource for the organization, rather than as a cost that the organization should minimize [5]. In his book "Managing Human Resources," Schuler defines human resource management as the use of a set of management activities to ensure the effective management of human resources for the benefit of the individual, society, and the enterprise [6]. This definition is in line with the humanistic perspective. Human resource management, according to Robert et al. [7] and others, is the use of human resources to accomplish organizational goals. Sherman et al. [8] and other academics argue that all organizations are made up of individuals, particularly, all successful organizations, which rely on diverse groups of people working together to achieve a common goal. This is the essence of human resource management.

The second one is considered by Henneman et al. [9] that HRM is a new name for personnel management. It is a type

of employee management that is performed by professionals and is a management practice related to people. This concept is predicated on the notion that the management methods now in use are the most effective and appropriate ones to utilize in order to manage personnel efficiently, and that these management practices can be improved upon throughout time. For example, according to this view, Dessler et al. [10] debate that human resource management (HRM), or more specifically personnel management, denotes to the numerous policies and practices that want to be learned in order to successfully accomplish the jobs involved in managing individuals. Similarly, Wright et al. [11] and others scholars argue that human resource management talks about numerous strategies, management rehearses, methods, and structures that, in fact, influence employee arrogances, comportment, and enactment. According to Beech [12] and others, human resource management (HRM) can be considered as a comparatively innovative methodology to personnel management that considers people and individuals as key resources.

2.2. Information Integration. Huang et al. [13] proposed to break through information silos in 2019. They established a standard information database through many trials and communications, breaking the current situation that departments and systems are independent and separated from each other. Through information integration, they have broken through information silos, which facilitates managers to manage human resources comprehensively from a strategic perspective. The fundamental concept is to build an HR information management system and create an information integration platform [13]. The establishment of information integration platform can make some modules of HR information management system and multi-departmental management system interrelated, and realize the sharing and exchange of relevant data through LAN. Gradually, the system realizes the all-round and whole process dynamic management of people. By assigning accounts and setting permissions, the department's personnel rotation and deployment permissions are assigned to the project department, operation department and other related departments. Each functional department will redeploy project personnel in the system according to the flow of personnel in that month to realize dynamic management of personnel. The HR department can effectively deploy and manage project personnel, break the drawbacks of static management of the previous system, and realize the dynamic display of information.

According to Park et al. [14], the original performance management model needs to be optimized and innovated in addition to being integrated with big data technology to evaluate and study the management content in order to truly improve the quality and level of HR performance management. The following aspects can each be used to carry out particular management tasks. In the process of data operation and management, objective and comprehensive basic data primarily refer to comprehensive, particular, and focused data analysis, inquiry, and study on the relevant human resources basic information. In order to build a solid foundation for the subsequent performance management, the relevant departments use this as an objective basis to carry out actual personnel deployment and transfer in accordance with the actual situation of personnel. Second, "dynamic personnel data" primarily refer to internal people transfers for work or transfers made for personal reasons. Additionally, it encompasses things like talent introduction and corporate recruitment. Using a big data system and the pertinent statistical content data, human resource management must quickly respond to the corresponding personnel changes.

In order to successfully achieve the efficacy and accuracy of employee management and avoid the condition of information lag and management irregularities, data software can be used to input, alter, and remove the relevant information. The third is personnel data that are of a specified standard. It is mostly based on the tallied performance data of employees on a daily basis. To get high-quality employee data, the contributions made by the employees to the business are examined and integrated in light of the significant performance appraisal outcomes. The methods of centralized investigation, collection, analysis, and management of employee information are also further stressed in order to guarantee the thoroughness and accuracy of performance appraisals and to fundamentally enhance the authenticity, thoroughness, and objectivity of employee analysis.

2.3. Model for Optimal Allocation of Human Resources. Many scholars and managers favor the project-oriented organization structure due to the fact that Mithas et al. [15] proposed it, from independent firms to alliance or network firms, and from project-level flexibility to business organization flexibility. Park et al. [14] expressed doubts about project-oriented organizational structures in business management and conducted a series of experiments to show that we must pay attention to whether such structures fit the organization. Sanders and Premus [16] described the latest developments in project-oriented organizational structure, summarized the conditions for a mature structure, and argued that project management practices and structure influence each other. With the growth in technology, the scholars' research is becoming more "project-oriented" and concrete [16].

Devaraj et al. [17] argue that resource scheduling is the core of project team management, but limited resources require a reasonable and efficient plan. Management is challenged by the fact that the project and others are competitive. The model theory research has made great strides in human resource allocation and staffing. Bhatt and Grover [18] studied manager assignments in tech-driven organizations using a competency model. Through literature review, expert interviews, and case studies, they proposed a project manager competency model. Wang [19] studied the employee evaluation and assignment problem, proposed that organizational goals and strategies be considered in the employee assignment model, and developed a fuzzy theory

scoring model to measure employee-job fit. Some scholars have also studied staffing from a competency perspective, which is practical.

There are many studies on project team or enterprise resource allocation. Zhang [20] used a particle swarm optimization algorithm to solve the Pareto solution for optimal human resource allocation from a multiobjective decision-making perspective. Xue [21] used genetic algorithm to solve optimal human resource allocation and proposed a simple two-way selection allocation method. Wu [22] created a heuristic algorithm for optimal allocation of human resources based on constraint satisfaction and backtracking search algorithm to reduce enterprise cost. They obtained the optimal algorithm sequence by example operation: first, the heuristic algorithm was used to select the optimal configuration, and then the selected personnel were assigned using the algorithm proposed in this article.

3. Method and Design

3.1. The Matrix Organization Structure. In a matrix organization, permanent functional departments and temporary project departments are crossed vertically and horizontally. When a company is awarded a new project, a project manager consults with the heads of the functional departments to determine how each function can help. This project does not require re-establishing functional departments, but rather temporary staff. This person can help with multiple projects at once, improving human resource utilization and reducing business costs. When the project is over, they can return to the function to work on other projects. As shown in Figure 2, it is the matrix organization.

The old functional and project-based organizational structures are combined here, as shown in Figures 3(a) [11] and 3(b), [12], which are schematic diagrams of functional and project-based organizational structures, respectively, so the matrix organizational structure brings together the advantages of both structures and avoids the singularity and some disadvantages of individual structures.

The matrix organization has the following major benefits.

(1) The organization is flexible, and its project-based structure allows for more activities. When the external environment or project changes, the project manager can adjust the plan and get functional department support. When the project schedule encounters obstacles, he can tap the group's experience and wisdom.

(2) It is beneficial to use the human resources function's technical supporters and behavior supervisors of multiple project-related functions. In fact, personnel mixes may vary. Therefore, they can play to their strengths and avoid their weaknesses, optimizing the project's organization.

(3) Increase mobility: The matrix organization structure meets project needs and breaks down barriers between functions, strengthening coordination and cooperation. Functional employees can gain horizontal project knowledge and vertical professionalism, advancing their careers.

This should be noted that we should avoid dictatorship problems that can be reported to the project manager or functional head. Moreover, employees can choose which principal can be reported to based on their own interests, which helps to identify and solve problems. The matrix structure flaws include the following.

(1) Project manager–functional head conflicts: Dual subordination and improper hierarchy are problems with the matrix management design. When project managers and functional heads clash, employees become timid about following orders, and powerful people control subordinates. Matrix organization design will not be flawed if project managers and functional managers can negotiate rationally and give up some of their rights to subordinates.

(2) Enterprise and project department resource competition: In cases of limited resources, the enterprise maximizes overall benefits while the project manager pursues project interests. Project managers consume too many quality resources, leaving businesses short. This organizational structure must also establish a resource flow mechanism.

(3) Uneven project manager authority: Matrix organization is more complicated than linear. This model connects people into a network structure, which is cumbersome for the project manager. As the project's leader, the project manager must communicate and coordinate effectively. The project manager must deal with department heads, clients, and multiple companies. Despite having many responsibilities, there is no effective authority to support the process, and the project manager cannot gain more power. The project manager's lack of authority hinders progress. Functional and project-based organizational structures do not work here.

3.2. Enterprise Organization Structure Optimization Configuration Scheme

3.2.1. Enterprise Organizational Structure Configuration. The stability of enterprise-level organizational structure and the temporary nature of project-level organizational structure lead to various inconsistencies and conflicts. In this study, after studying the organizational structure design and related theories and development trends of various construction and project-based enterprises, the evolutionary design of the enterprise organizational structure is carried out according to the industry background and the current situation of the enterprise. The main problems to be solved in this design include: information transfer barriers, talent shortage, lack of corporate culture, disconnection between corporate and project management, and rigid organizational structure; the organizational structure theories used include: learning organization, network organization, and project-oriented organization. As shown in Figure 4, it is the set-up optimized organization.

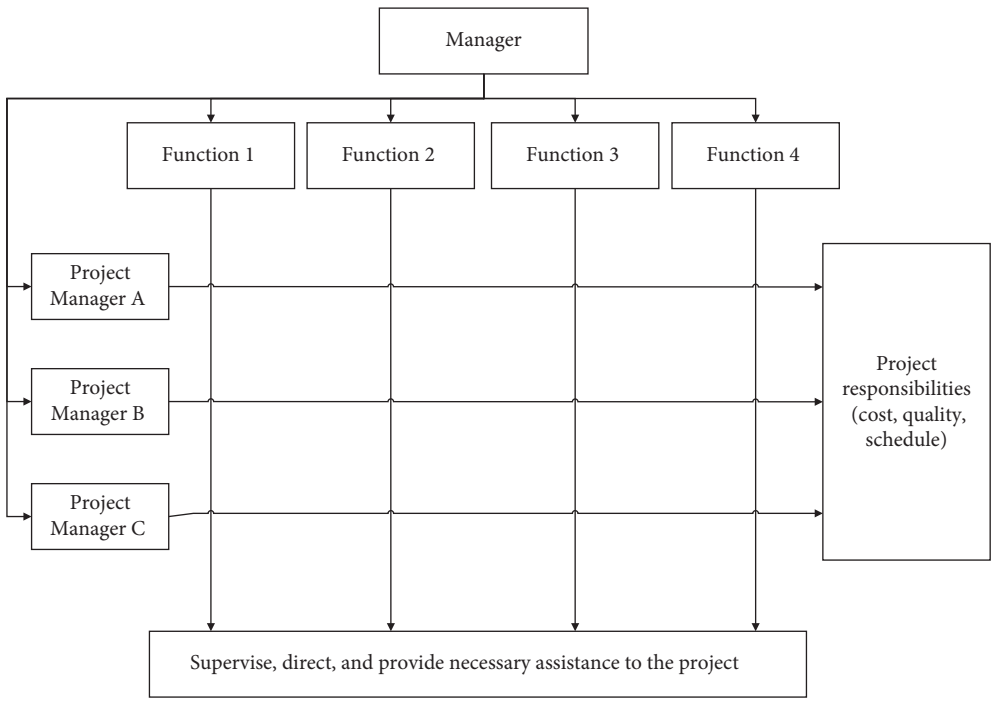
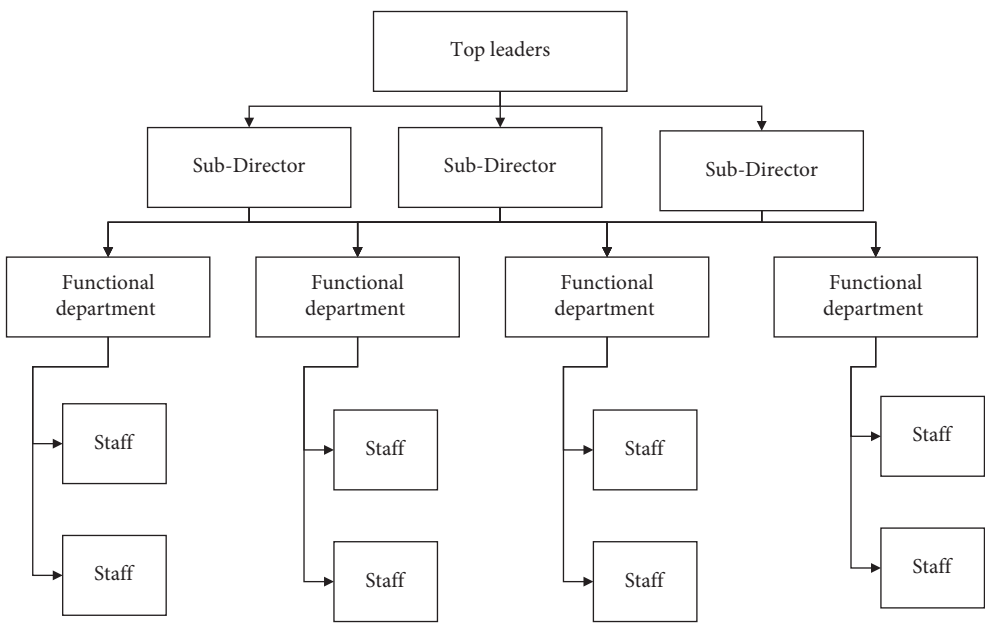


Figure 2: The enterprise rectangular organization chart.



(a)

Figure 3: Continued.

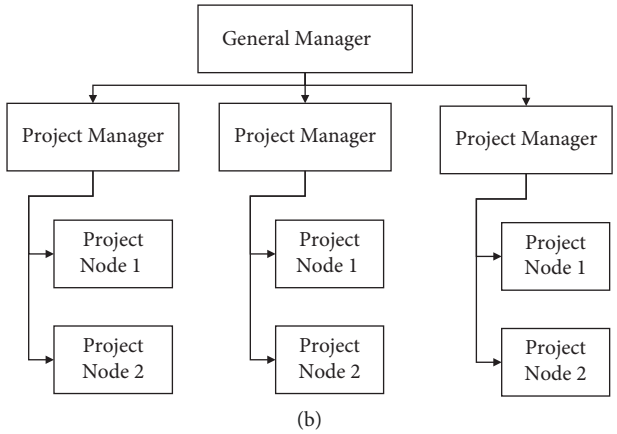


Figure 3: Other enterprise structures (a) for functional organization and (b) for project organization.

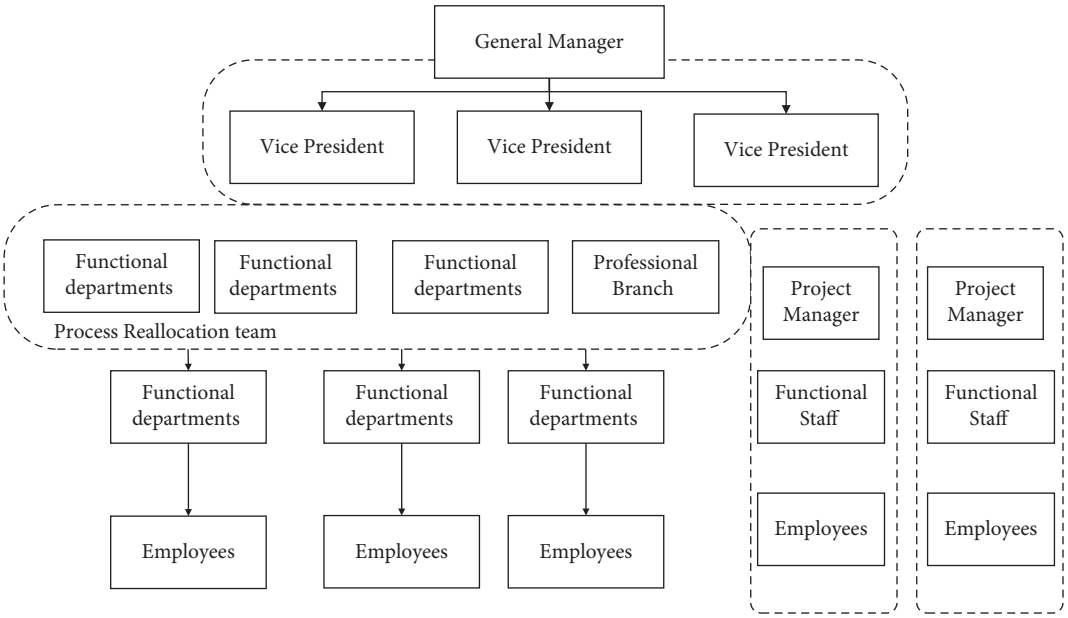


Figure 4: Enterprise organization structure optimization design.

3.2.2. Analysis of the Organizational Structure of the New Enterprise. Based on the analysis of the organization structure for several enterprises, we conclude the following observations.

(1) Project-oriented organization theory is applied to the management of functional departments at the enterprise level, so tasks are formed from the bottom up according to the progress and needs of each project. Functional departments are responsible for their tasks and strengthen communication and cooperation with other departments to form a "construction process reengineering team". The team's direct supervisor is responsible for planning and interdepartmental communication. This structure allows functional departments to directly serve clients (i.e., the project department). This should be kept in mind that this is customizable by project that allows direct information from each project. Furthermore, it allows easy access to the company's knowledge and experience, saving decision time and reducing errors. A project-oriented organization can generate fast information transfer and efficient problem handling through effective resource integration, as the project manager is placed under each function and branch. Each function has decision-making authority over scarce resources and corporate issues. The project manager is responsible for schedule, quality, and cost control, but functional departments oversee his authority.

(2) Large projects benefit from project-based organization. One situation is too complex for interdepartmental communication and cooperation; the

other is too regionally different for functional departments to plan rationally by time and location. Senior corporate management gives project managers in project-based organizations the authority of a functional department director. The two projects are not independent of the enterprise's functional departments. The enterprise sends or trains project staff, and timely information is sent to identify and correct problems. This organizational structure should be tightly managed. The company should meet project resource needs. Competition for scarce resources should rely on project manager–function communication. When needed, senior leaders should coordinate.

(3) To maintain long-term competitiveness, businesses must establish a learning organization. Facing the industry's fierce competition is like sailing upstream. If not, it will go backward. Construction companies gain knowledge and experience through projects. The organization structure viewed the project as a one-time physical finished product and neglected soft power building. Some good experiences and methods were abandoned after the projects were finished. As the category with the highest quality in construction enterprises, the top leadership team faces various decisions and choices, shoulders the mission of enterprise development, and must improve continuously. In the next phase, the top-down learning begins. Functional department heads who take over projects and large and overseas project managers understand project success and failure best. As their superiors, senior leaders can learn. The top learning group will improve its corporate culture by analyzing these projects' successes and failures. Moreover, the corporate culture reflects the leaders' values. The company will continue to improve through debriefing and cultural exchange.

(4) It combines various organizational theories and avoids traditional organizational flaws. Construction companies have a talent shortage, low efficiency, and employment problems. Project-oriented organization theory uses functional personnel's rich project experience to manage projects, reducing the need for many talents. Functional personnel in projects create a link between projects and functional departments, open communication channels, and facilitate training and tapping. Learning organization theory promotes corporate culture, reduces internal conflicts and senior talent turnover, and unites employees. This hybrid organizational structure facilitates site-specific management, strengthens project monitoring, and weakens project managers' resource appropriation ability.

3.3. The Fuzzy Evaluation Mathematical Model. In the enterprise evaluation index system, due to the different influencing factors of each indicator, some indicators can be obtained by statistical methods. Similarly, some other indicators can only be evaluated by expert evaluation methods. In fact, for such evaluation problems, the use of fuzzy mathematical methods, i.e., fuzzy comprehensive evaluation method can get more objective conclusions [23].

3.3.1. First-Order Comprehensive Evaluation Model. Let's suppose: the set of factors $U = \{u_1, u_2, \ldots, u_n\}$, and u_i means the considered factors, $i = 1, 2, \ldots, n$. Furthermore, the set of comments $V = \{v_1, v_2, \ldots, v_n\}$, and v_j denotes the evaluation result, such that $j = 1, 2, \ldots, m$.

The fuzzy subset $W = (w_1, w_2, \ldots, w_n)$ on the factor set U is called the weight assignment, and w_i is the weight of factor u_i being considered. Then, a single-factor evaluation is made. A fuzzy mapping f from U to V is established as given by:

$$f: \longrightarrow (r_{i1}, r_{i2}, \ldots, r_{im}), \ldots \\ \left(0 \leqq r_{ij} \leqq 1, i = 1, 2, \ldots, n, j = 1, 2, \ldots, m\right), \tag{1}$$

where r_{ij} denotes the degree of recording genus of factor u_i to rubric v_j. The fuzzy relationship R can be induced from f to obtain the fuzzy matrix as illustrated in equation (2):

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}, \tag{2}$$

where R is called the single-factor evaluation matrix and also the transformation matrix of comprehensive evaluation.

In this way, when the weight assignment and transformation matrix are known, the composite operation of the fuzzy matrix can be applied to perform the comprehensive evaluation, which leads to the first-order comprehensive evaluation model as follows in equation (3):

$$B = W \circ R = (b_1, b_2, \ldots, b_m), \tag{3}$$

where B is the result of fuzzy comprehensive evaluation.

3.3.2. Two-Level Comprehensive Evaluation Model. By dividing the factor sets, the above model can be extended to a two-level fuzzy comprehensive evaluation model. First, the factor set U is divided into s subsets according to certain attributes, which are $U_1, U_2, \ldots, U_n$, and satisfy [23]. This relationship is mathematically expressed as given in equation (4).

$$\bigcup_{i=1}^{s} U_i = U, \\ U_i \cap U_j = \phi, (i \neq j). \tag{4}$$

Let us suppose that the factors of each subset be defined as:

$$U_i = (U_{i1}, U_{i2}, \ldots, U_{ik}), \quad (i = 1, 2, \ldots s), \tag{5}$$

where W_i, R_i, and B_i denote the weight assignment, single-factor evaluation matrix, and comprehensive evaluation

results at the second level, respectively. The two-level fuzzy comprehensive evaluation model can be obtained as given by equation (6):

$$B = W \circ R = W \circ \begin{bmatrix} B_1 \\ B_2 \\ \dots \\ B_s \end{bmatrix} = \begin{bmatrix} W_1 \\ W_2 \\ \dots \\ W_s \\ \circ \\ \circ \\ \circ \\ \circ \\ B_1 \\ B_2 \\ \dots \\ B_s \end{bmatrix}, \quad (6)$$

where W is the weight assignment of s factors U_i in $U = \{U_1, U_2, \dots, U_s\}$. Similarly, W_i is the weight assignment of the K factors u_{ij} in $U_i = (u_{i1}, u_{i2}, \dots u_{ik})$. Furthermore, R and R_i are the transformation matrices of the combined evaluation of U and U_i, respectively. Note that B is the integrated evaluation result of U.

4. Experimental Results and Analysis

4.1. Evaluation Index. The evaluation of corporate managers' performance can be measured by the following nine indicators: sales margin, return on total assets, return on capital, capital preservation and appreciation rate, gearing ratio, current ratio, quick ratio, accounts receivable turnover ratio, and inventory turnover ratio [24]. Based on the analysis of the quality, ability and performance composition of corporate managers, we established a comprehensive evaluation index system for corporate managers, as shown in Table 1.

Table 2 shows the HRD training effectiveness evaluation index system.

4.2. Optimization Results. Faced with different performance evaluation methods, companies and employees will make different choices from their own perspectives. For the above indicators, we use fuzzy evaluation method to evaluate different enterprises. As shown in Figure 5, after the enterprises use our proposed HR optimization organization model, the costs of the enterprises can be greatly reduced. Furthermore, we observed that the enterprises' indicators are better than before, and the employees' motivation and learning ability are greatly improved.

4.3. Comparison of the Evaluation Methods. Due to the large number of evaluation indexes, the mathematical model of the second-order fuzzy evaluation is used in this article. In the experiment, we compared the fuzzy evaluation method and the hierarchical analysis method. Table 3 shows the comparison results of the two methods on the sample size of enterprise employees.

From Table 3, we can see that the fuzzy evaluation method is relatively better under the same evaluation index. This proves the effectiveness of the proposed fuzzy evaluation mathematical model.

4.4. Costs Comparison. In order to illustrate the effectiveness of our suggested HR optimization allocation model, we compared the costs before and after the HR optimization for different levels of personnel drawn from the enterprise to do the sample. Note that the number of samples will change with the number of times, after each extraction. To show the impacts of our outcomes in a better way, we will do the average of the cost of employees that were, in fact, randomly selected employees as shown in Table 4.

It can be seen from Table 4 that after the model optimization, our manpower cost is increased by 18.6%, but the enterprise's revenue increased by 22.1%. Moreover, it can be also seen that the loyalty and trust of the manpower are greatly improved. These outcomes prove that our suggested model is of great reference value to the enterprise.

Table 1: Comprehensive evaluation index for business managers.

Business manager qualities	Moral qualities Knowledge qualities Experience quality Spiritual quality Physical qualities
Business manager competencies	Innovation ability Decision-making ability Organizational leadership ability Resilience Social skills
Business manager performance	Profitability of sales Return on total assets Return on capital Capital preservation and appreciation rate Gearing ratio Inventory turnover ratio

Table 2: Effectiveness of corporate HRD training.

Training effort	Average training time per employee Proportion of trained employees per year
Learning outcomes	Degree of improvement in knowledge Degree of improvement in skills Degree of improvement in corporate culture identity
Behavior change	Error rate The rate of rework Rate of damage to goods Saving rate

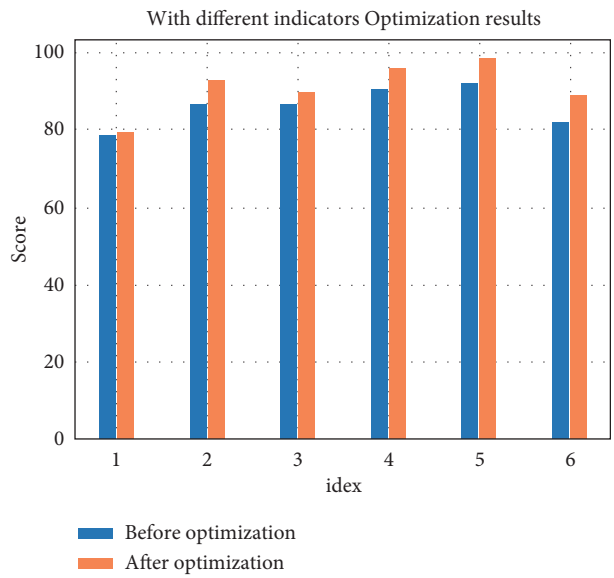


Figure 5: Optimization results with different indicators.

Table 3: Comparison experimental results.

Number of employees	Fuzzy evaluation	Hierarchical analysis evaluation
50	87.66	87.39
100	88.21	84.69
200	88.90	88.82
300	89.49	88.61
500	91.29	85.90

Table 4: Comparison and experimental results.

	Labor cost	Enterprise benefit	Employee loyalty (%)
Before optimization	4712	28418	40
After optimization	5588	34698	60

5. Conclusions and Future Work

Human resource management in modern enterprises requires managers to constantly innovate, abandon old traditional human resource management models and methods, build new management systems and management models, and construct a management environment that meets the characteristics of human resource information management. This paper proposes that managers should collect employee information within the framework of ensuring information security and legal authority, enrich the management system database, realize the HR optimization model, and give full play to the management platform, actively carry out the integration of various information, link HR management information with that of other departments, improve the comprehensive integration of information, facilitate managers to inquire and read relevant talent information, and realize information sharing under certain conditions. The experiment proves that this resource optimization allocation model has an important role for managers to make human resource management plans, improve the information technology content of management, and improve the information level of management, so as to improve management efficiency and promote enterprise development.

We will encourage the digitized building of new models, such as particle swarm optimization for optimizing human resource allocation, in the future with the aid of information technology. By doing this, businesses and organizations will take the lead, invest more in capital projects, innovate new development models, boost the effectiveness of service delivery, and effectively enhance the mechanisms for allocating human resources and their management systems. In order to improve accuracy and reliability, we will also look into machine learning and other cutting-edge technologies like the Internet of things and edge computing techniques. The computational cost of the proposed model can also be considered for minimization. We will use other optimization methods, for instance, particle swarm optimization (PSO) in

order to optimize the human resource allocation problem for various companies and enterprises.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that he has no conflict of interest.

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Retraction

Retracted: Design of Experiential Teaching System for Solfeggio in Normal Universities Based on Machine Learning Algorithm

Mobile Information Systems

Received 25 July 2023; Accepted 25 July 2023; Published 26 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] K. Liu and J. Awang bin Othman, "Design of Experiential Teaching System for Solfeggio in Normal Universities Based on Machine Learning Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 3622567, 14 pages, 2022.

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Research Article

Design of Experiential Teaching System for Solfeggio in Normal Universities Based on Machine Learning Algorithm

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At present, with the rapid development of the Internet and its close connection with our life, more and more educators apply the Internet to teaching. However, there is little research on the application of the Internet in solfeggio teaching, and there are some problems in the teaching process, such as nonstandard use methods, inability to highlight teaching objectives, and mismatch with students' professional level. On the premise of fully understanding the teaching objectives of solfeggio in China, this paper designs an experiential teaching system of solfeggio in normal universities based on machine learning algorithm, studies the application of digital technology in solfeggio, including Internet technology, multimedia digital technology, and the use of music software, and analyzes the auxiliary role of digital technology in solfeggio teaching by combining the specific teaching contents of online solfeggio teaching during the epidemic period. In this experiment, the average classification accuracy of WNB algorithm is 0.767, while that of BP algorithm is 0.683. Experimental results show that WNB algorithm outperforms BP algorithm in classification. At the same time, in terms of time efficiency, the average time consumption of WNB algorithm in this experiment is about 0.026 s, while that of BP algorithm is about 0.45 s. Compared with WNB algorithm, the time consumption of WNB algorithm is less. Through concrete practice, it is proved that the combination of solfeggio teaching and digital technology is of great significance to both teachers' teaching and students' learning.

1. Introduction

With the progress of the times, digital technology based on computer has been widely used in all fields of society, and digital music teaching has made considerable progress in China in recent years. As a basic subject in the field of music education, many teachers have realized the importance of digital technology in solfeggio teaching and need to make use of the development of digital technology to improve the quality of solfeggio teaching. This is a problem that solfeggio teachers should consider. In 2020, due to the epidemic situation, each school adopted the online teaching method to complete the teaching plan. Although various problems were encountered in this process, it also fully proved the superiority of digital technology in the development of Chinese education. Combining solfeggio teaching with digital technology, through research, making full use of the development of digital technology, aiming at improving the teaching quality and progress of solfeggio, this paper solves the problems of listening, solfeggio, flipping classroom, and online teaching in solfeggio course, analyzes the advantages and disadvantages of the influence of music software development on solfeggio, and puts forward some teaching suggestions related to the combination of traditional solfeggio teaching and digital technology. We summarize the specific links and problems in online solfeggio teaching and, through practice, analyze how to combine traditional solfeggio teaching with digital technology, so as to make the solfeggio teaching process more complete and more conducive to the improvement of students' solfeggio level.

Solfeggio teaching is becoming more and more important. Aycan K. observed that, without pronouncing syllables in roll-call sounds, there would be no rhythm structure. The vocal music practice in class suitable for Bona found that Solmization

syllables can alleviate solfeggio [1]. Zhou and Yan developed a music solfeggio teaching system to serve the curriculum study of music majors, which has important practical significance and application value for promoting the development of information technology in music education [2]. In order to teach traditional songs in solfeggio and music education courses, Kodela has explored and studied the traditional music heritage by using the methodology of ethnomusicology, which is helpful to better understand, preserve, and transfer the music practice of traditional local music expressions that are gradually disappearing [3]. In order to better carry out music learning, Qiao and Yan have completed the design and implementation of music solfeggio teaching system in combination with the actual teaching situation of Conservatory of Music. The platform design provides an effective learning and testing means for the implementation of solfeggio teaching [4]. Traditional solfeggio (music theory) learning methods usually do not use computer-based support. The purpose of Debevc et al. research is to test the effectiveness of interactive mobile application mySolfeggio in learning solfeggio [5]. Folk-oriented music education has a long history in Russia. Pivnitskaya research shows that there are two trends in ethnomusicology, among which the consistent logic system is related to the unique characteristics of different regions [6]. However, the above solfeggio teaching research has not been combined with machine learning.

The use of CAI to assist teaching did not play its due role. Quan research applied artificial intelligence and intelligent prediction to teaching and collected different students' teaching portraits to differentiate their behaviors [7]. Christiane et al. research supports the development of machine learning models and their deployment and how tools are developed and evaluated [8]. Huang studies how to use machine learning to provide more accurate teaching for teaching. By combining improved algorithms to improve related models, it provides a reference for the integration of the two [9]. Liu et al. research is based on machine learning algorithms, combined with intelligent image recognition technology to improve machine learning algorithms, so as to achieve automatic essay scoring [10]. Using effective evaluation to evaluate the quality of English online teaching, Fang used machine learning to evaluate the quality of teaching and built an SVM model to improve it [11]. The application of computer-assisted instruction or computer learning system is conducive to improving the quality of English teaching. Wen is committed to the design of intelligent teaching system based on computer-assisted instruction research. According to modern educational theories and policies, it makes use of computer network collaborative learning mode and network teaching function to conduct research [12]. But the above machine learning research is only combined with teaching research.

At the same time, the cross-validation experiments of BP network and WNB algorithm are compared. The novelty of this paper lies in the use of basic theoretical knowledge of musicology in the design, which is conducive to the construction of digital music resource database and the realization of music resource visualization technology through learning and comparison.

2. Experiential Teaching Method of Solfeggio in Normal Universities Based on Machine Learning Algorithm

2.1. Features of Solfeggio. Solfeggio has both theoretical and technical characteristics. The theory means that, in the process of learning solfeggio, it is necessary to systematically learn basic music theory knowledge, harmony, musical form, etc., so as to assist listening and solfeggio practice, and apply theoretical knowledge to practice [13]. That is, when technology involves solfeggio and listening, students need to gradually master the technical characteristics of solfeggio in the learning process and improve students' solfeggio listening ability from the auditory training of single tone, interval, chord, and melody [14]. Especially in the context of the gradual enrichment of the teaching content of solfeggio in recent years, the emergence of various multipart solfeggio repertoire and atonal solfeggio exercises put forward new requirements for students' solfeggio ability. At the same time, digital technology, that is, the emergence of various computer music software tools, in the process of students using computer music software to assist solfeggio teaching, also fully reflects the theoretical and technical characteristics of solfeggio [15].

Solfeggio, as a basic subject in the field of music education, has a direct impact on the improvement of students' own level [16]. The recipients are students of different majors and levels, which requires teachers to be targeted in teaching, and to choose teaching methods suitable for students.

2.2. Solfeggio Diversified Teaching Problems. In recent years, solfeggio teaching methods have gradually diversified, such as flip classroom, online teaching, and music software application, all of which put forward new requirements for teachers' classroom teaching ability. Faced with many freshmen's teaching methods, we should avoid problems in teaching, clarify the advantages and disadvantages of a certain teaching method, and choose a teaching method suitable for students. Diversification is not a blind choice. We should carefully choose teaching methods according to the training objectives of students at different stages, so as to improve the course quality of solfeggio and avoid teaching mistakes [17].

Due to the characteristics of high accuracy, various forms, and high efficiency of multimedia, in building a modern multimedia solfeggio classroom, we need not only the stacking of software, but also the maximization of the practicality of multimedia teaching [18]. We will integrate and adjust the software and hardware with the traditional solfeggio course, trying to absorb the "essence" of the two models and eliminate the "dross" of the two models. In order to better meet the application of software in solfeggio course, some adjustments should be made in the curriculum arrangement of colleges and universities, so that students can learn more operational skills in other classes [19].

The hardware configuration of multimedia solfeggio classroom can be arranged according to the expected funds of the school. Firstly, the hardware configuration is relatively

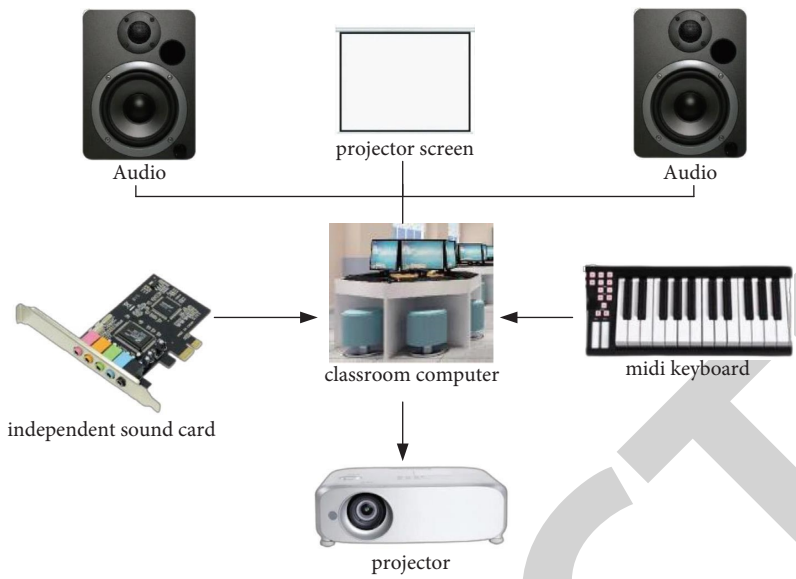


Figure 1: "Lecture-style" multimedia teaching platform.

simple with little capital investment. The venue can choose the existing conventional classroom. The "lecture-style" multimedia teaching platform is shown in Figure 1.

As shown in Figure 1, the configuration of this hardware facility can improve the traditional classroom platform or configure a modern telescopic platform, which we can call "lecture-style" multimedia teaching platform. Preclass preparation and after-class homework formulation of solfeggio play an extremely important role in improving students' solfeggio level [20]. In the traditional solfeggio teaching, the preview before class only allows students to understand some basic music knowledge from words, and the content is rather boring. Homework is mainly to arrange solfeggio and exercises for students after class, and the completion of students' solfeggio homework cannot be guaranteed. In the face of the rapid development of digital technology, whether teachers can make use of the convenient conditions brought by digital technology to improve the quality of preclass preview and after-class homework formulation of solfeggio and improve students' ability to understand and think about problems, if the quality of these two links can be improved, it will also mean that teachers' teaching quality and efficiency of problem solving in class will be improved [21].

The second multimedia technology configuration, which we can call "all-round" multimedia solfeggio classroom, is shown in Figure 2.

As shown in Figure 2, the final running environment of this system is the Solfeggio Professional Training Room of Conservatory of Music. In the teaching of solfeggio, students have professional teaching laboratories, and the corresponding supporting facilities include input and output devices such as computers, midi electronic organ, headphones, and microphones. The examinations are conducted in different batches in the same place under the organization of teachers [22]. At the same time, it is hoped that the solfeggio teaching system developed does not depend on the external network environment and requires strong data processing ability, high security performance, and fast response speed. Considering the above factors, through the analysis of the advantages and disadvantages of C/S and B/S structures, the architecture of this system decided to adopt C/S mode. At the same time, C/S mode can flexibly process audio files and realize audio processing in this machine. At the same time, this system is a student-oriented learning and examination module of teaching resources, which has strong interactivity, large amount of audio information, and high requirements for system stability. Using C/S gives full play to its strengths.

2.3. Bayesian Knowledge Tracking Model. The original knowledge tracking model is constructed according to the structure of HMM model. Each hidden state node in the HMM model is defined as the knowledge node of the knowledge tracking model, and each visible state node is defined as the performance node of the model. It is assumed that the states among the learners' nodes are irreversible.

Through BKT model, this paper analyzes the process of learners' mastery of knowledge nodes, observes the relationship between the states of each node, and trains model parameters for a series of data series with correct or false answers. By referring to the conditional probability table CPT, the Bayesian formula of current learners' learning performance can be obtained, and the learners' learning situation at the next knowledge node can be inferred.

When the learner's current answer is correct, consider two situations in which the learner answers correctly: if the knowledge points have been mastered, the error of the learner's answer will have a greater impact on the correct answer than the probability of guessing. At this time, it is not necessary to consider the guessing of the learner's answer,

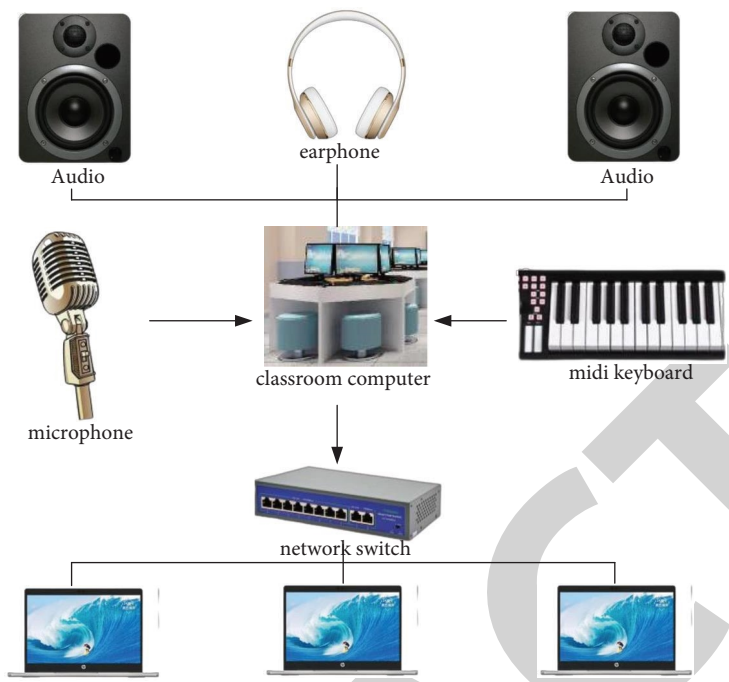


Figure 2: "All-round" multimedia solfeggio classroom.

but only consider the correct answer when the learner answers with small errors [23]. If the knowledge points are not mastered, the influence of learners' mistakes in answering questions on the correctness of answers is smaller than that of guesses. At this time, consider the influence of learners' guesses on the answers. Therefore, the probability of learners' correct answers can be expressed by the following formula:

$$P(\alpha) = P(\chi_n)(1 - P(H)) + (1 - P(\chi_n))P(G). \quad (1)$$

When the learner's current answer is wrong, consider two situations of the learner's wrong answer: when the knowledge points have been mastered, the guessing of the learner's answer is also not considered, but when the probability of the learner's wrong answer is high, the answer will be wrong. When the knowledge points are not mastered, there is no need to consider the error probability in the process of answering questions. Only when learners guess wrong, the probability of $P(m)$ can be expressed by the following formula:

$$P(m) = P(\chi_n)P(H) + (1 - P(\chi_n))(1 - P(G)). \quad (2)$$

If the learner's answering performance is known, the learning prior probability of the current knowledge node can be derived: according to the correct and wrong sequence of the learner's answering result, the learner's learning prior probability is obtained. If the learner's current knowledge answering situation is correct, then the learned correct prior probability $P(\chi_n|\alpha)$ is obtained, which can be expressed by the following formula:

$$P(\chi_n|\alpha) = \frac{P(\chi_n)1 - P(H)}{P(\chi_n)(1 - P(H)) + (1 - P(\chi_n))P(G)}. \quad (3)$$

If the current answering situation is wrong, the prior probability $P(\chi_n|m)$ of the learner's learning error is obtained, which can be expressed by the following formula:

$$P(\chi_n|m) = \frac{P(\chi_n)P(H)}{P(\chi_n)P(H) + (1 - P(\chi_n))(1 - P(G))}. \quad (4)$$

If the current answering situation is wrong, the prior probability $P(\chi_n)$ of the learner's learning error is obtained, which can be expressed by the following formula:

$$P(\chi_n) = P(\chi_n|\alpha) + P(\chi_n|m). \quad (5)$$

The model is processed according to a series of right and wrong sequences of learners' each answer, and the Bayesian formula is used to update learners' learning of the next knowledge point. When the forgetting factor is not considered in the model, the posterior learning knowledge probability of the future knowledge node state is updated only by the learning transition probability $P(T)$; that is, the learner's mastery probability of the next knowledge point can be expressed by the following formula:

$$P(\chi_{n+1}) = P(\chi_n) + (1 - P(\chi_n))P(T). \quad (6)$$

2.4. Bayesian Knowledge Tracking Model Based on Learning Behavior. This section mainly studies the influence of learners' online learning behavior on the prediction results of the model, analyzes and uses learners' rich behavior characteristics to track the changes of learners' learning

state, and uses deep learning technology to optimize the data set used in BKT.

By improving the model structure of Bayesian knowledge tracking, in the B-BKT model, no matter whether learners have mastered the knowledge points or not, learners' behaviors will have certain positive or negative effects on guessing or making mistakes in answering questions, which will affect the judgment in the final answer, resulting in certain differences in the final performance state. Therefore, we will consider the influence of different knowledge states and behavior states in the process of answering questions on the correct or wrong answer results.

Therefore, according to the four situations when learners answer questions, updating the probability formula that learners answer questions correctly is simplified from formulas (7) to (8).

$$\begin{aligned} P(\alpha) = {} & P(\chi_n)(1-P(H)) + P(\chi_n)P(G)(1-P(H)) \\ & + (1-P(\chi_n))P(G) \\ & + (1-P(\chi_n))P(G)(1-P(H)), \end{aligned} \tag{7}$$

$$\begin{aligned} \Rightarrow P(\alpha) = {} & P(\chi_n)(1-P(H)) + (1-P(\chi_n)) \\ & + P(G)(1-P(H)). \end{aligned} \tag{8}$$

When the answer is wrong, consider four situations in which the learner answers incorrectly:

In the B-BKT model, the phenomenon of learning forgetting is not considered. When learners have mastered the state of knowledge points and behave positively, learners may make mistakes when they make mistakes.

When learners have mastered the knowledge points, and their behavior state is relatively negative, it may lead to mistakes in the process of answering questions. At this time, learners may guess wrong when answering questions.

When the learner has not mastered the knowledge points, and his behavior state is positive, it is assumed that, in the ideal state, after learning for a period of time, the learner will have a little understanding of the knowledge points, but in the final answer, there will still be a probability of guessing wrong in the case of mistakes, resulting in wrong answers.

When the learner's knowledge state is not mastered, and the state of learning behavior is relatively negative, there are guesses in the process of answering questions, which lead to wrong answers.

At this time, updating the probability that the learner's answer is wrong can be simplified by formula (9) to obtain formula (10).

$$\begin{aligned} P(m) = {} & P(\chi_n)P(H) + P(\chi_n)(1-P(G)) \\ & + (1-P(\chi_n))(1-P(G))P(H) \\ & + (1-P(\chi_n))(1-P(G)), \end{aligned} \tag{9}$$

$$\begin{aligned} \Rightarrow P(m) = {} & P(\chi_n)P(H) + (1-P(\chi_n))(1-P(G)) \\ & + (1-P(G))P(H). \end{aligned} \tag{10}$$

According to the correct and incorrect sequence of the learner's answering results, the learner's learning prior probability is updated. When the learner's current knowledge answering situation is correct, the probability of $P(\chi_n|\alpha)$ is updated, which can be expressed by the following formula:

$$P(\chi_n|\alpha) = \frac{P(\chi_n)(1-P(H)) + P(\chi_n)P(G)(1-P(H))}{P(\chi_n)(1-P(H)) + (1-P(\chi_n))P(G) + P(G)(1-P(H))}. \tag{11}$$

When the answer is wrong, the probability of updating $P(\chi_n|m)$ can be expressed by the following formula:

$$P(\chi_n|m) = \frac{P(\chi_n)P(H) + P(\chi_n)(1-P(G))P(H)}{P(\chi_n)P(H) + (1-P(\chi_n))(1-P(G)) + (1-P(G))P(H)}. \tag{12}$$

After all answers are completed, the updated probability of $P(\chi_n)$ can be expressed by the following formula:

$$P(\chi_n) = P(\chi_n|\alpha) + P(\chi_n|m). \tag{13}$$

Predicting the learner's mastery probability at the next knowledge node can be expressed by the following formula:

$$P(\chi_{n+1}) = P(\chi_n) + (1-P(\chi_n))P(T). \tag{14}$$

2.5. Algorithm for Determining the Weights of Evaluation Attributes Based on Weighted Naive Bayes. In order to reduce the computational cost, the naive Bayesian algorithm assumes that the conditional attributes are independent of each other, and another implicit assumption is that the importance of each conditional attribute to decision classification is the same; that is, the weights are all set to 1. In practical application, the importance of each conditional attribute to classification is different, so when all weights are set to 1 by default, the accuracy of classification will be reduced.

In this paper, Weighted Naive Bayes (WNB) classification algorithm is used to assign a reasonable weight to attributes according to their contribution to classification, which not only keeps the high speed of WNB algorithm, but also reduces the influence of conditional independence assumption of attributes on classifier performance. The calculation formula is as follows:

$$P(A_i|\beta) = \arg\max_{A_i} P(A_i) \prod_{j=1}^{n} P(C_j|A_i)^{wj}. \quad (15)$$

Among them, w_j represents the weight of the attribute C_j, which determines the importance of different attributes in the classification process. The larger the w_j value, the more important the corresponding attribute C_j for the classification. In the specific application, how to determine the specific weight for each attribute is the key issue of the weighted naive Bayesian model.

According to the correlation between the evaluation attributes of the teaching evaluation data and the comprehensive evaluation value, it can be seen that the value of each index has different degrees of influence on the evaluation results. Therefore, this paper proposes a method to determine the weight of each evaluation attribute by using the correlation probability of the class attributes. Each attribute A may have K different values, which are represented by k_a, where $a \in K$. Assuming a specific instance β, when the attribute C_j of β takes the value of k_a, for the category A_i, the calculation formulas of the correlation probability C_j and the irrelevant probability A_i of the attribute $P(C_j|\text{rel})$ about $P(C_j|\text{norel})$ are as follows:

$$P(C_j|\text{rel}) = \frac{\text{count}(C_j = k_a \wedge A_i)}{\text{count}(C_j = k_a)},$$
$$P(C_j|\text{norel}) = 1 - P(C_j|\text{rel}), \quad (16)$$

where count represents the number of statistics. When the value of the attribute C_j is A_i and belongs to the k_a class, the attribute weight calculation formula is as follows:

$$w(C_j, k_a, i) = \frac{P(C_j|\text{rel})}{P(C_j|\text{norel})}. \quad (17)$$

Therefore, the specific calculation formula of weighted naive Bayes classification algorithm is as follows:

$$P(A_i|\beta) = \arg\max_{A_i} P(A_i) \prod_{j=1}^{n} P(C_j|A_i)^{w(C_j,k_a,i)}. \quad (18)$$

In dataset D, if there are M class labels, N attributes, and K possible values for each attribute, the total weight of all attributes is $m * n * k * N * K$. If the specific values of the same attribute are different, the weights are different. When the same attribute has the same value, the weights are different in different categories. Finally, according to the specific value of each attribute, the weight of the probability related to the current category label is selected for calculation, and the result values of each category are compared, and the category corresponding to the maximum value is the classification result.

3. The Realization of Music Solfeggio Teaching System

Based on the overall structure design and module function design of the system, this paper further expounds the concrete realization of the main functional modules of the system, that is, teaching knowledge resource bank, examination question bank, knowledge learning and testing, and the function of selecting topics and generating test papers, and gives the realization method, system user interface, and program analysis of other main functional modules in the system. Finally, it analyzes the considerations of system security.

3.1. System Logic Structure Design. The system adopts the C/S structure development mode of combining foreground application with background SQL server database and adopts C# as the development language. According to the requirements of the music solfeggio teaching system, this project needs a large number of user interfaces. Because it is used in the local area network, the WinForm interface application program, which is familiar under the NET platform, is first selected to be responsible for interacting with operators, receiving input and displaying output. In this system, the core technologies that need to be solved are how to access data in the most reasonable way and which data components should be selected to achieve specific purposes according to different needs. The logical structure diagram of the system is shown in Figure 3.

As shown in Figure 3, under normal circumstances, SqlCommand control can be used to execute SQL statements without returned record sets, such as adding, modifying, and deleting user information, or SQL statements with returned sets, such as query and statistics of students' grades. With the data read by the SqlDataReader object, the Fill method can be used to call the Select command in the SQL statement, or the Update method can be used to Update the changes recorded every day to automatically call the implicit Insert, Update, and Delete commands.

3.2. Implementation of Key Technical Modules

3.2.1. Management of Teaching Resource Bank. The management function of the teaching resource database of the system is similar to that of the question bank. It mainly realizes the management of adding, deleting, and modifying the basic knowledge points of solfeggio, and its realization principle is basically the same. The difference is that the management of knowledge points needs to be presented in the form of a tree diagram directory in the student login interface.

Set the system knowledge point resource management function in the "Knowledge Point Management" module of "System." In the system, the parameter information of knowledge points in different chapters is different. Here, take the "scale" knowledge point as an example, and design the interface display. The management information of knowledge points in this module directly controls the display catalogue and detailed contents of knowledge points of students' clients. In the knowledge point resource management, information such as resource ID number, parent knowledge point ID, resource description, level, mid-audio resource location, and URL address of music score stored in the server is set for each music resource field.

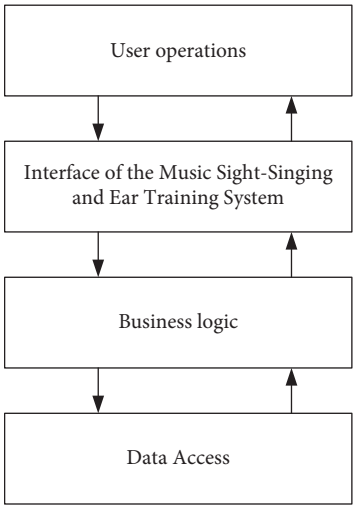


Figure 3: System logic structure diagram.

3.2.2. The Design of Question Template. The examination questions involved in the system are mainly divided into five types: syllable recognition, interval comparison, music reading and pronunciation recognition, sound bundle dictation, and rhythm style. In the question bank management system, the questions corresponding to various questions are added, deleted, modified, and queried. The system needs to design the management interfaces of various questions respectively. For the attribute information of various questions is different, in order to facilitate the management of the questions, according to the main attributes in the solfeggio knowledge database, such as the content of the questions, midi audio files, music score pictures, knowledge chapters, and difficulty levels, according to the requirements of different questions, different management templates are designed for each question. The following are brief introductions to each question:

(1) Scale recognition

The question of scale identification is to examine students' cognition and proficiency in scale of mode and tonality system by listening and distinguishing various scales.

(2) Interval comparison

The interval comparison test is to play two midi single notes, respectively, compare their sizes, and mainly examine students' ability to perceive the distance between the two notes.

(3) Reading music and recognizing sounds

The score reading test is to give the musical scores in different modes and tonality systems. Students are required to identify the clef information of their musical scores, fill in their answers, and submit the answer results. This type of question examines the students' mastery of basic notes and clefs by viewing music scores.

(4) Bundle chords

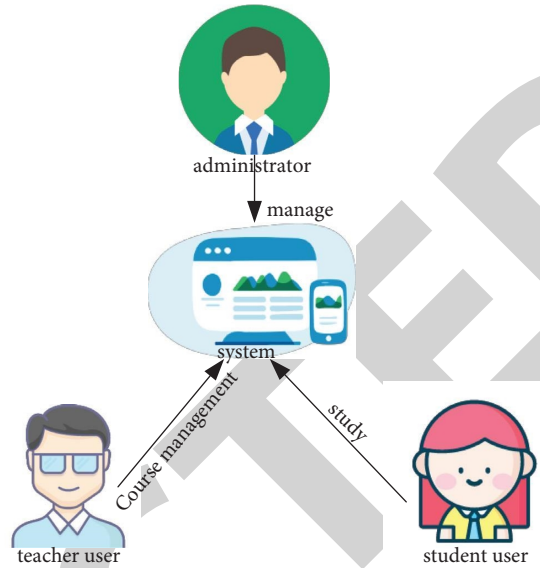


Figure 4: System role assignment structure diagram.

Bundle and chord test questions cover the investigation of knowledge points of chord composing, chord listening, and bundle and chord discrimination. By playing a piece of music information, we can identify its bundle and chord content and select the correct answer from the alternative answers and save it.

(5) Rhythm style

The style test is to identify the style type by playing an audio rhythm segment, select the correct item from the alternative answers, and press OK to answer. This type of question examines students' mastery of rhythm types and sound, and at the same time, through grasping different beat numbers and rhythm styles, they can understand the music background embodied in different rhythm styles and improve students' ability to appreciate music.

According to the software development process in this chapter, the requirements analysis and general framework outline design before development are completed, in which the requirements analysis includes functional requirements and nonfunctional requirements. There are three types of users in this system, namely, administrators, students, and teachers. The distribution structure of roles is shown in Figure 4.

As shown in Figure 4, the overall architecture system of online teaching system based on personalized recommendation and the overall architecture design of the system help developers control the general level development structure of the whole system, so that each module of the system development is independent and highly aggregated within blocks, and the division of labor is clear.

3.2.3. System Architecture. By analyzing the system architecture diagram, we can easily understand the system structure information and the data interaction process

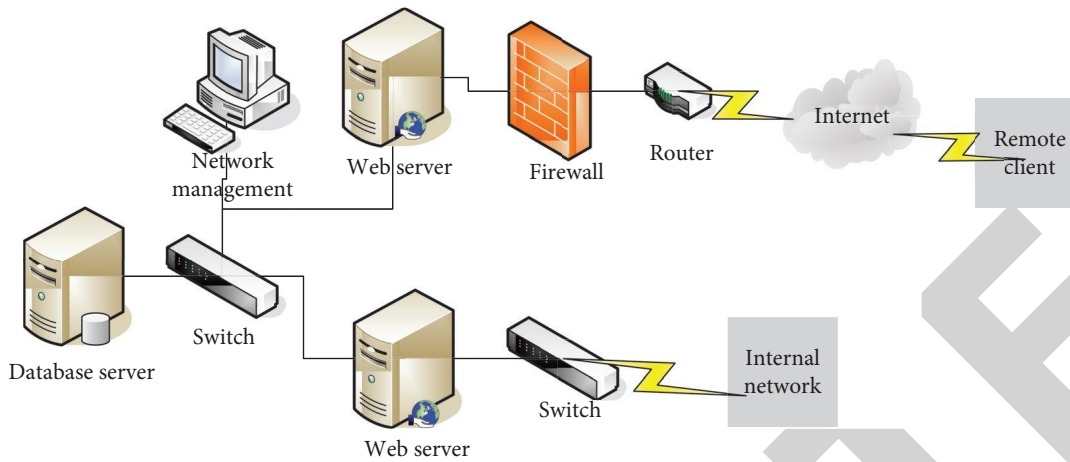


Figure 5: Topology diagram of solfeggio experiential teaching network in normal universities.

between each functional module and other layers. The overall system architecture design is shown in Figure 5.

As shown in Figure 5, the internal network can be directly connected to the internal network of the local server, which is located in the same domain as the server, thus facilitating various operations. The server mainly includes Web server, firewall, database server, switch, and router. The remote client uses the Internet to log into the server, which is convenient for all operations.

3.3. Design of Logical Structure of Database. The function of database logic design is to finally determine all kinds of information tables needed in the system database and the fields contained in each table. The structure of the table in the main part is introduced below.

(1) The fields contained in the user login information table are shown in Table 1.

(2) Student information table, which is used to store the detailed information of students, is shown in Table 2.

(3) Teacher information table is shown in Table 3.

Table 1: UserInfo table.

Field name	Type of data	Length	Illustrate
ID	Int	Four	System number
UserFlag	Int	Four	User type
UserCh	Varchar	40	Username
UserName	Varchar	40	Username
UserPwd	Varchar	40	User password
IsTest	Int	Four	Whether to take the exam

Table 2: StudentInfo table.

Field name	Type of data	Length	Illustrate
SNO	Varchar	45	Student ID
SName	Varchar	45	Name
ClassID	Int	Eight	Class number
Grade	Varchar	40	Grade
EmailInfo	Varchar	40	E-mail address

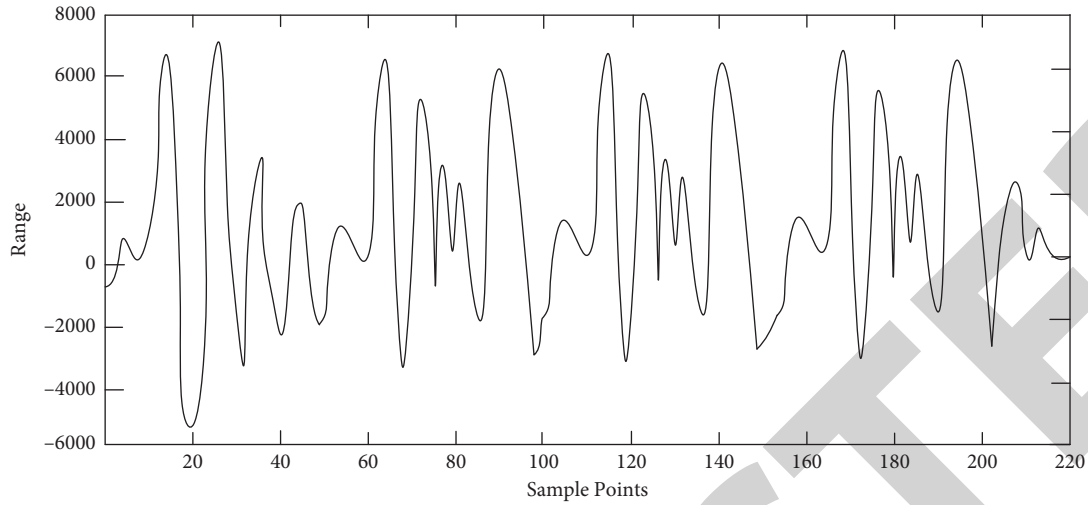
Table 3: TeacherInfo table.

Field name	Type of data	Length	Illustrate
TeacherID	Varchar	20	Teacher username
Password	Varchar	15	Password
Name	Varchar	20	Teacher name
Class	Varchar	10	Class

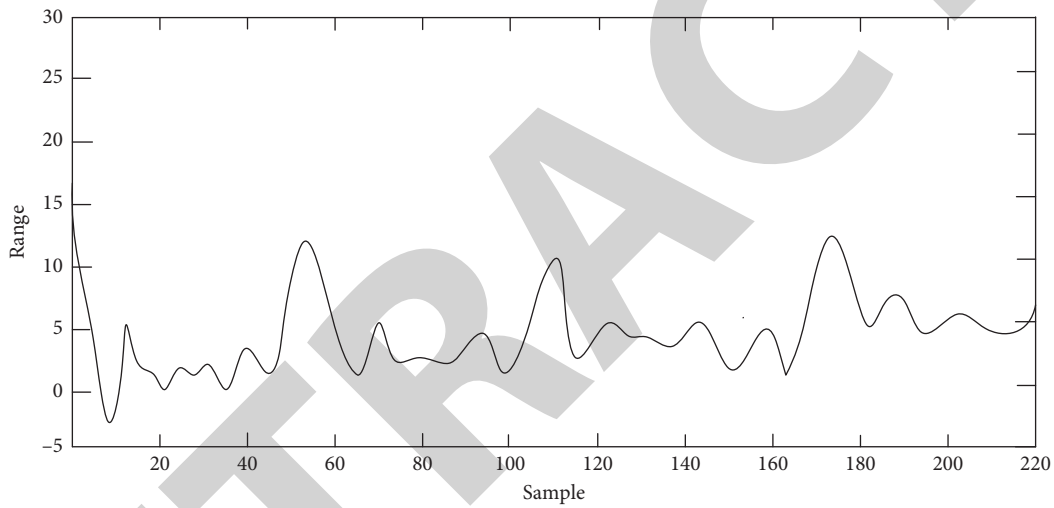
4. Experimental Analysis of Music Solfeggio Teaching System under Machine Learning

4.1. Experimental Analysis of Audio Feature Extraction and Matching. Through audio input devices such as microphone, the system inputs the user's sight-singing signal according to the Atlas into the computer, which is basically stored in binary or compressed data stream in PCM format. As far as the original data is concerned, on the surface, we cannot see the intrinsic characteristics of music. When compared with the Atlas, we cannot directly use the original data, and the accuracy of solfeggio of users of the system cannot be completely tested. In the solfeggio teaching system, the most important step is to extract the features of audio signals. After feature extraction, all kinds of signal features can be extracted from audio data, and the extracted features can fully reflect the basic features of the original data, and the original data's own signals or its own music meanings can be represented, which is quite beneficial to the evaluation of solfeggio results. The short-time random original signal and autocorrelation function are shown in Figure 6.

Figure 6(a) shows a randomly selected frame of speech signal, and the autocorrelation function of this frame of speech signal after autocorrelation processing is shown in Figure 6(b). It can be seen from the figure that the peak value of autocorrelation function is reflected in the pitch period, and the average value of pitch period is the distance between these peak points. The short-time original signal and autocorrelation function are shown in Figure 7.

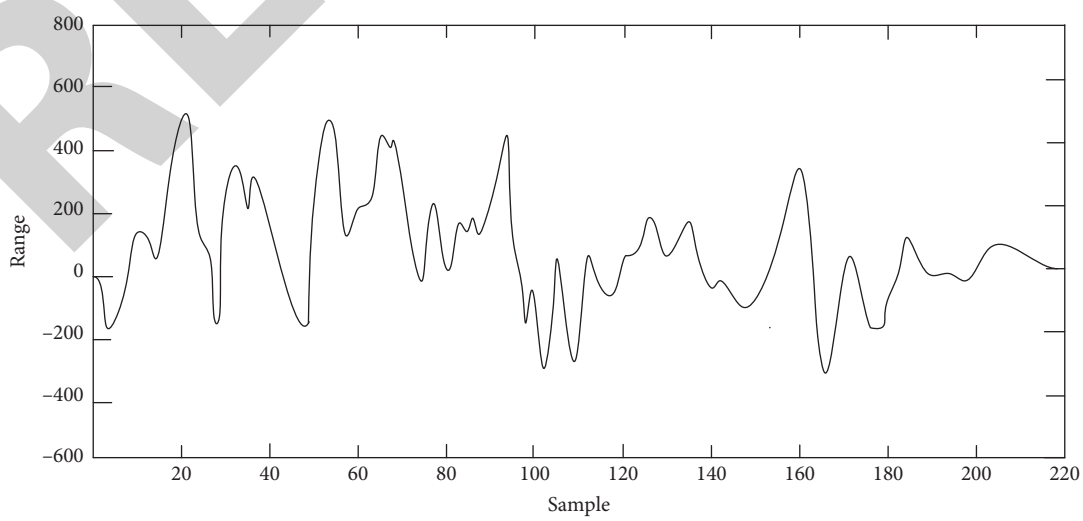


(a)



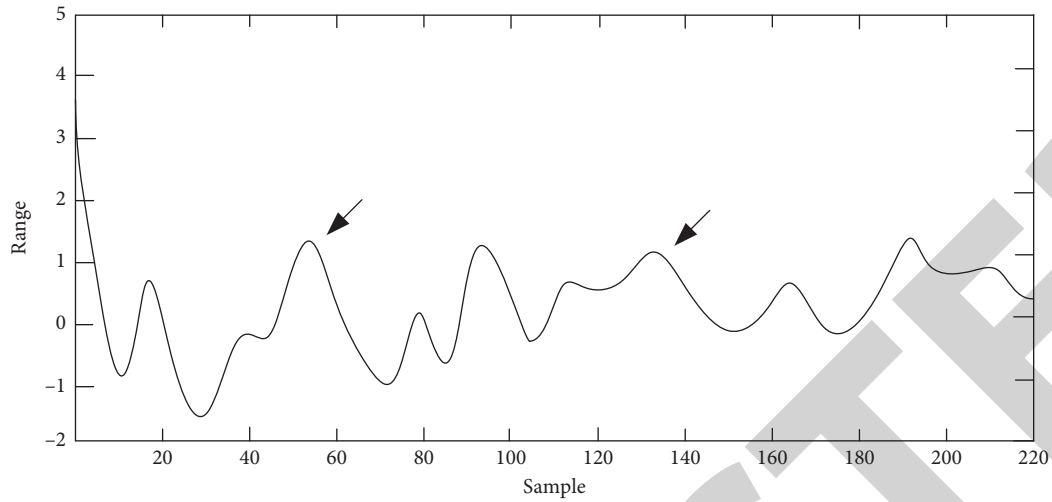
(b)

Figure 6: Short-time random original signal and autocorrelation function. (a) Random original signal. (b) Random autocorrelation function.



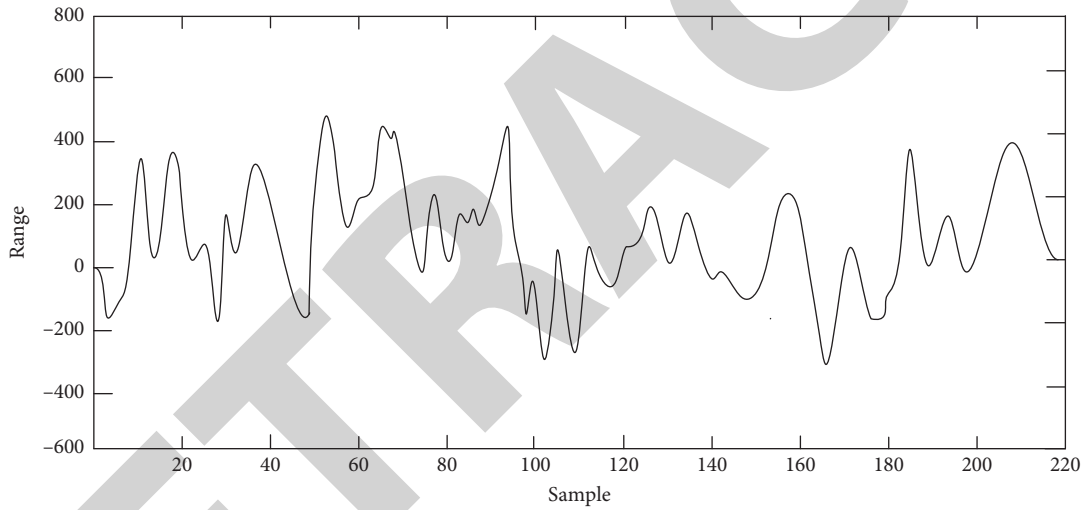
(a)

Figure 7: Continued.

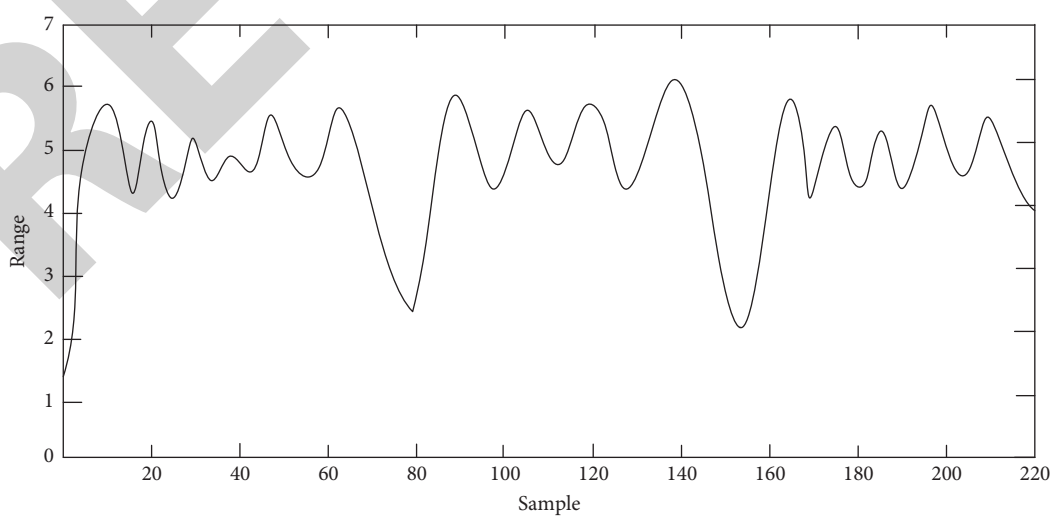


(b)

Figure 7: Short-time original signal and autocorrelation function. (a) Original signal. (b) Autocorrelation function.



(a)



(b)

Figure 8: Random original signal and average amplitude difference function. (a) Random original signal. (b) Random average amplitude difference function.

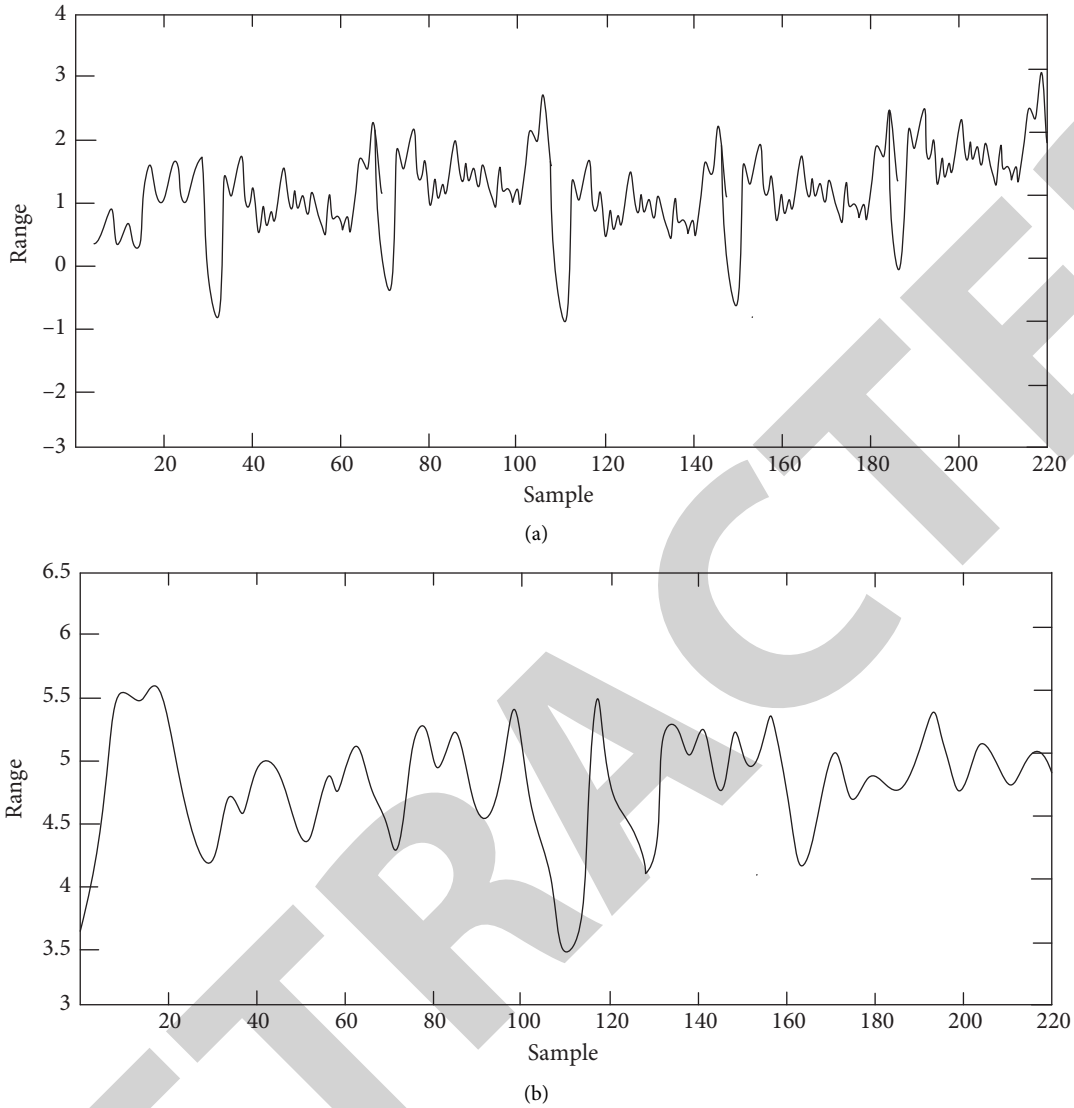


Figure 9: Noise signal and average amplitude difference function. (a) Noise signal. (b) Average amplitude difference function.

As shown in Figure 7, it can be seen that the pitch period detected by the autocorrelation function is not deeper than that of the original signal, but only half of it. The reason for this situation is the harmonic peak point indicated by the arrow in the figure, which is the frequency doubling phenomenon we mentioned earlier. Although AMDF method is extremely effective in extracting the base period, when the speech environment is harsh and noisy, and the signal-to-noise ratio is low, the detection effect is not ideal, and other methods must be used to deal with it. The original signal and the average amplitude difference function are shown in Figure 8.

As shown in Figure 8, the average amplitude difference function is calculated using frames randomly selected from the speech signal. It can be seen that the average amplitude difference function of the base period shows the number of holes, and the base period is the distance between these holes. If noise with a signal-to-noise ratio of 2 dB is added to this speech signal frame, the result is shown in Figure 9.

As shown in Figure 9, when calculating the average amplitude difference function of frames with noise in the speech signal, it can be seen that many harmonic components are added to the average amplitude difference function, and the basic sound waves are not found in these harmonic components at all. The basic cycle cannot be determined at all.

4.2. Comparison and Analysis of Classification Accuracy of NB Algorithm and WNB Algorithm. The data of the experiment comes from the database of teaching evaluation, and 220 data records are randomly selected as the training set and 70 data as the test set, and the cross-validation experiment is carried out. Through 10 cross-validation experiments, the classification accuracy of NB algorithm and WNB algorithm is measured. The specific experimental results are shown in Figure 10.

As shown in Figure 10, it can be seen from the experimental results that the average classification accuracy of Naive Bayes algorithm is 0.713 on this data set, while that of

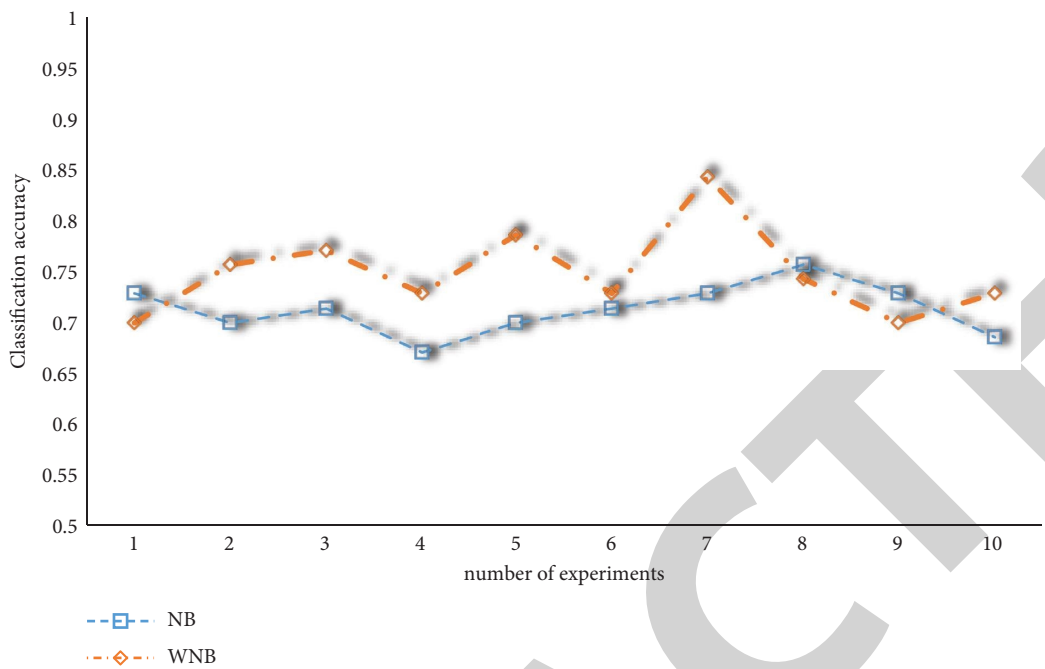


Figure 10: Comparison of classification accuracy between NB algorithm and WNB algorithm.

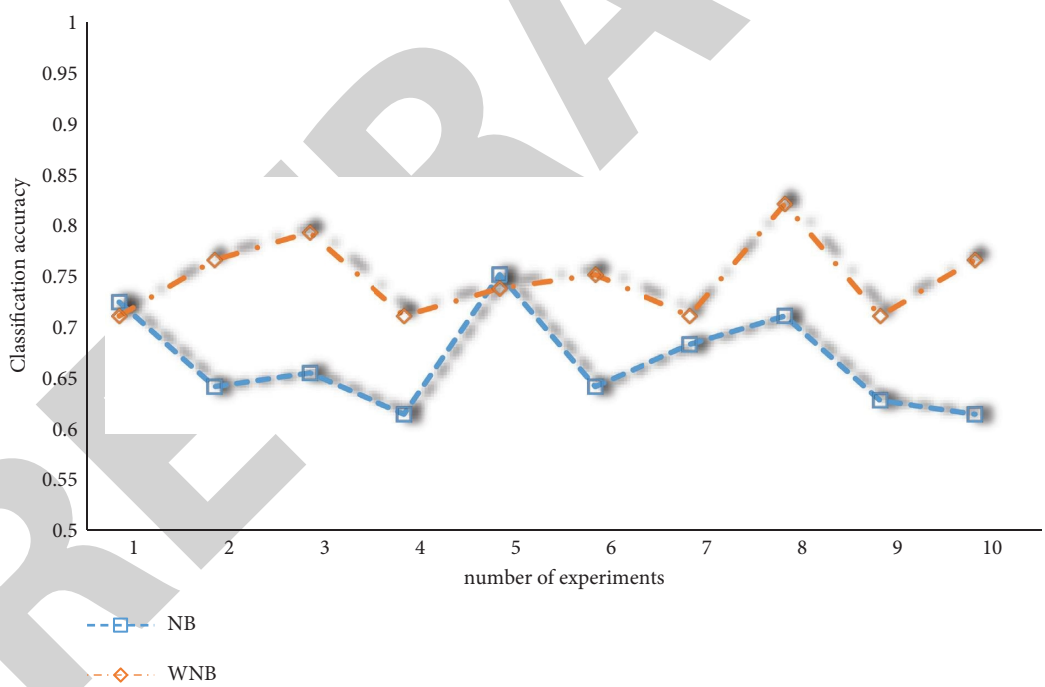


Figure 11: Comparison of classification accuracy between BP algorithm and WNB algorithm.

weighted Naive Bayes algorithm is 0.75. Generally speaking, the classification accuracy of weighted Naive Bayes algorithm is better than that of traditional Naive Bayes algorithm on teaching evaluation data set.

4.3. Comparative Analysis of Classification Accuracy between BP Algorithm and WNB Algorithm. From the data analysis of all experimental results, it is found that, in the actual evaluation process, the 100-point evaluation value given by students is generally very high, so in the process of model training, it is easy to overfit, which leads to a generally high prediction level. Therefore, after preprocessing, the score value of 100-point system is discretized into the evaluation value of five-level system, and the data of different levels are randomly selected and mixed into training data sets, among which there are 220 data sets in the training set and 70 data sets in the testing

set, and the cross-experiment comparison between BP network and WNB algorithm is conducted. The experimental results are shown in Figure 11.

As shown in Figure 11, in the actual teaching evaluation data set, there are many excellent grades and relatively few other grades in the evaluation grades. Therefore, when the hierarchical data is used to train the classification model, different training data sets will have a certain degree of influence on the experimental results. In this experiment, the average classification accuracy of WNB algorithm is 0.767, while that of BP algorithm is 0.683. Experimental results show that WNB algorithm outperforms BP algorithm in classification. At the same time, in terms of time efficiency, the average time consumption of WNB algorithm in this experiment is about 0.026 s, while that of BP algorithm is about 0.45 s. Compared with WNB algorithm, WNB algorithm has less time consumption and higher classification accuracy, so WNB algorithm has greater advantages in teaching evaluation.

5. Conclusions

Combined with the development trend of solfeggio teaching in China, this paper thinks about the development of digital technology in the field of music, the influence of computer music software on solfeggio training, the specific application of digital technology in discipline training, the auxiliary role of digital technology in solfeggio teaching, etc. and puts forward targeted suggestions for solfeggio teaching under the background of digital technology. In this paper, a musical solfeggio teaching system has been preliminarily established, which integrates the functions of knowledge management, examination questions management, online examination, after-class practice, assessment and scoring, performance management, and statistical analysis. The system adopts three-tier C/S mode and is used in LAN. Teachers and students use the system by installing client programs. Combining digital technology with solfeggio teaching can enrich teachers' teaching content, make up for students' lack of hardware facilities in after-class practice and formulate reasonable after-class homework for students at different levels, so that digital technology can become a good tool to assist solfeggio teaching and improve students' comprehensive ability of solfeggio. In the future research, we can introduce the current popular smart client architecture combining B/S and C/S, which makes the system easier to deploy and manage and brings fast response speed and rich user experience to users.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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Retraction

Retracted: A Diversified Integration Method of IPE Teaching Resources Based on Ant Colony Algorithm

Mobile Information Systems

Received 25 July 2023; Accepted 25 July 2023; Published 26 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] S. Shan and S. Li, "A Diversified Integration Method of IPE Teaching Resources Based on Ant Colony Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 6938811, 8 pages, 2022.

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Research Article

A Diversified Integration Method of IPE Teaching Resources Based on Ant Colony Algorithm

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In the era of big data, cloud computing, and machine learning, this has become essential to promote the better development of ideological and political education (IPE) in institutions and universities. In fact, we must pay close devotion to the integration and utilization of online teaching resources, take full benefits of the assistances of big data, machine learning, and continuously collect and sort resources that are conducive to IPE in higher vocational academies, so as to optimize the educational process. In fact, the resource allocation within the context of the IPE is not well-addressed in the existing literature; and the allocation of resources is quite unreasonable. In higher vocational education, the form and content of the IPE will enhance its effectiveness. In this paper, we use the ant colony algorithm to efficiently obtain the solution set for resource allocation, thereby addressing the issues of unreasonable allocation of IPE resources and inefficient testing. In addition, the local search method is incorporated into the ant colony optimization technique to perform a local search on the solution set of the obtained resource allocation in order to increase the algorithm's performance. On the standard test set, algorithm comparison experimentations are carried out to validate the efficacy and efficiency of the suggested algorithm.

1. Introduction

The speedy growth of the network technology over the preceding few years has contributed to an upsurge in the significance of large amounts of data. The prioritization and improvement of online teaching resources in IPE can help to improve the content of that education, as well as improve the screening, mining, and integration of online IPE resources, which can lead to the development of new models of that education [1–3]. This can be accomplished by improving the screening, mining, and integration of online IPE resources. Students in higher education will have more opportunities to learn about politics and ideology, as well as the current state of affairs, political climate, and important issues facing the nation if big data technology is used to establish and improve an online resource sharing platform for higher education. This platform can be created using the technology of big data and using excellent moral, ideological, and political qualities at the same time [4, 5].

The current IPE teaching in colleges and universities is characterized by the phenomenon of emphasizing theoretical teaching while ignoring practical teaching. Additionally, the dearth of practical teaching resources has had an effect on the role of teaching [6], as can be seen through the summary of a number of classroom teaching experiences. In higher education, there is a growing consensus that IPE studies should be taught in a hands-on manner. This is the primary method for cultivating students' practical application ability, so it makes sense that this should be the case. As a consequence of this, how are educational institutions like colleges and universities supposed to promote IPE programs? The integration of practical teaching resources and the improvement of the practical teaching effect of IPE courses should remain a primary focus at colleges and

universities for a considerable amount of time to come [7–11].

The proliferation of uses for big data technology has been made possible by the continuous advancements that have been made in the Internet information technology. It is imperative that in this period of big data, cloud computing, deep learning, the integration of network education resources be strengthened in order to provide students with the most up-to-date, interesting, and comprehensive IPE that is possible. Taking into consideration the current situation, it is imperative that the integration of network education resources be strengthened [12–14]. The utilization of educational cases can be incorporated into the curriculum and activities of an IPE program in order to make it more effective and engaging for the students. While this is going on, a number of schools of higher learning offer dull classes on IPE that are confined to classrooms and textbooks. IPE in higher educational institutions will be restricted and hampered as a result of this issue because students will not be able to focus on specialized teaching while the instructor is speaking [15].

The artificial ant colony optimization (ACO) procedure has been the subject of a great deal of research and has been put to use in a diverse range of industries, such as the scheduling of manufacturing and the distribution of logistics. A significant portion of the potential of ACO's extension to project scheduling has not yet been explored, particularly in the domain of resource planning for IPE. It is a common knowledge that ACO possesses global parallelism, robustness, and efficient search capabilities. In this paper, an ACO is presented as a potential solution to this problem. In order to further increase the performance of the suggested ACO procedure, an Insert and Swap neighborhood search that is based on logical constraints has been integrated into it. The efficiency of the method has been demonstrated through experimentation. The IPE teaching resources are integrated with one another and can be configured in a variety of different ways.

The key contributions of this research can be summarized as follows. (i) We use the ant colony algorithm to efficiently obtain the solution set for resource allocation, and addressing the issues of unreasonable allocation of IPE resources and inefficient testing. (ii) The local search method is incorporated in order to perform a local search on the solution set of the obtained resource allocation in order to increase the algorithm's efficiency. (iii) Similarly, in order to further advance the performance of the algorithm, an Insert and Swap neighborhood search that is based on logical constraints has been integrated into it.

The remaining paper is organized as follows. In Section 2, the background study has been completed. In Section 3, an ant colony optimization algorithm is suggested. Results and simulations study is presented in Section 4. Section 5 discusses the state-of-the-art related works. Section 6 summarizes the research and offer guidelines for future investigations.

2. Background

2.1. Status of Resource Integration. In this section, we investigate and analyze the up-to-date state of efficient integration of the IPE resources, and put forward several relevant recommendations for the shortcomings.

Because of the singular and time-honored mode of education, many educational institutions, including academies and universities, do not pay sufficient consideration to the application of big data, and they do not have the mining and integration of network education resources that are necessary at the present time. Higher vocational education suffers from a deficit of IPE because its content and form are overly simplistic and uninteresting. This deficit can be attributed to the lack of diversity in the curriculum.

2.1.1. Single Education Model. They place an excessive amount of emphasis on the application of mechanized education concepts and models in their IPE programs, despite the fact that many of the educational ideas and models used by college and university teachers are relatively straightforward and traditional. Students have a difficult time learning because they lack the self-motivation and enthusiasm necessary for learning new things and expanding their knowledge base. If there is a lack of motivation and passion to learn new things and broaden one's horizons, then IPE will suffer as a consequence. There is a lack of capability to use information technology (IT), computing, and big data technology to assist in IPE, and many academies and universities have not paid consideration to carrying out targeted training activities for the educators. In addition, the model of IPE that the teachers receive is mechanized. Due to the low average educational attainment of IPE professors, it is difficult for various institutions and universities to increase the quality of the IPE they provide their students.

2.1.2. Insufficient Integration of Resources. Because educators are not paying adequate consideration to the integration of online educational resources, and because they lack a certain amount of initiative and creativity in the use of Internet teaching technology, IPE in colleges and universities is lacking in color and spirituality. This is due to the fact that the educators are not able to use the Internet to its full potential to teach the students. Education that is both IPE and that is well-developed and carried out to a high standard. As a consequence of this, some educators hold antiquated teaching ideas and single concepts, lack a certain understanding regarding the mining and integration of online education, and fail to recognize or make use of the vast IPE resources available on the network. As a consequence of all of these factors, the degree to which online education is integrated is limited. Even though there is a large quantity and variety of online educational resources, it is possible that educators will not be able to extract the information that is both pertinent and comprehensive from them. Your assistance is needed to improve the IPE at colleges and universities.

2.1.3. Difficult to Utilize Resources. In this day and age of big data, one of the most common problems that arise is an inefficiency in data mining, acquisition, and integration

caused by the use of standard software or technologies. When students are looking for educational resources online, if they come across information or materials that are unfavorable, it will have a detrimental effect on their way of thinking as well as the values they hold. This is especially the case if the information or materials include pornography, violent content, or supernatural beliefs. The education of students in political and ideological perspectives may become more challenging as a result of the failure of many educators to identify and eliminate inaccurate or misleading information in a timely manner. For the purpose of elevating the level of IPE instruction received by students, classroom instructors must become more discriminating in the materials they choose and the ways in which they incorporate them.

2.2. Resource Integration Measures

2.2.1. Mining of Teaching Resources. At the college and university level, IPE is a complex field that involves many different aspects of both theory and practice. Take note that this particular aspect of the content is not fixed and is closely related to the progression of time, to put it another way, the content needs to follow the development of time. Make adjustments in order to keep up with the rapidly shifting times. As a result, educational institutions such as colleges and universities ought to institutionalize the idea of keeping up with the times, actively explore the practical instructional resources that are available both inside and outside the institution, and make effective use of these resources. The practical teaching activities of IPE courses should be integrated with the resources found off campus. This should be your primary focus. In conclusion, make use of the current circumstances to develop a cooperative linkage mechanism for the practical teaching of IPE courses, with the goal of promoting the role that each subject plays.

2.2.2. Reasonably Divide the Priority of Resources. The only way to successfully improve the multiple integration of ideologies and politics in college classrooms is for the administrators of schools that provide ideological or political education to devise reasonable plans for the existing practical resources, differentiate between primary divisions and secondary divisions of teaching resources, and finally combine problems with the existing IPE practices. Increase the overall standard and quality of classroom instruction by making effective use of the various teaching resources that are at your disposal. Teachers at IPE colleges and universities need to constantly coordinate their responsibilities and obligations, fully utilize the teaching resources of their colleagues, actively innovate classroom teaching models, and provide students with a high-quality classroom experience. This is in addition to recognizing the positive role that their own resources play in practical teaching and the resources for educators.

We can begin to rationally standardize practical teaching resources for IPE courses in colleges and universities by dividing them up according to a thorough understanding of the students' level of IPE construction. This will allow us to dig deeply into the spirit and characteristics of our time while also beginning to rationally standardize practical teaching resources. It is actively looking for new ways to teach in the hopes of achieving its ultimate objective, which is to improve the effectiveness with which universities' IPE classes make use of practical teaching resources. In addition to this, it helps to increase the proportion of time that the practical teaching resources are put to use.

2.2.3. Carry Out Practical Teaching. Theorizing is the foundational activity upon which all other activities are constructed. If you acknowledge the significance of applying what you learn in IPE courses to real-world scenarios in the classroom, you can help IPE studies at colleges and universities to become more effective. Teaching in the classroom is hampered to a large extent by the use of IPE textbooks, which make it difficult for teachers to convey advanced and scientific IPE content to students. Students are not particularly interested in IPE teaching courses offered at colleges and universities. IPE teaching textbooks are a major barrier to effective classroom teaching. Educators in higher education must therefore acknowledge the significance of IPE instruction, alter their traditional approaches to teaching that are based on theory and practice, acknowledge the students' predominance in classroom instruction, and develop curriculum that is constantly tailored to the students' individual IPE learning needs. All of these things must be done in order to ensure that the students receive an education that is effective.

In addition, administrators of IPE in colleges and universities need to clarify the primary position of IPE, actively integrate the idea of quality education into classroom instruction, and comprehend the effective amalgamation of theoretical teaching and practical teaching in order to fulfill their responsibilities. It is essential for college IPE instructors to acquire a deeper comprehension of how to instruct students in a classroom environment. Time allotted in the classroom for the study of ideology and politics should be distributed in a manner that not only captures the attention of the students present but also helps students become more capable practically and makes the most of the time allotted for IPE instruction.

2.2.4. Using Multimedia Teaching Technology. The traditional classroom teaching model has been significantly rethought as a result of today's modern information technology, which has resulted in the development of multimedia educational facilities that are centered on the Internet. The network currently has widespread adoption across a diverse range of sectors and domains. The departments of politics and ideologies in colleges and universities are obligated to make use of multimedia technology in order to increase the overall superiority of classroom instruction, encourage and motivate students to learn, and enhance classroom instruction. This is an essential component of ensuring that the students graduate with the appropriate perspective on the meaning and values of life.

Because of the current issues with teaching IPE practice in colleges and universities, these institutions need to continue to innovate and reform the content that is taught in classrooms, introduce contemporary multimedia teaching facilities, and integrate and optimize the various teaching resources.

This is an additional issue to the ones that have already been present. On the other hand, the availability of open access to and the free exchange of multimedia resources make the classroom instruction easier. This makes it possible for students to have more complex theoretical information intuitively presented in front of them, which in turn satisfies their requirements. On the other hand, in order for schools to cater to the varied educational requirements of their students, they should focus more on the development of multimedia teaching platforms, establish network-based WeChat and Weibo accounts, organize ongoing events, produce periodic publications, and make a subtle effort to influence these platforms.

3. The Proposed Ant Colony Algorithm

This paper divides IPE resources into four parts: human resources (H), material resources (M), cultural resources (C), and information resources (I), as shown in Figure 1. The core of the integration of IPE resources is the rational allocation of four parts of resources to IPE teaching. The goal of the algorithm is to search for the optimal solution of the four resources.

The method that is proposed in this paper primarily makes use of parallel search among each population in accordance with the set conditions in order to discover the best and optimum solution independently. Additionally, the method communicates information with each other through the use of information entropy. The following formulas (1) and (2) is an explanation of the formula used to calculate the information entropy:

$$E = -k \sum_{i}^{n} p_i \ln p_i, \tag{1}$$

$$\sum_{i=1}^{n} p_i = 1. \tag{2}$$

where p_i is the probability of state i and the ln characterizes the natural logarithm.

The Ant Colony algorithm is a bionic heuristic optimization technique that, in fact, models the way in which ant colonies go about their search for food. This system uses a mechanism known as positive feedback parallel autocatalysis. When the ants reach the crossroads that they have never been to before, they will pick a direction to travel through at random out of the available options. And release pheromone, the amount of pheromone released is inversely proportional to the length of the path taken by the pheromone. The ants that then make their way to this intersection will choose the route that leads to a larger pheromone, thereby creating a positive feedback mechanism. On the path that leads to the best solution, the quantity

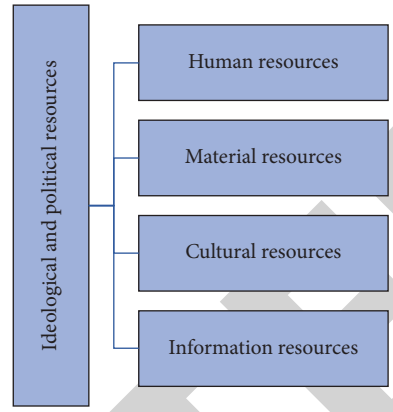

Figure 1: Components of an IPE.

of information will continue to increase while it is being accumulated. The longer the amount of information is collected along the nonoptimal path, the more the pheromone that is present along the path will gradually decrease, and eventually, through the movement of the entire ant colony, the optimal path will be found.

Ant k selects tuple s for pathfinding as follows in formula (3):

$$s = \begin{cases} \arg\max q \in T_k \{\alpha_u \cdot \beta_u\}^{\theta}, \\ q \le q_0, \\ S, q > q_0, \end{cases} \tag{3}$$

where T_k are the remaining tuples, α represents the number of pheromones, β is the heuristic value, and θ is the influence factor of β on the number of pheromones. Furthermore, $q \in [0.1]$ is a uniformly distributed random variable.

The probability that the ant k randomly selects s for the next pathfinding is given by the formula (4):

$$p_u = \frac{(\alpha_u \cdot \beta_s)^{\theta}}{\sum_{u \in T_k} (\alpha_u \cdot \beta_u)^{\theta}}. \tag{4}$$

The calculation formula of β_s is mathematically illustrated in the following equation:

$$\beta_s = (R_1 - R_2 + R_s)^{-1}. \tag{5}$$

where R_1 is the total teaching resources, R_2 is the used teaching resources, and R_s is the used of capacity value.

The global pheromone update rule is stated in formula (6):

$$\beta_s = (1 - \delta) \cdot \beta_s + \delta \cdot \Delta'_{\beta_s}. \tag{6}$$

where Δ'_{β_s} is the amount of superfluous pheromones, which is calculated as given by formula (7):

$$\Delta'_{\beta_s} = f(L^*). \tag{7}$$

where L^* is the optimal global migration route.

Given the global pheromone, we give the calculation method of the local pheromone given as follows:

$$\beta_s' = (1-\varepsilon)\cdot\beta_s^* + \varepsilon\cdot\beta', \tag{8}$$

$$\beta^* = (|L|\cdot|P|)^{-1}. \tag{9}$$

This time interval is not permanent, nevertheless is estimated according to the information of all of the populations, in other words, it changes with the convergence of all of the populations. The algorithm requires that the communication of the population takes place at a certain time interval. The following conditions are met by the time interval for population communication that is mathematically estimated by formula (10):

$$G = e^{\sum E_i/h}\cdot\gamma. \tag{10}$$

where γ is a parameter.

4. Results and Discussion

The first thing that should be taken into consideration when integrating and assigning ideological and political education resources is the energy consumption of resource allocation. This includes things like the consumption of CPU and memory as well as resource waste. When determining the total quantity of energy (measured in KWh) that is spent by the data center's physical resources, the workload of the application is taken into consideration.

In some studies, the evaluation index for determining the level of resource integration is comprised of the amount of software and hardware data consumed in addition to the amount of educational resources that are wasted. This indicator is also used to evaluate the degree of resource integration in the same article as previously mentioned.

In order to more effectively establish and validate the actual consistency of the simulation outcomes, we carried out the simulation experiment a total of five times, each time with a different set of parameters. Figures 2 and 3 show a comparison of the total amount of energy used and the average amount of energy used from the first iteration through the fifth iteration, respectively. This should be noted that RI1 and PRI are the algorithms being compared, and it can be plainly comprehended that the energy consumption of the suggested method, presented in this paper, is significantly lower than that of the RI1 and PRI algorithms being compared. The energy consumption of RI1 is as high as more than 5.0 kW sec, the energy consumption of PRI procedure is approximately 4.9 kW-sec, and the energy consumption of the algorithm proposed in this paper is only less than 4.8 kW-sec. Subsequently, we noted that the energy consumption of this algorithm is more stable. The RI1 has the highest energy consumption of the three algorithms.

We simulate the ideological and political teaching resources under different parameters γ, as shown in Figure 4.

The experiment with simulation is primarily based on the process of resource fragmentation, and a method for simulating the resource allocation of system load has been designed. More specifically, in order to simulate the resource allocation in the actual environment, multiple resource allocation models are used for the same load. This study uses

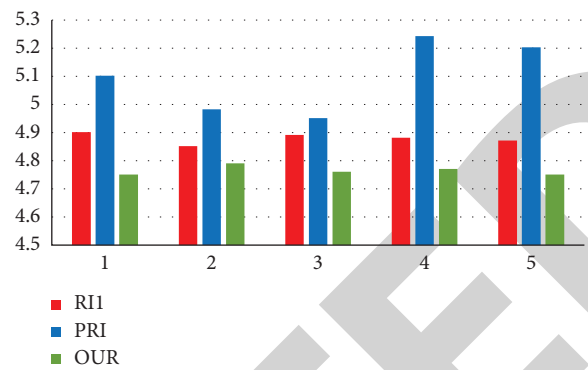

Figure 2: Energy consumption comparison of five experiments.

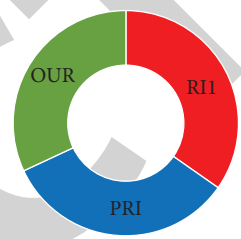

Figure 3: Comparison of the average energy consumption of the three algorithms.

the MATLAB software to simulate and analyze the experimental data, and it simulates the resource usage in the ideological and political (IPE) teaching system over a long period of time. Figure 4 depicts the actual distribution of the available resources.

The process of integrating ideological and political resources in educational institutions like colleges and universities is one that requires a lot of resources. It will make the source physical host use more of its CPU resources, it will make the source physical host and the destination host use more of their bandwidth resources, and it will pause the services that are running on the virtual machine that is being migrated. Lengthened amount of time is required for integration and migration. As a consequence of this, one of the objectives of the algorithm that is described in this paper is to decrease the number of migrations to the extreme degree conceivable. The duration of the migration is approximately equal to the amount of time necessary to allocate memory during the migration amongst the network bandwidth link of the source physical machine and the network bandwidth link of the destination physical machine.

As can be comprehended in Figure 5, the migration times of the procedure proposed in this paper are approximately 4 times, which indicates that they are relatively stable throughout each iterative experiment. The RI1 algorithm is capable of accomplishing a maximum of thirty times the migration of a virtual machine and a minimum of eight times this number. The PRI algorithm's migration times can also reach approximately 30 times at the most, and more than 10 times at the least, however, unlike the two algorithms discussed previously, there are no rules to be found in the PRI algorithm. It should come as no surprise that the

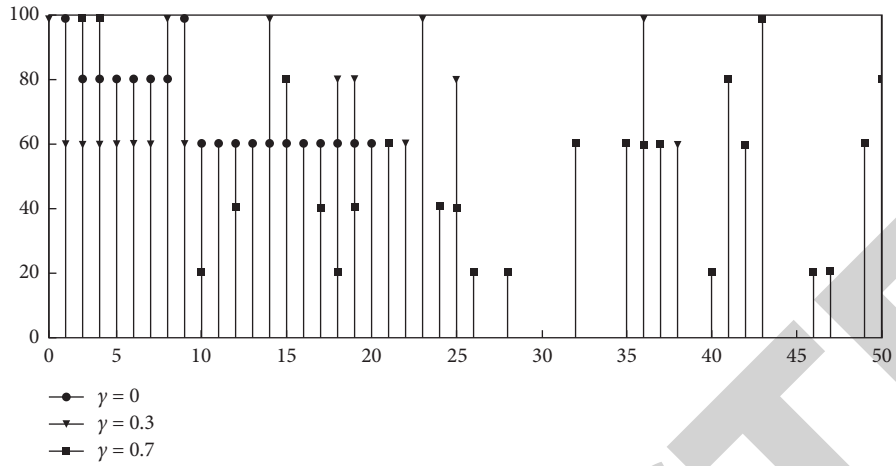

Figure 4: Simulation map of resource integration.

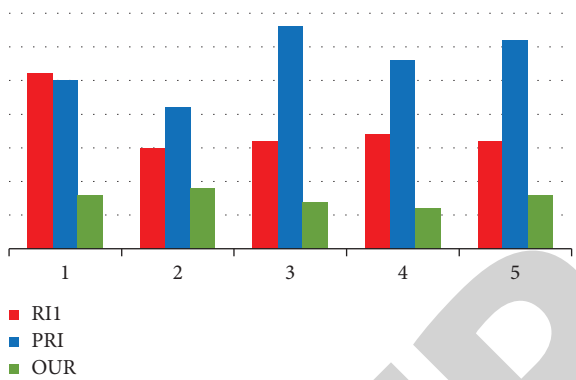

Figure 5: Comparison of migration times of the three algorithms.

algorithm presented in this paper has a significantly lower number of migrations than the other two algorithms.

5. Related Work

Many networked and information-based educational concepts have gradually had an impact on traditional teaching methods and concepts, and some modern teaching methods have become widely used. In addition, many online educational resources are also easily integrated and utilized [16–20]. If teachers are confined to classrooms or books, it will be difficult to carry out IPE work as well as improve the educational effect. It is therefore imperative that the educational institutions focus on and strengthen the integration of online educational resources that are in line with the development trend of the big data era and also match the direction of ideological education reform in my country. Utilizing these online educational resources makes it possible to carry out educational activities pertaining to ideology and politics in a more manageable manner.

Because we live in an information age, therefore the way that college students think is more innovative and current, and they have a strong working knowledge of the resources that can be found on the Internet. If teachers' pay significant consideration to the incorporation of online education resources and provide students with the appropriate guidance, it will have a multiplier effect on the IPE that the students receive [21–23]. One can observe the trend toward, as well as the inevitability of, the incorporation of online educational resources into the IPE programs of colleges and universities.

Research into scheduling optimization under the constraints of limited IPE resources is of great value. The goal of this research is to maximize the performance indicators like cost while adhering to IPE constraints. It is possible to boil down many real-world manufacturing and service issues into resource-constrained project scheduling issues. The practical application of engineering frequently involves dealing with factors such as large scale, stringent constraints, multiple objectives, and uncertainty. The development of effective optimization algorithms for solving resource-constrained project scheduling issues is currently a popular research topic in academic circles as well as in a variety of application industries [24–26].

Over the progression of the historical few ages, there has been a mounting importance in the field of MORCPSP research among academics (multi-objective resource-constrained project scheduling problem). It is a reasonable approach that has been proposed by some researchers to solve the problem of two resource constraints. The enumeration interaction algorithm is what has been proposed as the solution. When planning the completion of the project, both the amount of time and the resources that will be needed are taken into account. Some researchers have proposed a two-stage algorithm as a solution to the problem of multi-objective project scheduling. This algorithm takes into account the optimization objectives of minimizing the total cost, duration, and net present value of the project. In the first stage, the Pareto algorithm is used to produce a set of nondominated solutions. In the second stage, the solution produced in the first stage is improved through the use of the speed of light search. An efficient optimization algorithm for MORCPSP has been developed with the help of the simulated annealing and tabu search mechanisms [3, 27]. This algorithm takes into account the length of the project, the investment resources, and the activity delays. Some researchers have proposed a tabu search algorithm that would

add robustness to the dual-objective resource-constrained project scheduling problem. This problem would involve scheduling projects. In order to investigate issues relating to time, quality, and money, the horizontal form of mixed integer programming is utilized [28, 29].

6. Conclusions and Future Research

In higher vocational education, the effect of IPE will be amplified if the form and content of IPE are both strengthened. In this paper, we implemented the ant colony procedure to efficiently obtain the solution set of resource allocation in an effort to combat the issues of unreasonable allocation of IPE resources as well as low test efficiency. Both of these issues are addressed in the introduction. In addition, the local search method is incorporated into the algorithm in order to advance and increase the performance of the suggested technique by performing local search operations on the solution set of the obtained resource allocation. In conclusion, the algorithm comparison experiments are performed on the standard test set in order to authenticate the usefulness and productivity of the anticipated algorithm.

In the future, we will continue inventing more effective strategies for the IPE-related research problems. In order to further advance the performance of the suggested method, an Insert and Swap neighborhood search that is based on logical constraints can be integrated into the proposed ant colony algorithm. Moreover, we will further look into the applicability of particle swarm optimization (PSO) method, as well as, other evolutionary techniques due to the fact that the resource allocation issues are potentially multi-objective optimization issues. For example, we will take into account various other optimization objectives, i.e., minimizing the total cost, duration, and net present value of the project. In fact, we will think over how the Pareto algorithm can be integrated to the suggested ant colony method in order to produce a set of nondominated solutions.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Risk Assessment of Debris Flow in Huyugou River Basin Based on Machine Learning and Mass Flow

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The Huyugou river basin is a typical debris flow river basin in the Shanxi Province, which has great harm after the outbreak and seriously affects the safety of people's lives and property. Therefore, it is urgent to carry out debris flow risk assessment. In this paper, a machine learning algorithm is implemented to assess the disaster susceptibility of each branch gully in a river basin of the Huyugou. Furthermore, its high-susceptibility branch gully and main gully were selected as the starting points of debris flow simulation for numerical simulation. The machine learning algorithm is implemented in a cloud-edge platform to minimize the model training and prediction times. Under the simulated rainfall conditions of major debris flow disasters, e.g., the one that occurred in 1996, the accuracy rate reached 84%. The results show that the debris flow susceptibility of each branch gully in the study area is mainly affected by the peak flow rate of the river basin, the length of the main gully, and the relative height difference of the river basin. The total risk area of debris flow is $1.91 \times 105\ m^2$, and the high-risk area accounts for 52.18% of the total area. It is mainly located in the upper part of the main gully accumulation area and the confluence of each channel and the main gully. The middle-risk area accounts for 36.14% of the total area, and the low-risk area accounts for less. We also observed significant reduction, from 34.68% to 36.98%, in the training and prediction times of the machine learning models when implemented over the proposed edge-cloud framework. The reappearance of debris flow in the study area is relatively accurate, which provides a certain scientific basis for the risk assessment of debris flow in the future.

1. Introduction

The Shanxi Province is located in the west side of Taihang Mountain, in the middle of Loess Plateau, and the eastern edge of Ordos Basin. The structure is complex, the altitude gap is relatively large, and therefore many tragedies are likely to happen [1]. Although the incidence of debris flow disasters is far less than other disasters, it poses a serious threat to people's health and property safety, and the degree of risk is self-evident [2]. Similarly, the rise of state-of-the-art computational technologies such as big data, Internet of things, and cloud computing can enhance the safety through introducing some sort of monitoring system. With the growth of big data and storage technologies that are becoming more and more mature, the mining data acquisition becomes simple and convenient. However, the data analysis of mining disaster datasets is no longer limited to the simple statistical analysis. In fact, machine learning approaches such as logistic regression, decision tree, and XGBoost algorithms become more essential. The main problem with the machine learning methods is the time required to train the model and then predict the disaster that should be minimized. The new concept of edge computing can solve the issues related to data analysis.

The Huyu River Basin in the Taiyuan City is the main river connected with the Xishan coalfield. In 1996, a major debris flow disaster occurred. The flood caused by rainstorm and the debris flow mixed together with solid deposits hit down, rushed through the coal mine and coal power group [3]. After the debris flow left the mountain area, it continued to move eastward along the street and finally entered the Fenhe River. The affected area was 15 km long from east to west, and the affected area was about 8 square kilometers. The disaster caused many people to be killed, and more than

100 people were trapped underground. The trapped time was very long. The direct economic loss caused by the damaged houses and roads is as high as CNY 240 million [4]. With the harm of debris flow to modern society, the problem of Huyugou has seriously affected the urbanization construction of the Taiyuan City, so it is of great significance to study the river basin quickly to monitor and prevent debris flow disasters [5, 6].

In this paper, based on the traditional geographic information system (GIS) evaluation system, combined with numerical simulation method, field investigation, and multiparty data analysis, the random forest (RF) method in machine learning was used to evaluate the susceptibility of debris flow in the study area [7]. Moreover, we also used other methods to assess the correctness and precision of the proposed system. The suggested RF method has been implemented in different modules that run on different layers of the edge computing model. On this basis, the numerical simulation of major debris flow, which occurred in 1996, was reproduced and compared with field data and the risk zoning was carried out to deliver practical basis for the monitoring, avoidance, and control of local debris flow tragedies. The major contributions of this study are as follows.

(1) A machine learning algorithm is implemented to assess the disaster susceptibility of each branch gully in a river basin of Huyugou.

(2) The high-susceptibility branch gully and main gully were selected as the starting points of debris flow simulation for numerical simulation.

(3) The machine learning algorithm is implemented in a cloud-edge platform to improve the training and prediction times.

The rest of the paper is structured as follows. In Section 2, we give an overview of the study area that was used in this research. In Section 3, evaluation of the debris flow susceptibility is presented which is based on the random forest method. Risk assessment of the debris flow in Huyugou based on mass flow is deliberated in Section 4. Evaluation of the proposed methods, obtained findings, and discussion are given in Section 5. As a final point, Section 6 completes this study and offers directions for future research.

2. Overview of the Study Area

The debris flow in the study area is located in the southwest mountainous area of the west mountain in Wanbailin District, Taiyuan City, Shanxi Province. In fact, it is a small river basin within the scope of the Huyugou river basin, with an area of about 12.1695 km^2, and is dominated by low-middle mountains. The terrain is gradually reduced from west to east. The elevation of the main gully in the study area is about 1585.6 m, and the elevation at the gully mouth is about 1070 m, and the relative elevation difference is approximately 515.6 m. The study area is located in the interior of the continent, far from the ocean, and the monsoon climate is obvious. The maximum annual rainfall can reach 800 mm, and the spatial and temporal distribution of rainfall is uneven, mostly concentrated in summer. The rainfall can reach 80% of the total annual rainfall. The average temperature in the region is low, about 2°C~6°C, and the lowest temperature can reach −7°C, and the highest temperature can reach as high as 22.7°C. The study area is located in the Duerping-South Korea fault zone, with a length of about 26 km. The fault zone is formed by the Duerping fault and the Yayadi fault, toward northeast. The fault generally strikes northeast, which is a normal fault. This should be noted that the study area is distributed by Carboniferous, Permian clastic rocks, a small amount of Ordovician carbonate rocks, and Holocene gravel.

There are abundant sources in the basin, and the main solid source is the product of weathering of clastic rock layer. The solid material source comes from the loose accumulation caused by a large amount of slope instability that is subsequently caused by coal mining, road construction, bridge construction, and other activities in the region. Furthermore, it also includes domestic waste, cinder, and stone slag, which provide a large amount of material source for debris flow. In summary, the debris flow in Huyugou mining area has been an important area of debris flow disaster prevention and mitigation in the Taiyuan City. It is a major task to study and analyze, simulate, and promote the implementation of debris flow protection measures. Figure 1 shows a view of the river basin diagram of the study area.

3. Evaluation of Debris Flow Susceptibility Based on Random Forest Method

In this section, we first illustrate the proposed edge intelligence framework that is used to implement the machine learning algorithms. The main purpose of the edge computing is to bring computation closer to where the data is produced. In this way, the data can be preprocessed and can be fitted well for training purposes. The entire framework is shown in Figure 2 below. In the proposed framework there are three layers, namely, the IoT layer, the edge layer, and the cloud layer. The IoT sensors may include cameras and other data collection devices. Once the data is gathered, it could be preprocessed over the edge devices because the IoT devices have very low processing capabilities. The preprocessing may include data aggregation methods that can remove duplicate and unnecessary data. This duplication may occur when data from overlapping regions are collected. This should be noted that, due to (i) no availability of duplicate entries and (ii) small size of the dataset, we do not use any aggregation technique in this work. Largely, the well-known Euclidean distance equation is used to identify whether two particular collected data points (through sensors) belong to either the same region or two different regions, which is used for data aggregation purpose [8, 9]. The processed data is then moved to the cloud for long-term storage. It should be noted that, in the proposed framework, machine learning algorithms can be used in three different manners: (i) perform the prediction at the edge; (ii) perform the prediction at the cloud; and (iii) train the model on cloud and perform prediction on the edge [10]. However, in case of (i) different algorithms

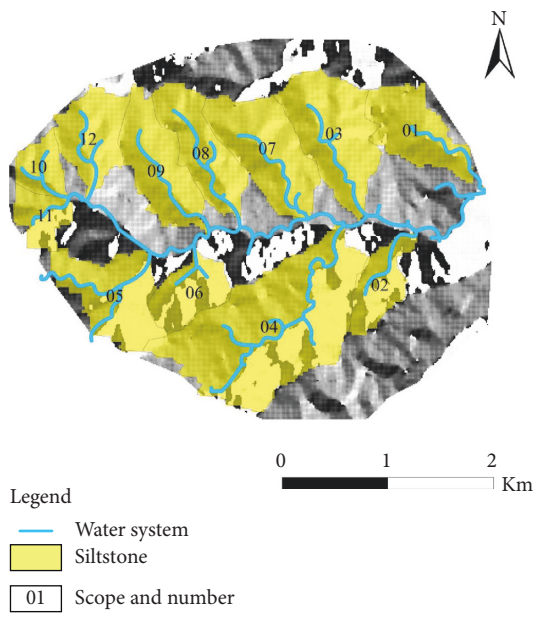

Figure 1: River basin diagram of the study area.

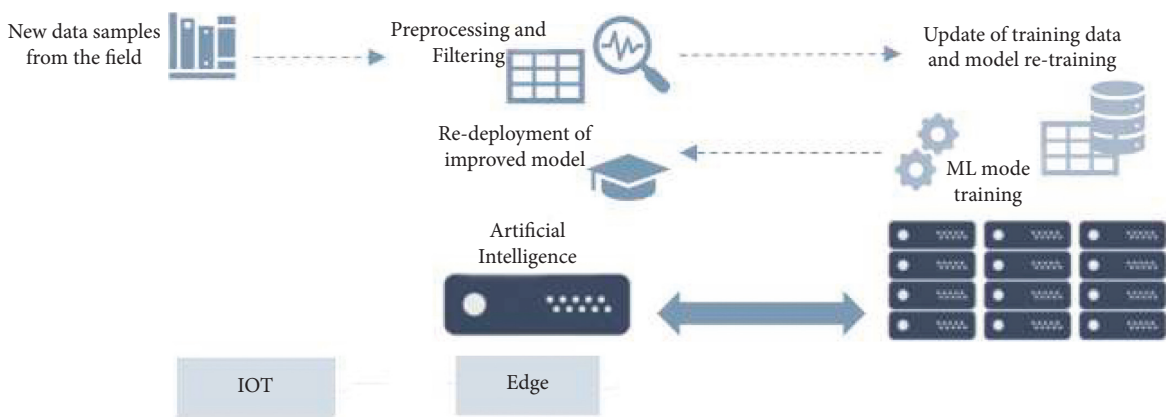

Figure 2: Edge computing for machine learning.

have different computational times and it might not be possible for the edge (limited resources) to compute quickly. In the case of (ii), networks are the bottlenecks and it will take quite long time, dependent on the data size, to do predictions. In the case of (iii), the model is trained at regular intervals to make sure that prediction outcomes are more accurate.

Figure 3 shows the flow of data between the edge and cloud in terms of machine learning. The lower part illustrates the scenario when edge computing is not taken into account. This type of setup might be helpful in offline learning, but for real-time online learning this might not be a good option. The upper part describes two situations: (i) when machine learning methods are used over the stored data while preprocessing happens at the edge and (ii) when machine learning is used over the reproduced data over the cloud and the preprocessing along with data aggregation method is used at the edge. The machine learning algorithm is then run in two different modules. The first module is the training that runs on the cloud. In case that enough data is not available, then more data can be produced through synthesized workloads [11]. Also, the IoT sensors continuously collect data and send it to the edge for preprocessing. Subsequently, the processed data is moved to the cloud for training purposes. The second module runs in the edge and predicts the unseen situations based on the data stored and trained model. It should be noted that, to reduce the training time, the amount of data can also be reduced through data aggregation techniques such as Euclidian distance. In this work, we do not suggest any data reduction mechanism.

3.1. Principle of Random Forest Method. The RF (Random Forests) is one of the most popular algorithms used to solve multiclassification and prediction problems [12–14]. It is an integrated method of binary decision trees trained independently. It was introduced by Breiman in 2001 and combines multiple decision trees used for classification and

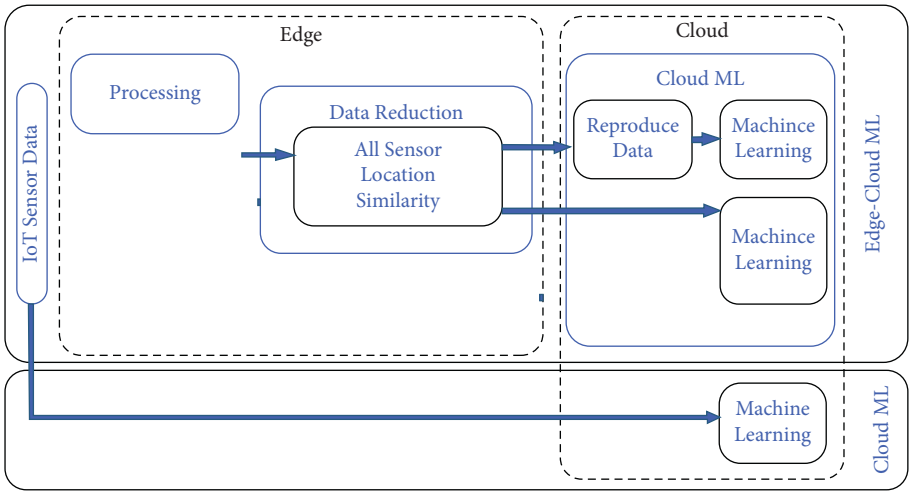

Figure 3: Edge-cloud computing framework for machine learning.

prediction. It has obvious effect in classification and regression problems [15, 16]. The RF can be defined as a set of random trees (decision trees). The basic method for classification problems is based on training each decision tree alone, and the final result is estimated by considering the results obtained by each decision tree.

The random forest algorithm works as follows:

(1) Resample the original data and repeat it several times.

(2) In each resampling process, a group of disaster-pregnant factors are randomly selected as the eigenvalues.

(3) The resampling and the corresponding eigenvalue of the disaster-pregnant factor are estimated to obtain the decision tree set.

(4) Aggregate the estimated decision tree set in order to obtain a single decision tree.

Therefore, the basic notion of the RF procedure is to generate multiple decision trees on a random subset [17]. In fact, the performance of the suggested RF method predominantly depends on the amount of decision trees (Ntree), as well as the candidate features that are enclosed in the subset (mtry) [18]. It should be kept in mind that larger Ntree values may potentially increase modeling time, while the smaller Ntree values may cause prediction errors. The RF model can summarize and minimize the risk of overfitting without any pruning process. The training process involves creating many different boot samples from the original data set, one-third of which is excluded from the process as test cases, and based on this test case to estimate unbiased test error, known as out-of-bag-error, which represents the predictive ability of the RF model [19]. For the purpose of classification, the RF model uses the high variance between individual trees. This is achieved by voting each tree as a class member and allocating the corresponding class value according to the public vote. Furthermore, the RF classifier is more accurate and robust than a single classifier, because it has many advantages; for example: (i) it can handle large databases relatively very effectively, and (ii) it offers a way to calculate the proximity between pairs of cases used to locate outliers, etc. [20, 21].

The RF algorithm also uses the Gini index as the attribute selection metric to measure the purity of attributes and classes. Assuming that the sample R # corresponding to the characteristic index in the data preprocessing set R^* contains J categories, then its Gini index is given by the following equation [22]:

$$\text{gini}(T) = 1 - \sum_{j=1}^{N} p_j^2, \tag{1}$$

where p_j is the probability of the jth sample. After one segmentation, the set R^* is divided into m parts $\{N1, N2, \ldots, Nm\}$. Then, the segmented Gini index *ginisplit (T)* is given by

$$\text{gini}_{\text{split}}(T) = \frac{N_1}{N}\text{gini}(T_1) + \ldots + \frac{N_m}{N}\text{gini}(T_m). \tag{2}$$

The final *ginisplit (T)* is the Gini index corresponding to each feature sample, and its set is set as $G = \{g1, g2, \ldots, gj\}$. The weight corresponding to each feature index is illustrated usingt

$$\theta_j = \frac{g_j}{\sum_{i=1}^{j} g_i}. \tag{3}$$

Finally, the weight set is $\theta = \{\theta_1, \theta_2, \ldots, \theta_j\}$.

3.2. Influence Factors of Debris Flow Susceptibility. The initiation of debris flow is caused by many factors such as precipitation, topography, geomorphology, and human factors. In this paper, the selection of debris flow factors is mainly considered in the above aspects. The following factors affecting the development of debris flow are selected: river basin area, average slope of the river basin, shape coefficient, channel length, longitudinal shrinking slope of the main gully, relative height difference of the river basin, rainfall, vegetation coverage rate, and the peak flow of the

Table 1: The actual values of each factor in the study area.

Number	River basin area (km^2)	Average slope of the river basin (°)	Shape factor	Channel length (m)	Longitudinal shrinking slope of the main gully (‰)	Relative height difference (m)	Rainfall (mm)	Vegetation coverage (%)	Peak flow (m^3/s)	Strata lithology
1	0.527	19.61	1.1	857	164.53	349	439.462	15.4401	4.39	Siltstone
2	0.324	15.64	1.18	917	186.48	280	439.604	21.7935	2.85	Siltstone
3	0.786	16.98	1.23	1321	146.86	336	439.34	19.8264	6.97	Siltstone
4	1.794	16.79	1.17	2714	64.11	339	439.489	22.7433	17.93	Siltstone
5	0.623	19.72	1.13	1024	87.89	229	439.205	37.3686	5.53	Siltstone
6	0.351	19.69	1.30	484	161.16	255	439.319	24.7348	3.27	Siltstone
7	0.721	18.35	1.29	1225	130.61	342	439.359	21.793	8.80	Siltstone
8	0.532	15.83	1.09	1432	201.12	371	439.155	19.9189	4.60	Siltstone
9	0.585	18.30	1.07	1328	164.16	374	439.11	19.8484	4.06	Siltstone
10	0.211	17.60	1.31	580	193.10	180	438.935	35.3991	1.33	Siltstone
11	0.226	19.09	1.21	526	62.74	167	438.993	36.2723	2.27	Siltstone
12	0.452	15.55	1.22	1005	150.25	285	438.972	29.2496	4.02	Siltstone

river basin [23]. The actual values are detailed and given in Table 1.

Although the scope of the study area is small and the rainfall is basically the same, in order to ensure the integrity of the factor selection, the stratigraphic lithology is still listed in Table 1. The clear water flow of each river basin is calculated by the debris flow clear water flow formula, which is given by

$$Q_b = 0.278\text{Fri}, \tag{4}$$

where Q_b represents the clear water flow in the region (m^3/s); F represents the river basin area (km^2); i is the production flow coefficient and its value is assumed as $i = 0.9$; and r represents hourly surface rainfall (mm/h).

The critical rainfall value of debris flow within 24 hours in Shanxi Province is about 30 mm [24]. According to the characteristics of Huyugou climate and the analysis of rainfall in Taiyuan City, it is concluded that the daily rainfall should be approximately 120 mm/d when Huyu gully triggers severe rainstorm [25, 26].

The calculation formula of peak flow Q_c in debris flow basin is given by

$$Q_c = (1 + \varphi)Q_b D_c, \tag{5}$$

where φ represents the sediment coefficient of the basin; and D_c represents the blockage coefficient in the basin.

Thus, the peak flow in each river basin of debris flow can be obtained.

According to the geological hazard risk assessment standard and related research results [27, 28], the factors are divided into four levels: high (IV), middle (III), low (II), and very low (I), and the classification results are substituted into the random forest method to calculate the weight. The grading standards and weight calculation results are shown in Table 2, and the grading results are shown in Figure 4.

3.3. Results of Debris Flow Gully Susceptibility. As shown in Figure 5, after calculation, the zoning results are as follows: (i) No. 4 and No. 7 are high-prone debris flow branch gullies; (ii) No. 1, No. 3, and other seven branch gullies are high-prone debris flow branch gullies; and (iii) No. 2, No. 10, and other three branch gullies are low-prone debris flow branch gullies.

4. Risk Assessment of Debris Flow in Huyugou Based on Mass Flow

According to the evaluation results of debris flow susceptibility, area 4, area 7, and main gully in the high-susceptibility area are selected for evaluation.

4.1. Simulation Parameter Value and Working Condition Design

4.1.1. Unit Weight of the Debris Flow. The determination of unit weight can be roughly divided into three methods, namely: (i) field investigation method, (ii) morphological investigation method, and (iii) standard look-up table method. The debris flow severity used in this numerical simulation is mainly determined by field investigation method that can be mathematically expressed as follows:

$$\gamma_c = \frac{G_c}{V}, \tag{6}$$

where γ_c is heavy debris flow fluid (t/m^3); G_c is slurry quality (t); and V is the mud volume (m^3).

As shown in Table 3, the field method is used to investigate the density of debris flow. The slurry is mixed at the upstream of channel, middle and lower reaches of the channel, and the exit of the channel in the study area, respectively. Multiple experiments are carried out and the average value is finally obtained. The comprehensive analysis shows that the average unit weight of debris flow in the study area was $\gamma_c = 1.602\ t/m^3$, and the density is moderate, belonging to rare debris flow. At the same time, according to the morphological investigation method, the fluid and motion characteristics of debris flow are described by the affected villagers [29]. It is concluded that the fluid properties of debris flow should be between dense debris flow and

Table 2: Evaluation factor weights and development grades.

Impact factors	High (IV)	Middle (III)	Low (II)	Very low (I)	RF weight
River basin area	0.2~5	5~10	10~100	>100	0.082375
Average slope of the river basin	>32	32~25	25~15	<15	0.090375
Shape coefficient	<1.1	1.1~1.2	1.2~1.3	>1.30	0.105375
Channel length	>10	10~5.0	5~1	<1	0.180375
Longitudinal shrinking slope of the main gully	>200	200~150	150~100	<100	0.103375
Relative elevation difference	>500	500~300	300~100	<100	0.118375
Vegetation coverage	<10	10~30	30~60	>60	0.080375
Peak flow	>10	10~6.85	6.85~3.36	<3.36	0.239375
Value range	(0.75, 1)	(0.5, 0.75]	(0.25, 0.5]	(0, 0.25]	

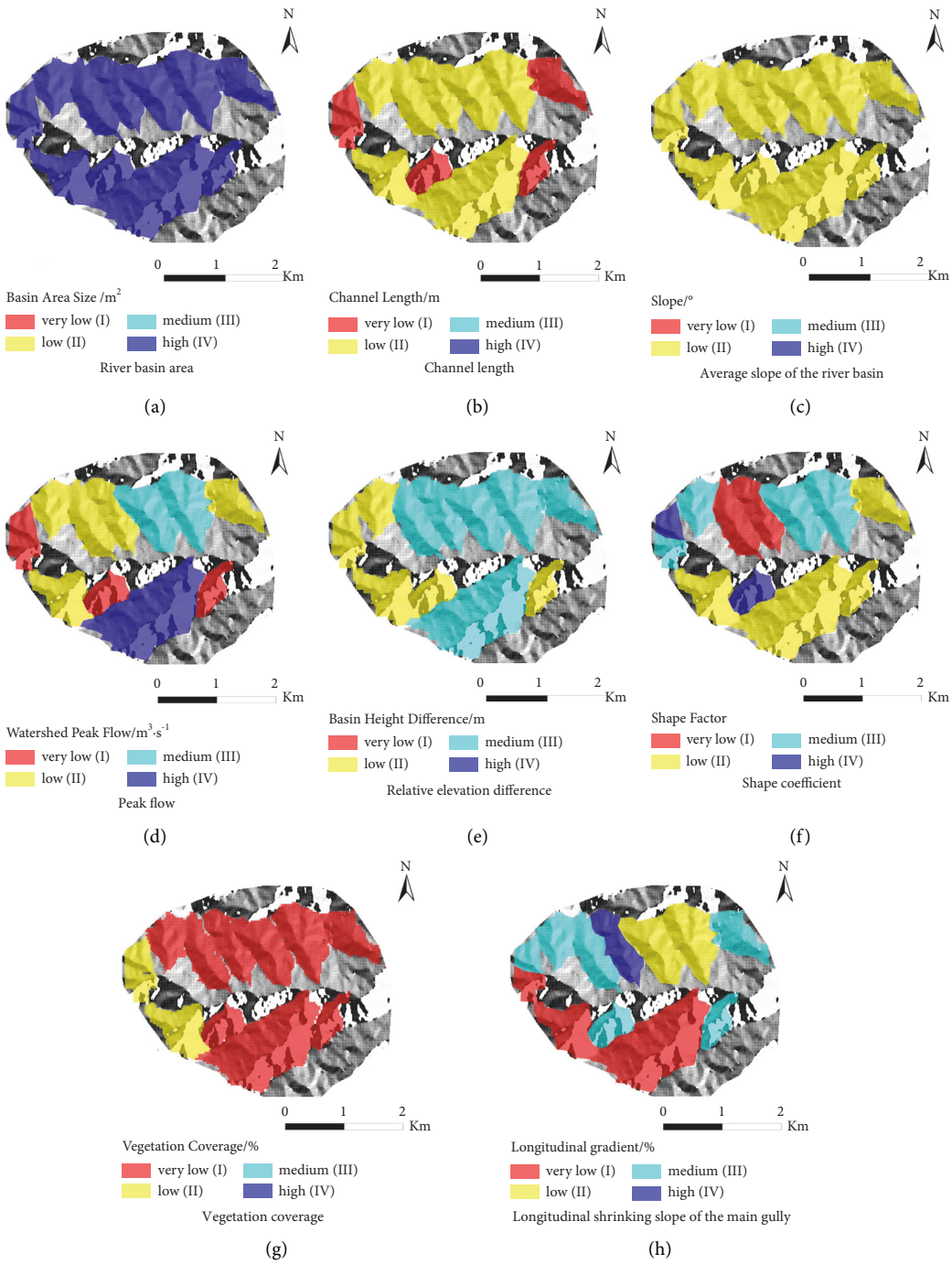

Figure 4: Quantitative classification and grading results of factor susceptibility. (a) River basin area; (b) channel length. (c) Average slope of the river basin; (d) peak flow. (e) Relative elevation difference; (f) shape coefficient. (g) Vegetation coverage; (h) longitudinal shrinking slope of the main gully.

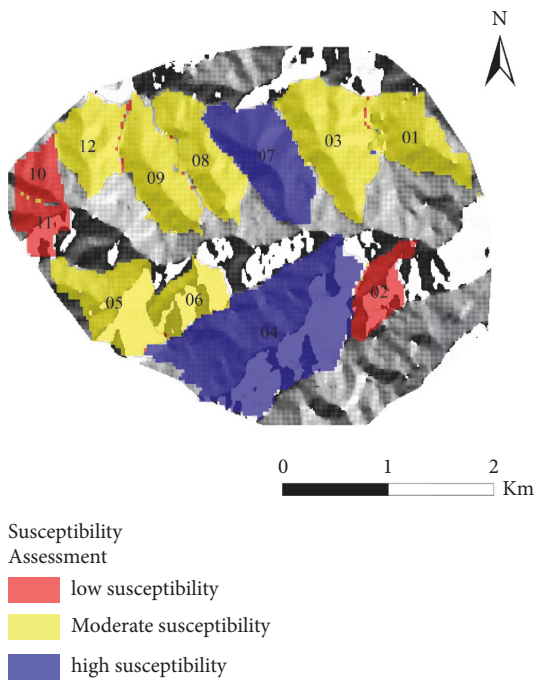

Figure 5: Evaluation results of debris flow susceptibility in the study area.

Table 3: Calculation of severe field slurry mixing for debris flow in the research area.

Test position	Mud weight (G_c/kg)	Mud volume (V/L)	Severe debris flow (γ_c/t·m^{-3})
The upstream of the channel	78.6	50	1.572
The middle and lower reaches of the channel	47.9	30	1.605
The exit of the channel	48.9	30	1.630

dilute debris flow; that is, the unit weight is 1.60 t/m^3, indicating that the field experiment is accurate.

4.1.2. Debris Flow and Flow Process Line. The clear water flow and debris flow in the river basin have been calculated, respectively, in the above factor calculation, which is not described here. The method used in this simulation is the generalized pentagon theory with high recognition. The method is to take 1/3 of the complete debris flow time as the node, and the peak flow calculated above is substituted into the boundary point with 1/3 and 1/4, respectively, so as to describe the flow process line of debris flow outbreak [30].

4.2. Modeling Results. Figure 6 is the simulation results of the debris flow movement process in the study area under the condition of actual rainfall. Figure 7 shows that the maximum velocity of debris flow is 5.53 m/s~6.41 m/s and the maximum mud depth is 5.1 m~6.5 m under the condition of major debris flow rainfall in Huyugou in 1996, which is located in the middle and upper part of the gully accumulation area and the confluence of each channel and the main gully. Note that the measured total risk area is approximately $2.28 \times 105\,\mathrm{m}^2$, the numerical simulation risk area is $1.91 \times 105\,\mathrm{m}^2$, and the accuracy is about 84%.

4.3. Risk Assessment of Debris Flow. According to the study of Xu [31] in the Shanyang County (Table 4), the hazard zoning of the debris flow in Huyugou in 1996 is carried out, as shown in Figure 5. The results of debris flow hazard evaluation show that the total area of debris flow hazard zone is $1.91 \times 105\,\mathrm{m}^2$, and the high hazard zone accounts for 52.18% of the total area, which is mainly located in the downstream of the main gully and the intersection of the branch gully and the main gully. Furthermore, the area of medium-risk area is $0.69 \times 105\,\mathrm{m}^2$, accounting for 36.14%, and the low-risk area is relatively small. In general, the study area is a relatively dangerous debris flow, which needs strict prevention.

4.4. Machine Learning and Edge-Cloud Results. In this section, we discuss the results of the machine learning techniques and the training and prediction model were supposed to run on different platforms. From the algorithm perspective, we consider two different machine learning algorithms, namely: (i) random forest (RF) and (ii) CNN. Each algorithm runs in two phases: (i) training and (ii) prediction. From the platform perspective, we use different scenarios. In scenario A, we assume that both phases of each algorithm run over the edge. In this case, since the data is stored on the cloud, we assume that the required data is moved to the edge. Once the data is used, it is deleted from the edge server. In scenario B, we assume that both phases run on the cloud. In scenario C, we assume that the training happens on the cloud while the prediction runs over the edge server. We report the timing durations for the training and prediction phases [32]. The results are illustrated in Table 5.

The findings suggest that, for various algorithms, the response time can be significantly decreased (i.e., from 24.64% to 33.24%) using the proposed cloud-edge platform. Furthermore, we also noted approximately 34.68% to 36.98% reduction in the prediction durations. This improvement is possible at some cost of prediction duration. Furthermore, we observed the RF method outperforms the classical CNN approach (i.e., ~25.54%), but we believe these outcomes will change in line with the amount of data.

5. Discussion and Model Accuracy

In this section, we briefly discuss the findings of this research and accuracy of the machine learning methods. After verification, this paper gets the following conclusions and understanding:

(1) The debris flow susceptibility of each branch gullies in the study area is mainly controlled by the peak flow rate of the river basin, the length of the main gully, and the relative height difference of the river basin. There are 12 branch gullies, 2 high-prone

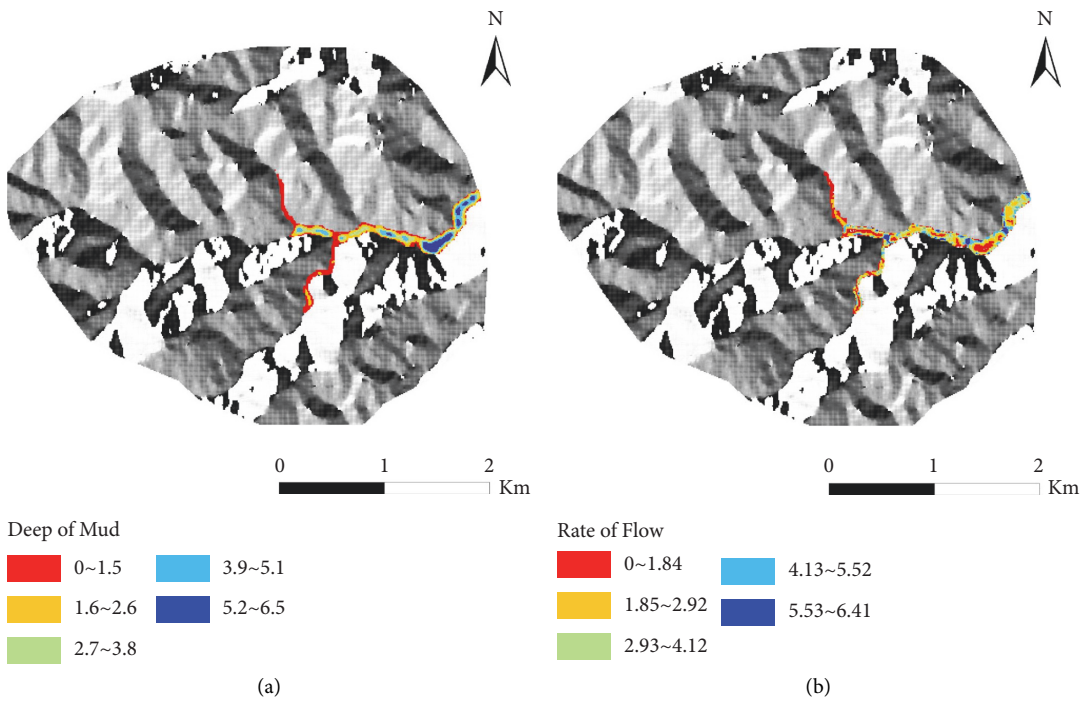

Figure 6: Mud depth and velocity of debris flow in the study area.

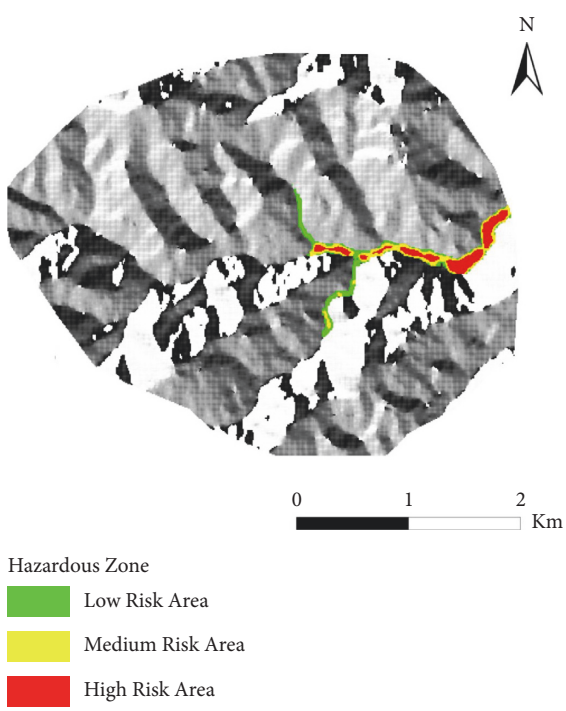

Figure 7: Risk zoning map of debris flow in the study area.

Table 4: Hazard zoning parameters of the debris flow.

Dangerousness	Depth of mud	Association	Mud depth and flow velocity product
High	$H \geq 3.0$	Or	$\mathrm{VH} \geq 3.0$
Middle	$0.5 \leq H < 3.0$	And	$0.5 \leq \mathrm{VH} < 3.0$
Low	$0 < H < 0.5$	And	$0 < \mathrm{VH} < 0.5$

branch gullies, 7 middle-prone branch gullies, and 3 low-prone branch gullies in the region.

(2) Through the previous multifactor superposition analysis and parameter calculation, the motion state of the study area is reproduced by numerical simulation. The simulation results show that the mud depth of debris flow at the accumulation of gully mouth and the intersection of gully and main gully in the study area is the largest, about 6.5 m, and the maximum velocity is 6.41 m/s at the middle and lower reaches of the gully and the steep terrain. By testing the goodness of fit of the simulation results, the accuracy is about 84%. The high-risk areas of debris flow in the study area accounted for 52.18%.

The return accuracy of debris flow in the study area under the condition of heavy debris flow rainfall in 1996 is relatively close, which provides corresponding scientific suggestions for the comprehensive evaluation and risk zoning of debris flow in the future. The experimental findings were assessed using different evaluation metrics, i.e., (i) precision or accuracy, (ii) recall rate, (iii) F1-measure, and (iv) IoU. In fact, accuracy is the proportion of correctly forecasted samples to all predicted samples. The recall rate is calculated as the proportion of accurately anticipated positive samples to all real positive samples. Moreover, the F1 score is the harmonic average of recall rate and precisions (accuracy). Finally, the IoU is the crossing of pixels labelled as building in the ground truths and anticipated outcomes and subsequently divided by the union of pixels labelled as building in the ground truths and forecasted outcomes [8]. The following are the calculating formulas:

Table 5: Results of the algorithm and implementation methodology

Algorithm	Scenario	Time (seconds)		
		Training	Prediction	Response
RF	A	3532.1	176.44	11.12
	B	3721.69	46.31	388.42
	C	**3387.01**	**61.2**	**2.74**
CNN	A	3679.3	169.84	11.07
	B	3861.42	51.58	402.39
	C	**3495.3**	**62.5**	**3.68**

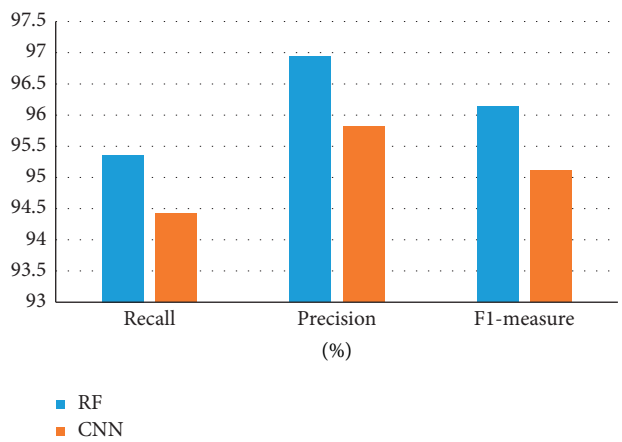

Figure 8: Accuracy results of the machine learning approaches (the higher values represent a more accurate approach).

$$P_r = \frac{TP}{(TP + FN)},$$
$$P_p = \frac{TP}{(TP + FP)},$$
$$F_1 = 2 \cdot \frac{P_p . P_r}{\left(P_p + P_r\right)}, \quad (7)$$
$$\text{IoU} = \frac{TP}{TP + FP + FN},$$

where TP stands for the quantity of correctly taken out pixels, FP for the quantity of incorrectly pulled out pixels, and FN for the amount of lost or misplaced pixels. The accuracy of the RF and CNN methods is shown in Figure 8. We can observe that the RF method is more accurate than the CNN approach in terms of all evaluation metrics.

6. Conclusions and Future Work

Based on the investigation of debris flow disasters in the distribution areas in Shanxi Province, this paper selects the debris flow in the study area as a representative river basin for analysis to explore a relatively reasonable evaluation method of debris flow in the Loess Plateau, especially in Shanxi Province. The method in this paper is mainly based on the weight calculation of the random forest method and the combination of multifactor superposition and numerical simulation. Through the evaluation of various factors in the river basin, namely, rainfall, topography, and geomorphology, the susceptibility of debris flow in each channel in the region is evaluated, and it is used as the main material source of debris flow. Numerical simulation is combined with the results of multifactor analysis to simulate the movement characteristics of debris flow under this condition and carry out risk zoning. The two complement each other, and the evaluation of debris flow has a more detailed process. The results are more reasonable than a single way.

In the future, we will take into account deep learning techniques that are more suited for mines and the operational monitoring systems, like graph convolutional network (GCN), U-net, and attention networks. But as we saw, not all neurons can be stimulated by the activation function used in this paper, which results in restricted precision and accuracy. As a result, finding the best activation function and improving the model's structure are ongoing research projects. Similar to this, we will look into the effects of the activation functions employed in conjunction with deep learning techniques. To enhance the performance of the suggested system, robust data reduction or aggregation approaches should be looked at.

Data Availability

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also form part of an ongoing study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

A Classification Method for National Culture Propagation Using Deep Learning

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This paper combines the artificial intelligence (AI) and deep leaning technologies to classify the spread of national culture. First, we use the Python language to build a crawler technology in order to obtain the sample data of national culture from authoritative websites. Then, we use the natural language processing (NLP) expertise to analyze and preprocess the text of national diversity. In this way, we realize vectorization and the feature word extraction of the text related to national cultural resources based on the doc2vec technology. The vectorized texts of national cultural resources are clustered based on the K-means clustering technique. Moreover, the elbow rule process is implemented to determine the optimal number of clustering clusters. Finally, the text association relationship of the national cultural resources is obtained. Moreover, this paper adopts the unsupervised training method, which can reveal the semantic information contained in the text of national cultural resources. This can also help us during the identification process of the category connection amongst the texts of national cultural resources and provide us with methodological support for the gathering, storing, and other smart services of enormous national cultural resources. The outcomes demonstrate that the correctness rate of the suggested algorithm is greater than the accuracy of the linear regression and can reach up to 80%.

1. Introduction

With the increasing modernization and internationalization of social development, the protection, defense, and inheritance of ethnic minority traditional culture are facing a crisis. Using information technology (IT) to comprehend the digitization, sharing, and dissemination of minority culture has become an important means for the fortification, inheritance, development, and exploitation of minority culture. At present, the digitization of minority culture and the main means of communication are various minority culture websites. Due to the characteristics of diversity, dispersion, group closure, and so many other factors, the content of ethnic culture resources of similar ethnic culture websites is relatively scattered, with unstructured characteristics, which is difficult to be found, applied, and integrated. At the same time, different websites and platforms have inconsistent descriptions and understandings of minority cultures, resulting in ambiguity or differences in people's understanding and understanding of minority cultures, which is not conducive to the dissemination and protection of national cultures. By means of distributed web crawler, data mining, natural language processing (NLP), and machine learning techniques to collect, examine, process, and cluster the text of national cultural resources will help automatically collect, recognize, and share massive national cultural resources, better understanding the deep semantics of national cultural resources text. Furthermore, this may also help in offering technical support for the intelligent and smart services of national cultural resources.

The multiplicity of human beings and their accomplishments regulates the productivity and variety of social culture. There are differences in the cultures of different regions and nations, and there is no completely unified development model. The same cultural phenomenon can be interpreted differently in different cultures and obtain different cultural meanings. Any social group is constrained by the culture that has continued from history, and it is under

the action of the same culture that the members of this social group show the consistency of mutual recognition in their way of thinking, values, behavior patterns, and customs. For other cultures, this consistency becomes the difference or particularity that distinguishes them. In modern civilization, if any two cultures are compared together, differences are reflected in all aspects. The formation of cultural diversity has gone through a long historical process. At the beginning of the formation of human beings on the Earth, culture is relatively single. Even if they live in different regions of the world and face different natural environments, overall, culture still reflects more similarities, and differences are not that obvious.

The evolution of culture has its own laws. The cultures designed in dissimilar areas will change bestowing to the laws and regulations of their specific growth, but, in fact, this development is by no means synchronous. For thousands of years, the rapid progress of human technology in transforming nature has not only brought Earth shaking changes to human society, but also constantly endowed a culture with various characteristics different from other cultures [1, 2]. Although the similarities of primitive cultures can also be seen from those ancient cultures, however, the speed of progress of different civilizations has been gradually replaced by cultural differences. The differences of world cultures formed in the long-term historical development process are gradually fixed as the basic characteristics of a culture [3]. The technical problem to be solved in this paper is to provide a technique of clustering analysis for the ethnic cultural communication diversity that is constructed on the deep neural network (DNN) models. Similarly, based on the cultural diversity text data, the suggested method can improve the recognizability and understandability of substantial cultural resources and assist the smart sharing and recommendation of immense cultural resources. The following are the major contributions of our research.

(i) To classify the spread of national culture, we use Python to build a crawler technology to obtain the sample data of national culture from authoritative websites;

(ii) We use the natural language processing (NLP) expertise to analyze and preprocess the text of national diversity and realize the vectorization and the feature word extraction of the text of national cultural resources based on doc2vec technology;

(iii) The obtained data is clustered based on K-means clustering procedure, along with the elbow rule technique, which is used to determine the optimal number of clustering clusters;

(iv) Finally, the text association relationship of national cultural resources is obtained.

The remainder of this paper is structured in the following manner. We deliver an overview of the state-of-the-art works in Section 2. Application of in-depth learning in the dissemination and classification of ethnic documents is illustrated in Section 3. An empirical study on the influence of national cultural communication on audiences is provided in Section 4. In Section 5, the obtained results in terms of prediction error and precision are deliberated. Finally, Section 6 summarizes this study and provides some future research directions.

2. Related Work

How to use multimedia to spread history and culture? How can the spread of history and culture promote the development of local economy and various undertakings? This is a major topic for scholars and journalists of news communication theory and business research. Many researchers are concerned about this and are discussing it carefully. In foreign countries, researchers have conducted various aspects of research on cultural inheritance and dissemination. The authors in [1] have discussed popular culture, the collection and editing of cultural information, influential media celebrities, and the dissemination of local culture. Furthermore, the research conducted in [2] demonstrates that social media, online consumer behavior, and cross-cultural trends are conducive to the emergence of new channels for the global dissemination of culture, which will change the face of the cultural industry. Population changes and mixing, trade, and long-distance dissemination of cultural characteristics will clue towards fluctuations in cultural symbols used by human beings. The authors in [3] introduced the thoughts and experience of new media that combines art, technology, exhibition, communication, and service tools to realize cultural inheritance, protection, development, and innovation. Pinto et al. studied the problem of cultural communication in different situations and how the mass media can attract more potential users by establishing a feedback mechanism. Rigaud et al. [4] used personal decorations as a carrier to record the changes of cultural geography to study the transition period from the Mesolithic Age to the Neolithic age. The cultural heritage of a city is a unique symbol of its identity. Deep excavation, effective utilization, and dissemination of urban cultural wealth are important measures to highlight the characteristics of urban culture and promote urban development based on the research on the new media display system of Pingdingshan Museum.

In addition, the research results of multimedia communication are also very rich. Anderson et al. [5] have provided clear evidence for media violence to increase the possibility of short-term and long-term environmental violations and violence through the research on violent TV programs, films, video games, and music. The research in [4] used the Parliamentary records of MKS political activities and the regularity of the MKS news as test data. The structural equation model shows that the confidence of politicians, over the media power, rises their enthusiasm and efforts in exposure of media, which will subsequently produce greater media influence and more parliamentary activities. Similarly, the authors in [6] studied and investigated the impact of media factors on the brand launch effect in the real-life environment. Based on the survey of 1195 viewers, it is found that the type of program, the attitude of program, and the information value of program show a constructive

part in the response of brand layout. The category of audience behavior is partially reconciled by the perceived information value of the program. The research shows the importance of environmental factors to the brand launch effect. In [7], the authors have conducted the research on the defense of famous cultural and historical capitals, towns, and villages, in the republic of China. Furthermore, the authors proposed that the protection and development of prominent cultural and historical capitals in the process of urbanization have their own characteristics and laws, which conform to the objective laws of the defense and expansion of famous cultural and historical towns and cities.

Beside the above works, the authors in [5] put forward the principles of the protection and development of famous historical and cultural cities through the investigation and research of prominent historical and cultural capitals in Yunnan. Taking Jinan as an example [8], the authors discussed the safety and rational utilization of Jinan's renowned historical and cultural municipalities by explaining the noncontradictory relationship between the defense of renowned and well-known historical and cultural municipalities. Moreover, they deliberated the economic development of Jinan, drawing on the defense examples of prominent historical and cultural municipalities at home and abroad and using the frontier theories, principles, and scientific protection methods of domestic historical and cultural heritage protection. Furthermore, the authors in [9] profoundly elaborated on the defense of prominent historical and cultural municipalities, townships, and rural community and proposed to further strengthen the theoretical research, adopt positive response ideas, strategies, and public policies, promote protection and development to complement each other, achieve harmony and win-win results, and strive to get out of the misunderstanding of large-scale demolition and reconstruction. Apart from the above discussion and research, the researchers in [10] analyzed the importance of cultural protection, the protection process from international to domestic the current situation, and working methods of historical and cultural heritage protection in China. Beskow et al. [11] reviewed the development of urbanization and the fortification of historical and cultural municipalities in the republic of China after the founding of new China and pointed out that the protection situation of cultural and historical cities in China is still severe, and the phenomenon of constructive destruction has not been effectively curbed.

From the perspective of regional economics, historical geography, management, and other disciplines, it is not only limited to the "cultural" connotation of the ancient city, but also from the perspective of advertising and brand in the strategic and strategic aspects of historical and cultural cities, especially with the rise of cultural and creative industries. From "creativity" to "brand," the idea of constructing the ancient city culture communication is to find a practical path. For example, [12] focuses on Hunan, analyzes the problems existing in the media selection, communication mode, media strategy, comprehensive benefits, and other aspects of the main body of Hunan food culture communication, adopts CIS Theory, constructs the Hunan food culture communication system, and puts forward the communication strategy of multiple media linkage communication mechanism. Based on the analysis of the main problems faced by Xi'an in the dissemination of history and culture, similarly, [13] made a SWOT analysis of how to promote the dissemination of Xi'an history and culture with the help of the animation industry, so as to summarize the strategies of the animation industry to promote the dissemination of Xi'an history and culture [11].

The authors of [14] also looked at how national cultures effect initial public offerings' underpricing abroad (IPOs). In short, Lee and David [15] established a framework based on Hofstede's concepts of the cultural context of accounting and accounting and culture to explain how national culture impacts national accounting systems. The study emphasizes that social preferences based on culture regarding the avoidance of uncertainty contribute to the understanding of cross-national differences in the current financial system configuration, building on research that examines why some financial systems are based on banks and others on markets. According to a theory put forth by researchers in [16], political institutions constrain this relationship. The research done in [17] presents collaborating skills that guarantee the integration of educational contents that are absolutely intended for encouraging the ethnic, national, and religious tolerance. Furthermore, with respect to dissimilar culture's values, the authors have engrossed on various aspects of cross-cultural communication, enculturation, and also the socialization factors of the individual.

The analysis of the influences of formal institutions and national culture on corporate risk-taking is one of [18]'s contributions. The core objective of authors in [19] is to lay out a dominant pattern of the state-supported Islamization process. Similar to [20], which examines the fusion of national culture Furthermore, by shedding light on the cultural roots of cross-functional coopetition, [12] brings cross-functional coopetition to the international management literature. The objective of authors in [21], consequently, is twofold. Other influential works that have focused on the BP neural network and other deep learning techniques include [12, 13, 22].

3. Application of In-Depth Learning in the Dissemination and Classification of Ethnic Documents

3.1. The BP Neural Network and Its Basic Working Mechanism. The BP neural networks are also recognized as error backpropagation neural networks. It is a typical error correction method. Theoretically, it has the ability to approximate nonlinear continuity functions and has simple structural signs. It is easy to be programmed and processed by computer. Its application fields are very wide. The topology of BP neural network in the form of single hidden layer feedforward network is shown in Figure 1. In practical applications, three-layer network structure is usually selected, namely, input layer, hidden layer, and output layer. Its characteristic is that there can be no connection between

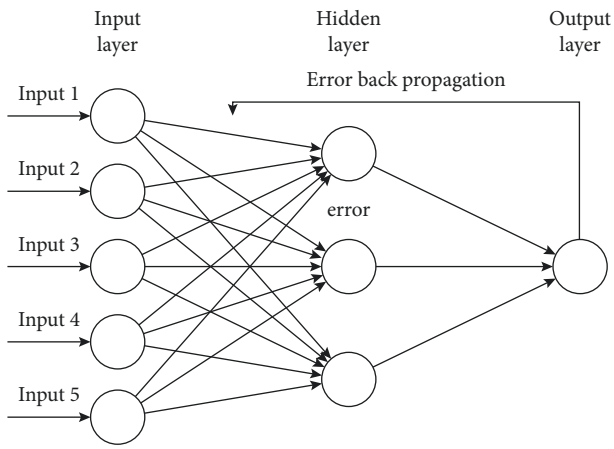

Figure 1: The BP neural network structure.

the units of the same layer, and the activation signal can only be output from the units of each layer to the units of the high layer [23]. Changing the weight coefficient of any layer can change the performance of the whole multilayer neural network. In terms of determining the number of neurons in each layer, the number of neurons in the input layer and the output layer can be set according to the specific classification problems encountered, while there is no universally applicable criterion for determining the number of neurons in the hidden layer.

The internal mechanism of the BP neural network is as follows: the external input information is input into the network through the neurons of the input layer and then transmitted to the intermediate layer for information transformation and information processing. The processed information continues to be propagated and processed to the output layer, and finally, the information processing outcomes are fed to the freestanding layer through the output layer [24]. In fact, the BP neural network is a particular category of the multilayer feedforward neural networks with one-way propagation, which can solve the learning problem of neural connection weight hidden in multilayer networks. In short, the BP neural network take account of two processes: (i) forward propagation of information; and (ii) backpropagation of error. It is a highly nonlinear mapping from input to output. The signal of BP neural network is transmitted forward, and it has no feedback and interlink structure within the layer. The output of each layer of neuron node only affects the input of the next layer of neuron node.

Through the error backpropagation process, the network can modify the connection weight of the network and adjust the parameters to make the network output ideally close to the expected output under the condition of minimum mean square error. If the output result of the output layer is significantly different from the expected output, the input backpropagation process needs to be carried out, and the error between the actual output and the expected output needs to be transmitted back layer by layer through the output layer, the hidden layer, and the input layer. The process of BP neural network is repeated, and cyclic correction is the process of BP neural network learning and training, which continues until the final error reaches an acceptable range or reaches the preset learning times.

For a mathematical model of the three-layer BP neural network, let $X = (x_1, x_2, \ldots x_i, \ldots x_n)^T$ be the input vector of the model; $Y = (y_{1,}, y_{2,}, \ldots y_j, \ldots y_n)^T$ is the output vector of the hidden layer of the model; $O = (o_1, o_2, \ldots o_k, \ldots o_l)^T$ is the output vector of the model output layer; $d = (d_1, d_2, \ldots d_k, \ldots d_l)^T$ is the expected output vector of the model. $V = (V_1, V, V_J, V_m)$ represents the weight matrix from the input layer to the hidden layer, in which the subvector V_j is the weight vector corresponding to the jth neuron of the hidden layer; $W = (W_{1,}, W_{2,}, \ldots W_k, \ldots W_l)$ represents the weight matrix from the hidden layer to the output layer; and the subvector W_k in it is the weight vector, which is essentially consistent with the kth neuron of the output layer [25].

It should be noted that, for the output layer, there exist the following formulas:

$$o_k = f(\text{net}_k), \quad k = 1, 2, \ldots, l, \tag{1}$$

$$n_k t_k = \sum_{j=0}^{m} w_{jk} y_j, \tag{2}$$

where f is the function that defines the BP network model and k denoted the layer. For the hidden layer, there exist the following formulas:

$$y_j = f\left(\text{net}_j\right), \quad j = 1, 2, m, \tag{3}$$

$$\text{net}_j = \sum_{i=0}^{n} v_{ij} x_i, \quad j = 1, 2, \ldots, m. \tag{4}$$

Using equation (5), we set the transformation functions $f(x)$ to be unipolar sigmoid functions:

$$f(x) = \frac{1}{1 + e^{-x}}. \tag{5}$$

Derivation can be obtained using the following equation:

$$f'(x) = f(x)[1 - f(x)]. \tag{6}$$

We define the output error, characterized by E, as given by the following equation:

$$E = \frac{1}{2}(d - O)^2 = \frac{1}{2}\sum_{k=1}^{l}(d_k - o_k)^2. \tag{7}$$

After this, we extend the error definition to the hidden layer, and then, the error is given by the following equation:

$$E = \frac{1}{2}\sum_{k=1}^{l}\left[d_k - f(\text{net}_k)\right]^2 = \frac{1}{2}\sum_{k=1}^{l}\left[d_k - f\left(\sum_{j=0}^{m} w_{jk} y_j\right)\right]^2. \tag{8}$$

Finally, we have the input layer as illustrated in the following equation:

$$E = \frac{1}{2}\left\{\sum_{k=1}^{l} d_k - f\left[\sum_{j=0}^{m} w_{jk} f\left(\mathrm{net}_j\right)\right]\right\}^2 = \frac{1}{2}\sum_{k=1}^{l}\left\{d_k - f\left[\sum_{j=0}^{m} w_{jk} f\left(\sum_{i=0}^{n} v_{ij} x_i\right)\right]\right\}^2. \tag{9}$$

3.2. Experimental Steps of Deep Learning in the Classification of National Cultural Propagate. We use the elbow rule technique to decide the optimal amount of clusters and finally obtain the text association of national cultural resources [26]. The clustering analysis technique of the national cultural resources is founded on the deep neural network (DNN) model according to the previous statement, which is characterized in that; and the specific steps are given as follows:

(i) Step 1: text data crawling of ethnic cultural resources: obtain the text data of ethnic cultural resources from ethnic culture related websites and databases through distributed web crawler technology.

(ii) Step 2: pretreatment of ethnic cultural resources: the following substeps are performed.

  (i) Step 2.1: preprocess the data of national cultural resources obtained in step 1, including detagging, deleting the content of head and other irrelevant areas, and label escape, so as to extract the body content of the text and obtain the text of national cultural resources.

  (ii) Step 2.2: yes, step 2.1. Remove the stop words from the national cultural resource text obtained in step 1, and retain the entity words. The stop words include prepositions, adjectives, and adverbs, and the entity words include verbs and nouns.

  (iii) Step 2.3: Chinese word segmentation of the text of national cultural resources processed in step 2.2.

(iii) Step 3: vectorization of national cultural resources: the following substeps are performed.

  (i) Step 3.1: based on the deep neural network model doc2vec, build the distributed bag of words model, and carry out model training and feature extraction for the text of national cultural resources.

  (ii) Step 3.2: according to Step 3.1, express the text of national cultural resources as a text vector with ID.

  (iii) Step 3.3: set Step 3. The output result of Step 2, that is, the text feature vector of national cultural resources, is normalized to the [0, 1] interval.

  (iv) Step 3.4: execute Step 3 n times 1-Step 3. Step 3: get the vector matrix of national cultural resources. Moreover, N is the number of texts inside the national cultural resources. After vectorization, we get the following matrix of national cultural resources:

$$\phi_i = \left[\phi_{i(1)}, \phi_{i(2)}, \ldots \phi_{i(n)}\right], \tag{10}$$

  where $\varphi_i \in \mathrm{R}^{n\times m}$, and m characterizes the total amount of characteristic words inside the text of national cultural resources.

(iv) Step 4: clustering of national cultural resources: after carrying out the text vectorization process of national cultural resources, through Step 3, the corresponding feature vector of each text can be acquired. This is due to the fact that the topic resemblance amongst the texts can be quantified through the clustering procedure [27]. Furthermore, so as to realize the association and distinction between the national cultural resources texts, in order to acquire the paramount clustering outcome, the elbow rule can be used to select the best cluster number K. In fact, we set the initial value of the number of clusters K to 1 and cycle through Step 4.1 to Step 4.2 m times. The specific steps are illustrated as follows:

  (i) Step 4.1: obtain the K value of the number of clustering clusters, and increase the K value by 1 every cycle. Call the K-means clustering procedure to make clusters of the text vector matrix for national cultural resources.

  (ii) Step 4.2: determine the sum of squares of errors, denoted by SSE. Moreover, calculate and record the sum of squares of errors SSE value of each clustering process. The sum of squares of errors (SSE) of text data of national cultural resources is premeditated by the following equation:

$$\mathrm{SSE} = \sum_{i=1}^{k}\sum_{p\in C_i}\left|p - m_i\right|^2. \tag{11}$$

  where C_i characterizes the ith cluster, m_i is the average rate of all samples that belong to C_i cluster, and p is the sample point in C_i cluster. Note that the SSE metric, in fact, represents the error in clustering of all samples and characterizes the advantages and disadvantages of clustering influence.

(iii) Step 4.3: execute Step 4 after M cycles 1-Step 4. After 2 steps, m k values and SSE values are obtained, so as to draw the relationship graph between K values and SSE values, and the K value corresponding to the elbow in the graph is selected as the number of nearest clustering clusters.

(v) Step 5: outputs: finally, the clustering results of national cultural resources based on topic similarity are obtained.

4. An Empirical Study on the Influence of National Cultural Communication on Audiences

This paper deals with and analyzes the data collected through the interview survey of different audiences, establishes multiple regression models and the BP neural network model to study the current situation of multimedia on national culture communication, and finds out the strength and differences of the influencing factors of multimedia national culture on different audiences. Furthermore, the paper also studies the strategies and regulations that multimedia should adopt for national culture communication according to the questionnaire [28].

The construction of multiple regression model and the BP neural network model is usually realized established on SPSS software and MATLAB software, respectively. In view of this, the general workflow of this paper is as follows:

(i) Step 1: according to the characteristics of the two models, we preprocess the collected audience data, so that redundant data can be avoided, and we divide the samples into the training group and testing group.

(ii) Step 2: we use the training group data and SPSS software to realize the modeling process of multiple regression model; then, with the help of MATLAB software and the BP neural network toolbox, the modeling process of the BP neural network is realized through independent programming.

(iii) Step 3: finally, we use the test group data to realize the prediction function of the two models and use the comparison between the model output values and the actual values to reflect the prediction accuracy.

The accuracy of the prediction results can be measured using the well-known mean average percentage error (MAPE) and root mean square error (RMSE) evaluation metrics as given by the following equations:

$$\text{MAPE} = \frac{1}{z}\sum_{i=1}^{z}\frac{\left|\widehat{x}_t - x_t\right|}{x_t},$$
$$\text{RMSE} = \sqrt{\frac{1}{z}\sum_{i=1}^{z}\left(\widehat{x}_t - x_t\right)^2}. \tag{12}$$

In the above equations, `x_i and x_i denote the predicted value and the real value, respectively. Furthermore, z characterizes the total number of samples that were used for validation purposes. The lower the values, the more accurate the prediction, and vice versa.

5. Results and Discussion

Table 1 gives the descriptive statistics of the total 212 samples. The average score of each item is in descending order: overall broadcast media score, overall paper media score, overall TV media score, overall network media score, overall mobile media score, and overall score. This is consistent with the situation of real life. With the development of Internet technology, traditional radio and paper media are declining, and their influence is becoming smaller and smaller. Compared with radio and paper media, TV media have a stronger influence on the dissemination of national culture. Internet media and mobile media have the strongest impact on cultural communication, and their average scores are roughly the same. It can be comprehended that the Internet has changed the traditional mode of communication of national culture.

When constructing the communication strategy of national culture, we should consider the influence of modern technology as much as possible, especially the influence of the Internet, which will make the communication strategy more efficient. This can also be comprehended from the results reported in Table 1 that the average value of the overall score is the highest, indicating the positive evaluation given by the respondents to the effect of the overall dissemination of national culture. This can be perceived from the standard deviation statistics that the standard deviation of the overall score is the smallest, followed by the standard deviation of the overall online media score. Overall, the standard deviation is a little larger than the average score, which shows that the respondents' score value for the spread of national culture fluctuates greatly, and they have different attitudes.

From the side, the dissemination of national culture did not allow all respondents to achieve a better unified understanding, and there is still room for improvement in the dissemination of national culture. In the next demonstration, the last 32 samples of the total 212 samples are used as the prediction group, and the others are used as the test group to identify and predict the model. Next, we carry out prediction and analysis. For the prediction of multiple linear regression model, the value of specific independent variables is substituted into the following regression equation:

$$y = 18.644 - 0.172x_1 + 0.201x_2 + 0.339x_3 - 0.229x_4 + 0.657x_5. \tag{13}$$

After comparing with the actual filling value of the questionnaire, it is concluded that, among the 15 prediction samples, 3 are misjudged, and the accuracy rate is 80%. Figure 2 shows the BP neural network training and test results.

From Figure 2 and the model output results, we can know that the training process of the BP neural network

Table 1: The overall descriptive statistics.

	Average values	Standard deviation	Number of cases
Overall score	82.934	9.4621	212
Overall paper media score	60.495	20.3226	212
Overall broadcast media rating	59.726	18.6977	212
Overall TV media rating	77.858	13.5359	212
Overall online media rating	82.524	11.5609	212
Overall mobile media score	82.868	12.4395	212

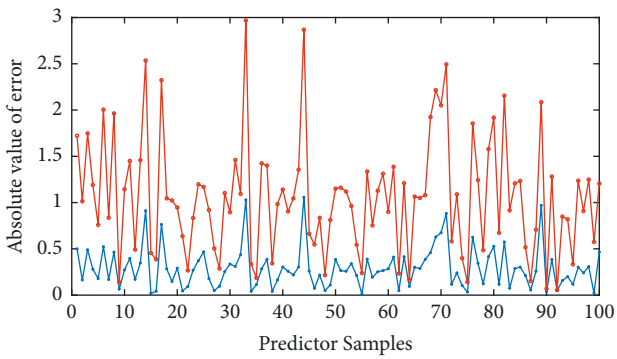

Figure 2: The predictor values.

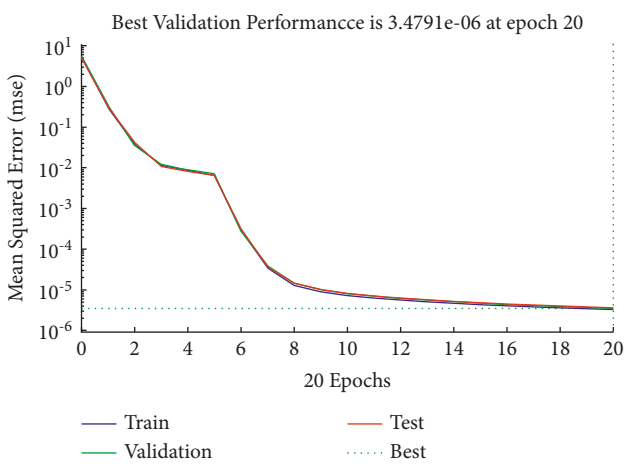

Figure 3: The best validation performance.

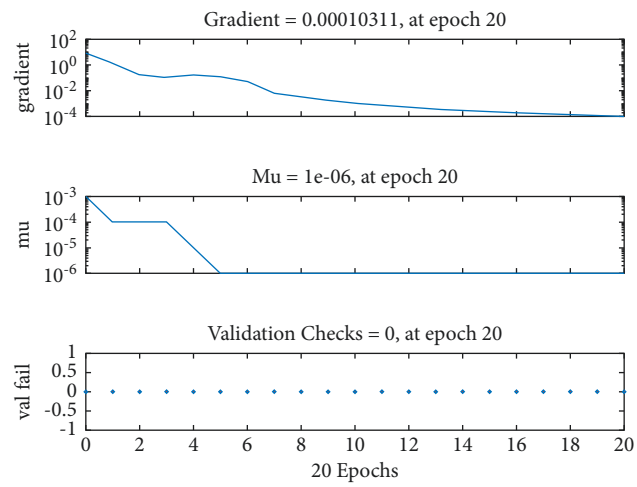

Figure 4: The Gradient calculation.

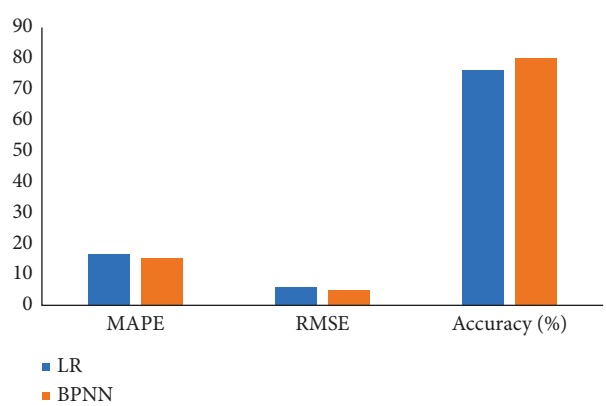

Figure 5: The prediction accuracy results for linear regression (LR) and the backpropagation neural network (BFNN) model [the lower the values for MAPE and RMSE, the more accurate the prediction].

performs well; nevertheless, in the prediction process, only 9 samples are predicted correctly, and the others are predicted incorrectly.

The best validation performance is shown in Figures 3 and 4. From the outcome's values reported in Figures 3 and 4, we know that the best validation performance reaches up to 10^{-5} with the 20 epochs. Figure 5 demonstrates the prediction accuracy, in terms of MAPE and RMSE, for linear regression (LR) and the backpropagation neural network (BFNN) model. The higher the values, the more accurate the prediction, and vice versa. The proposed BP neural network is more accurate than the classical linear regression technique. The accuracy of the proposed method can reach up to 80.11% along with higher values for the MAPE and improved RMSE.

This paper collects the data of the impact of multimedia cultural diversity on the audience through a questionnaire survey. This questionnaire survey adopts the sampling method of subregions, levels, and the nature of work units, and the respondents are selected according to the nature of population work units [29]. The questionnaire takes into account the respondents' age, position, identity, work, and other information. As of July 1st, 2020, a total of 280 questionnaires have been distributed, and 252 copies have been recovered. After preliminary data analysis, the

remaining 212 copies are valid. Through the processing and analysis of the data collected from the interview surveys of different audiences, the multiple linear regression model and BP neural network model are established to study the current situation of multimedia on the dissemination of cultural diversity.

With the help of SPSS and MATLAB independent programming, the empirical research results show that students and respondents under the age of 25 do not have a deep understanding of cultural communication and have different opinions. When building cultural diversity communication strategies, we should focus on this group. Among the five kinds of media analyzed, mobile media and TV media are the most important. In the process of systematic planning and overall scheme construction of cultural diversity communication, these two kinds of media should be given priority. Through the comparison and analysis of the prediction results of multiple regression model and BP neural network model, it can be seen that the classical multiple linear regression analysis is a model worth considering when analyzing the data with strong subjectivity of evaluation and classification.

6. Conclusions and Future Work

In this paper, we established multiple linear regression models and the BP neural network model to carry out empirical research on the impact of multimedia publicity and cultural diversity on the audience. The two confirm each other and have strong persuasion. The empirical results have a certain guiding role for the construction of cultural diversity communication strategies. The relevant media leaders can formulate a systematic plan and overall plan for cultural diversity communication for audiences of different ages and identities according to the empirical results of this paper. We believe that the proposed algorithm will promote cultural diversity in an all-round way through positive public opinion and mutual cooperation. Of course, the research method of this paper is generic and can play a certain reference role for the media practitioners in the whole province and even the whole country. The empirical evaluation and experiments, using real datasets, showed the superiority of the proposed method over classical linear regression model.

In the future, we will propose other deep learning models to increase the prediction precision and improve the execution time of the training period. The dataset used in this work is small, and we will consider larger dataset to generalize our results. We will investigate further how the activation function of the neural network will affect the neurons, and therefore, the accuracy of the prediction results. Finally, we will deeply look into the convolutional networks (CNNs) and other state-of-the-art mechanism like big data and edge infrastructure, so that the training time can be significantly reduced. In the training process, if the data is large, or the deep learning method has more layers, then the training will take long time, and that needs to be optimized.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Research Article

Student's Physical Health Prediction Model Based on the Deep Neural Network

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The arrival of the Internet of Things era has brought us a series of conveniences, but it is also devouring the physical and mental health of most of us. Especially students, as the future main force of the motherland, their health cannot be ignored. To more accurately and appropriately predict the physical health of students, this paper establishes a deep convolutional neural network (CNN) model and uses its own strong function mapping ability, and using the general physical index of students' physical health to obtain the total score as the input parameter and the total score of physical health as the output parameter, so as to establish a deep CNN prediction model for students' physical health. The model firstly overcomes the shortcoming of singleness brought by a simple NN, and it more accurately and clearly reflects the relationship between various physical measurement indicators and the overall physical health score. Secondly, the specific ROC curve and the R-P curve are obtained by comparing the traditional gray EGM prediction model. Finally, from the comparison results of the R-P curve, it can be seen that the AUC of the deep convolutional network is 0.98, while the AUC of the gray EGM prediction model is only 0.89, which shows that the data of the deep convolutional network model is more accurate.

1. Introduction

Rapid economic development, the abundance of material products, not only meets people's life needs and spiritual needs in terms of comfort, convenience, enjoyment, entertainment, etc., but also eats up health in the fast-paced era. Up to now, students of different age groups are mostly troubled by learning. Due to the long study time and heavy academic tasks, they have problems such as lack of exercise and unbalanced nutrition, which make their bodies gradually appear subhealthy. According to relevant data, whether it is college students, high school students, or even primary school students, subhealth problems are common. Students' physical health generally shows a downward trend. If this situation continues in this way, it will have a profound impact on society, families, and even individuals. Therefore, to reduce this unfavorable trend, it is necessary to learn to take targeted countermeasures such as using a gray EGM model or a deep convolutional neural network model to help students enhance their physique and grow healthily.

At present, the related research on the analysis of physical fitness prediction models is relatively scarce, including Fisher discriminant method, gray EGM prediction model, multilayer perceptron model, and other models. Although these models can make relevant predictions about the constitution of people at different ages, the effect is not satisfactory. Due to its own structure, the deep convolutional network can perform translation-invariant classification of the input information through the hierarchical structure, thereby minimizing the amount of computation. Therefore, in this situation, this paper establishes a deep CNN model, taking advantage of the complexity of the internal structure of the model, which can be used to accurately, sensitively, and efficiently evaluate the overall physical condition of students.

In the past, most of the prediction models of physical fitness used traditional prediction models, such as the gray EGM prediction model. However, these models need to calculate more data, and the data results obtained are not very accurate. It can be known through the traditional EGM prediction model and Fisher's discriminant method. A CNN model also has a convolutional layer because it has an input layer, a hidden layer, and an output layer. Therefore, this method is not only more predictive but also more widely applicable. The main innovation of this paper is that it provides a new method for predicting students' physical health.

2. Related Work

DNN is a technology in machine learning, and many people have in-depth research on its application. Among them, A Li et al. pointed out that in terms of image data analysis, it is crucial to select appropriate feature extraction and granulation methods for continuous 3WD-based image data analysis. While among the existing feature extraction methods, DNN has been widely considered due to its powerful representation ability [1]. According to Wang et al., the existing traffic mode detection from global positioning system (GPS) trajectories is highly complex and does not always work well [2]. Yan et al. proposed that to improve the efficiency of computing the similarity between images, deep CNN can be realized by proposing a single-stage supervised deep hashing framework (SDHP) to learn high-quality binary codes, which makes the similarity between the calculated images to be improved to a certain extent [3]. To reliably detect, track, and classify marine life in an underwater video without human intervention, Siddiqui et al. proposed a CNN model that not only requires a small amount of data but also has an accuracy rate close to 100% [4]. Quan et al. constructed prediction intervals (PIs) by implementing a neural network (NN)-based method. He applied and extended a newly introduced method, called lower upper bound estimation (LUBE), to develop PI using a NN model, which can more effectively address the uncertainty of power systems compared to the cost function [5]. Although there are a large number of literature studies on how to apply DNN to image processing, audio and video processing, etc., there are only a handful of applications in the physical health detection of students. Nowadays, most students are in a subhealth state due to high pressure and unbalanced nutrition. As the main force of the motherland in the future, their physical health is particularly important.

In recent years, due to factors such as students' learning pressure and environmental pollution, the physical health of adolescents has attracted increasing attention. Many people have put forward their own opinions on how to more efficiently and accurately detect the model of students' physical health. Among them, Xu established a prediction model based on BP neural network (BPNN) to more accurately predict the risk of hypertension, with a relative error of 2.418%. And it was demonstrated that a system with a decision tree BP model can be a useful tool for more accurate health assessments and recommendations for individual students [6]. Yin believed that the physical and mental health of adolescents is the foundation of all-round development of society and the key to improving people's health quality [7]. Li et al. proposed IoT-assisted physical activity monitoring devices to track students' physical activity and improve outcomes [8]. Wang et al. pointed out that with the accelerated pace of life and increased pressure, the physical quality of students has generally declined, and the incidence of health diseases has continued to rise. To reduce the occurrence of this trend, he believes that this purpose can be achieved by storing and analyzing the data of students' health [9]. Sortwell and Ramirez–Campillo combined examples of the 2019 coronavirus disease (COVID-19) delta variant to detect physical health indicators in children [10]. For students' physical health detection, there is a small amount of literature based on neural network research, but because the factors affecting students' physical fitness are diverse, to measure more accurately and effectively, it is obvious that DNN can meet this demand.

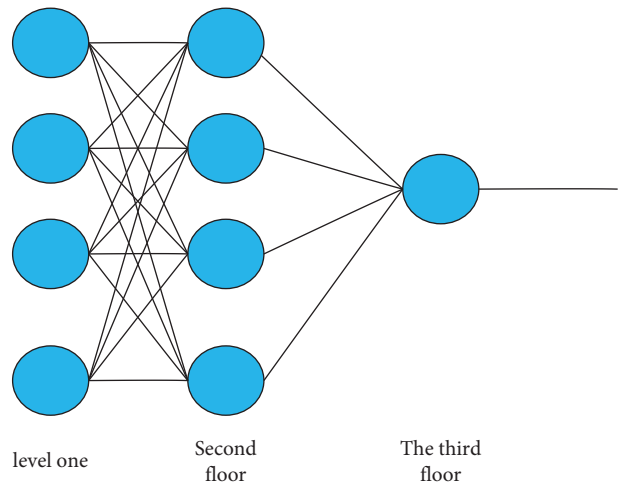

Figure 1: BPNN structure model.

3. Prediction Method of Students' Physical Health

3.1. Basic Structure of NN. NN is mainly composed of neural units. If there are more neural units, the structure will be more complicated. The simpler structure is BPNN, which consists of three layers of neural units. The more complex one is DNN, whose neural unit layer composition is uncertain [11]. Figure 1 is NN composed of three layers of neural units.

Although BPNN has only three layers of neurons, each layer of neurons can have m inputs. After the calculation of neurons, the results are output to the next layer of neurons. The specific calculation process is as follows: the first step is a weighted summation of the m input values; the second step is through the activation function, the final result is obtained, which is then output to the next layer of neurons [12]. The calculation formula is

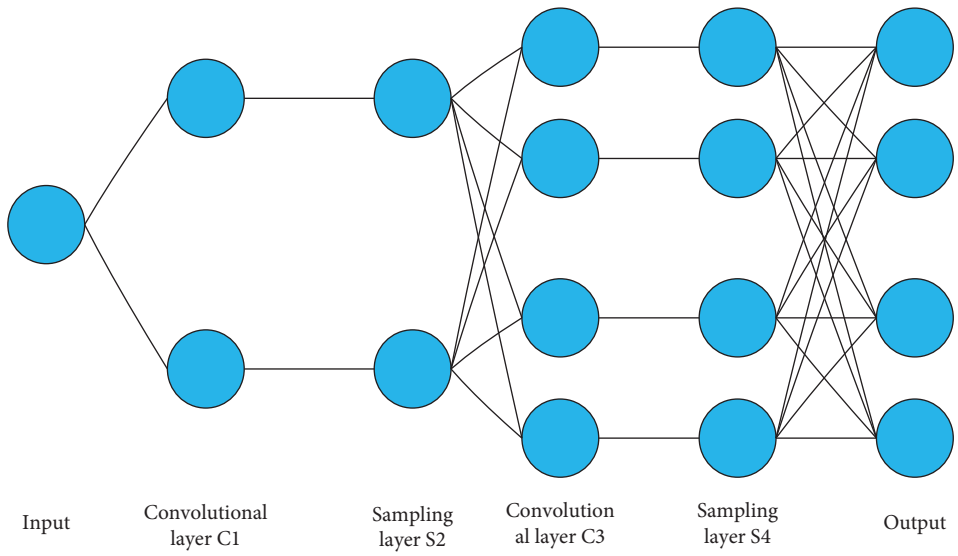

Figure 2: NN model structure.

$$\begin{aligned} c1 &= p1u1 + p2u2 + p3u3 + \cdots + pmum \\ y &= f(c1). \end{aligned} \tag{1}$$

Among them, $f\sum_1^m (piui)$ is the activation function of the neuron, and y is the output value of the neuron. The specific calculation process is

$$\begin{aligned} c_1^{(2)} &= f\left(p_{11}^{(1)}u1 + p_{21}^{(1)}u2 + p_{31}^{(1)}u3 + d_1^{(1)}\right) \\ c_2^{(2)} &= f\left(p_{11}^{(1)}u1 + p_{21}^{(1)}u2 + p_{31}^{(1)}u3 + d_2^{(1)}\right) \\ c_3^{(2)} &= f\left(p_{11}^{(1)}u1 + p_{21}^{(1)}u2 + p_{31}^{(1)}u3 + d_3^{(1)}\right) \\ hp, d(u) = c_1^{(3)} &= f\left(P_{11}^{(2)}c_1^{(2)} + P_{21}^{(2)}c_2^{(2)} + P_{31}^{(2)}c_3^{(2)} + d_1^{(2)}\right). \end{aligned} \tag{2}$$

3.2. Deep CNNs. As one of the DNN methods, CNN is a kind of feedforward NN with a computational and deep structure, which is mainly composed of input layer, hidden layer, convolutional layer, and output layer. Moreover, deep CNNs can establish two learning methods, supervised learning and unsupervised learning [13]. The difference between the two learning methods is that: supervised learning gives both data and results in samples; non-supervised learning only gives data and no results. The CNN structure model is shown in Figure 2.

As can be seen from the figure, the object is first input and then processed through the C1, C2, C3, and C4 layers, and finally the result is output.

3.2.1. Convolution Operation. The structure of the convolutional layer and the input layer is shown in Figure 3. Since the work in this paper is based on digital images for training, this section only describes the discrete convolution operation, which is expressed as follows:

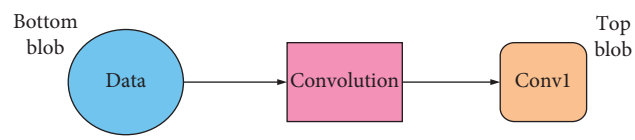

Figure 3: Convolutional layer and input layer.

$$S(i, j) = (F * K)(i, j) = \sum_m \sum_n F(m, n)K(i - m, j - n). \tag{3}$$

In formula (7), (i, j) represents the input data, and the "kernel function" is represented by $F(m, n)$, the size of the filter is represented by m and n, and the result value of the feature map is $S(i, j)$.

3.2.2. Pooling Operation. The pooling layer is generally divided into an average pooling layer and a maximum pooling layer. The average pooling layer propagates the average value of all input values in the receiving area to the next layer, and the maximum pooling layer transfers the maximum value in the receiving area. The values are propagated to the next layer [14]. Assuming that a is a pooling layer, the operation formula of pooling is as follows:

$$Hi = subsampling(Hi - 1). \tag{4}$$

3.2.3. Network Training. CNNs, like NNs, to get the desired network output, most people employ learning algorithms to alter their parameters (such as biases and weights). The backpropagation method is the most often utilized algorithm for this purpose [15]. Backpropagation computes the gradient of the loss function to determine how to tune network parameters to minimize errors that affect the performance.

$$MSE(w,q)=\frac{1}{|U|}\sum_{j=1}^{|U|}(U(j)-U(j))^2 \quad NLL(w,q)=\sum_{j=1}^{|U|}\log U(j). \tag{5}$$

Among them, w refers to the weight and q refers to the bias.

3.2.4. Full Connection Operation. Convolution is utilized to extract features, pooling is used to reduce dimensionality, and the fully connected layer is used as the final data output layer in the above analysis [16]. Therefore, as a "classifier" in deep CNN, it can achieve the role of a projection space mapping, projecting the extracted results from a feature space to a different feature space. The formula is as follows:

$$\mathrm{R} = Wmn\lambda + q. \tag{6}$$

Wmn, $\lambda = \{\lambda 0, \lambda 1, \lambda 2, \ldots, \lambda n\}$, $q = \{q0, q1, q2, \ldots qn\}$, and $z = \{z0, z1, z2, zn\}$ represent the weight coefficient, input vector bias, value and output vector, respectively.

3.2.5. Softmax Regression Function. The Softmax regression function is proposed to solve the multiclassification problem [17], and its specific expression formula is as follows:

$$P(v|u) = \frac{e^{h(u,vi)}}{\sum_{j=1}^{m} e^{h(u,vi)}}. \tag{7}$$

3.3. Gray System Theory (EGM). The gray system theory is mainly used to deal with incomplete information, because this theory is to sort out the original data, to find the law of data change [18]. Therefore, using this theory can predict the laws in a certain period and solve a large number of practical problems. The reason this method is used for physical health prediction is also based on the fact that it can predict the laws in a certain period. Suppose the original data sequence collected through the actual test is

$$W^0 = \left\{W^0(j) \geq 0, j = 1, 2, \ldots m\right\}. \tag{8}$$

The relevant formula is obtained by performing an accumulation generation operation (1-AGO accumulating generation operation) on the above formula:

$$W^1 = \left\{W^1(j) \geq 0, j = 1, 2, \ldots m\right\}. \tag{9}$$

Among them, $W^1(j) = \sum_{m=1}^{j} w^0(m)$., the background value of the gray model GM (,1,1) is

$$z(\lambda) = 0.5\left(w^{(1)}(\lambda) + w^{(1)}(\lambda - 1)\right). \tag{10}$$

In which, $\lambda = 2, 3, \ldots, n$.

The equation of the first-order gray model is

height weight | lung capacity | Run | Sitting forward | pull up | Sit-ups

Figure 4: Physical health testing items.

$$\frac{dw^t}{dt} + pw^t = q. \tag{11}$$

Among them, the development coefficient is represented by p and the gray action is represented by q. The two variables represent the development trend of the estimated value of the behavior sequence and the data mined from the behavior sequence. The formula reflects the relationship between data changes [19]. Let $\hat{p} = [p, q]^T$, B, V be the parameter series.

$$\mathrm{B} = \begin{bmatrix} \mathrm{U}^{(0)}(2) \\ \mathrm{U}^{(0)}(3) \\ \bullet\bullet\bullet \\ \mathrm{U}^{(0)}(n) \end{bmatrix} Y = \begin{bmatrix} -Z^{(0)}(2) & 1 \\ -Z^{(0)}(3) & 1 \\ \bullet\bullet\bullet & \bullet\bullet\bullet \\ -Z^{(0)}(n) & 1 \end{bmatrix}. \tag{12}$$

The parameter estimates can be obtained by the least squares method:

$$\hat{p} = \left(B^T B\right)^{-1} B^T V. \tag{14}$$

The solution to the equation of the gray model is

$$\hat{w}^{(1)}(\lambda + 1) = \left[w^{(1)}(0) - \frac{q}{p}\right]e^{-pt} + \frac{q}{p}. \tag{15}$$

Among them, $\lambda = 0, 1, \ldots, n$.

Taking $w^{(1)}(0) = w^{(0)}(0)$., the restoration value of the gray model is

$$\begin{aligned} \hat{w}^{(1)}(\lambda + 1) &= \hat{w}^{(1)}(\lambda + 1) - \hat{w}^{(1)}(\lambda) \\ &= \left(1 - e^{p}\right)\left(w^{(0)}(1) - \frac{q}{p}\right)e^{-pk}. \end{aligned} \tag{16}$$

Among them, $\lambda = 0, 1, \ldots, n$.

When $\lambda > n$, $\hat{w}^{(0)}(\lambda)$ is the predicted value of the original data series; and when $\lambda \leqq n$, $\hat{w}^{(0)}(\lambda)$ is the fitted value of the original data series $w^{(0)}(\lambda)$ [20].

4. Students' Physical Health Prediction Experiment

4.1. Data Collection. The experimental subjects of this article are students. The following is a specific illustration of the process of monitoring their physical fitness, as shown in Figure 4.

Table 1: Basic information of a middle school boys sample in 2020.

	Index	Height/ cm	Body mass/kg	Vital capacity/ mL	100 m run time/s	Sit and reach/cm	Standing long jump/cm	Pull up	1000 m run tine/ min
Schoolboys	Min	165	50	450	19.8	-20	110	0	2′50
	Max	188	86	5932	32.3	43	295	36	3′45
	Mean	173	75	4365	21.5	13	265	24	3′01

Table 2: Basic information of a sample of girls from a middle school in 2020.

Gender	Index	Height/ cm	Body mass/kg	Vital capacity/mL	100 m run time/s	Siting forward bend/cm	Standing long jump/cm	Sit up (number·min^{-1})	800 m run time/min
Schoolgirls	Min	148	37.5	230	18.9	−20	105	0	3′02
	Max	176	82	5365	35.7	35	275	12	4′09
	Mean	159.5	60.5	2465	28.6	12	223	8	3′59

Table 3: Basic information of a sample of boys from a primary school in 2020.

Gender	Index	Height/ cm	Body mass/kg	Vital capacity/mL	100 m run time/s	Siting forward bend/cm	Standing long jump/cm	Sit up (number·min^{-1})	1000 m run time/min
Schoolboys	Min	119	27.5	130	30.9	−20	85	0	5′02
	Max	150	50	365	40.7	10	175	9	6′09
	Mean	135	43.5	255	35.6	8	135	6	5′59

Table 4: Basic information of a sample of girls from a primary school in 2020.

Gender	Index	Height/ cm	Body mass/kg	Vital capacity/mL	100 m run time/s	Siting forward bend/cm	Standing long jump/cm	Sit up (number·min^{-1})	800 m run time/min
Schoolgirls	Min	125	24	125	29.9	−20	98	0	4′58
	Max	156	43	365	35.7	12	165	11	6′19
	Mean	136	35.5	285	31.6	10	158	9	5′48

It can be seen from the figure that the system health monitoring items are as follows: height, weight, vital capacity, running, sitting forward, bend, pull-up, and sit-up. The data studied in this paper are derived from the physical data of boys and girls in a primary and secondary school, including all registered students of the school in 2020. Among them, there are 512 boys and 398 girls in primary school; 1,535 boys and 1,729 girls in secondary school. The total score is calculated from the scores of boys and girls in the test items and is used to reflect the physical health of boys and girls in school. The specific sample information is shown in Tables 1–3, and 4.

Table 5: Dividing physical measurement indicators into eight categories.

Types	Index parameter
Class 0	Height
Class 1	Body mass
Class 2	Vital capacity
Class 3	50 m run time
Class 4	Sit and reach
Class 5	Standing long jump
Class 6	800 m run time/1000 m run time
Class 7	Pull up/sit-up

4.2. Prediction of Students' Physical Health Based on CNN

4.2.1. Model Construction of Student Detection Projects. The DNN structure used in this paper for the physical health prediction of middle school students has 8 input branches, which, respectively, receive 8 indicators and parameters from different sources. These 8 parameters are height, weight, vital capacity, 50 m and 1000 m, sitting forward, flexion, standing long jump, and the last test item is pull-ups for boys and sit-ups for girls. The input dimension of each branch is determined by the number of index parameters of each category. The eight categories of parameters used in this paper are shown in Table 5 and Figure 5.

To better know that this method is effective for predicting students' physical health, this paper uses the vital capacity of high school students as a variable, and the specific variation range is 2000 mL–4500 mL. The boy's physical condition is as follows: height 175 cm, weight 75.5 kg, standing long jump 200 cm, 50 m running time 19.2 s, pull-up 21/min, sitting body forward bending −10 cm, and 1000 m running 4 min30 s. The girl's physical condition is as follows: height 161 cm, weight 50 kg, standing long jump 1.5 m, 50 m running time 21.3 s, sit-

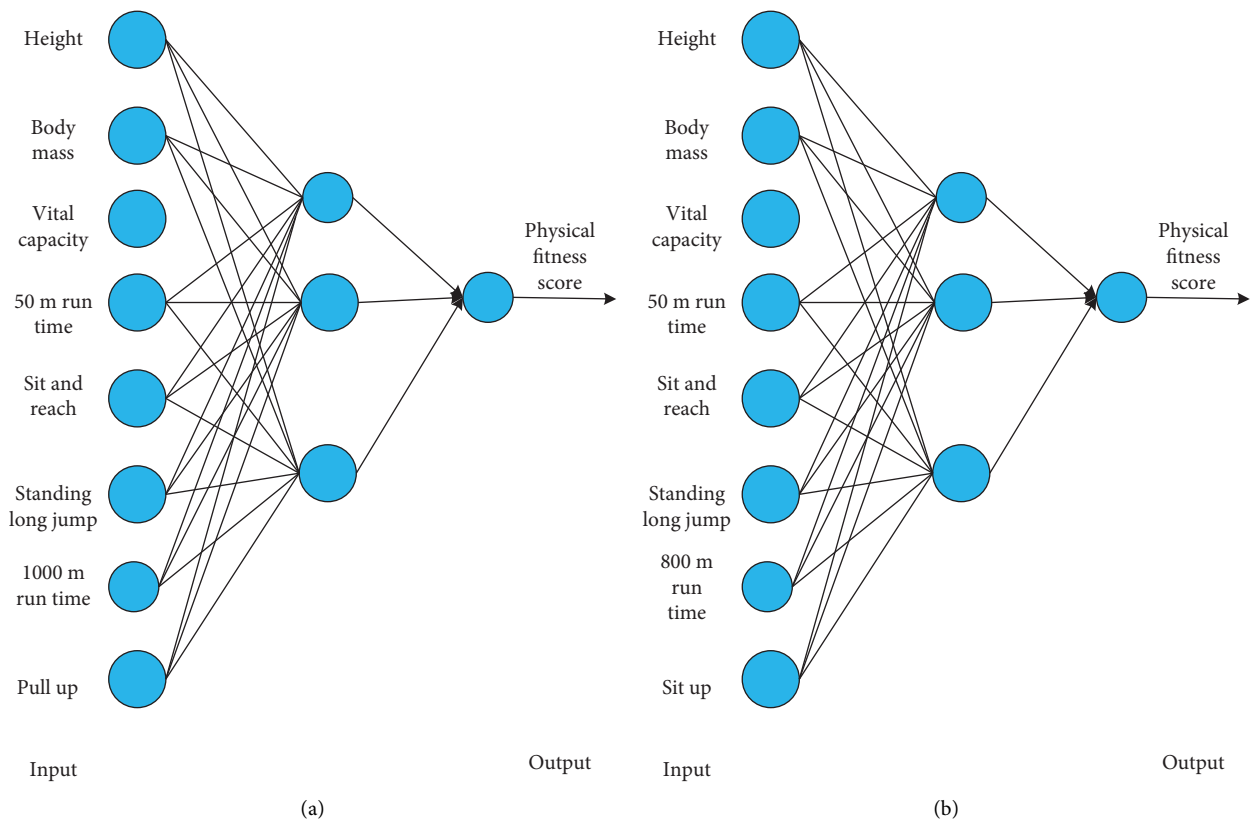

Figure 5: DNN architecture. (a) Physical examination of boys. (b) Physical examination of girls.

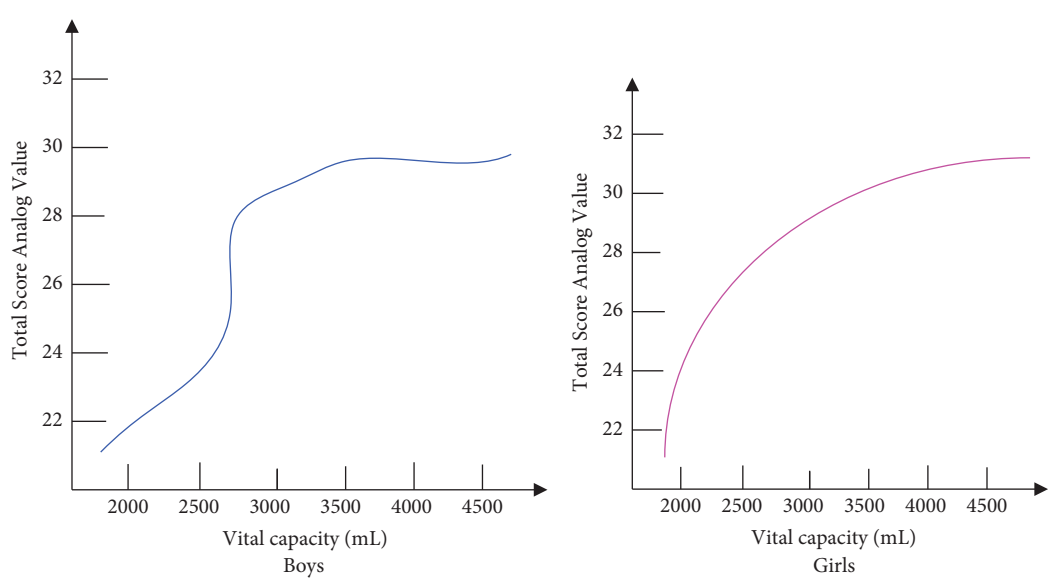

Figure 6: The amount of change in the system with different lung capacity.

ups 50/min, sitting forward flexion 16 cm, and 800 m running 3 min53 s.

It can be seen from Figure 6 that both boys and girls, with the continuous increase of lung capacity, their physique is also steadily improving. Although the physical health of each student may be more or less different, the simulation results produced by each student are also different. However, the overall results of the graph show that the method can predict the physical condition of students under the condition of different variables. Therefore, this method is feasible.

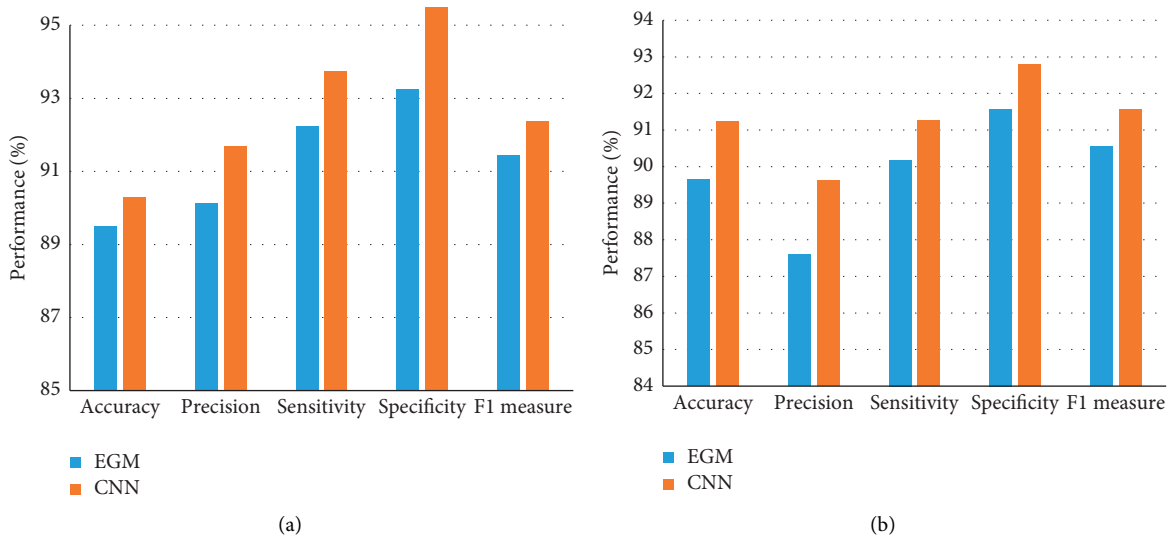

Figure 7: Performance comparison of EGM and CNN on different data. (a) Performance comparison of boys EGM and CNN on different data. (b) Performance comparison of girls EGM and CNN on different data.

Table 6: Performance comparison of EGM and CNN.

Classifier		Accuracy/%	Precision/%	Sensitivity/%	Specificity/%	F1 measure/%
Boys	EGM	86.12	89.38	85.42	91.56	89.98
	CNN	92.03	95.41	96.06	98.19	96.54
Girls	EGM	91.25	93.29	94.43	91.56	87.98
	CNN	92.03	96.23	95.98	97.56	95.23

To evaluate students' physical health prediction methods, this paper uses six performance measures, including accuracy, precision, sensitivity, specificity, F1 measure, and receiver operating characteristic (ROC), the area covered under the curve, namely, AUC (Area under the ROC curve). The relevant calculation formula is

$$\begin{aligned} Precision &= \frac{TP}{TP+FP} \\ Sensitivity &= \frac{TP}{TP+FN} \\ Specificity &= \frac{TN}{TN+FP} \\ F1 &= \frac{2TP}{2TP+FP+FN} \\ Accuracy &= \frac{TP+TN}{TP+TN+FP+FN}. \end{aligned} \tag{17}$$

Among them, in the above formulas: the full English name of T is true and the full English name of F is false. Therefore, TP is the number of correct predicted physical test items for students; TN is the number of correct predicted nonstudent physical test items; FP is the number of nonstudent physical test items that are predicted to affect students' physical health; FN is the number of students' physical test items that are predicted to affect students' physical health.

The size of the area under the ROC curve is proportional to the size of AUC. The larger the area covered under the curve, the better the performance of the body measurement indicator. As one of the methods commonly used to predict students' physical health, the gray EGM model will be devoted to compare it with deep CNNs under these five performances.

4.2.2. Experimental Results and Analysis. Figure 7 shows the performance comparison between EGM and CNN for boys and girls. As can be seen from the data in the figure, from the perspective of accuracy, whether it is EGM or CNN, girls are higher than boys. Table 5 compares the performance of deep CNN and the gray prediction model based on the feature vectors extracted in this paper for boys and girls in middle school. It can be seen from Table 6 that accuracy, precision, specificity, and F1 metric of deep CNN constructed in this paper are all optimal, of which the accuracy rates are 91.25% and 92.03%, which proves that the performance of deep CNN is better than the gray prediction model.

On the basis of Table 6, Figures 8 and 9 show the ROC curve and the P-R curve of EGM and CNN, respectively,

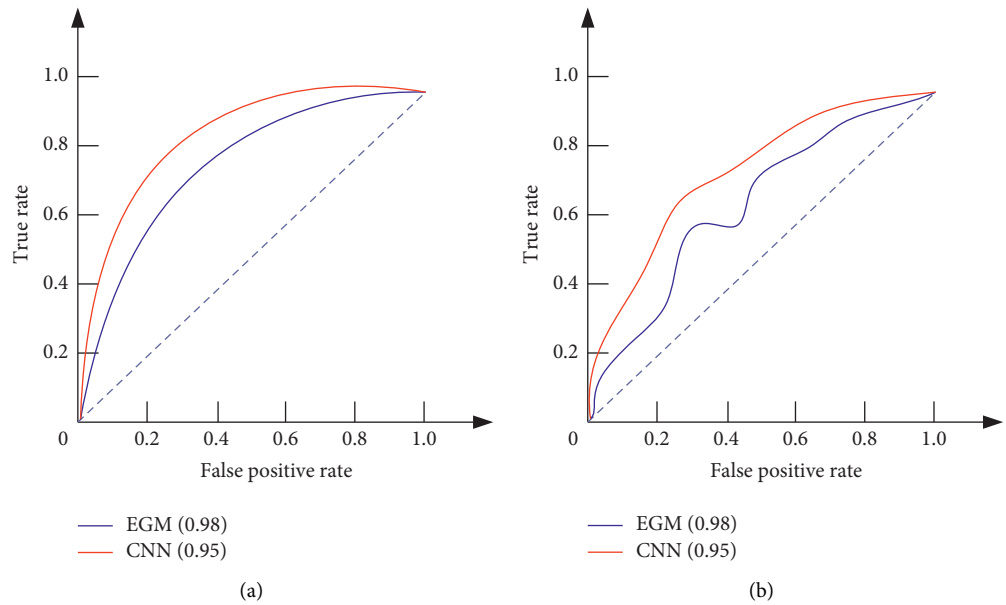

Figure 8: ROC curve graph. (a) Complete ROC curve. (b) Local ROC curve.

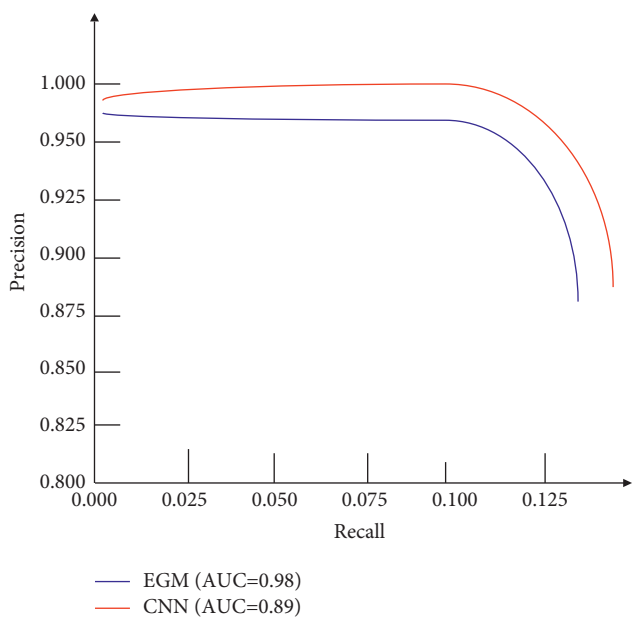

Figure 9: R-P curve graph.

where P refers to precision, and R refers to recall; P is the vertical axis, and R is the horizontal axis.

It can be seen from Figure 8 that the average AUC value of deep CNN is higher than that of the gray EGM model. Figure 8(b) is a partial enlarged view of the upper left corner of the ROC curve of deep CNN. It can be seen that the ROC curve of deep CNN can almost completely "envelope" the gray EGM model. Similarly, the P-R curve of the deep network in Figure 9 is also outside the gray EGM model. Clearly, deep CNNs outperform gray EGM models.

As can be seen from the above chart, whether it is the ROC curve or the R-P curve, all performances of CNN are higher than the gray EGM model. It can be seen that the CNN model can better predict the physical health of students.

5. Conclusion

This paper mainly conducts experiments on the application of CNN in the prediction of students' physical health. And a single neural network and a deep neural network are used to predict and analyze the physical health of primary and secondary schools. First, the basic principles of single NN and deep CNN are briefly introduced, and then CNN, one of the methods of DNN, is used to study the physical health of a middle school and to make relevant predictions. Students' physical health prediction is of a great significance to a family or a country. Their physical health is related to the future of the family and the country, and it is the future talent pool. Only when the physical health of young people is guaranteed, the family can be fulfilled and the country gain the corresponding value. Therefore, this paper proposes a framework for predicting students' physical fitness based on deep CNNs. Secondly, using weight, height, vital capacity, and other physical indicators of boys and girls in middle school to construct a related physical fitness prediction model and to provide a reference for the physical fitness evaluation of middle school students and other age groups. Finally, through the analysis of the comparative results, it can be seen that the CNN model has absolute advantages compared with the gray EGM model in terms of accuracy or other performance. Therefore, although the CNN model is somewhat complicated in application, this defect is acceptable compared to the ability to more accurately predict the physical health of students. It is believed that in the near future, by using this model, it can provide a better reference for the prediction of the student's physique model and enhance the students' physical health.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Bionic Optimization Design of Rotary Tiller Based on Fuzzy Algorithm

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In order to increase the structural performance of rotary tillage knife, a badger claw toe was selected as the bionic prototype of the rotary tillage knife, and the bionic optimization design of the rotary tillage knife was carried out. The structural similarity between the badger's claw toe and the rotary tiller is 0.7073 by the fuzzy algorithm, and the shape goodness of fit between the final mole's claw toe and the digging shovel is 0.9556 by MATLAB. Using 3D modeling software NX10.0, we established a three-dimensional model of the rotary tillage knife. Furthermore, we use Workbench to carry out static analysis on the three rotary tillage knives and obtain their stress and deformation. Similarly, we also obtain their vibration frequency through modal analysis, summarize, and compare the experimental data. The outcomes indicate that compared with the ordinary rotary tillage knife, the strain and stress of the bionic rotary tillage knife with sawtooth tangent blade arrangement are reduced by 5.20% and 2.84%, respectively. Moreover, the specific strength and specific stiffness are increased by 3.99% and 6.49%, respectively. The structural efficiency is improved by 11.36%. However, the stress of the bionic rotary tiller with full serration is reduced by 7.38%. We also observed that the specific strength and specific stiffness were improved by 11.97% and 2.37%, correspondingly. Overall, structural efficiency has increased by 14.64%. The rotary tiller has also attained noble optimization outcomes in terms of stability, strength, and stiffness.

1. Introduction

Tillage machines are the main and basic part of agricultural mechanization. It has played an active role in the transformation from Chinese traditional agriculture to modern agriculture. The tillage machine with high operation efficiency, multiple functions, and improving tillage storage and moisture retention capacity has become the main research direction of new agricultural machinery in various countries, and the rotary tillage knife is one of the leading and fundamental research directions of agricultural mechanization in China. The size and structure of the rotary tillage knife are an important factor for the increase in resistance and energy consumption. The rotary tiller is an important part of the rotary tiller and also a vulnerable part. Due to the changing working environment, its average working life is about 80 h [1]. One of the problems to be solved in the research of agricultural mechanization in China is to improve the working life of rotary tillage knives, improve farming quality, and optimize the structural rationality of rotary tillage knives.

Bionics of biological structure is an important direction of bionic optimization design. Through the analysis of biological structure, we can understand the characteristics of biological structure and then integrate its characteristics into the design to make its structure more flexible and reliable, so as to enhance the performance of products. In order to increase the structural performance of the rotary tillage knife, the badger claw toe was selected as the bionic prototype of the rotary tillage knife, and the bionic optimization design of the rotary tillage knife was carried out. Through the research and analysis of the functional and structural characteristics of the badger's claw toe, taking the badger's claw toe as the bionic prototype, the IT245 rotary blade is optimized. The structural characteristics of the badger's claw toe are applied to the blade part of the rotary blade, and the optimized bionic rotary blade is obtained, which improves the sliding cutting effect of the blade, straw, and weeds.

Through finite element static analysis and modal analysis, the experimental results show that the weight reduction, stress, and deformation of bionic rotary tillage knives are improved compared with ordinary rotary tillage knives. Through the calculation and analysis of mechanical properties, it is concluded that the specific stiffness, specific strength, and specific structural efficiency of the two bionic rotary tillage knives have also been improved. Improving the performance of rotary tillers is an important link to improving production efficiency.

(i) In this paper, our aim is to improve the structural performance of the rotary tillage knife, for which the badger claw toe was selected as the bionic prototype of the rotary tillage knife, and the bionic optimization design of the rotary tillage knife was carried out.

(ii) In the second phase, using 3D modeling software NX10.0, we established a three-dimensional model of the rotary tillage knife and used Workbench to carry out static analysis on the three rotary tillage knives.

(iii) Through experimental analysis, we obtained their stress and deformation, obtained their vibration frequency through modal analysis, and summarized and compared the experimental data.

The remaining of the paper is systematized in the following fashion. In Section 2, we deliberate on bionics based on natural organisms. In Section 3, we deliberate the bionic design of the rotary tillage knife in more detail. In Section 4, we carried out the optimization analysis of the bionic rotary tiller. Note that we use the recognized fuzzy algorithm for optimization purposes. In Section 5, we discuss the obtained results and summarize our observations. In the last Section 6, the paper is concluded.

2. Bionics Based on Natural Organisms

Improving the performance of the rotary tillers is an important step towards improving production efficiency. Haijie [2, 3] designed a wedge drag-reducing rotary tiller based on the mechanical cutting model. The average torque and average power consumption of the optimized rotary tiller are 7.65% and 7.87% lower than those of the national standard rotary tiller, respectively. Jianjun et al. [4] studied the structural form and main technical characteristics of rotary tillage tools at the present stage, optimized and technically analyzed the functional structure of rotary tillage tools, and improved the operation efficiency and effect of microtillage machines. The experiment shows that the horizontal resistance, vertical resistance, and average torque of the bionic rotary tillage knife are lower than those of the national standard rotary tillage knife [5]. After the optimization of the rotary tiller, the shaft torque and amplitude of the rotary tiller are diminished by a factor of 7% and 8%, correspondingly. Furthermore, the wear rate of the rotary tiller is reduced by 10% [6]. The improved blade has a positive impact on the growth of crops. A group of 15 cm high rice straw top anchors showed that the seed germination rate of wheat and maize increased by 95.89% and 78.65%, respectively [7]. Rajesh [6] pointed out that blade shape, forward speed, and rotation speed are the key considerations to decide the status of soil crushing.

Bionics of biological structure is an important direction of bionic optimization design. Through the analysis of biological structure, we can understand the characteristics of biological structure and then integrate its characteristics into the design to make its structure more flexible and reliable, so as to enhance the performance of products. Morphological bionics is essentially the imitation and redesign of original organisms [8]. Many aircraft take birds as morphological bionic objects to design bionic machines. Through the structural bionics of mollusks, the soft robot has the advantages of high structural flexibility, strong environmental adaptability, and continuous deformation and can realize high-level environmental operation and space exploration tasks [9–12]; Based on the structural characteristics of caterpillars, Rieffel et al. [13] designed a tensioning mobile robot to realize the function of creeping, bending, and crawling.

3. Bionic Design of Rotary Tillage Knife

3.1. Characteristics of Bionic Prototype. The badger has a high efficiency in digging holes. Through the study of its claw toes, it can be found that the front and rear toes of the badger are black and brown, and both have long and powerful claws, especially the front claws. During excavation, the front claw quickly breaks the solid ground and scoops it under the abdomen and then uses the rear claw to crush the gravel and soil behind it [14]. Its front and rear legs are combined with curved claw toes so that it can dig the soil faster than other cave creatures. The inner and outer contours of the badger's claw toes are composed of two smooth curves, and the toe tips are circular, which can promote the ability to penetrate the ground [15]. As shown in Figure 1, as is the length of the toe, that is, the distance from the tip of the toe to the root of the toe. The range of A is 21 ~ 26 mm, and B is the width of the root of the toe, which is 6 ~ 7 mm. Therefore, the range of A/B is about 3 ~ 4.3.

3.2. Similarity Analysis Established on the Fuzzy Algorithm. In order to analyze the similarity between the rotary tiller and the badger's claw toe, the similarity theory in the fuzzy evaluation standard is cited for verification. The similarity between the biological prototype and engineering structure is documented as given by equation (1), and the value range of Q is $(0 < < 1)$. This means that the greater the similarity, the closer the similarity between them, and vice versa [16]. The similarity element is recorded as the similarity characteristic points amongst the engineering structures and the bionic structure prototypes are documented, and subsequently, the similarity element is striking at every characteristic point. Therefore, the similarity can be mathematically illustrated by the following equation:

Figure 1: The badger claw toe.

$$Q = \sum_{i-1}^{n} (\beta_1 q(u_1) + \beta_2 q(u_2) + \cdots + \beta_n q(u_n)) = \sum_{i-1}^{n} \beta_i q(u_i), \quad (1)$$

where Q characterizes the similarity such that $0 < Q < 1$ is the similarity function of similar elements and denotes the weight coefficient of similar elements such that $0 \le \beta_i \le 1$; $\sum_{i=1}^{n} \beta_i = 1$.

This should be noted that the evaluation factor is composed of many similar elements in different aspects, and the set of each sub-factor of the evaluation factor can be composed of $U = \{u_1 + u_2 + u_3 + u_4 + \cdots + u_n\}$ = {structure, function, load, and constraint ...}. To show the judge the scale/calibration table of the matrix according to Table 1.

Then, the evaluation judgment matrix P can be expressed as follows:

$$P = \begin{bmatrix} u_{11} \cdots u_{12} \cdots u_{1j} \cdots u_{1N} \\ u_{12} \cdots u_{22} \cdots u_{2j} \cdots u_{2N} \\ u_{i1} \cdots u_{i2} \cdots u_{ij} \cdots u_{iN} \\ u_{N1} \cdots u_{N2} \cdots u_{Nj} \cdots u_{NN} \end{bmatrix} = \begin{bmatrix} 1 \cdots 3 \cdots 2 \cdots 3 \\ \frac{1}{3} \cdots 1 \cdots \frac{1}{2} \cdots 1 \\ \frac{1}{3} \cdots 2 \cdots 1 \cdots 2 \\ \frac{1}{2} \cdots \frac{1}{3} \cdots 1 \cdots 1 \end{bmatrix}, \quad (2)$$

$$\lambda_{\max} = \frac{1}{n} \sum_{i-1}^{n} \frac{\sum_{i-1}^{n} \mu_{ij} \beta_j}{\beta_i},$$

where $\lambda_{\max}$ is the maximum eigenvalue of the judgment matrix.

Matrix, >0, = 1, =, = (1, 2, . . ., 10), among i = (1, 2, . . ., N); and j =(1, 2, . . ., N). This can be judged that the eigenvector of matrix P is $\beta = \{\beta_1, \beta_2, \ldots, \beta_N\}^T$, next we collate and calculate $\beta = (0.45, 0.142, 0.267, 0.142)^T$, $\lambda_{\max} = 4.1198$.

Here, $q(u_i)$ is the ratio relationship between the eigenvalues of similar elements of the badger's claw toe structure and the rotary tillage knife structure in the fuzzy similarity system [17].

In this way, we can know that the similarity between them is $q(u_i) = (0.75, 0.6, 0.8, 0.5,)$; finally, the similarity between the badger's claw toe and the rotary tillage knife is

$$Q = 0.45 * 0.75 + 0.142 * 0.6 + 0.267 * 0.8 + 0.142 * 0.5 = 0.7073. \quad (3)$$

Through the analysis and calculation of the fuzzy similarity, it can be seen that the claw toe of the badger is more similar to the rotary tillage knife, so the claw toe of the badger can be used as the prototype for bionic optimization design of the rotary tillage knife [18].

3.3. Extraction and Inspection of Contour Curve. There are generally two ways to extract the characteristic curve of the badger's claws and toes. The first is to extract the samples of the badger's claws and toes, cut the badger's claws and toes, extract the slice samples of the claws and toes, and view the slices with an electron microscope or light microscope. Whether it meets the requirements, we then clean and dry the part and analyze and measure it with image analysis software to extract the curves of the upper and lower surfaces of the badger's claws and toes, so as to carry out bionic optimization design [19].

The second method is to collect the front and side images of the badger by a camera, three-dimensional scanner, or other means, use MATLAB software to ashing the collected images to obtain the pixel curve of the shape of the badger's claw and toe, then extract the original coordinate data from the curve, and get the fitting curve equation of the badger's claw and toe through MATLAB curve fitting. The 3D model construction and 2D drawing are carried out through UG. According to the actual conditions, the second scheme is selected [20]. The basic process is shown in Figure 2.

In MATLAB, the rgb2gray function is used to gray the badger's claw toe image. The built-in function of MATLAB is called to obtain the claw toe image contour, extract the fingertip original data coordinate points, import the x-axis coordinate and y-axis coordinate into two documents respectively, and fit the original coordinates through the MATLAB curve fitting tool. Due to the soft and smooth contour of the badger's claw toe and the convenience of analysis and calculation, it was decided to use a polynomial function equation to fit the obtained image data [21]. As shown in Figures 3and 4, the coordinates of the badger's toe tip are shown.

The fitting equation is obtained by fitting the data in MATLAB: $R^2 = 0.9556$,

$$y = -3.467e - 06 * x^4 + 0.001296 * x^3 - 0.1909 * x^2 + 13.59 * x - 192.5. \quad (4)$$

Table 1: The scale/calibration of a judgment matrix.

Scale	Calibration
1	Indicates that the two factors being compared have the same importance
3	Indicates that one of the two factors being compared is marginally more significant than the other
5	Indicates that one of the two factors being equated is considerably more significant than the other
7	Indicates that one of the two factors being equated is enormously significant relative to the other
9	Indicates that one of the two factors being equated is exceptionally significant relative to the other
2, 4, 6, 8	Indicates that the two factors being equated are between the above two adjacent judgment values

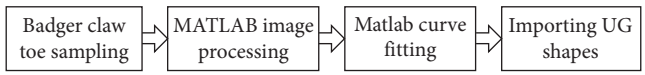


Figure 2: The curve fitting process.

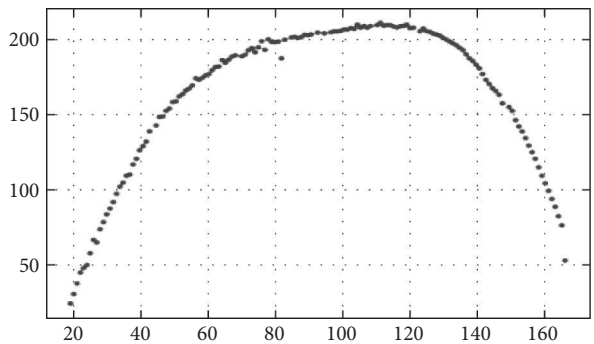


Figure 3: The coordinates of claw toe tip.

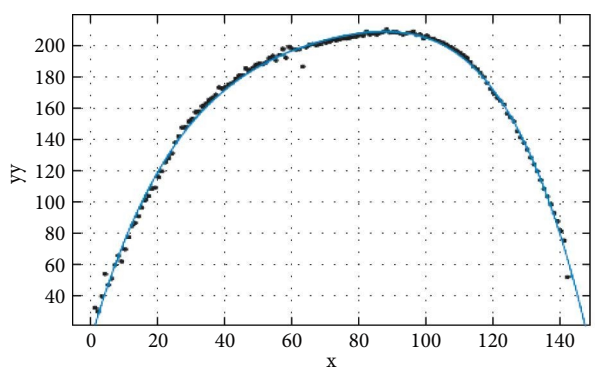


Figure 4: The fitting curve.

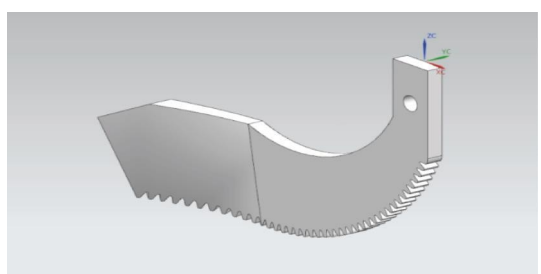


Figure 6: Full arrangement bionic rotary tiller model.

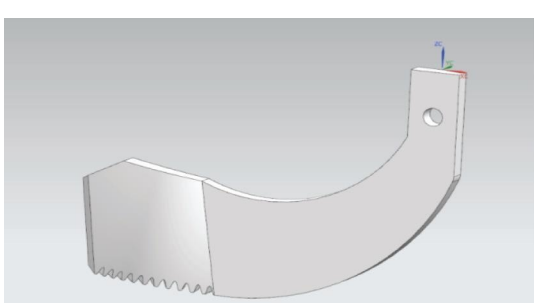


Figure 5: The bionic rotary tiller model with tangent blade arrangement.

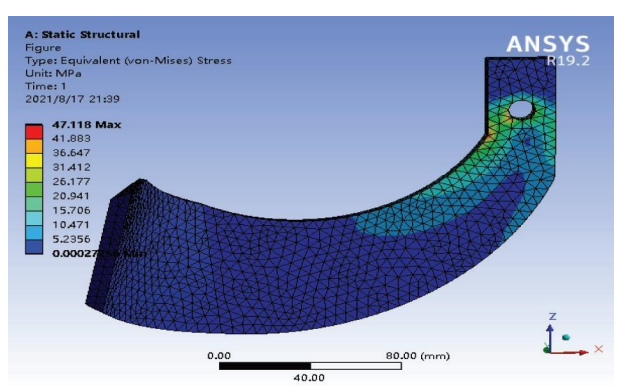


Figure 7: Equivalent stress diagram of the ordinary rotary tiller.

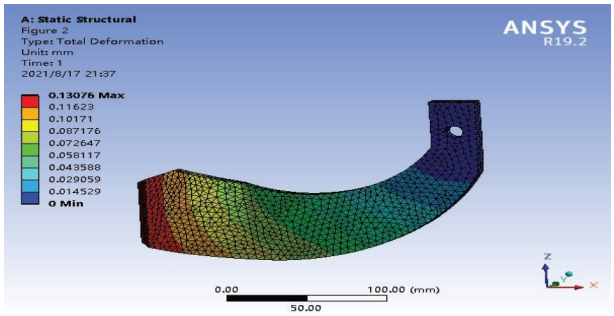
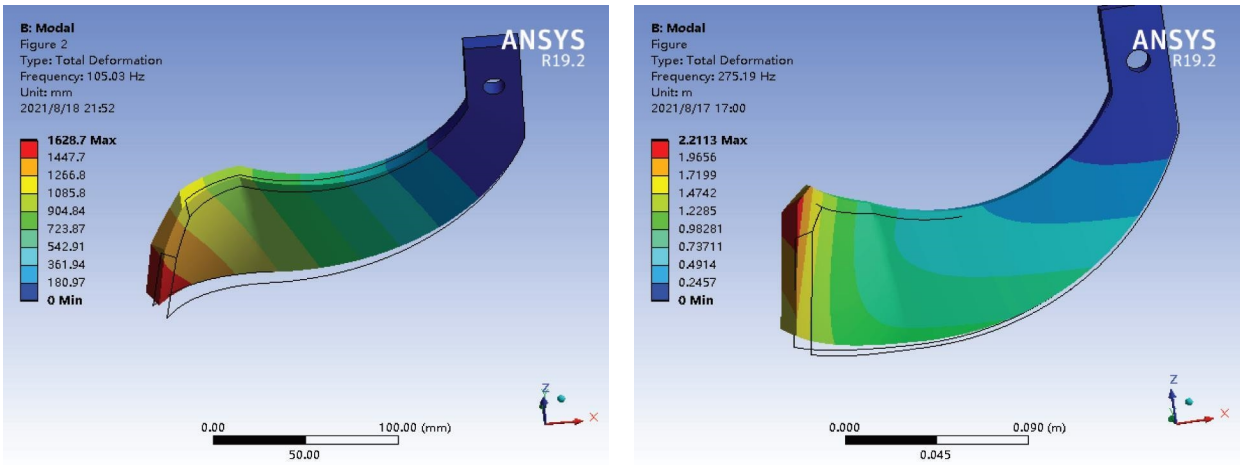
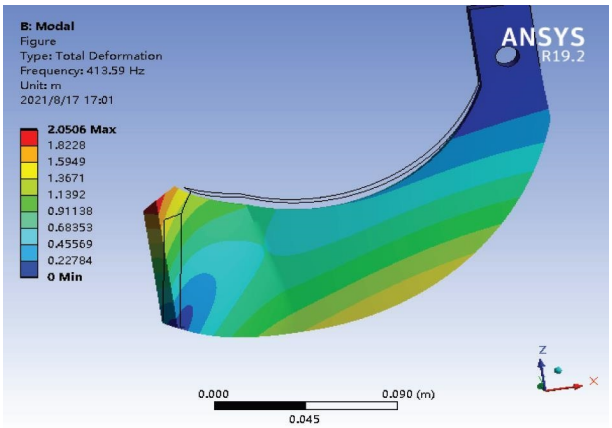


Figure 8: Deformation of the ordinary rotary tilla tillage knife.

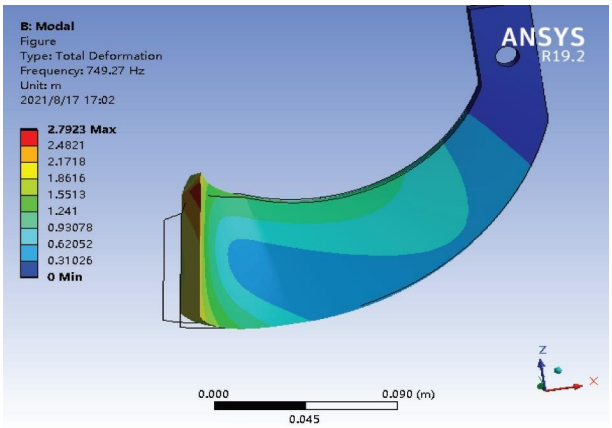


(a)

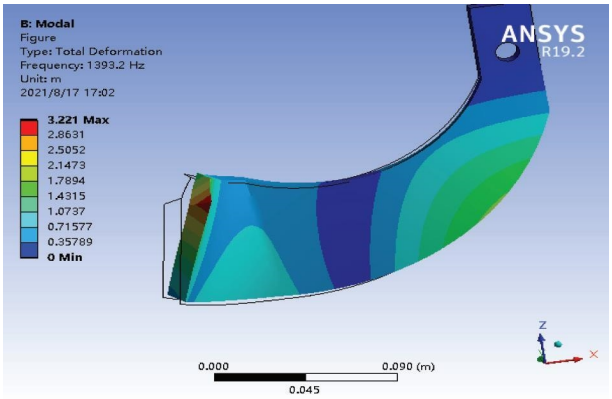
(b)



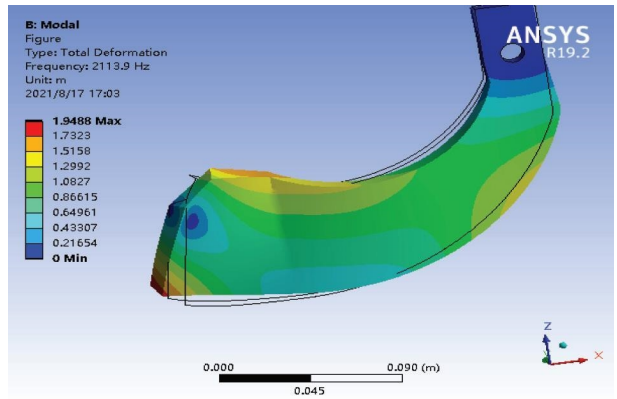
(c)



(d)



(e)



(f)

Figure 9: Sixth-order modal analysis diagram of the ordinary rotary tillage knife (a–f).

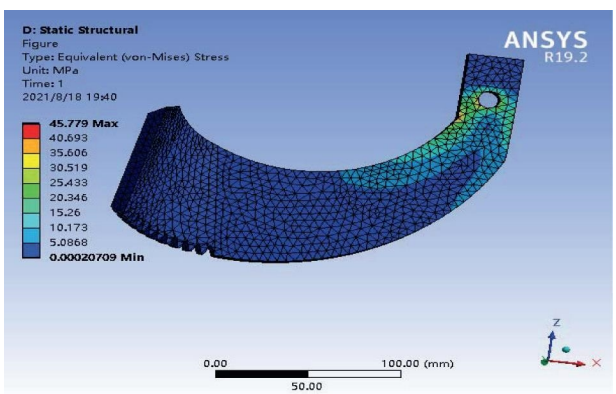


Figure 10: Equivalent stress of tangent blade arrangement.

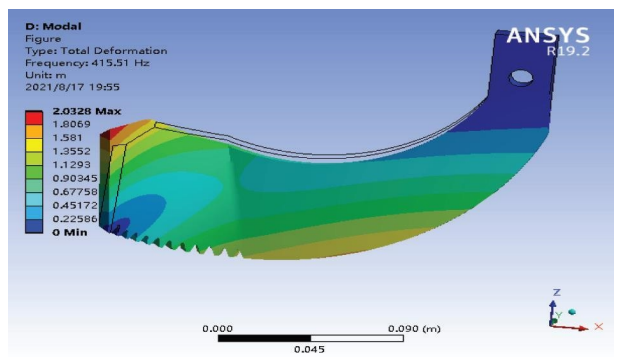


Figure 11: Deformation diagram of tangent blade arrangement.

4. Optimization Analysis of Bionic Rotary Tiller

4.1. Modeling of Bionic Rotary Tiller. Based on the three-dimensional discrete element model experiment established by Fang Huimin et al. [22, 23], the bionic rotary tiller model is constructed. We drew a sketch of the connection between the transition edge and the tangent edge. The regular curve in the UG only supports the parameter equation, so it is necessary to convert the fitting equation into the parameter equation available in the UG.

$$y = -3.467e - 06 * x^4 + 0.001296 * x^3 - 0.1909 * x^2 + 13.59 * x - 192.5. \quad (5)$$

The value range of X is 20 ~ 180. The default parameter of the UG is t, and t is the continuous number of 0 ~ 1 changes. Therefore, the parameter equation of X is

$$x = 20 + 160t,$$
$$yt = -3.467e - 6 * xt\hat{4} + 0.001296 * xt\hat{3} - 0.1909 * xt\hat{2} + 13.95 * xt - 192.5. \quad (6)$$

We wrote the above parameter equation into the UG expression tool, generate the curve through the regular equation, copy it to the sketch plane established by the previous knife surface, move it to the intersection of the tangent edge and the transition edge of the rotary tillage knife, adjust the length and width, the stretching length is 10 mm, evenly arrange the stretched entities on the tangent edge along the curve array, and then subtract the stretched entities and the entities obtained by the array from the rotary tillage knife as a whole. The bionic rotary tiller model with sawteeth arranged along the tangent edge can be obtained. On this basis, after the stretched solid model is arrayed along the side cutting edge, and then the stretched features and array features are subtracted, the bionic rotary tiller with sawtooth is fully arranged along the tangent edge and a side cutting edge can be obtained. The solid models of the two rotary tillers are shown in Figures 5 and 6.

4.2. Finite Element Analysis of the Prototype and the Bionic Rotary Tiller. We applied corresponding constraints and loads to the ordinary rotary blade, respectively, conducted static analysis on the ordinary rotary blade, selected the total deformation and stress distribution as the solution options, and obtained the stress distribution diagram and

deformation diagram of the ordinary rotary blade, as shown in Figures 7 and 8. After the static analysis is completed, drag the modal analysis option into the working area in the Workbench working interface to align the static analysis options. The data such as material and grid division can be shared, and the modal analysis is carried out for the ordinary rotary tillage knife, and the modal analysis does not apply the load, but only constraints. After the analysis, the first to sixth order vibration mode diagrams of the ordinary rotary tillage knife are obtained, as shown in Figure 9, in which the fifth order vibration mode is edge warping, and the other vibration modes are in plane warping.

The stress diagram and deformation diagram of the bionic rotary tiller with tangent blade arrangement are obtained through static analysis, as shown in Figures 10 and 11. After the static analysis is completed, the modal analysis of the bionic rotary tiller with tangent blade arrangement can be carried out on this basis, and the vibration mode diagrams of order 1 ~ 6 are obtained, as shown in Figure 12.

The static analysis of the fully arranged bionic rotary blade is carried out, and the stress diagram and deformation diagram are obtained, as shown in Figures 13 and 14. On the basis of statics, the modal analysis of the fully arranged bionic rotary blade is carried out, and the vibration mode diagrams of order 1 ~ 6 are obtained, as shown in Figure 15.

4.3. Analysis of Bionic Optimization Results of the Rotary Tillage Knife. The practical significance of structural efficiency is studied by reference to materials and is closely related to strength, stiffness, and weight. According to the design criteria and the evaluation basis of structural efficiency, the specific strength and specific stiffness of the rotary tillage knife are calculated. The specific stiffness and strength of the bionic body and the prototype are obtained and analyzed. Specific strength and specific stiffness are also important indicators that reflect the stability of the structure. Through the comparison, we can get the performance of bionic and prototype in strength and stiffness. The greater the specific stiffness and strength value, the better the stiffness and strength performance of the structure.

$$\begin{aligned}
\text{Structural efficiency} &= \frac{(\text{Material ultimate strength/structural stress})x\,(\text{Material elastic modulus/structural deformation})}{\text{Structural weight}},\\
\text{Specific strength and structural efficiency} &= \frac{(\text{Material ultimate strength/structural stress})}{\text{Structural weight}},\\
\text{Specific stiffness structural efficiency} &= \frac{(\text{Material ultimate strength/structural deformation})}{\text{Structural weight}}.
\end{aligned} \tag{7}$$

The data in Tables 2 and 3 are obtained through a calculation using the above formulas.

5. Discussion

Through the research and analysis of the functional and structural characteristics of the badger's claw toe, taking the badger's claw toe as the bionic prototype, the IT245 rotary blade is optimized. The structural characteristics of the badger's claw toe are applied to the blade part of the rotary blade, and the optimized bionic rotary blade is obtained, which improves the sliding cutting effect of the blade, straw, and weeds. Through finite element static analysis and modal analysis, the experimental results show that the weight reduction, stress, and deformation of bionic rotary tillage knives are improved compared with ordinary rotary tillage knives. Through the calculation and analysis of mechanical properties, it is concluded that the specific stiffness, specific strength, and specific structural efficiency of the two bionic rotary tillage knives have also been improved.

(1) It is determined that the working load of the rotary tillage knife is 522N, and the tangent and side cutting edges of the rotary tillage knife are the stress plane. Through the finite element analysis, it is found that the maximum deformation of the ordinary rotary tillage knife is 0.13076 mm, which occurs at the tip of the rotary tillage knife. Towards the knife seat, the deformation gradually decreases, and it is zero near the knife seat. The maximum stress is 47.778 MPa, which is concentrated at the connection with the knife roller.

(2) The working conditions of the two bionic rotary tillage knives are the same as that of the ordinary rotary tillage knife. The analysis results show that the self-weight of the tangent blade arranged bionic rotary tillage knife of the tangent blade sawtooth arranged bionic rotary tillage knife is reduced by 0.0111 kg, 0.94%, and the self-weight of the fully arranged bionic rotary tillage knife is reduced by 3.31%. Furthermore, the strain and stress are reduced by 5.2% and 2.84%, respectively, when compared with an ordinary rotary tillage knife. The specific stiffness, specific strength, and specific structural efficiency are increased by 6.49%, 3.996%, and 11.364%, respectively. The stress of the bionic rotary tiller with full serration is to be observed approximately 7.38% lower than that of the ordinary rotary tiller, and the strain increases slightly, but the increase is small. Within the acceptable range,

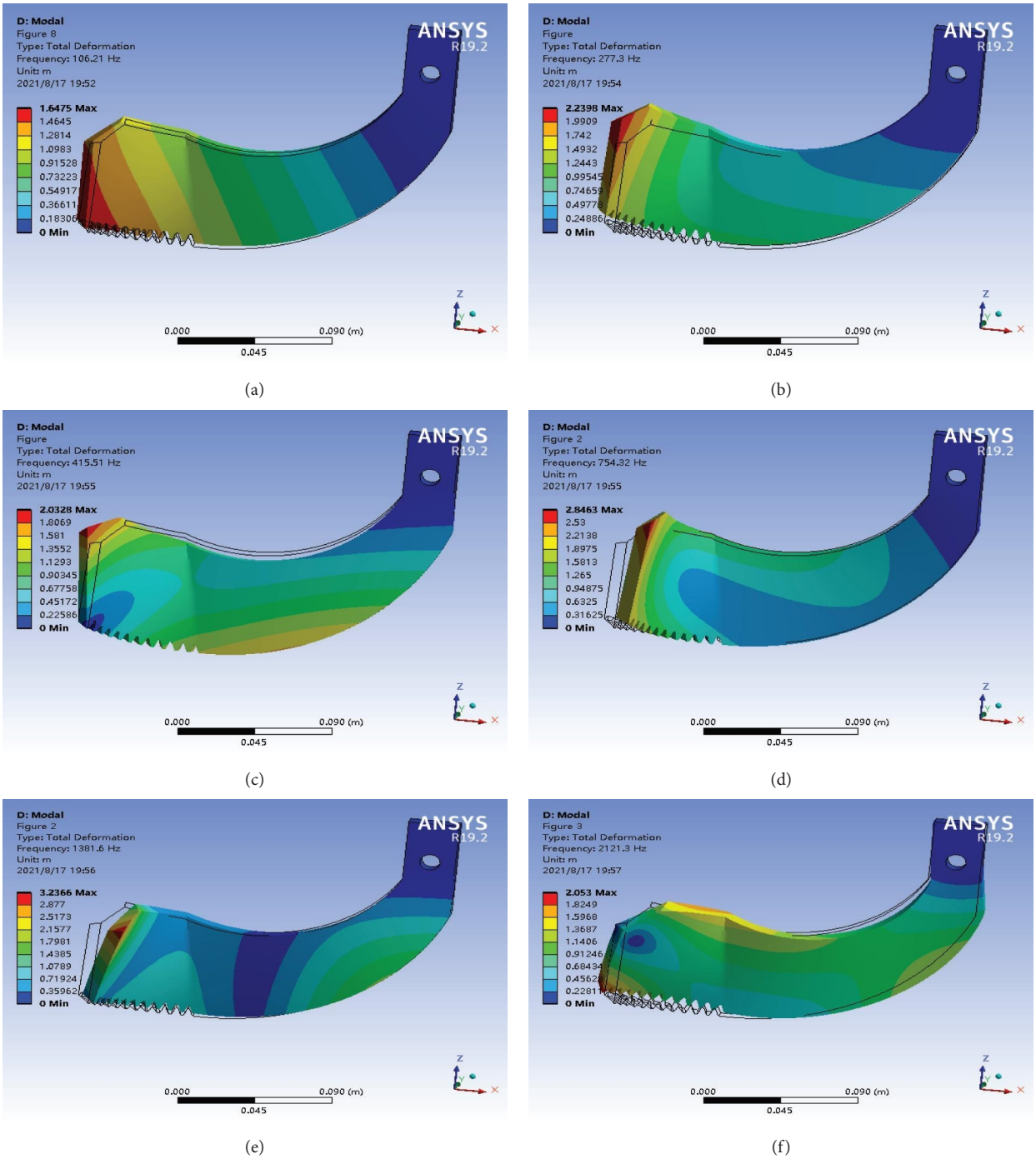


Figure 12: Sixth-order modal analysis diagram of the rotary tillage knife with tangent blade arrangement (a–f).

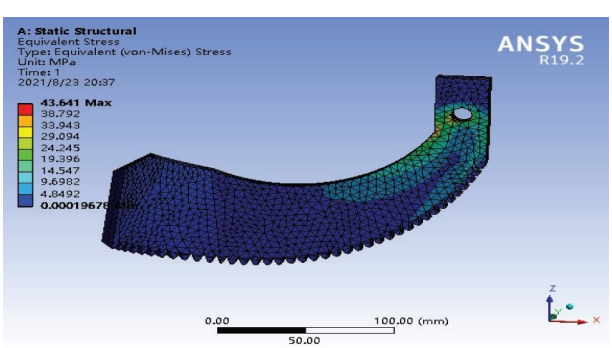


Figure 13: Full arrangement equivalent stress.

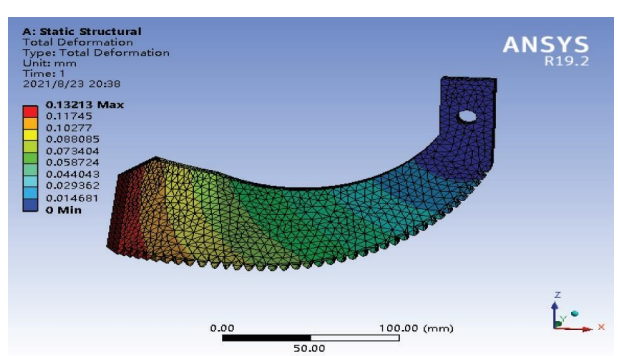


Figure 14: Deformation diagram of full arrangement type.

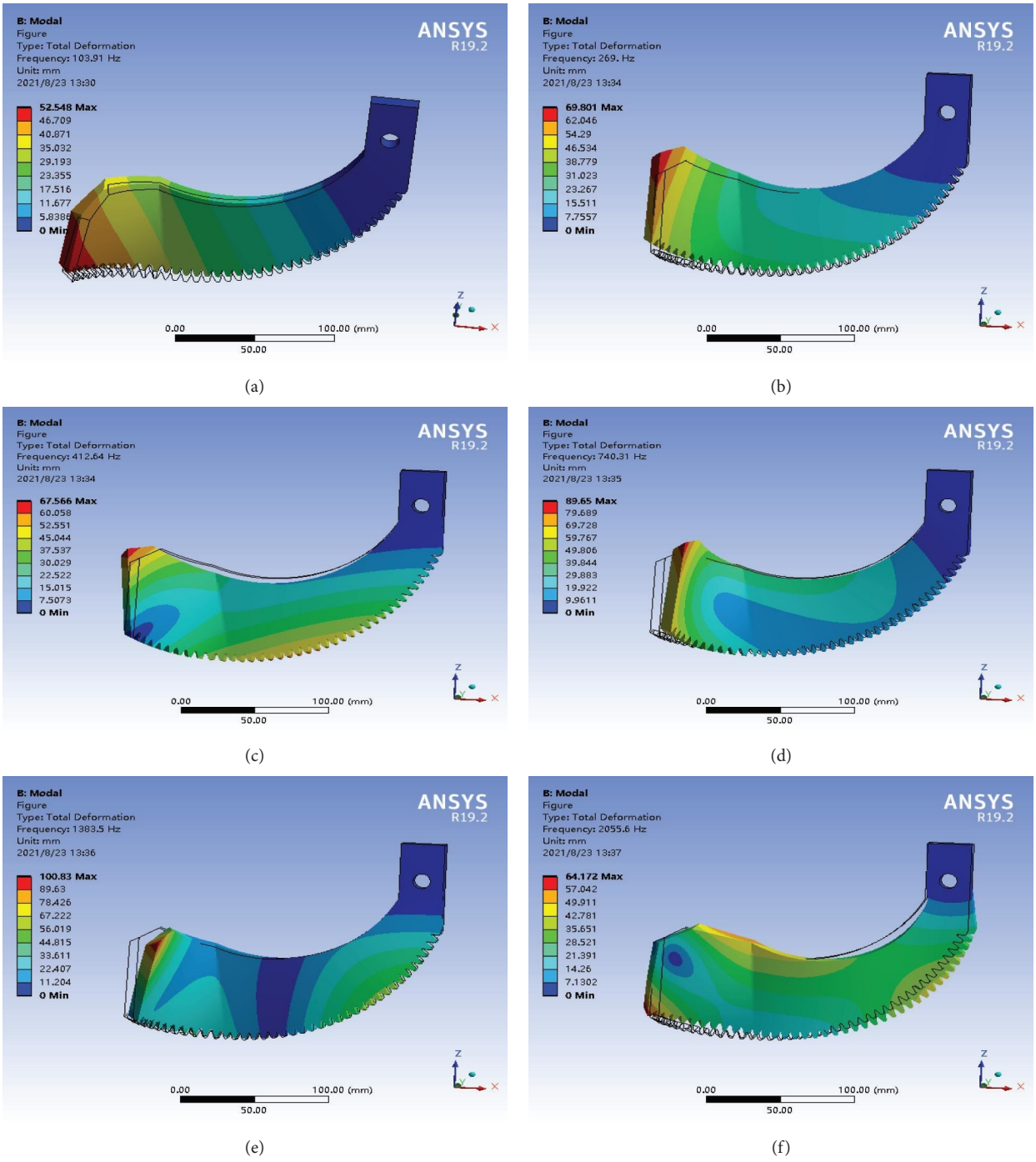


Figure 15: Sixth-order modal analysis diagram of fully arranged bionic rotary tillage knife (a–f).

the specific stiffness, specific strength, and specific structural efficiency are increased by 2.37%, 11.966%, and 14.64%, respectively. The weight of the bionic rotary blade is lower than that of an ordinary rotary blade. A comprehensive comparison shows that the weight, strain, stress, and mechanical properties of the bionic rotary blade are better than those of the ordinary rotary blade.

Table 2: The effectiveness data sheet.

	Rotary blade prototype	Tangent blade arrangement type	Full arrangement type
Structural efficiency	0.00444	0.0049	0.00509
Specific strength and structural efficiency	0.00351	0.00365	0.00393
Specific stiffness structural efficiency	1.264	1.346	1.294

Table 3: The data sheet of optimization results.

	Rotary blade prototype	Tangent blade arrangement type	Full arrangement type	Tangent blade arrangement increased (decreased) (%)	Full array increase (decrease) (%)
Specific strength	0.00351	0.00365	0.00393	3.996	11.966
Specific stiffness	1.264	1.346	1.294	6.49	2.37
Structural efficiency	0.00444	0.0049	0.00509	11.364	14.64
First-order mode (Hz)	105.03	106.21	104.16	1.12	−0.92
Second-order mode (Hz)	275.19	277.3	269.92	0.	−1.92
Third-order mode (Hz)	413.59	415.51	413.91	0.464%	0.08
Fourth-order mode (Hz)	749.27	754.32	741.89	0.674	−0.9
Fifth-order mode (Hz)	1393.2	1381.6	1387.7	−0.833	−0.395
Sixth-order mode (Hz)	2113.9	2121.3	2061.5	0.35	−2.49
Weight (kg)	1.2703	1.2584	1.2282	−0.94	−3.31
Maximum stress (MPa)	47.118	45.779	43.641	−2.84	−7.38
Maximum deformation (mm)	0.13076	0.12397	0.13213	−5.2	1.05

6. Conclusions and Future Work

In order to improve the structural performance of the rotary tillage knife, the badger claw toe was selected as the bionic prototype of the rotary tillage knife, and the bionic optimization design of the rotary tillage knife was carried out. The structural similarity between the badger's claw toe and rotary tiller is 0.7073 by fuzzy algorithm, and the shape goodness of fit between the final mole's claw toe and digging shovel is 0.9556 by MATLAB. Using 3D modeling software NX10.0, we established a three-dimensional model of the rotary tillage knife, used Workbench to carry out static analysis on the three rotary tillage knives, obtained their stress and deformation, obtained their vibration frequency through modal analysis, and summarized and compared the experimental data. The results show that compared with the ordinary rotary tillage knife, the proposed approach has superior results.

We will continue this work while proposing new algorithms for further improvement of the proposed model. In the near future, we intend to implement the particle swarm optimization (PSO) algorithm and other artificial intelligence techniques to solve the mentioned optimization problem. In fact, PSO has the capability to solve multi-objective optimization with a high convergence rate. We also intend to reduce the algorithm computational complexity when the optimization problem is considered a multiobjective.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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Research Article

Dynamic Load Prediction Model of Electric Bus Charging Based on WNN

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Electric buses have a significant penetration rate and high charging frequency and amount. Therefore, their charging load has a momentous influence on the power grid's operation and dispatch. There are important theoretical and practical reasons to study electric bus charging load prediction; however, the intermittent and random charging behavior of buses makes it more difficult to predict charging load predictions, particularly, in real time. To accomplish this, in this paper a WNN (wavelet neural network)-based dynamic load prediction model for charging electric buses is suggested. We start by using distance and shape to group the charging load curve which, in fact, is done with spectral clustering. As a second step, we take into account a wide range of charging load-affecting variables such as temperature and time of day, in order to better train the WNN. Moreover, the charge loads for each cluster are predicted based on model parameters; subsequently, the forecast day's total charging load is then calculated by summing the prediction results for each cluster; finally, the proposed method is validated using a real city data set. In our empirical evaluation, it has been found that, under various indicators, the proposed method's ability to precisely forecast the charging load of electric vehicles has significantly improved. In fact, this allows for better guidance of charging user, planning, and expanding the power grid in consideration of electric vehicle charging loads.

1. Introduction

The USA, the European Union, and the Republic of China all plan to achieve carbon neutrality goals by 2050, indicating that the energy system's transformation and reform are imminent. It has become critical to the transformation of the energy system to rapidly advance the development of electric vehicles and the efficiency with which those vehicles use energy [1, 2]. In light of the widespread adoption of electric vehicles, the planning and operation of the energy system will face new challenges. There is a lot of interest in dispatched energy systems and related topics from both domestic and international researchers [3–5].

As smart grids and intelligent transportation networks come together, the development, application, and research of electric vehicles and their charging infrastructure have all been moving forward at breakneck speed in recent years [6]. A large number of public transportation vehicles are being used in the promotion and application of transportation electrification, including buses. Electric buses have a significant penetration rate and high charging frequency and amount, so their charging load has a momentous influence over the power grid's operation, management, and dispatch. Consequently, the study of electric bus charging load prediction is of great theoretical and practical importance. Buses, on the other hand, depart at set times each day and only stay for a short period of time. As a result, it is more difficult to predict the charging load over time due to the intermittent and random charging behavior of buses [7, 8].

There are a wide range of traditional methods for predicting power loads. New load types, such as distributed generation and electric vehicles, have posed significant challenges to traditional methods of load forecasting because of the widespread availability of these new load types. The distribution of EV (electric vehicle) charging load time is different from the law of electric load because of the

characteristics of different charging methods, travel rules, charging efficiency, charging frequency, etc. As a result, the EV charging load is subject to a greater degree of randomness in time. This is due to a wide range of factors, including weather, road conditions, and operating status [9].

Many AI (artificial intelligence) and learning-based methods have recently been used to predict the amount of electricity needed to charge an electric vehicle, such as shallow networks and deep learning algorithms. A common problem with traditional approaches established on shallow networks is their inability to deal with both learning and convergence at the same time. As an example, deep learning (DL) can characterize complex functions with less parameters thanks to its excellent feature learning ability. In order to predict EV charging load at multiple time scales, some researchers proposed a new DL method utilizing an LSTM, i.e., long short-term memory [9, 10]. The kernel principal component analysis (PCA) and a noninferior sorting genetic algorithm have been proposed as a way to optimize the parameters of convolutional neural networks for EVs. Besides these approaches, numerous methods for predicting the short-term demand have been also suggested in the literature. To predict electric vehicle charging loads, some researchers used the LSTM network model, and experiments have shown that LSTM forecasting is accurate and effective. In addition, the charging load of electric buses is intermittent and temporal because of the short interval between electric buses. As an example, the LSTM neural network model can be used to effectively solve the time scale problem of EV charging and improve the accuracy in load prediction [11–13].

Through comparing electric buses with electric taxis or private cars, we find that their operating times and routes are more predictable. However, depending on how frequently and at what times they run, different routes of electric buses are affected [14]. It is because of the characteristics that the driving laws are quite different, which results in a large difference in charging load. Current electric bus loading forecasting methods focus on charging loads for individual electric bus groups. A clustering algorithm can be used to group EV users with similar characteristics into one cluster, which can then be analyzed to better understand individual differences in order to improve overall load forecasting accuracy. Load clustering allows us to gain a better understanding of the electricity consumption patterns of individual customers by comparing trends and periodicities in the load curve and by accurately measuring similarities in the load's shape and contour over time clustering.

Cluster analysis of user load has been the subject of numerous studies in the last few years. Algorithms for clustering data include the well-known and most widely used K-means, DBSCAN, FCM, and spectral algorithms. To perform a load curve clustering analysis, some researchers have proposed an improved variant of the K-means algorithm that incorporates agglomerative hierarchical clustering [15]. Additionally, some researchers have employed spectral clustering to categorize the load curves in massive data sets using information direct segmental aggregation approximation. In fact, the spectral clustering has advantages in data dimensionality reduction, load classification effectiveness, stability, and computational complexity. Most current clustering methods, on the other hand, rely solely on distance to determine how similar two curves are [16–18].

This paper uses a spectral clustering algorithm based on distance and morphological similarity measures to address the aforementioned issues, and it takes into account the unique characteristics of electric buses when clustering the information. In addition, EV charging load has time series characteristics such as trend and periodicity, as is typical for time series data. Spectral clustering and a WNN are used in this paper to develop a charging load prediction method for electric buses. The foremost and most important contributions of the research conducted in paper could be shortened as follows.

(i) A WNN-based dynamic load prediction model for charging electric buses is suggested.

(ii) By using distance and shape to group the charging load curve, a particular spectral clustering approach is presented.

(iii) We take into account a wide range of charging load-affecting variables such as temperature and time of day in order to better train the WNN.

(iv) Finally, charge loads for each cluster are predicted based on model parameters, and the forecast day's total charging load is then calculated by summing the prediction results for each cluster.

The rest of the paper is arranged as follows. In Section 2, state-of-the-art related work is discussed. The methodology of the research is presented in Section 3. This section also discusses the proposed method in detail. In Section 4, we deliberate experimental settings, parameters, and the attained outcomes. Lastly, we conclude this paper in Section 5 and also deliberate several directions for future consideration.

2. Related Work

As a result of the double carbon target and the related strategic layout, it is becoming increasingly challenging for the distribution network to keep up with the rapid growth and disorderly charging of electric vehicles [1, 3–5]. This is because of the double carbon target. When electric vehicles are allowed to connect to the power grid, there is a risk that the local distribution network will become overloaded, there will be a decline in the power's quality, and there will be a decline in the economy of the grid. It is possible to reduce the negative effects of EV charging on the distribution grid while also creating significant economic and social benefits if new technology can be used to charge electric vehicles in an orderly manner. This is made possible by the fact that electric vehicles can be charged on demand [6, 8].

Therefore, an accurate EV charging load prediction is essential for assessing the impact of disorderly charging on the distribution network, formulating distribution network power planning, and implementing an orderly charging

control Xiao strategy. These three processes are all related to implementing an orderly charging control Xiao strategy [9]. It is important to collect basic load data from a variety of locations, including neighborhoods, office buildings, and commercial areas, as well as massive travel data from users and data on the demand for charging electric vehicles. Because people, vehicles, roads, and piles all affect the charging load of electric vehicles, it is also important to collect data on the demand for charging electric vehicles. Because there are so many different data categories and information dimensions [11], it is possible to derive a variety of widely used methods for predicting the amount of load that will be generated when charging an electric vehicle.

Because electric vehicles are mobile loads, each one's charging characteristics are unique. The charging behavior of each vehicle is difficult to analyze and accurately model. Research approaches for electric vehicle (EV) charging load are currently separated into three different groupings: (i) behavior analysis, (ii) simulation, and (iii) data analysis [8, 13, 14]. The vehicle travel patterns can be analyzed using Markov chains and other models, such as traffic travel matrices, to build models that reflect the travel patterns of vehicles in a specific area and time period. The Monte Carlo simulation and hypercube sampling algorithms are used in simulation analysis [15]. Create a probability model for the charging load of electric vehicles. Analysis of historical data is accomplished by applying statistical methods, machine learning, and cloud computing. For example, some academics have used survey data to estimate the probability distribution of EV charging behavior and then developed an EV charging load model, realizing that the enormous and difficult-to-explain EV charging load can be broken down into an EV charging load probability model with multiple types. A multi-objective optimization model of the charging network is built using the Monte Carlo simulation technique, which simulates the EV charging load and incorporates the random characteristics of the EV charging load. A power supply imbalance can occur when models of EV charging load are limited to just time series or space, as discussed above [16, 17]. But these models do not account for the full spatiotemporal characteristics of EV charging load. As a result, the distribution network must take into account the EV charging load and duality of space and time. To better understand the impact on network reliability, some researchers have constructed a spatiotemporal model of the EV charging load in the full trajectory space. It is important to take into account the spatiotemporal characteristics of EV charging loads when developing an integrated energy system plan [18].

Some researchers have developed a real-time dynamic path stochastic simulation based on travel chains and Markov decision processes [13]. This simulation helps researchers circumvent the issue of having to charge electric vehicles at fixed locations at the same time and more accurately reflects the stochastic nature of the spatial movement of electric vehicles in real time. Other researchers categorize the travel space according to the purpose of the activity, and then they use the travel chain and the Markov primary state transfer matrix to obtain the characteristics of the vehicle's spatial movement [19]. This allows them to determine the spatiotemporal distribution characteristics of the charging load. The abovementioned literature is able to determine how various factors affect the charging load by simulating a user's travel demand and analyzing the results. On the other hand, due to the randomness and complexity of the model, it is difficult to predict [20]. A number of researchers have proposed a model for the prediction of charging demand. This model takes into account the road topology and travel speed in the area surrounding the charging station. Additionally, this model supplies parameter values for the queuing theory model by employing a dynamic traffic flow model as an additional type of probabilistic analysis method [7, 14, 21]. Furthermore, methods comparable to these are, albeit, able to take into consideration the spatial distribution features of charging load and, subsequently, can show a significant part in the design, production, and process of charging stations; however, they have some limitations in manipulating the complete charging load of the system and need to be studied further to overcome these limitations.

The station network configuration layout of integrated energy systems is currently being researched in both the USA and other countries, and it can be roughly divided into two categories. One of these categories is known as a hybrid configuration, and the other is known as a distributed configuration [22]. The first thing that needs to be done is to optimize the equipment selection and capacity of the pipe network layout in the station's energy supply area based on the configuration of the station's energy supply area. Second, it is necessary to simultaneously optimize the capacity selection or network layout of each station in addition to the energy supply station and its supply range in the planned area. The first approach takes into consideration only the planning of the supply side because, in today's world, energy supply and demand scenarios are becoming increasingly complex and diverse. These are the kinds of investigations that fall under the rubric of related studies, and their objectives include not only optimizing the lower-layer structure of a number of energy hubs but also planning the upper-layer expansion of the energy network. Others suggest a two-layer method for optimizing the configuration of the distribution network in order to cut down on the daily operating costs as well as the total cost of multiple optical storage. The concept of a smart integrated energy system has been floated by a number of scholars in the academic community. This system creates an optimization model for the location and sizing of multiple integrated energy stations while taking into account traffic flown; however, it does not take pipeline network optimization in the region into consideration. Others investigate how to optimally plan the pipe network according to the characteristics of the region's load, but they do not take into account how to optimally optimize station selection and capacity within the region's multiple combined cooling, heating, and power systems. When planning the energy station network, the literature cited above takes into account load characteristics; however, EV charging load is not one of those characteristics [13–15].

The ability to accurately forecast short-term electric load has a momentous influence on both the dispatching and planning of electric energy. Accurate load forecasts can help grid dispatching units develop cost-effective and reasonable dispatching plans, and they are also a successful manner to increase the entire utilization and management of power generation equipment and the grid's reliable and safe operation. In addition to this, accurate load forecasts can help improve the grid's reliability and safety. In the past few years, load forecasting has seen an increase in the application of both swarm intelligence algorithms and neural network models. Several researchers came up with the idea of a fruit fly optimization algorithm that was improved as well as a generalized regression neural network. An enhanced method for load forecasting has been developed through the utilization of particle swarm algorithms and RBF neural networks. The accuracy of a BP neural network prediction model was improved with the help of a multi-island genetic algorithm. A new wavelet network-optimized firefly algorithm is a suggestion that has been made by a number of researchers. The overall performance of all of the models described above is superior to the performance of just one model taken on its own [7, 17, 20].

3. Proposed Method

The conceptual framework for this paper's dynamic load prediction method for charging electric buses is depicted in Figure 1. The charging load characteristics of an electric bus are inextricably linked to the vehicle's operating hours as well as the routes that it takes. Following some basic data preprocessing and cleaning, the charging loads are grouped together into a cluster of electric buses with similar patterns of electricity consumption. This is made possible by the fact that the charging loads are clustered based on distance and shape. WNN is utilized in the process of both group training and charging load prediction. In conclusion, the total predicted charging load is obtained by adding up the predictions that were produced by the various WNNs.

The way in which electric buses are operated can have a significant impact on the amount of load that is placed on the various charging lines. If electric buses are grouped solely according to route, then the daily load of each individual bus will not be taken into account, and neither the load volume nor the load curve trend will be able to provide a clearer picture of the daily load. As a consequence of this, clustering can be utilized to take into account the unique ways in which different people carry out their tasks. Before the raw data can be used for clustering, it must first go through the steps of preprocessing and cleaning as outlined below.

Firstly, standardize the bus electric load data using

$$y_i(t) = \frac{x_i(t) - x_{i,\min}}{x_{i,\max} - x_{i,\min}}, \tag{1}$$

where $x_i(t)$ is the load value of load curve i in time t, and $x_{i,\min}$ and $x_{i,\max}$ are the minimum and maximum load values of the load curve i, respectively. Then, we have the load matrix $\mathbf{Y}$ which is given by

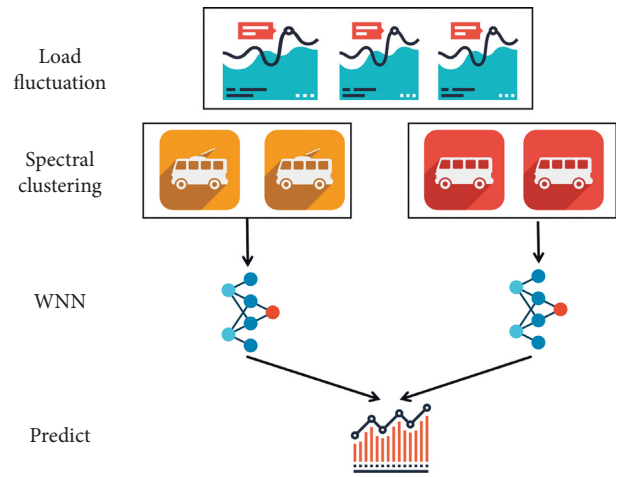

Figure 1: Framework of dynamic load forecasting method for electric bus charging.

$$\mathbf{Y} = \begin{bmatrix} y_{11} & \cdots & y_{1T} \\ \vdots & \ddots & \vdots \\ y_{n1} & \cdots & y_{nT} \end{bmatrix}, \tag{2}$$

where n is the amount of load curves, and we assume that its value is predefined in this work. The spatial characteristics of the charging load are, to a large extent, predetermined, as the working hours and driving routes of buses, as well as the locations of charging stations, are clearly defined. Due to the relatively short amount of time that passes between electric bus departures, it is not possible to maintain continuous long-term charging, as shown in Figure 2. As a direct consequence of this, the charging load curve for electric buses exhibits characteristics of being intermittent.

The spectral graph theory is the theoretical foundation for another type of clustering algorithm called the spectral clustering algorithm. By first constructing an undirected weighted graph based on similarity, the problem of clustering is converted into that of graph partitioning. The weight of the connection that corresponds to each piece of data that has been preprocessed and cleaned is used by the algorithm to determine which data point will serve as the vertex of the graph. If you are going to divide the graph using graph theory, the best way to do it is to maximize the similarity between subgraphs and minimize the similarity between subgraphs. In other words, you want to maximize the amount of overlap. The spectral clustering algorithm is utilized to determine distance and shape similarity, in addition to load curve similarity, in order to classify the data. This allows for the classification of load curves.

The distance between different load curves d_{ij} is given and can be estimated in

$$d_{ij} = \left(\sum\left(y_i(t) - y_j(t)\right)\right). \tag{3}$$

Similar to the load matrix, at this time we can obtain the similarity matrix $\mathbf{D}$ using

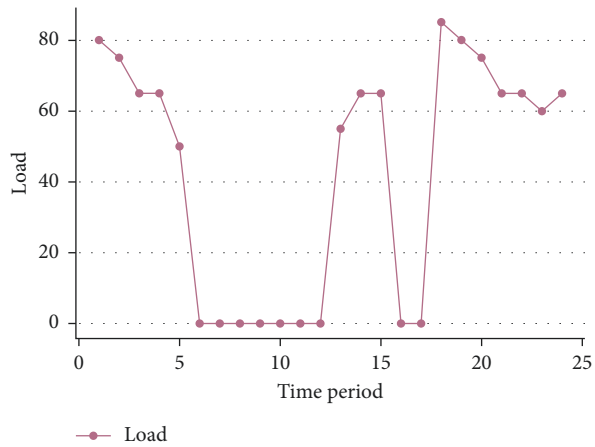

Figure 2: The load during the different time periods in a day.

$$\mathbf{D} = \begin{bmatrix} d_{11} & \cdots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{n1} & \cdots & d_{nn} \end{bmatrix}, \tag{4}$$

$$d_{11}, d_{22}, \ldots, d_{nn} = 0. \tag{5}$$

After obtaining the distance matrix, we also need additional indicators to describe the difference between different load curves. In this paper, the gray correlation coefficient is used to describe the similarity of different load curves. The gray correlation coefficient is illustrated mathematically as given in

$$L_{ij} = \frac{\min_{ij}\left|y_i(t) - y_j(t)\right| + \alpha \max_{ij}\left|y_i(t) - y_j(t)\right|}{\left|y_i(t) - y_j(t)\right| + \alpha \max_{ij}\left|y_i(t) - y_j(t)\right|}, \tag{6}$$

where α is the resolution factor. The calculation method of the degree of correlation is as follows:

$$C_{ij} = \frac{\sum L_{ij}}{T}. \tag{7}$$

Then, we can get the similarity matrix $\mathbf{C}$ using

$$\mathbf{C} = \begin{bmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{n1} & \cdots & c_{nn} \end{bmatrix}. \tag{8}$$

Then, we can run spectral clustering to get classification results.

The genetic algorithm (GA) is an evolutionary technique that determines the optimal parameter assignment for complex calculations by using the genetic and evolutionary properties of natural organisms. This method is named after the computer program that uses this approach, which is called a genetic computer. The GA is a form of random algorithm, in its most basic form. It starts with a population in a set of representative problems that already have solutions and then performs constant evolution in accordance with the evolution mode of the language and the fitness function of the proportion. It is possible to determine, through the processes of GA evolution and mutation crossover, which parameters from a global pool of parameters produce the best results. The fitness function for this paper is as follows in

$$\text{Fit} = \frac{1}{1 + E}, \tag{9}$$

where E is the loss function of the WNN model. This should be noted that when used with a wavelet neural network, the GA improves the speed and accuracy of finding the optimal starting point for the network. This should be noted that the WNN model contains (a) an input layer, (b) a hidden layer, and (c) an output layer. The basic organization of the WNN model is shown in Figure 3.

The wavelet neuron can be articulated mathematically as given in

$$w(x) = \cos(1.75x)\exp\left(-0.5x^2\right). \tag{10}$$

The output of the hidden layer h_i is expressed in

$$h_i = h_i\left(\frac{\sum w_{ij}x_i - b_i}{a_i}\right). \tag{11}$$

The output of the output layer is mathematically expressed in

$$z(m) = \sum w_{im}h(i). \tag{12}$$

Lastly, the predicted value is characterized by E and is estimated using

$$E = \sum(\hat{y}(m) - y(m)). \tag{13}$$

In conclusion, the methodology of this paper is systematized into the succeeding three contiguous sections:

(1) The first concern is the management of data. The data that were acquired are subsequently evaluated and subjected to correlation analysis. Following the removal of factors that did not exhibit a significant correlation with the data on energy consumption, multiple linear regression is carried out on the factors that continue to have an effect, and the data are then split into a training set and a test set.

(2) The second strategy is called GA optimization, and it involves adding the training set and test set to the GA for training, encoding the initial value, setting the fitness function, and then carrying out operations such as selection and crossover mutation, after selecting appropriate network weights and scaling translation scale values. After this, the original value should be replaced in WNN.

(3) At long last, the conclusion of the WNN prediction model is presented. After determining the optimal weights and scaling translation scale values, the next step is to determine whether or not the training process should be stopped based on the maximum number of network model training iterations and the convergence error of the training network. This is done after obtaining the optimal weights. After running the simulation, the results are obtained.

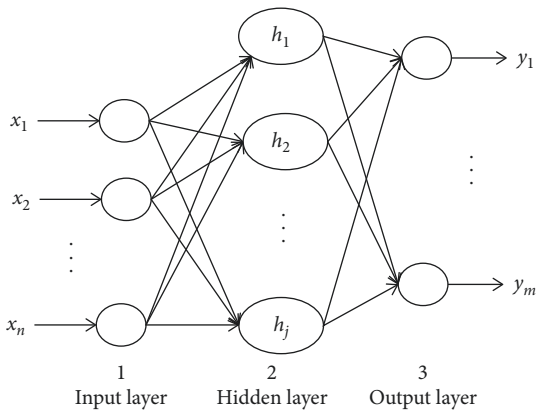

Figure 3: The framework of the WNN model.

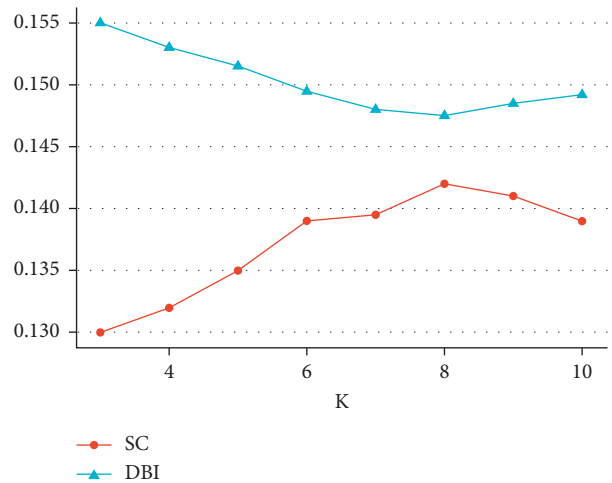

Figure 4: The SC and DBI values and their change with respect to K.

4. Experiments and Results

In the data set that was released in February 2022, and which was used for this investigation, there are a total of 85 electric bus numbers, as well as, other important information of EVs, for instance, transaction volume, charging start time, charging end time, and electric bus numbers. In February 2022, the Meteorological Data Network will be capable of providing complete day-to-day weather data while also taking into account the effects of climate change. The assumption is made that the weather will continue to be the same for the full twenty-four hours; consequently, the charging loads are counted every sixty minutes.

The data from 85 different electric buses' daily charging loads are selected and then clustered using spectral analysis in this paper. The data cover a period of 31 days. SC and DBI are the indicators that are being used for the evaluation, and Figure 4 illustrates the change curve. Figure 4 demonstrates that when K is equal to 8, both the SC index and the DBI index have reached their ideal values. These values are shown to be optimal in the figure. In light of this, the ultimate number of clusters decided upon was eight.

As a result of the cluster analysis performed in the second section, a total of eight distinct clusters of charging load curve classification are obtained, with each cluster containing a unique set of line vehicles and charging load curves originating from a distinct range of dates. The actual value of the charging load that is taking place in each cluster at the given date and time is accumulated as the input of each WNN for the purpose of load training and prediction. A ratio of 8 : 2 is maintained between the training set and the test set for every data type.

As can be seen in Figures 5–7, predictions are made for the first three classes in order to determine how well our method performs in terms of its ability to make predictions. Although it is obvious that the EV charging loads of various classes vary considerably from one another, the daily load distribution rules between classes are relatively consistent, and the level of accuracy with which they can be predicted is high.

Figure 8 illustrates how the loss value shifts during class 3 training as the amount of time spent in the training phase increases. The example used here is class 3. The data

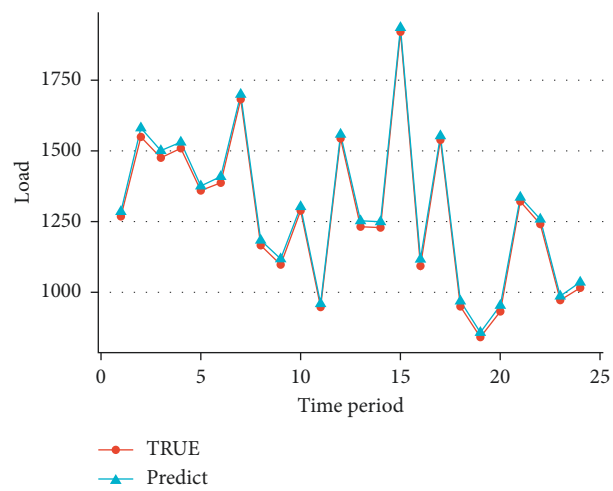

Figure 5: Predict performance of class 1.

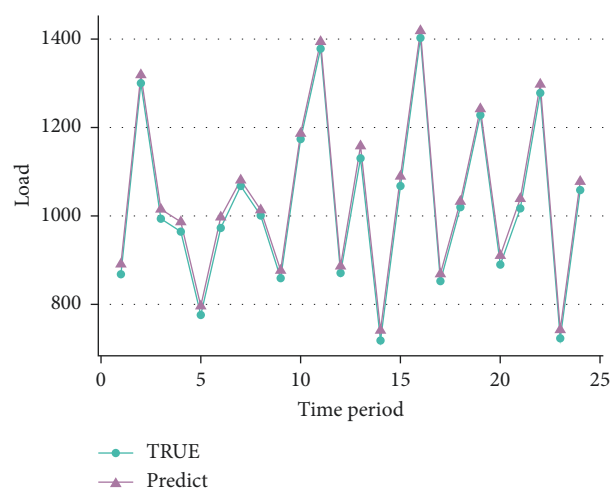

Figure 6: Predict performance of class 2.

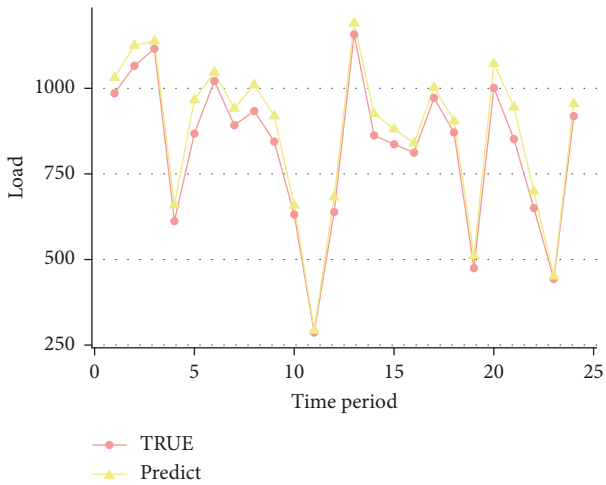

Figure 7: The prediction performance of class 3.

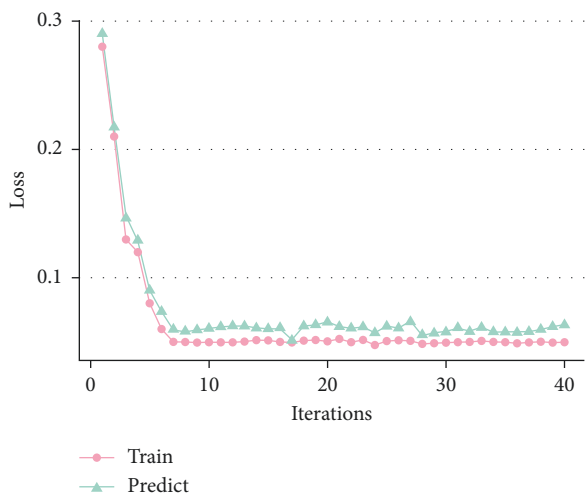

Figure 8: The change curve of the loss during training phase.

presented in the figure demonstrate that the training of the model can converge steadily and has a significant predictive effect.

The process of recharging electric vehicles has a significant impact on the distribution network in two different ways:

(1) The first effect is the immediate one that is caused by centralized charging. An electric vehicle is a piece of electrical equipment that has a high power output and a nonlinear load. A temporary voltage drop that is greater than the norm may occur if a large number of electric vehicles are charged at the same time by the same charging station. If only one phase of the grid's power is used for AC charging, an imbalance in all three phases of the grid's power will result. From this point of view, optimizing the charging load curve in such a way that the user's charging time is spread out and the charging load is constant over time can help alleviate the power quality issue that is caused by the charging of electric vehicles on the power grid.

(2) The second step is to expand the capacity of the distribution network so that it can carry a greater load. The total load that is placed on the distribution network is equal to the addition of the charging load to the load that is considered to be conventional. Charging electric vehicles in a disorganized manner raises the total amount of electricity consumed and widens the power gap between the peak and the valley. In the worst-case scenario, transmission congestion will occur because of the superposition of the charging load curve and the conventional load curve if the two curves have complementary shapes. As the total load curve flattens out, there will be an increase in the percentage of time that distribution network equipment is put to use.

5. Conclusions and Future Work

The electric buses have a significant penetration rate, as well as, a high charging frequency and amount; therefore, the charging load that they produce has a momentous impact over the operation, management, and dispatch of the power grid. Despite the fact that the intermittent and random charging behavior of buses makes it more difficult to predict charging load predictions in real time, there are important theoretical and practical reasons to study electric bus charging load prediction. A WNN-based dynamic load prediction model for charging electric buses is being proposed as a means of achieving this goal. We evaluated the proposed model by utilizing distance and shape in order to group the charging load curve. Spectral clustering is the method that is used to accomplish this. In the second step, we trained the WNN, in a better way, by taking into account a wide range of variables that affect the charging load. These variables include temperature and the time of day, for example. The charge loads for each cluster are predicted based on the model parameters, the forecast day's total charging load was then calculated by adding the prediction results for each cluster, and finally, the proposed method was validated utilizing actual data from the city.

The ability of the proposed method to precisely and exactly forecast the charging load of electric vehicles has been found to have improved under a variety of indicators. This allows for better guidance for charging users as well as for planning and expanding the power grid in consideration of electric vehicle charging loads. In the future, we will focus on how to apply deep clustering and deep neural network-related technologies to electric bus power loads. Moreover, we will also investigate that how deep learning methods along with the attention mechanisms can be used to improve the forecasting accuracy. We can also use the proposed method to predict the traffic flow which is also a related research field, and we intend to use the prediction method for similar purposes. The data gathered from the EVs can be huge, and this would also be essential to reduce its size through integrating a data aggregation approach. We plan to integrate a data reduction mechanism and use the edge model to improve the performance of the system. When

complete day-to-day weather data are available, then we will also take this into account to study the effects of climate change.

Data Availability

The data used to support the findings of this study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

A Situation Awareness Approach for Network Security Using the Fusion Model

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Aiming at the limited learning ability of a single model, the objective of this paper is to investigate situational awareness of the network security which is established on the fusion model. In this paper, a convolutional neural network (CNN) and long short-term memory (LSTM)-based model for situational assessment of the network security condition are provided. According to different fusion methods, the parallel and serial CNN-LSTM fusion models were constructed to evaluate the UNSW-NB15 data set, and both the situation values and levels were obtained. The investigational outcomes illustrate that the evaluation accuracy of the two models can reach up to 85.19% and 92.59%, respectively. A situation prediction model called IPSO-ABiLSTM is suggested and is based on improved particle swarm optimization (IPSO) and attention fusion bidirectional long short-term memory (ABiLSTM). The IPSO has the characteristics of faster convergence speed to optimize the ABiLSTM network parameters and obtain the optimal parameters for situation prediction. The investigational outcomes illustrate that the suggested IPSO-ABiLSTM model has a fitting degree of up to 0.9922, which can effectively achieve the situation prediction in the network security.

1. Introduction

With the prompt growth of 5G networks, the Internet, and smart cities, it is becoming more and more difficult to defend against attacks. Traditional network security facilities include anti-virus software, firewalls, vulnerability scanning, and other facilities, all of which belong to passive protection systems. When each new virus appears, it often takes several days or tens of days for manufacturers to make the passive protection system detect. When it comes to these new viruses, the time difference between them will stance a great threat to the network security, and it is challenging to encounter the network security requirements of the current era. Therefore, the research on this passive protection system has encountered a bottleneck. Being able to evaluate the current situation of the network security in a timely manner, and founded on the present and past security situation, forecast the change tendency of the situation for network security in the next period of time is particularly critical to protect resource security. For that reason, the research on awareness of the network security situation is an urgent need.

The idea of situation awareness and assessment was first suggested by Endsley [1] in 1988. With the goal of improving pilots' air combat capability, the authors constructed a classic three-layer situation awareness model, namely situation: (i) element extraction, (ii) assessment, and (iii) prediction. The application of perception is only in the Air Force combat domain. Subsequently, Bass et al. [2] combined the concept of situational awareness with the cybersecurity, which indicated that the next-generation network intrusion detection system (IDS) should be integrated with the data gathered by multiple short-term network sensors and long-term data to achieve cyberspace situation

awareness. Due to these limitations, the situation awareness in the network security has become a major research hotspot.

Yan et al. [3] constructed a network security threat assessment model by combining the fuzzy concept with the game matrix and demonstrated the evaluation usefulness of the suggested model with an example. Zhang et al. [4] applied convolutional neural networks (CNN) to network security situation prediction. In order to enhance the learning capability of the CNN and reduce the training time of the CNN, a network based on composite convolution structure was suggested. The network security condition is well predicted, but in fact, the effect of the CNN on time series prediction problems needs to be improved. Chen et al. [5] constructed a network security condition prediction prototype which is established on the Gravitational Search Algorithm (GSA) that can help to elevate Support Vector Machine (SVM). To a certain extent, the accuracy of situation forecasting has been improved, but SVM is slightly insufficient in the ability of time series forecasting, and the accuracy of situation prediction needs to be improved. Zhang et al. [6] constructed a network security condition assessment model using a deep self-encoding network, combining unsupervised training and supervised fine-tuning training. The investigational outcomes expressed that the suggested model has high evaluation correctness, but the disadvantage is the data set used. It is too old and needs to be verified on a new dataset. Wang et al. [7] optimized the correction factor of probabilistic neural networks (PNN) through genetic algorithm (GA), which improved the stability and accuracy of the model, but when dealing with small sample data. The disadvantage is that the evaluation takes a relatively long time. Xu et al. [8] proposed a reasoning method to realize network security situational awareness, which is more capable than traditional methods. Zhang et al. [9] combined LSTM and decision tree to achieve network security situation prediction. LSTM was used to predict data sets, and DT to identify attack types. The experiments proved that the situational awareness model proposed in this paper has a high accuracy.Dai et al. [10] constructed a zero-trust method situational awareness model, which is a new theory emerging in recent years and has good application prospects.

To sum up, machine learning models are being used to a greater extent in the arena of network security, in particular for situation awareness, nonetheless, we believe that the learning ability of a distinct model is still limited. Bestowing to the advantages and characteristics of dissimilar models, this paper will conduct in-depth investigation on the two key parts of network security, that is, (i) position assessment, and (ii) prediction. The suggested work is in fact established on the fusion model, so that relevant personnel can have a deeper understanding of the network security condition, and at that moment make reasonable decisions. In terms of the former point (i) for network security, a situation calculation method for the network security is suggested that combines both the classical CNN and LSTM networks. In fact, the CNN and the LSTM are two models with strong learning abilities in deep learning. Similarly, in order to build a model with stronger learning ability and to realize condition assessment in the network security, CNN's convolution and pooling operations can extract important local features, while LSTM has certain advantages in extracting time series data. The model evaluation after the fusion of the two models is that the accuracy can reach 85.19% and 92.59%.

In terms of situation prediction within the context of network security, in this paper, we suggest a forecasting model which is established over the idea of an IPSO, Attention, Fusion, and Bidirectional Long Short Term Memory (IPSO-ABiLSTM) network with improved particle swarm optimization and attention mechanism. This should be noted that the IPSO balances the global and the local searching abilities, speed up the convergence swiftness, and relieves the procedure from deteriorating into the local optimal solution. Furthermore, the BiLSTM approach can combine the before and after conditions, and then integrate the BiLSTM approach with the attention technique to improve the model's attention to key information. The network structure of the ABiLSTM approach is optimized by IPSO algorithm to increase the performance of the suggested model. The investigational outcomes express that associated with other models, in this paper, the forecasting influence of the suggested technique is better than others. The fundamental contributions of this research are listed, in bullets form, as follows:

(i) A network security situation assessment model which is established on the fusion of CNN and LSTM techniques is suggested.

(ii) According to the different fusion methods, the parallel serial CNN-LSTM fusion models were constructed to evaluate the UNSW-NB15 data set, and both the situation values and levels were obtained.

(iii) A condition forecasting model which is grounded on the IPSO, as well as, the ABiLSTM, that is, IPSO-ABiLSTM is suggested.

(iv) The IPSO has the characteristics of faster convergence speed to optimize the ABiLSTM network parameters and obtain the optimal parameters for situation prediction.

The rest of this manuscript is prescribed in the following fashion: in Section 2, we talk over the CNN-LSTM fusion network security condition valuation model. In Section 3, creation of the network security condition indicator system is deliberated. In Section 4, we discuss BiLSTM fusion Attention Mechanism network security situation prediction. In Section 5, experimental analysis and the attained outcomes are discussed in detail. Finally, Section 6 completes this article and delivers future research guidelines and instructions.

2. The CNN-LSTM Fusion Network Security Situation Assessment Model

2.1. The CNN Model. In 1989, LeCun suggested that the LeNet5 convolutional neural network is constructed on gradient descent for reading documents and text recognition [11]. The LeNet5 is the classic structure of modern CNN, and then CNN was widely used to solve multiclass problems, such as image segmentation [12], object recognition [13], and computer vision [14]. The basic structure of the CNN model, in fact, comprises five layers, that is (i) an input layer,

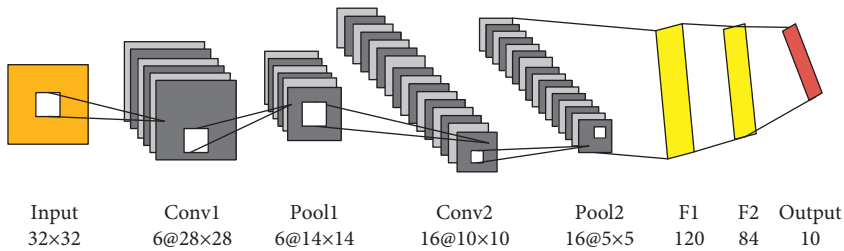

Figure 1: The basic organization of the CNN model.

(ii) a convolutional layer, (iii) a fully connected layer, (iv) a pooling layer, and (v) an output layer. The basic view of the CNN construction and various layers is shown in Figure 1.

We assume, in this paper, that the activation function of each layer of the CNN model embraces the RELU function. The RELU function can answer the main issue of gradient disappearance that may potentially exist in the model training. Furthermore, this may also help to reduce the computation and calculation amount of the model training, over the datasets, and subsequently accelerate the training process of the network model.

2.2. The LSTM Model. The recurrent neural network (RNN) model establishes a connection between neurons in the concealed layer. In other words, that is, the output of a neuron can be used as an input at the next moment, so that the entire network structure has a memory function. For that reason, it can be used as an input and also can be used to deal with the computation timing issues.

After a lot of practice, the RNN has been proved to have the major issue of gradient explosion and gradient disappearance [15]. Therefore, it only has the ability of short-term memory. In order to recover the issues existing in the RNN model, Schmidhuber et al. [16] suggested the LSTM approach. The LSTM model, in fact, improves the working principle of the concealed layer which is used in the RNN model. This should be noted that the LSTM structure comprises forgetting gate, input gate, output gate, memory unit, candidate memory unit, and output value. The specific mathematical equations of a particular LSTM unit at particular time, denoted by t, are as follows from formula (1 to 6):

$$\tilde{c}_t = \tan h\left(W_c \cdot \left[h_{t-1}, x_t\right] + b_c\right), \tag{1}$$

$$i_t = \sigma\left(W_i \cdot \left[h_{t-1}, x_t\right] + b_i\right), \tag{2}$$

$$f_t = \sigma\left(W_f \cdot \left[h_{t-1}, x_t\right] + b_f\right), \tag{3}$$

$$c_t = f_t \otimes c_{t-1} + i_t \otimes \tilde{c}_t, \tag{4}$$

$$o_t = \sigma\left(W_o \cdot \left[h_{t-1}, x_t\right] + b_o\right), \tag{5}$$

$$h_t = o_t \otimes \tan h\left(c_t\right). \tag{6}$$

In equations (1) to (6), W and b are the equivalent weights and biases, $\tan h$ is the tangent activation function, σ is the sigmoid activation function, and $\otimes$ represents the matrix Hadamard product. Note that further discussion and explanation of these equations are given in subsequent sections.

2.3. Implementation of the Situation Assessment for Network Security Founded on the CNN-LSTM Fusion Model. Each neural network model has its own unique advantages. For example, CNN can successfully excerpt local structures and characteristics of data through convolution kernels, but cannot learn the relationship between data time series. The gating mechanism introduced in LSTM can be very good. In case of handling relative time series data, it should be kept in mind that the features in the network attack PCP data that are complex and changeable and have different degrees of importance. There may also be some relationship between the attack data. According to the respective advantages of CNN and LSTM, this paper combines the two neural network models. Each has its own advantages to increase the correctness of network attack recognition.

In fact, the fusion of CNN and LSTM has two methods: serial and parallel. Serial fusion is to extract the input data through CNN features and then go through LSTM. The parallel fusion is that CNN and LSTM approaches usually extract various characteristics from the input data at the same time, and then subsequently connect the extracted features from the two parts. The effects of the two methods may also be different on different problems. In this paper, Serial CNN-LSTM (CNN-LSTM-S) and Parallel CNN-LSTM (CNN-LSTM-P) are constructed, respectively. Two models are used to verify the advantages of the fusion model for situation assessment in the network security. The specific structures of the CNN-LSTM-S and the CNN-LSTM-P models that are used in this paper are revealed in Figures 2 and 3, respectively.

The situation assessment process of the network security system of the CNN-LSTM approach is shown in Figure 4.

3. Construction of the Network Security Condition Indicator System

The realization of situation assessment for the network security first requires the support of the network security condition index system, and at that moment builds a suitable evaluation model. The model evaluates the network security position value as well as its level rendering to the index system of the network security situation. The assessment results can enable relevant personnel to comprehend the present situation of the network security. Whether it is safe

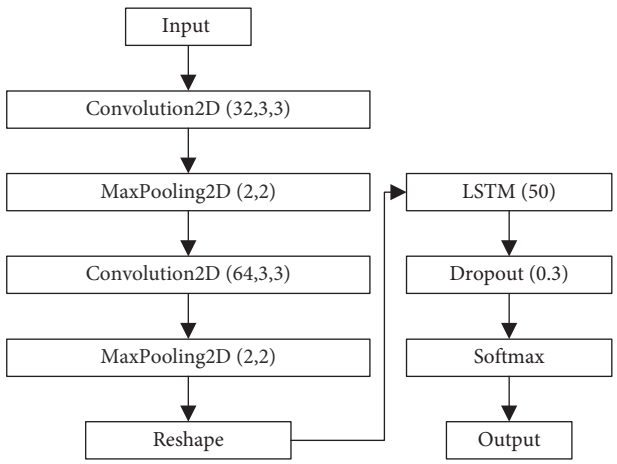

Figure 2: The CNN-LSTM-S model structure.

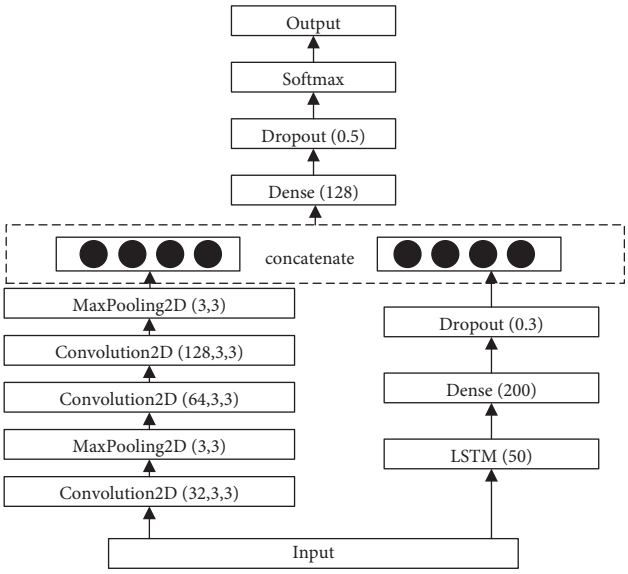

Figure 3: The CNN-LSTM-P model structure.

and what kind of threats exist, make corresponding decisions according to the problems existing in the network.

3.1. Network Security Position Indicator System Established on Attack Impact. In this paper, we establish a situation indicator system for the network security founded on the attack impact. First, fully consider the internal correlation of each main influencing element in the network. Second, the means of network attacks are increasingly complex, diversified, and frequent, and different types of attacks have different impacts on the entire network. Only by improving the detection rate of the network attacks received can the network status be more accurately perceived.

Situation indicator factors include the following:

(1) Attack quantity factor: This factor refers to the number of attack samples received by the network in a certain period of time, represented by N.

(2) Attack threat factor: This factor refers to the degree of threat to network security by different attack types in the network, represented by X.

The calculation formula of the situation value of the period is as follows in formula (7):

$$\begin{aligned} \mathrm{SA}(t) &= f(N, X_i) \\ &= \sum_{i=1}^{N} X_i. \end{aligned} \tag{7}$$

The attack traffic characteristics and methods collected by the commonly used KDD cup99 and NSL-KDD [17, 18] datasets can no longer represent the network conditions of the current era. The novel UNSW-NB15 dataset [19, 20] does not contain the situation value in the UNSW-NB15 dataset, so we adopt the above calculation method to generate the situation value representing the security degree of the network. According to the sequence of each sample collected in UNSW-NB15, 3000 samples are taken as a period. The threat factors corresponding to the attacks in the data set are shown in Table 1 The true situation value of the data set is calculated according to formula (7), and the data set is the situation values of all periods are converted into the [0, 1] interval. After quantification, the UNSW-NB15 test set consists of 27 periods in total. The UNSW-NB15 dataset attack threat factors are presented in Table 1.

3.2. Classification of Network Security Situation Levels. This paper combines the introduction of the straightforward network security condition, along with a simple assessment model, of the National Internet Emergency Center with the actual situation of modern networks. The network security level is divided into four levels, which correspond to different situation value intervals. By dividing the security level, relevant departments can understand more intuitively and quickly the current state of the network. The grading rules are displayed in Table 2.

4. The BiLSTM Fusion Attention Mechanism for Network Security Situation Prediction

4.1. The BiLSTM Model. The BiLSTM model consists of forward and reverse LSTM layers superimposed [21]on each other, and the output is jointly determined by the two LSTM layers, and its structure is shown in Figure 5. This should be noted that the forward layer of the LSTM model can be regarded as a forward calculation from the start time to the last time. On the other way, the reverse layer of the LSTM model can be regarded as a reverse calculation from the last time to the start time. Note that both layers are treated and handled in the same manner. Finally, the model combines the outputs of the model's forward layer and the model's reverse layer, at each moment, in order to get the output of the model at that particular moment.

4.2. The Attention Mechanism. The BiLSTM model has achieved good results in extracting sequence information,

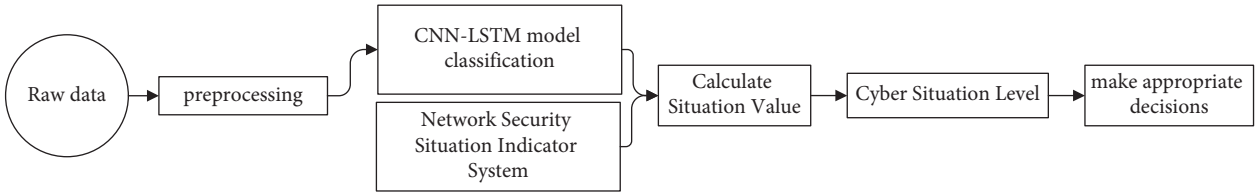

Figure 4: The CNN-LSTM model network security situation assessment process.

Table 1: The threat factors in the UNSW-NB15 dataset attack.

Attack category	Attack threat factor	Attack category	Attack threat factor
Normal	1	Generic	6
Analysis	2	Shellcode	7
Reconnaiss	3	Worms	8
Fuzzers	4	Exploits	9
Dos	5	Backdoor	10

Table 2: The classification of network security levels.

Level	Situation value	Security level	Situation description
1	[0.00–0.25]	Safety	Network is working fine
2	(0.25–0.50]	Low risk	Network is slightly affected
3	(0.50–0.75]	Medium risk	Network is affected
4	(0.75–1.00]	High risk	Network is highly affected

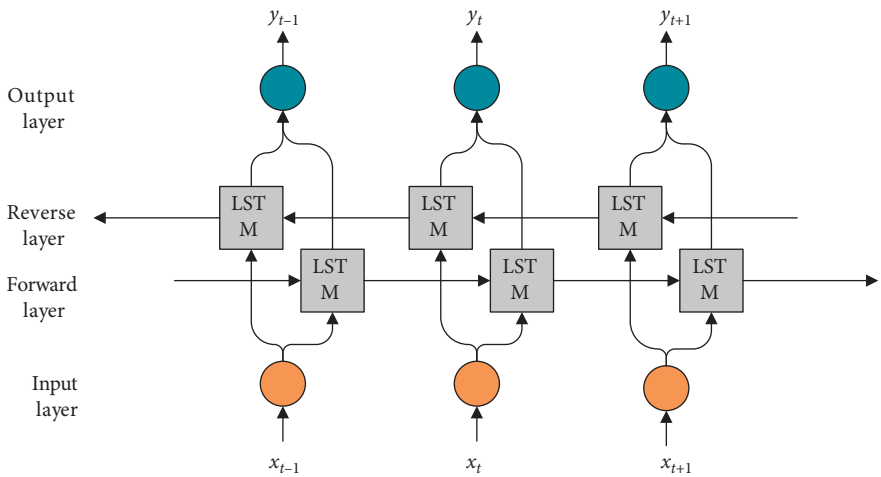

Figure 5: The basic structure of the BiLSTM network.

but the importance of different features in real network conditions is also very different. BiLSTM alone cannot identify the importance of features in sequences.

The attention mechanism is inspired by the working mechanism of human brain. In the process of cognition of the things around us, people will always give priority to what they want to see, thus ignoring some things they do not need. This is evident from the literature that the attention method has been widely implemented and used in many research fields. For example, literatures [22–24] applied the attention mechanism in the arenas of image analysis, computer vision, and natural language processing, and accomplished worthy and noble outcomes. Adding the attention mechanism to BiLSTM can offer more consideration to the influence of different inputs on the output and focus on selective learning of the input to improve the learning effects of the neural network [25]. The basic view of various layers and organization of the ABiLSTM model, constructed in this paper, is exposed in Figure 6.

For the ABiLSTM network, the parameter selection in its structure is crucial to the effect of the model, for instance, the total amount of hidden layers, weights, the quantity of hidden layer units, and the frequency or rate of learning. Many researchers determine these parameters based on

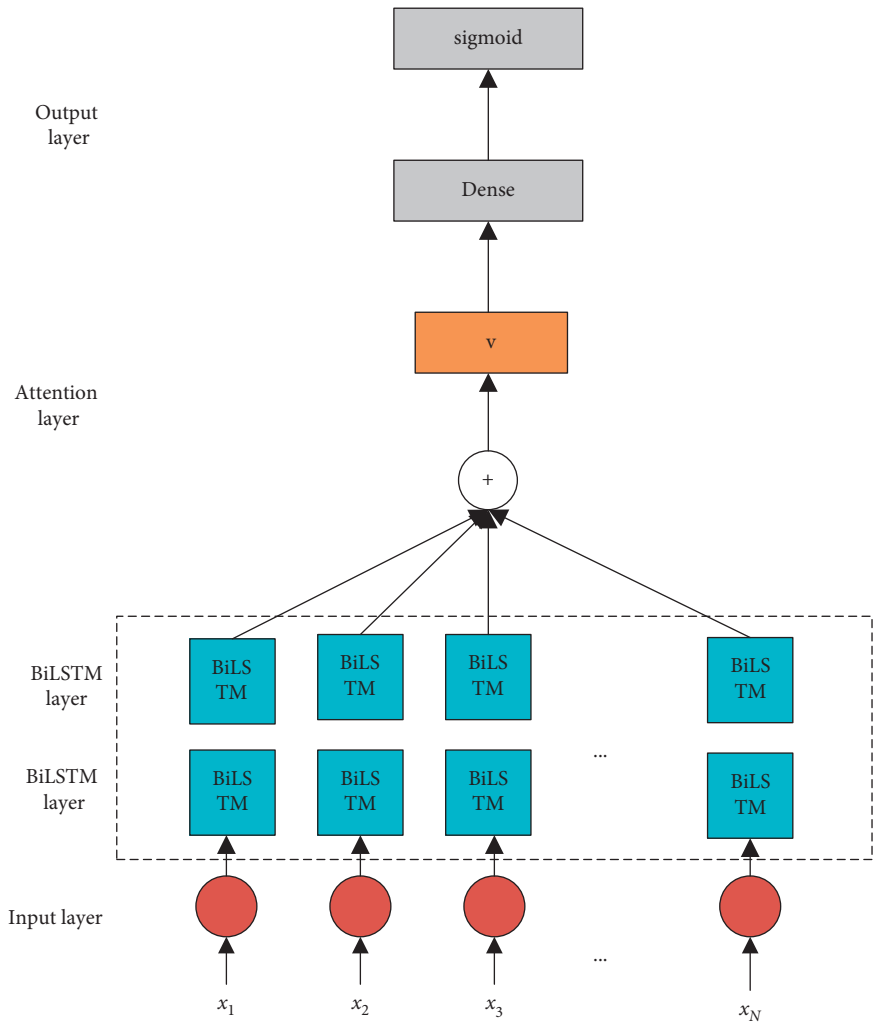

Figure 6: The ABiLSTM model network structure and layers.

experience or trial and error. Parameters which make the robustness and accuracy of the model unreliable. Therefore, this paper selects the well-known and widely used particle swarm optimization procedure, which is simple in principle, low in complexity, fast in convergence speed, and suitable for dealing with real-valued problems, to optimize the structural parameters of the ABiLSTM network.

4.3. The IPSO Method. The PSO method is a bionic swarm optimization procedure suggested by Dr. Eberhart and Dr. Kennedy [26] in the year 1995. The algorithm originated from the investigation on the regular predation comportment of birds. The straightforward knowledge of the PSO method is to treat each answer of the problem as a D-dimensional massless particle. Moreover, every particle has a fitness value which is computed through the fitness function. In the search space, each particle is optimal according to the individual. The location and, more formally, the global optimal location are used to update its own speed and position, and through iterative search, the optimal station of the complete particle swarm is obtained [27].

In each iteration, the particles in the swarm determine the direction and distance of their search by their velocity. The update formulas both for the particle's velocity, as well as, position of the basic particle swarm are as given in equations (8) and (9), respectively:

$$V_{i\,d}^{k+1} = wV_{i\,d}^{k} + c_1 r_1\left(p\,\mathrm{best}_{i\,d}^{k} - X_{i\,d}^{k}\right) + c_2 r_2\left(g\,\mathrm{best}_{g\,d}^{k} - X_{i\,d}^{k}\right), \tag{8}$$

$$X_{i\,d}^{k+1} = X_{i\,d}^{k} + V_{i\,d}^{k+1}. \tag{9}$$

In equations (8) and (9), w exemplifies the inertia weight factor, that is, the ability of the particle to inherit the speed of the previous iteration, and k exemplifies the present iteration number. Furthermore, c_1 and c_2 represents the two acceleration factors, which are used to regulate the guidance of the specific optimal solution and the global optimal solution on the speed of each iteration. Note that the sum is a random number between [0, 1]. Moreover, both the V_{id}^{k} and X_{id}^{k} variables characterize the speed and position of the d-dimensional space of the ith particle in the kth iteration, correspondingly. Finally, the $p\mathrm{best}_{\mathrm{id}}^{k}$ and the $g\mathrm{best}_{g\,d}^{k}$

variable correspondingly characterize the specific optimal position (the former one) and the global optimal position (the latter one) of the dth dimensional space of the ith particle in the kth iteration.

In the PSO algorithm, the factor of inertia weight and the factor of acceleration are very important to the efficiency and results of the PSO algorithm. When the factor of inertia weight and the factor of acceleration are significantly large, then the global optimization ability is better. However, if the factor of inertia weight and the factor of acceleration is small, then the smaller the factor, the better is the local optimization ability. Since the factor of inertia weight and the factor of acceleration coefficient in the traditional particle swarm optimization procedure are stationary, then along with the local optimization capability, the global optimization ability of the procedure is also limited. Furthermore, it is also very trivial and easy to make the algorithm fall into the local minimum value, that is, premature convergence. In view of the limitations of the algorithm, the factor of inertia weight and the factor of acceleration are improved in this paper, so that the change of speed is changed from linear to nonlinear.

The improvement to the inertia weight factor w is mathematically illustrated using (10) as follows:

$$w = -\pi * \arcsin(0.01 * (t - \max\_\text{iter})). \tag{10}$$

The improvements to the acceleration factors are as follows and mathematically illustrated in (11) and (12):

$$c_1 = c_{1\max} - (c_{1\max} - c_{1\min}) * \left(\frac{t}{\max\_\text{iter}}\right) * *2, \tag{11}$$

$$c_2 = c_{2\max} - (c_{2\max} - c_{2\min}) * \left(\frac{t}{\max\_\text{iter}}\right) * *2. \tag{12}$$

In equations (11) and (12), max_iter exemplifies the maximum amount of iterations, and t symbolizes the present numeral figure of iterations. Similarly, the two variables $c_{2\max}$ and $c_{2\min}$ characterizes the maximum and minimum values for the factors of acceleration, in the previous iteration, correspondingly. It should be noted that the two variables denoted by $c_{1\max}$ and $c_{1\min}$ exemplifies the maximum and minimum values for the factor of acceleration coefficient, after the update, correspondingly.

4.4. Implementation of the Situation Assessment in the Network Security Constructed on the Suggested IPSO-ABiLSTM Model. The process for situation prediction in the network security using the suggested IPSO-ABiLSTM model is given away in Figure 7.

5. Experimental Analysis

The computer and its hardware specification that was used for the tests to evaluate the method suggested in this paper, which is as follows: the system model was Intel(R) Core(TM) i5-8250U CPU @ 1.60 GHz CPU and having 1 TB mechanical hard disk, 12 GB memory, 64 bit Windows operating system, and NVIDIA GeForce GT 730 graphics card. The experimental environment was Tensorflow2.2.0 and Keras2.3.1 framework based on *Python* 3.6 environments, and the IDE was PyCharm2020.2.3. We used machine learning libraries such as Sklearn, integrated with Matplotlib in order to assist in completing experiments.

5.1. Experimental Results Analysis for the Situation Assessment Model

5.1.1. Experiment Evaluation Index. In order to authenticate the model's performance that is suggested in this paper, we choose the commonly used evaluation indexes and metrics in the field of network intrusion detection, prediction, and machine learning, that is, (i) Accuracy, (ii) Precision, (iii) Recall, and (iv) F1 score. Using these indexes, we compare the performance of suggested model with other state-of-the-art techniques and closest rivals.

(1) *Accuracy* is represented by *Acc* and is defined as the proportion of data samples that were appropriately categorized or predicted by the suggested approach to the entire quantity of data samples.

(2) *Precision* is represented by P and is defined as the proportion of ordinary data samples that were properly categorized or predicted by the suggested approach to entire data samples categorized as positive.

(3) *Recall* is represented by R and defined as the proportion of normal data samples that were acceptably categorized or predicted by the suggested approach to the complete amount of true normal samples.

(4) *F1 score* is represented by $F1 - \text{score}$, is in fact denotes the harmonic average of accuracy (precision), and the recall rate. Taking precision recall into consideration, the higher the F1 score, the more balanced the precision and recall, and the improved or higher the overall performance of the model.

The above four evaluation metrics are calculated using formulas (13)–(16) which are given as follows:

$$\text{Acc} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}, \tag{13}$$

$$P = \frac{\text{TP}}{\text{TP} + \text{FP}}, \tag{14}$$

$$R = \frac{\text{TP}}{\text{TP} + \text{FN}}, \tag{15}$$

$$F1 - \text{socre} = \frac{2 * P * P}{P + R}. \tag{16}$$

In equations (13)–(16), TP refers to the quantity of normal data samples appropriately classified, and TN represents the amount of abnormal data samples acceptably classified by a particular model. Furthermore, FP represents the abnormal data samples that were in fact erroneously classified, and FN represents the inappropriate and incorrect classification by the model in terms of the normal data sample.

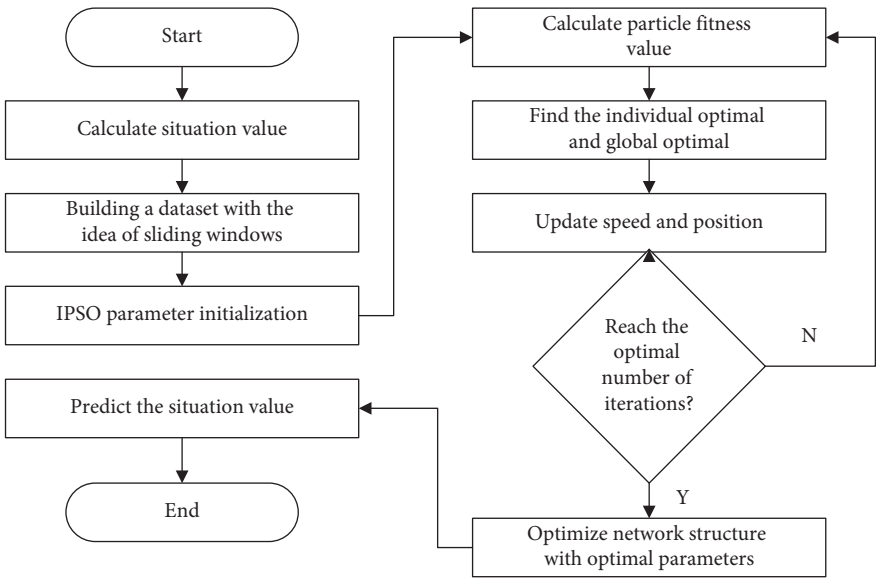

Figure 7: The IPSO-ABiLSTM prediction process.

5.1.2. Two Classification Experimental Analysis. In the first experiment, the labels of the dataset are distributed into two groupings: (i) normal, and (ii) abnormal. In order to prove that the suggested CNN-LSTM fusion technique has a stronger learning ability, it is compared with a single model. The evaluation index results of each model are given away in Table 3.

By observing Table 3, it can be comprehended that the correctness, as well as, the recall rate of the CNN-LSTM-P and CNN-LSTM-S methods that were suggested above are significantly higher than the closest rivals, that is, the four single models, ranking first and second, respectively. At the same time, the precision rate is also second only to CNN. Considering the contradiction among the accuracy rate and the recall rate, we further investigated and observed the index of the F1 score. The F1 score of the two models suggested in this paper are 88.36% and 84.35%, respectively, ranking first and second. Second place, and well above the F1 score of the other models.

Model time is also a very realistic metric. In the same experimental environment, the detection time of the two models suggested in this paper is shown in Table 4. This can be comprehended from the observations and assessment that the two-classification time of the CNN-LSTM-P technique is approximately 79.41s less than that of the CNN-LSTM-S method. Moreover, we also noted that the attack recognition effectiveness of the CNN-LSTM-P model is significantly higher than the CNN-LSTM-S method.

5.1.3. Ten Classification Experimental Analysis. The second experiment is a ten-category experiment. The model that is suggested in this paper is matched with a single model. The evaluation index outcomes of various models and methods are shown in Table 5.

By observing Table 5, this can be easily comprehended that the correctness, exactness, recall, and the F1 score index of the suggested CNN-LSTM-P and CNN-LSTM-S models are meaningfully superior than the other four single methods. Among them, the correctness rate, recall rate, and F1 score of the CNN-LSTM-S method are the best values among all compared models. The CNN-LSTM-P model accuracy, recall, and F1 score are all suboptimal values for all models, and the precision is the optimal value. Combining the experimental results of two-class and ten-class, this could be observed and well understood that the learning performance of the suggested model has been meaningfully enriched as matched with the traditional single methods.

Table 3: Assessment of the two classification results of each model.

Model	Acc (%)	P (%)	R (%)	F1 score (%)
CNN-LSTM-P	89.71	95.22	82.43	88.36
CNN-LSTM-S	87.32	97.53	74.33	84.35
CNN	85.63	98.55	69.03	81.19
LSTM	82.13	92.03	61.47	75.56
BiLSTM	83.55	94.02	67.70	78.72
GRU	82.56	96.66	63.39	76.57

In the subsequent discussion, we further investigate and analyze the performance of the suggested model from the perspective of time consumption. Under the same experimental environment, the detection time of the two models suggested in this paper is shown in Table 6. The ten-class time-consuming of the CNN-LSTM-P method is approximately 93.15s less than that of the CNN-LSTM-S method. Furthermore, the CNN-LSTM-S method has relatively lower performance. The detection efficiency of the CNN-LSTM-P model is higher than all the closest rivals. Combining the time-consuming comparison of the two classifications methods, it can be understood that the suggested CNN-LSTM-P method is always less time-consuming than the CNN-LSTM-S method, and is more efficient while maintaining accuracy.

Table 4: Time-consuming comparison of two classifications.

Model	Training duration (seconds)	Testing duration (seconds)	Total time (s)
CNN-LSTM-P	585.79	10.26	596.05
CNN-LSTM-S	665.31	10.15	675.46

Table 5: Assessment of ten classification results of each model.

Model	Acc/%	P/%	R/%	$F_{1\text{-score}}$/%
CNN-LSTM-P	77.15	96.78	78.60	86.75
CNN-LSTM-S	78.47	95.38	82.94	88.72
CNN	75.27	95.56	74.49	83.72
LSTM	72.61	95.06	69.87	80.54
BILSTM	72.71	93.12	71.16	80.67
GRU	72.73	95.48	69.28	80.29

Table 6: Time-consuming comparison of 10 categories.

Model	Training duration (seconds)	Testing duration (seconds)	Total time(s)
CNN-LSTM-P	587.23	10.59	597.82
CNN-LSTM-S	680.73	10.24	690.97

5.1.4. Analysis of Network Security Situation Assessment Results. The training results of the suggested CNN-LSTM-P method, as well as, the CNN-LSTM-S model are quantified according to Formula (7). In this way, we are able to acquire the situation value of each and every period, and the network security level corresponding to each period is divided according to Table 2, and the security level of 27 periods is obtained. The comparison between the network security situation assessment outcomes of the suggested model and the real situation level is presented in Figure 8.

Observing Figure 8, this could be easily understood that the suggested CNN-LSTM-S method has errors in only two periods. In the fourth period, the "high risk" error is evaluated as "medium risk," and in the eighth period, the "medium risk" error is evaluated as "Low risk." In fact, through analyzing this, this could be even more easy to found that the suggested CNN-LSTM-S method has a weak ability to identify attacks with a high degree of threat and tends to identify attacks with a relatively low degree of threat. The evaluation grades for the remaining periods matched the true grades exactly. This should be noted that the CNN-LSTM-P model has more mis-evaluation periods, which are in 8, 23, 25, and 27 periods, respectively.

In the 27 evaluation periods, the number of correct evaluations and the correct rate of the model in this paper are shown in Table 7.

By observing Table 7, the number of correct samples for the evaluation of the CNN-LSTM-P model is 23, and the correct rate is approximately 85.19%. Similarly, the number of correct samples for the evaluation of the CNN-LSTM-S model is 25, and the correct rate reaches 92.59%. Although, the model still has many shortcomings, it is enough to prove that the suggested model can be precisely implemented on situation assessment in the network security.

5.2. Analysis of the Results of the Situation Prediction Experiment

5.2.1. Number of BiLSTM Input and Output Neurons. According to the sliding window idea, the situation value data set used for prediction is divided according to its time sequence, and the organization of the divided data set is presented in Table 8.

In the second row of Table 8, $m+1$ represents the size of the sliding window, and the amount of neurons in the input layer of the LSTM model is equivalent to m during prediction. As the experiment in this paper is a single-value prediction, we assume that the amount of neurons in the output layer is 1.

5.2.2. Experiment Evaluation Index. In order to confirm the predictive capability of numerous methods that are used in this paper, the Coefficient of Determination (R^2) and the Mean Absolute Percentage Error (MAPE) were selected as the model evaluation indicators. The calculation formulas for the MAPE and R^2 metrics are as given in (17) and (18), respectively.

$$\text{MAPE} = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{\widehat{y}_i - y_i}{y_i}\right| \times 100\%, \tag{17}$$

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\left(y_i - \widehat{y}_i\right)^2}{\sum_{i=1}^{N}\left(y_i - \overline{y}\right)^2}. \tag{18}$$

In equations (17) and (18), the variable y_i exemplifies the true situation value, while the variable $\widehat{y}_i$ symbolizes the forecasted situation value. Furthermore, N characterizes the quantity of samples, while the variable $\overline{y}$ signifies the

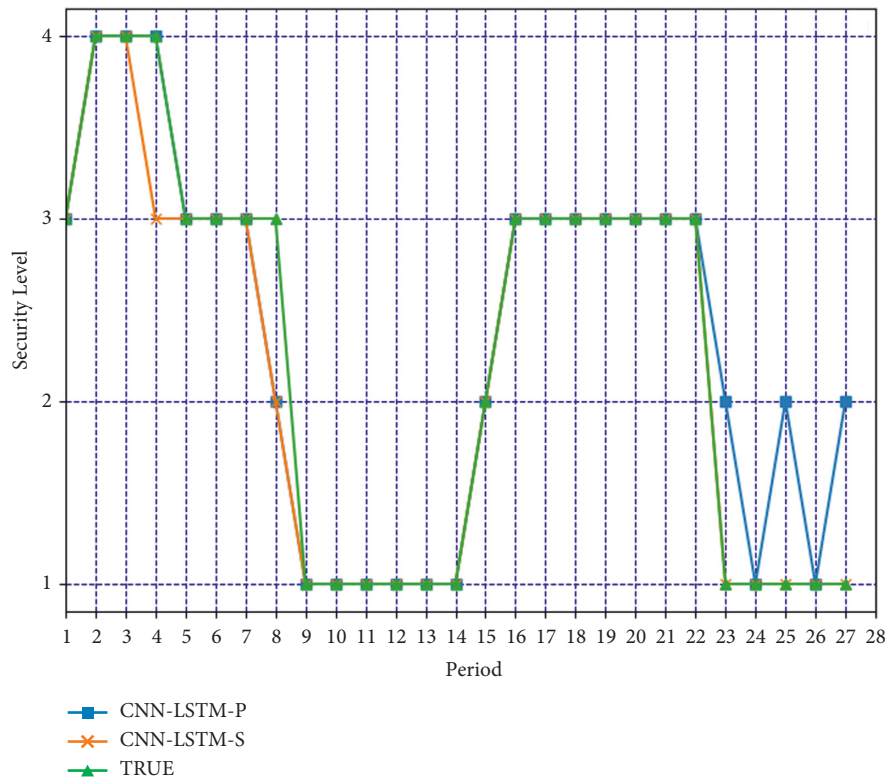

Figure 8: Evaluation outcomes for situation assessment in network security.

Table 7: Assessment of correct rates of network security situation assessment.

Model	Correct number	Correct rate (%)
CNN-LSTM-P	23	85.19
CNN-LSTM-S	25	92.59

Table 8: Data set structure for prediction.

Number	Input	Output
1	$(x_1, x_2, \ldots, x_m)$	x_{m+1}
2	$(x_2, x_3, \ldots, x_{m+1})$	x_{m+2}
...	...	...
$n-m$	$(x_{n-m}, x_{n-m+1}, \ldots, x_{n-1})$	x_n

statistical mean value of the true situation value. This should be noted that the lesser the mean percentage error, the better and superior will be the model performance and vice versa. Furthermore, the coefficient of determination of the goodness of fit is between the range of [0, 1]. Note that, for the goodness of the fit, the nearer its value to 1, the superior will be the model fitting and vice versa.

5.2.3. Experimental Analysis of Situation Prediction for Network Security. In order to confirm the specific prediction effect of each model, this paper provides the prediction outcomes of every method when the window size is 2, 3, and 4, as shown in Figures 9–11. A window of 3 means that the situation values of the previous two time periods are selected to predict the situation values of the next time period.

In fact, this can be comprehended from Figures 9 to 11 that when the window is 2, the IPSO-ABiLSTM suggested in this paper almost completely fits the real situation value, while the other three models all have a certain degree of fitting deviation. The window size is 3 and 4. In the first three time periods, the IPSO-ABiLSTM prediction effect suggested in this paper is not ideal, but it is almost completely fitted in the later time periods. Overall, the fit of IPSO-ABiLSTM is still better than the other three models. The evaluation indicators of each model in different windows are presented in Table 9.

From the outcomes of various methods and their analysis, as given away in Table 9, the following fundamental conclusions can be drawn:

(1) When the window value is 2, the MAPE value of the suggested IPSO-ABiLSTM method is 0.0223, 0.1583, and 0.2278 lower than that of PSO-BiLSTM, PSO-LSTM, and BiLSTM, respectively, and the fitting coefficient R^2 is compared with the other three models. They were 0.0115, 0.1203, and 0.2277 higher, respectively. In fact, this confirms that the performance of the suggested approach is superior than the other three methods when the window value is 2.

(2) When the window value is 3, the MAPE value of the suggested IPSO-ABiLSTM approach is 0.0878, 0.0968, and 0.0533 lower than that of PSO-BiLSTM, PSO-LSTM, and BiLSTM, respectively, and the

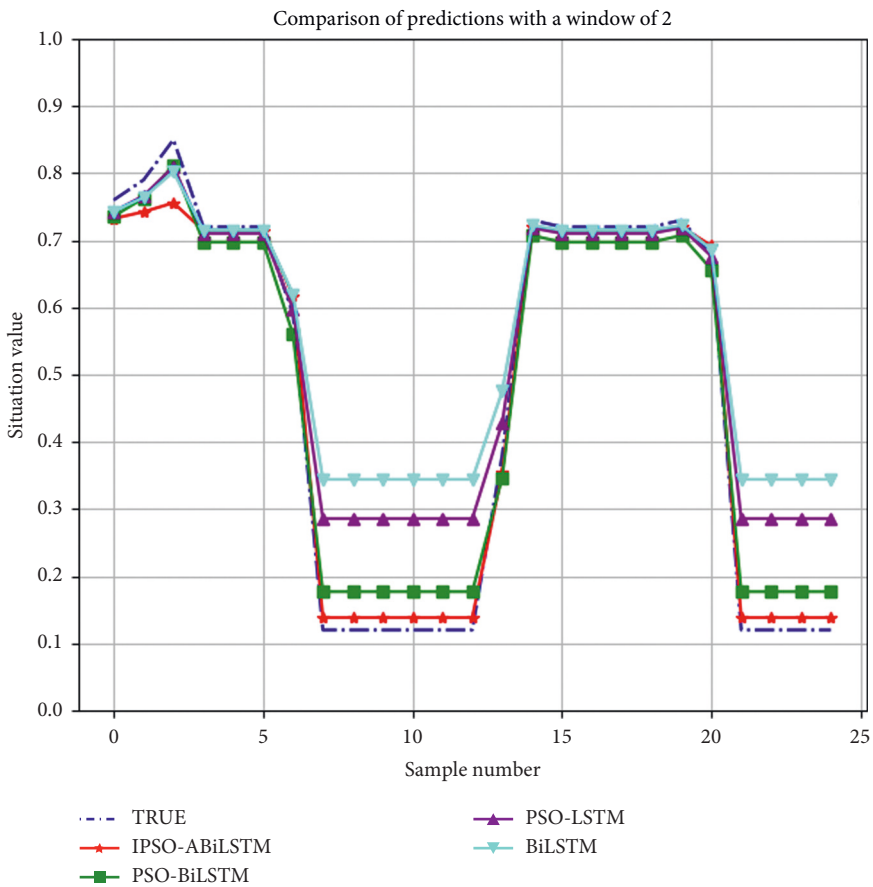

Figure 9: Comparison of window value 2.

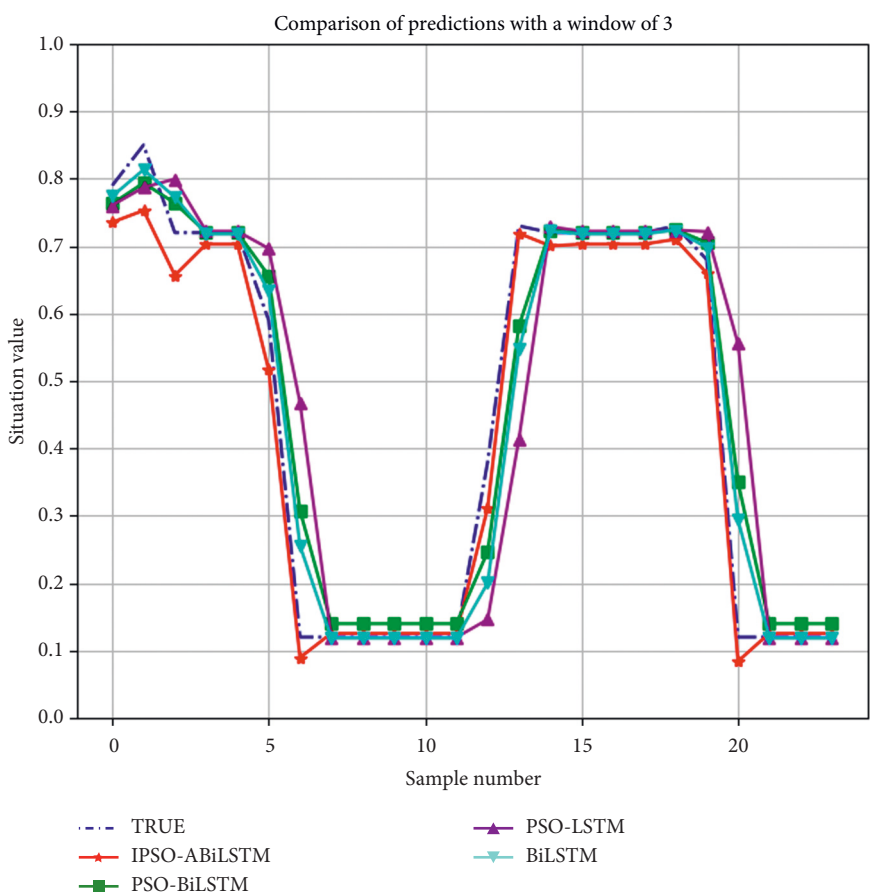

Figure 10: Comparison of window value 3.

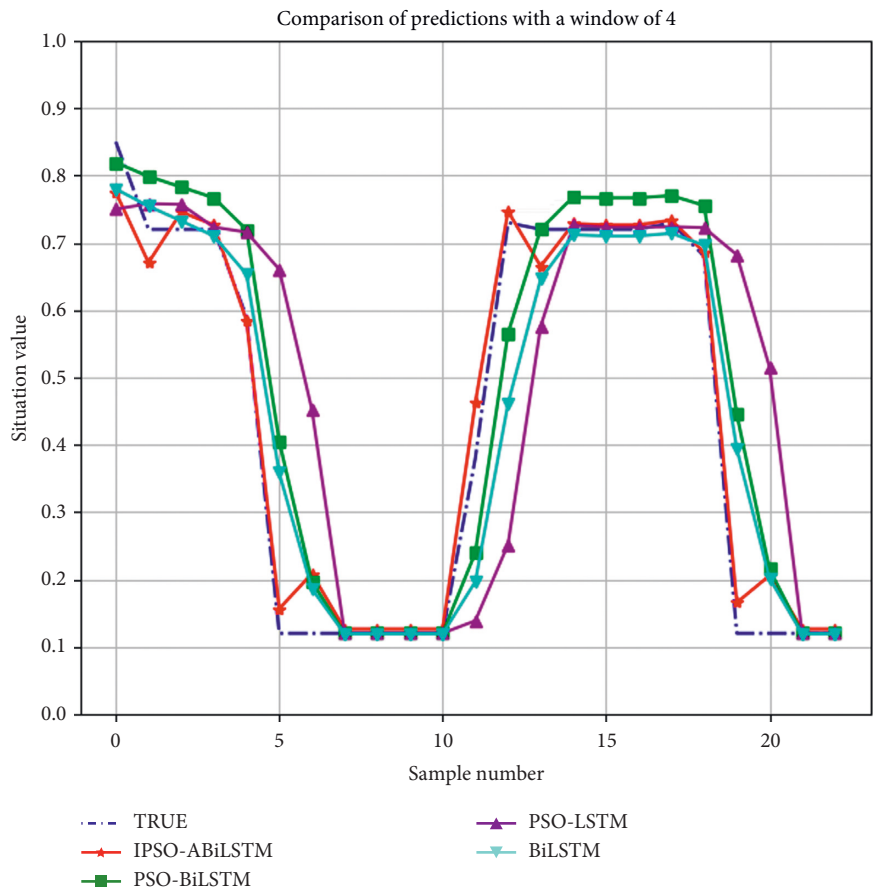

Figure 11: Comparison of window value 4.

Table 9: Assessment outcomes of evaluation indexes of each model.

Size	Index	IPSO-BiLSTM	PSO-BiLSTM	PSO-LSTM	BiLSTM
2	MAPE	1.4038	1.4261	1.5621	1.6316
	R^2	0.9922	0.9807	0.8719	0.7645
3	MAPE	1.3712	1.4590	1.4680	1.4245
	R^2	0.9849	0.9327	0.7678	0.9425
4	MAPE	1.4541	1.5728	1.5617	1.4328
	R^2	0.9809	0.8528	0.3910	0.8666

fitting coefficient R^2 is lower than the other three models are 0.0522, 0.2171, and 0.0424 higher, respectively. The performance of the suggested approach is superior than the other three methods when the window value is 3.

(3) When the window value is 4, the MAPE value of the suggested IPSO-ABiLSTM approach is 0.1187 and 0.1076 lower than that of PSO-BiLSTM and PSO-LSTM, respectively, and the fitting coefficient R^2 is higher than that of the other three models: 0.1281, 0.5899, and 0.1143. Combining the two indicators, the suggested method performs superior than the other three models when the window value is 4.

(4) For prediction problems, different window sizes often have an influence on the prediction outcomes. This paper also conducts comparative experiments on more window values. As far as the method in this paper is concerned, when in fact the value of the window is slighter, then the prediction effect of each model is often the better. Through the lateral analysis of (1)–(3), when the sliding window size is the same, the IPSO-BiLSTM model suggested in this paper has a higher fitting degree than the PSO-LSTM method, the PSO-BiLSTM approach, and the traditional BiLSTM approach. This should be kept in mind that, at the same time, the fitting coefficient R^2 of each model is compared longitudinally when the window value is 2, 3, and 4. As displayed in Figure 12, this can be easily comprehended and concluded that when the window value is 2, the model in this paper can accomplish the paramount fitting impact, and the fitting coefficient can be 0.9922, which is almost a complete fit. Subsequently, the above discussion and

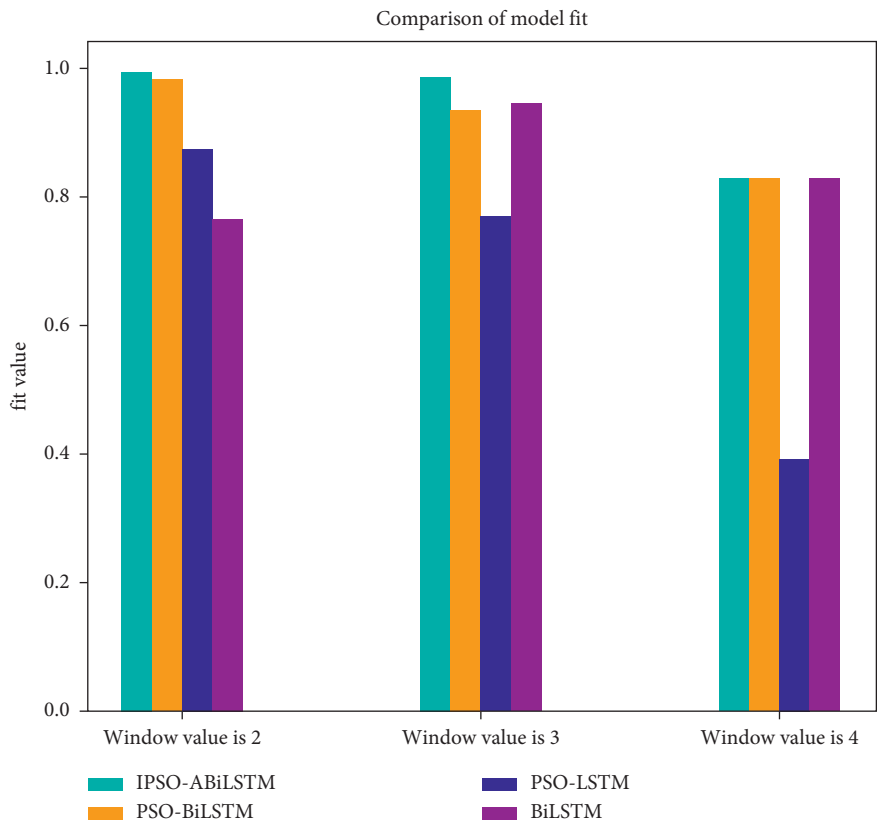

Figure 12: Comparison of model fitting degree.

analysis of the outcomes prove the efficiency of the prediction approach suggested in this paper, in particular, for the problem of network security situation prediction.

6. Conclusions and Future Work

Aiming at the problem of insufficient learning ability of a single model, in this paper, we constructed a network security position assessment and forecasting model which is established on the fusion model, and expounds the specific implementation of the fusion model. In fact, for network security condition assessment, this paper constructs two fusion models, that is, (i) CNN-LSTM-P; and (ii) CNN-LSTM-S, respectively, and conducts two-class and ten-class experiments on the UNSW-NB15 dataset. The attained outcomes illustrate that the detection effect of the CNN-LSTM fusion model is better, and the correct rate of situation assessment can reach 85.19% and 92.59%. Moreover, for network security condition forecast, we also suggest a network security condition extrapolation model which is established on the IPSO-ABiLSTM method. In the model construction, in view of the defects of slow convergence of the PSO technique and its defect of informal collapse into the local minimum, nonlinear inertia weight, and acceleration are introduced. We believe, these factors can help to improve the PSO algorithm and its immature convergence. At the same time, in order to learn more about the correlation between sequences, the BiLSTM network integrating the attention mechanism is introduced to forecast the situation, and the suggested IPSO mechanism is implemented to enhance and boost the ABiLSTM, as well as, to increase the forecasting ability of the suggested model. The investigational outcomes confirm that the IPSO-ABiLSTM model has higher fitting degree and smaller prediction error.

In the future, we will use other variants of the PSO method that have the capabilities to adaptively adjust numerous factors with the aim of the algorithm convergence can be enriched. Moreover, we will consider the Markov jumping technique in the PSO that can divide the entire populations in to substages and avoid the local optima convergence. On the hand, we will also look deeply into other deep learning models and improve the prediction accuracy. Limited resources are also considered as a fundamental issue that unswervingly distresses the training and prediction durations of the network. Therefore, we will investigate, in the future, how the big data analysis and technologies like cloud and edge infrastructure within the domain of networks will help to reduce the durations for the model training and prediction.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Color Enhancement Algorithm for Visual Communication Posters Based on Homomorphic Filtering

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In order to increase the image quality of visual communication posters and to solve the problems of uneven pixel distribution, distortion, and poor visual effect caused by the lighting environment, an image filtering method, with features based on wavelet and block homomorphic, is proposed on the basis of homomorphic filtering. According to the component change defect of red, green, and blue (RGB) color space, the image color space that needs to be processed is converted into HSV form and then processed in blocks. At that moment, the wavelet transform method is applied to replace the traditional Fourier transform in the block homomorphic filtering to decompose the luminance component. Furthermore, subimages that are decomposed by the wavelet are divided into blocks and then subjected to high-pass filtering so as to obtain a clear image. The investigational outcomes express that the proposed algorithm has an obvious enhancement effect on the visual communication poster image under the variable illumination situation. Furthermore, the suggested technique effectively rectifies the overall brightness of the image and significantly advances the detail contrast of the visual communication poster image. The signal-to-noise (SNR) ratio of our algorithm at different bit rates is higher than that of the LICE and CIE methods. Similarly, the enhancement impact demonstrates that the image statistical parameters of our algorithm are substantially better than those of the LICIE and CIE methods.

1. Introduction

It is possible for natural environmental variables or human causes to cause a lack of illumination, poor visual effects, and low image quality during the process of capturing photos [1–3]. This can happen for a number of reasons one of the challenges that we face. The resolution of the aforementioned issues not only has significant theoretical significance but it also has significant application prospects in practical applications such as aerial images, images obtained through remote sensing, and dark cloud images obtained through video surveillance. Those are just a few examples. Image enhancement technology that makes judicious use of homomorphic filtering [4–6] can fundamentally solve the quality problem of the image, make the visual impression of the image clearer, and better reflect the intricacies of the image.

In recent years, a great number of picture enhancement methods based on a variety of digital image processing applications through various techniques have been created [7–11]. The spatial domain or, more specifically, the spatial frequency domain is the viable option for their development. The enhanced photos offer information that can be helpful and useful for postprocessing, particularly in the segmentation phase of the process. Numerous academics have contributed to a wide range of review documents on various image normalization and segmentation approaches, and those articles have been published in the relevant academic literature. In recent years, a number of researchers have presented a strategy to reduce uneven illumination based on filtering. One of these methods is known as homomorphic filtering. Homomorphic filtering's primary purpose is to level off uneven illumination, reduce dynamic range, and boost contrast. In doing so, it boosts high frequencies and

reduces low frequencies by isolating components that reflect light. The wavelet transform is a method of time-frequency analysis that was created on the basis of the short-time Fourier transform [12–14]. Decomposing images with fluctuating illumination into low-frequency images and high-frequency detail subimages is accomplished with the help of the wavelet transform. Image feature improvement is applied to the subimage through processing, which, if done correctly, can meritoriously increase the image quality, and in particular, the quality of variable illumination images can be significantly improved.

This study provides a new method that can not only correct the color of the image; nevertheless, it enhances the edge and other characteristics and details of the images by combining homomorphic filtering and wavelet transform. Its goal is to address the poster artifact and the blurred edge of features. After the single-scale Retinex algorithm grounded on the concept of bilateral filtering has been used to estimate the reflection component of the image, the color of the R channel has been corrected, and then, in order to obtain the corrected image, the color correction of the G channel and the B channel has been obtained according to the ratio of the color attenuation coefficient. In order to increase the visibility and quality of the image that has been corrected, the homomorphic filtering approach along with a Butterworth notch filter is used. In fact, this filter enhances the details and edges of the high-frequency lines in a particular image while suppressing the low-frequency portion of the image. Furthermore, the Laplacian pyramid method is then used to fuse the two images together: images that have had their colors restored and that have been boosted. The key contributions of the research presented in this paper include the following:

(1) An image feature based on wavelet and block homomorphic filtering is proposed on the basis of homomorphic filtering;

(2) The wavelet transform is used to replace the traditional Fourier transform in the block homomorphic filtering to decompose the luminance component;

(3) The homomorphic filtering approach along with a Butterworth notch filter is used to enhance the edges of the high-frequency lines in a particular image while suppressing the low-frequency portion of the image; and

(4) The subimages decomposed by the wavelet are divided into blocks and then subjected to high-pass filtering so as to obtain a clear image.

The leftover part of the manuscript is structured in the following way. Related work and state-of-the-art image segmentation approaches are elaborated in Section 2. The research methodology and design is offered in Section 3. Moreover, filter theory and the proposed model along with the algorithm are also illustrated. Experimental results are obtained through simulations in Section 4. Section 5 summarizes the paper and put forward some interesting directions and planning for our future research.

2. Related Work

When applied to a particular image, the homomorphic filtering can significantly improve the contrast through amending the vividness of the image while instantaneously normalizing it. The method is simple to use and has the potential to generate satisfactory results, in particular when applied to an image that has lighting problems due to its initial capture. The discrete Fourier transform (DFT), logarithmic transform, exponential transform, and inverse discrete Fourier transform (IDFT) are all examples of homomorphic filtering methods. Note that $H(u, v)$ specifies the filtering category. In recent years, an expanding body of research literature has studied a variety of approaches that make use of homomorphic filtering in order to deal with lighting effects. The enhancement of an image's characteristics can be greatly improved, according to the findings of a number of researchers, by employing homomorphic filters that are based on morphology in conjunction with differential evolution algorithms. The method consists of first dividing the image into sub-band elements and then processing each sub-band independently in order to locate the elements with the optimal gain and structure. In the end, each sub-band is blended to produce an image that has been rectified.

Utilizing wavelet transforms for the purpose of picture segmentation has been proposed by a variety of writers [15–20] as the basis for novel strategies for wavelet-based image segmentation. Some researchers at Oleg Air have suggested a homomorphic method, which operates under the presumption that the noise in the log-transformed domain has the same characteristics as white Gaussian noise. A wavelet lifting of hole elimination strategy has been proposed by several academics. Wavelet transform and cross-validation thresholding are two of the strategies utilized by the methodology. Various researchers contributed a homomorphic approach to the investigation of denoising that was accomplished by employing a Bayesian estimator for this particular image. Denoising was accomplished by employing a Bayesian estimator for this particular image. The Gaussian distribution is utilized by some academics for the purpose of signal coefficient modeling, and they advocate for compression and the elimination of speckle noise. For the purpose of approximating the behavior of Gaussian white noise speckle noise, a number of researchers have recommended the use of an adaptive preprocessing filter. A method for removing speckles has been proposed by other researchers. This method employs the M-band wavelet transform and the Wiener filter, and it employs an adaptive threshold method that is based on weighted variance in order to diminish speckle noise. In current ages, researchers have carried out a wide variety of additional investigations on photographs.

Smoothing filtering and sharpening filtering are two distinct types of spatial filtering. The smoothing filtering comprises the mean filtering [21], median filtering [22], and Gaussian filtering [23]. Sharpening filtering is the opposite of smoothing filtering. The Sobel operator, the Roberts operator, and the Prewitt operator filter are all included in the

sharpening filter. The goal of smoothing filtering, which in fact is a kind of low-frequency enhancement spatial domain filtering technology that is essentially a low-pass filtering method, is to either blur the image or minimize noise. Smoothing filtering is essentially a low-pass filtering approach. The sharpening filter's primary function is to bring attention to the portion of the grayscale gradient that corresponds to the missing contour, improve the clarity of the image by bringing out the image's edges and that portion of the grayscale gradient, and compensate for the absence of the contour. The sharpening filter is distinct from the smoothing filter in that it employs the differential of the neighborhood as an operator. This increases the degree to which the pixels in the neighborhood differ from one another, hence drawing attention to any rapid changes in the image. Both of these have opposing impacts, which helps them complement one another. It is possible to achieve the effect of the sharpening filter by subtracting the result of the smoothing filter from the original image, and similarly, it is possible to achieve the effect of the smoothing filter by subtracting the result of the sharpening filter from the original image. At this point in time, there is a significant body of research literature that is connected to both smoothing filtering and sharpening filtering.

Some researchers begin by removing edge masks with the help of the Sobel operator and then move on to smoothing filtering in order to isolate details. When used together, these two techniques can provide photos with improved edge detail augmentation. There is, however, a phenomenon in which the edge information of the image is brightened to an extreme degree. Some researchers have proposed an adaptive unsharp mask depth image enhancement algorithm as a solution to the blurring of details that occurs during the smoothing process. This algorithm only extracts the high-frequency share of a particular image without any noise and overcomes the inability of the traditional unsharp mask algorithm to amplify the high frequency. The disadvantages of noise are as follows. However, in the process of fixing significant flaws, this method takes a lot of time, and the size of the filtering window does not satisfy the real-time requirements. Some researchers have proposed remote sensing image enhancement algorithms that are based on filtering and sharpening, and others have established image sharpening and enhancement operators that are based on Sobel and Laplacian in order to enhance image contrast. These solutions were developed in order to address the issue of low image brightness and contrast. However, the fact that some information can be readily lost in the two sharpening processes is not taken into consideration, which may result in the final enhanced image having insufficient information.

Homomorphic filtering [4–6], sometimes known as the HF algorithm due to its shorter form, is a specific technique for increasing the contrast of an image and compressing the brightness range of an image in the frequency domain. It does this by decreasing the low frequencies and increasing the high frequencies, which in turn decreases the changes in lighting and increases the edge detail. Homomorphic filtering can be recognized by the fact that it reduces the range of grayscale values while simultaneously raising the contrast. An underwater picture enhancement method that was offered by certain researchers and is based on the color line model and homomorphic filtering was developed with the goal of providing a more effective solution to the issues of low contrast and color deviation. This method is superior to the methods that are considered to be state of the art at the moment in four different respects: quantitative analysis, qualitative analysis, color accuracy analysis, and the restoration of synthetic underwater images [24]. However, this results in a significant rise in the amount of computing complexity. If you cannot satisfy its requirements, you should consider using parallel computing [25].

An adaptive weighted repeated value filtering technique is something that a few researchers have offered as a solution to the issues of low contrast and salt-and-pepper noise that are present in magnetic resonance MR images. MR images have been enhanced. Nevertheless, the effectiveness of this method is not particularly high, and the configurations of the homomorphic filtering parameters require additional testing and tweaking [26, 27]. An image color enhancement method has been offered by several researchers as a solution to the problem of photographs with low illumination. This method aims to improve the image's brightness as well as its overall quality. The local spatial homomorphic filter is used to improve the brightness while the gradient domain variance is used to suppress the noise and lastly to produce the effect of enhancing the image. In fact, both of these filters are applied simultaneously. However, the issues of contrast and information loss are not taken into consideration, which may result in the visual effect of the image being ambiguous [28, 29].

3. Research Design

3.1. The Filter Theory

3.1.1. Wavelet Transform. A low-frequency fairly accurate subimage and three other high-frequency detail subimages are generated for each layer of the decomposition of the digital picture by the fast decomposition algorithm of the Mallat wavelet. These results are obtained from the digital image. Let's say the initial image is $f(x, y)$. Then, the Mallat wavelet transform will be used to break it down into its component parts.

$$f(x, y) = \sum_{k,l} C_{J+1,k,l}\varphi_{J+1,k,l} + \sum_{k,l} V_{J,k,l}\Psi^1_{J,k,l} + \sum_{k,l} H_{J,k,l}\Psi^2_{J,k,l} + \sum_{k,l} D_{J,k,l}\Psi^3_{J,k,l}. \quad (1)$$

The low-frequency approximation subimage is the first item on the right side of the above equation (1), and the vertical high-frequency detail subimage is the second item. Similarly, the horizontal high-frequency detail subimage is the third item, and the diagonal high-frequency detail subimage is the fourth item. Note that C characterizes the low-frequency approximation coefficient of the image. This should be noted that high-frequency detail coefficients are denoted by the letters V, H, and D. Furthermore, J is the

number of different layers of breakdown. The rows and columns of the approximation component coefficient matrix $C_{J+1,k,l}$ are denoted by the notations k and $l \in z$, respectively. The rows and columns are denoted by the notation m and n ∈ z, respectively. Furthermore, the standard orthogonal scaling function $\varphi(x, y)$ and the wavelet function $\psi(x, y)$ are examples of functions that have dimensions of size equal to x and y, respectively.

The following, in equation (2), is an examination of the multiresolution data consisting of the approximate low-frequency components $C_{J,k,l}$ and the detailed high-frequency components $V_{J+1,k,l}$, $H_{J+1,k,l}$, and $D_{J+1,k,l}$.

$$\begin{cases} C_{J+1,k,l} = \sum_{m,n} h_{2m-k} h_{2n-l} C_{J,m,n} \\ V_{J+1,k,l} = \sum_{m,n} h_{2m-k} g_{2n-l} C_{J,m,n} \\ H_{J+1,k,l} = \sum_{m,n} g_{2m-k} h_{2n-l} C_{J,m,n} \\ D_{J+1,k,l} = \sum_{m,n} g_{2m-k} g_{2n-l} C_{J,m,n} \end{cases}, \tag{2}$$

where $\{h\}$ and $\{g\}$ are the coefficients of the dual-scale equation which describe the scaling function and the wavelet function, respectively. We can execute first-level wavelet decomposition on the image by using formula (1) and then continue to do two-dimensional wavelet decomposition on the approximation components by using formula (2) and so on for following levels or to produce multilevel decomposition levels. Figure 1 presents a diagrammatic representation of the decomposition of the problem.

In the wavelet decomposition procedure described above, the orthonormality criterion was satisfied by both the scale function and the wavelet function. As a result, the following equation (3) is what the wavelet reconstruction of the two-dimensional picture signal looks like.

$$\begin{aligned} C_{J,k,l} = &\sum_{m,n} C_{J+1,m,n} h_{k-2m} h_{l-2n} + \sum_{m,n} C_{J+1,m,n} h_{k-2m} g_{l-2n} \\ &\sum_{m,n} C_{J+1,m,n} g_{k-2m} h_{l-2n} \sum_{m,n} C_{J+1,m,n} g_{k-2m} g_{l-2n}. \end{aligned} \tag{3}$$

The image is broken up into its component parts using the wavelet transform so that information about the image's contours and details can be obtained at a variety of different scales. The image can be rebuilt by using the inverse wavelet transform once the deconstructed signal has been processed and analyzed.

3.1.2. Build a Homomorphic Filter Model. In light of the issues that are present in the methods that are currently in use, in accordance with the optical properties of the image, it is known that the image is composed of the natural illumination component $i(x, y)$ and the reflection component $r(x, y)$ of the primary target that can be seen in the image. This is known based on the optical characteristics of the image. It is possible to express the model as given by the following equation.

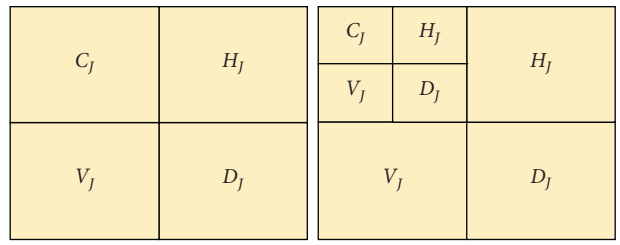

Figure 1: J and $J+1$ scale wavelet decomposition.

$$f(x, y) = i(x, y) r(x, y). \tag{4}$$

In a broad sense, the illuminance component $i(x, y)$ is able to completely reflect whether the lighting circumstances are favorable or unfavorable. If the illuminance component changes gradually, the spectrum will be located in the low-frequency region. Nevertheless, the reflection component $r(x, y)$ will be in the high-frequency zone. In the mapping image, the primary focus is on the particulars of the target object's content, and the component images' spectral regions are characterized by their high-frequency components. According to the previous distribution, all that needs to be done to improve the high frequency of the image is to separate the illuminance component $i(x, y)$ from the reflection component $r(x, y)$ in the frequency component $f(x, y)$ and then compress the low frequency of the image based on this information. The approach has the capability of lowering the brightness component of the image, which results in a visual effect that is more distinct, as explained in later sections.

The calculation is used to select a representative logarithm for both the left and right sides of formula (4). This allows the multiplication operation to be turned into a combination of addition and subtraction operations. Furthermore, this also ensures that there is one less variable than there was before.

$$\ln f(x, y) = \ln i(x, y) + \ln r(x, y). \tag{5}$$

The calculation result of the above formula indicates that the DCT transform should be used in place of the Fourier transform in the conventional homomorphic filter, and the following formula can be produced after the transformation:

$$F(u, t) = I(u, t) + R(u, t), \tag{6}$$

where

$$\begin{aligned} F(u, t) &= DCT[\ln f(x, y)], \\ I(u, t) &= DCT[\ln if(x, y)], \\ R(u, t) &= DCT[\ln rf(x, y)]. \end{aligned} \tag{7}$$

The result of applying the homomorphic filter function $H(u, t)$ to the input function $F(u, t)$ in the preceding formula is illustrated as given in the following equation:

$$S(u, t) = H(u, t) F(u, t) = H(u, t) I(u, t) + H(u, t) R(u, t). \tag{8}$$

We get this result after filtering, and then putting it through the inverse DCT transform (IDCT), we get the following equation:

$$\begin{aligned} s(x,y) &= IDCT[H(u,t)F(u,t)] \\ &= IDCT[H(u,t)I(u,t)] + IDCT[H(u,t)R(u,t)]. \end{aligned} \tag{9}$$

Following the calculation of the DCT transform, the exponential transform is carried out so that the filtered image can be obtained. The exponential transform is computed using the following equation:

$$g(x,y) = e^{s(x,y)}. \tag{10}$$

The logarithm of the image expansion is chosen using the uniform filtering procedure of the DCT transform operation. The logarithmic result is then achieved, and the DCT transform is carried out after that. We use transform homomorphism to transform the filter.

3.2. Proposed Algorithm

3.2.1. Block Effect Visibility Function Based on HVS. In order to successfully apply the idea of removing obstacles, it is important to integrate the qualities of the visual system. Some research that are linked have demonstrated that certain spatial activities and picture brightness can mask and eradicate the block effect. Nonetheless, the visibility of the block effect is slightly decreased in the texture part. As a consequence of this, the visibility of blockiness is significantly reduced in locations that have a high local background brightness. A local area of the block border is generally understood to refer to the block boundary that exists between a block and an adjacent block.

The vertical and local spatial activities have the ability to disguise the impacts of blocking, and horizontal and vertical functions are established based on the findings of homomorphic filtering calculations. This is denoted by the following equations:

$$A_h = \sum_{u=1}^{7} \sum_{v=0}^{7} R(u,v), \tag{11}$$

$$A_v = \sum_{u=1}^{7} \sum_{v=0}^{7} R(u,v). \tag{12}$$

In the above equations, A_h and A_v are described as the feature activity of block c in the horizontal or vertical directions, respectively. As a result, $R(u,v)$ can be made to represent the remaining blocks in the model of block c which reflect the local activity in the DCT domain value according to its characteristics. This allows $R(u,v)$ to be used to represent the remaining blocks in the model of block c.

In general, the activity in the vertical direction is the primary reason for the hiding of the block effect when there are block effects present in the horizontal direction. This is the case for any existence of block effects in any direction. As a result, each and every one of the actions associated with the vertical or horizontal block impacts can be calculated using the following formulas:

$$A_{\text{total}}^{h} = A_t + aA_h, \tag{13}$$

$$A_{\text{total}}^{v} = A_h + aA_v. \tag{14}$$

As a result, the following equation (15) is how the masking function M_h for the horizontal blocking effect of spatial frequency activity should be defined.

$$M_h = \left(1 + A_{\text{total}}^{h}\right)^{-1}. \tag{15}$$

The calculation formula for the average brightness can be put down if the results of the calculation using the preceding formula are taken into account. The average brightness of the image can be estimated using the following equation:

$$M_1 = 1 + \left(\frac{b}{b_0}\right)^{r-1}. \tag{16}$$

According to the results of the calculations that were done earlier, if the frequency of the spatial activity of the image is unable to reach the normal value range of the masking function, then the visibility of the block effect that is present in the image will also change in a manner that is proportional to this fact. Note that this relationship is given by equation (17). Figure 2 displays the algorithm flow chart that was developed for this article.

$$\eta_h = \beta \cdot M_h \cdot M_1 = \frac{\beta}{\left(1 + A_{\text{total}}^{h}\right) + \left(1 + \left(\frac{b}{b_0}\right)^{r}\right)}. \tag{17}$$

3.3. Experimental Data. For the purpose of determining whether or not the algorithm proposed and described in this paper is effective, a variety of poster images are retrieved from the Internet. Then, four distinct types of representative images that exhibit clear variations in light intensity are chosen to serve as the experimental test images. Besides these, several images were combined into another set that is used for the validation purposes. Figure 2 displays the algorithm flow chart that was developed for this article.

4. Results and Discussion

4.1. Results. This section primarily evaluates the prediction accuracy of the visual communication poster color enhancement algorithm (referred here and various graphs as OUR), which is based on homomorphic filtering. Additionally, this section compares and analyzes the following two algorithms: (i) the Low Illumination Color Image Enhancement (LICIE) algorithm and (ii) the Color Image Enhancement (CIE) algorithm.

As can be seen in Figure 3, the signal-to-noise ratio of the OUR algorithm at different bit rates is higher than that of the LICE method and the CIE method, which is an indication

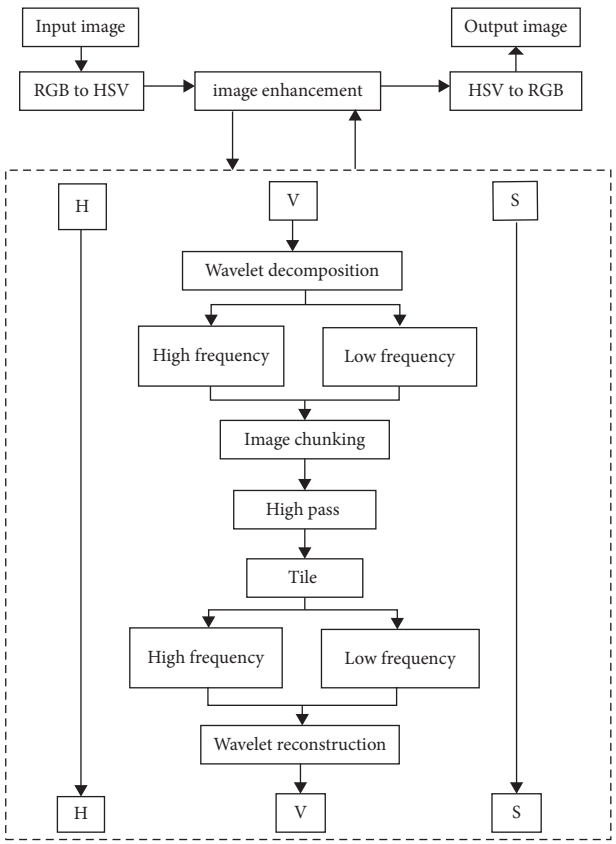

Figure 2: The proposed algorithm flow chart.

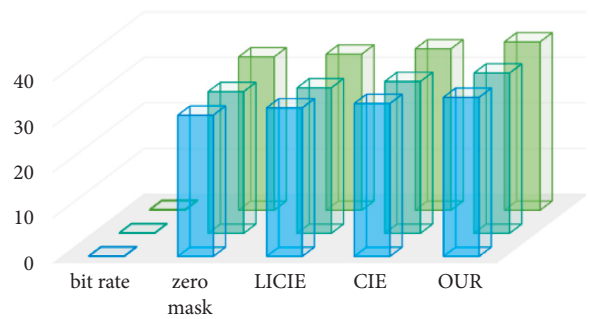

Figure 3: Signal-to-noise ratio at different bit rates.

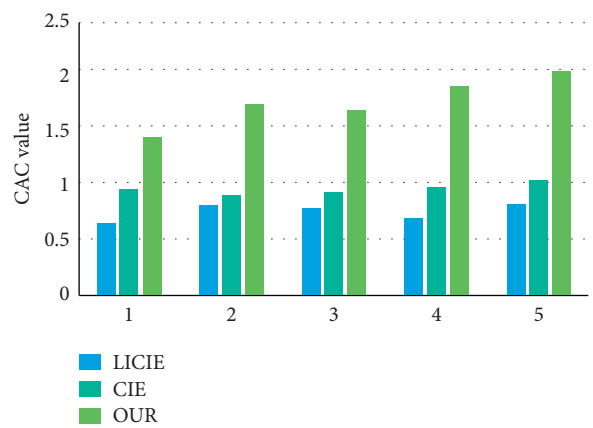

Figure 4: CAC values of four types of images.

that the proposed algorithm is able to effectively eliminate the block effect of the image, protect the edge information of the image, and enhance the image. This is because the lighting conditions make the photos produce different hues when shooting.

A comprehensive evaluation criterion of image objective quality is established in order to further verify the image color enhancement effect of the proposed method. This criterion is then used to evaluate various methods, and the comprehensive evaluation criterion is defined as CAC (Comprehensive Assessment Criteria Index). In order to further verify the image color enhancement effect of the proposed method, a comprehensive evaluation criterion of image objective quality is established. This should be noted that the evaluation criterion is defined as CAC and is given by the following equation.

$$CAC = E^m N^n C^p. \tag{18}$$

In the above equation (18), the E^m metric is the one that measures the similarity of picture structure. The normalized grayscale difference is denoted by the letter N^n. The color-weighted restoration degree is denoted by the letter C^p. The value of the CAC parameter determines how effective the image's color enhancement effect will be. Figure 4 presents the findings of a comparison of the CAC values obtained through the use of various methodologies. An examination of Figure 4 reveals that when the proposed method has been applied to improve the colors of various images, the CAC values that have been obtained are all greater than 1. The fact that this technique's CAC value is noticeably greater than that of the LICE method and the CIE method indicates that the image enhancement effect produced by the suggested approach is superior, which further substantiates this method's status as the superior option.

The results presented in Figure 5 show that the average grayscale value of the image after enhancement processing is greater than the value of the original image. This is due to the fact that each approach has the impact of increasing the brightness of the image to a certain degree. The information entropy values of the processed image are higher than the values of the original image, which indicates that the processed image contains a greater amount of information. Additionally, the average gradient is improved when compared with the value of the original image, which indicates that the image clarity has improved and that the details, such as edges, are more prominent. Contrast the three different kinds of algorithm. The enhancement impact of the algorithm demonstrates that the image statistical parameters of the OUR method are substantially better than those of CIE and LICIE. This indicates that the algorithm presented in this work has the best performance when it comes to the enhancement of images.

4.2. Discussion. During the process of imaging, image distortion or color darkening brought on by environmental or human factors will have an effect on the final visual product.

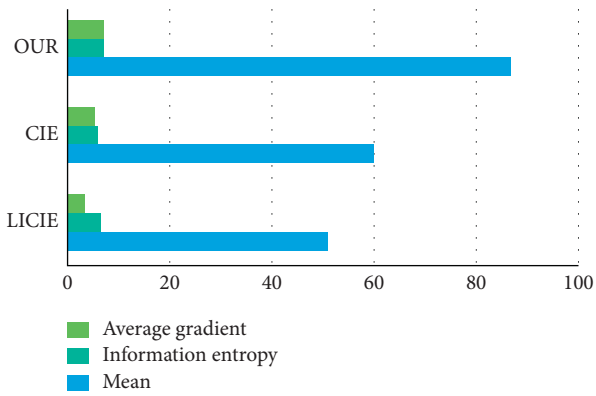

Figure 5: Comparison of the results of different algorithms.

This issue has rapidly risen to the status of one of the most pressing concerns that must be addressed in this area of research. In light of this, a planar vision image that utilizes homomorphic filtering has been proposed. The algorithm is for color enhancement. In order to get the best possible result while processing images, the RGB color space is transformed into the HSV color space according to the features of the color space, and then, a Butterworth-type homomorphic filter is built through the process of homomorphic filtering computation. In order to achieve a color-enhanced image, the block effect must first be removed. Because the threshold of the visibility function result needs to be accurate and effective in the calculation of removing the block effect, the result of the threshold needs to be repeated, and the next step will be to optimize the calculation process. Despite the fact that the algorithm in this paper can finally accomplish the purpose of image color enhancement, this is due to the fact that the threshold of the visibility function result needs to be accurate and effective. The detailed analysis of the proposed algorithm denotes its superiority.

The signal-to-noise ratio of the OUR algorithm at different bit rates is higher than that of the LICE method and the CIE method, which is an indication that the proposed algorithm is able to effectively eliminate the block effect of the image, protect the edge information of the image, and enhance the image. The CAC value of this algorithm is obviously larger than that of the lice method and the CIE method. This fact shows that the image enhancement effect produced by the method proposed in this paper is superior. Furthermore, the enhancement impact of the algorithm demonstrates that the image statistical parameters of the OUR method are substantially better than those of CIE and LICIE. This indicates that the algorithm presented in this work has the best performance when it comes to the enhancement of images.

5. Conclusions and Future Work

In this paper, we propose a variable illumination image feature enhancement algorithm that is based on wavelet and block homomorphic filtering. The goal of this algorithm is to improve the characteristics of some images that are affected by variable illumination, specifically their uneven brightness and low contrast. First, the image is converted from its original color space to the HSV space, and the image brightness component V is used as the enhancement object. Next, a wavelet transform is used in place of the conventional Fourier transform in the block homomorphic filtering in order to decompose the luminance component. Finally, the subimages that were decomposed by the wavelet are divided into blocks, and high-pass filtering processing is performed before the filtered images are reconstructed. This is done so that it is clear, based on the results of the evaluation and analysis of the visual effects and quantitative indicators, that the color enhancement algorithm for visual communication is successful.

When compared with more traditional algorithms, the posters that are based on homomorphic filtering that are suggested in this research have the ability to effectively correct the image brightness that is produced by variations in illumination. It is possible for it to considerably improve the contrast of the image's details, and it can also make the image with changeable illumination have improved global visibility. The fact that our algorithm is so excellent is demonstrated by the fact that it is able to improve the color of the poster extremely effectively. In the future, we will work towards proposing an updated version of the proposed algorithm, where machine learning methods should be used to enhance the accuracy and picture quality. Using big data and the graph convolutional network model will definitely improve the performance of the proposed technique. The filtering task is compute intensive, and the matching time could be significantly reduced using big data analytics.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Music Genre Classification Based on Deep Learning

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Human music life can be traced back to ancient times. The music art of human society is rich and colorful, which makes the music classification unable to classify efficiently and accurately. Moreover, the classification has become a daunting task. On this basis, this paper studies the method of deep learning for processing music classification. Not only is the design structure of music signal channel classified, but also all connected neural networks associated with the music are investigated to design an appropriate network model. According to different music sequence measurements, the feature sequence mechanism of music design feedback optimization is also investigated. The type probabilities of different calculated orbits are measured by *softmax* activation function, and the function value of cross loss is obtained. Finally, an Adam optimization algorithm is used as the optimization algorithm of the proposed network model. Subsequently, an independent adaptive learning planning rate is designed. By adjusting the network parameters, the first- and second-order estimates of the calculated gradient are classified. The experimental outcomes prove that the anticipated method can meritoriously increase the correctness of music classification and is helpful for music channel classification. Moreover, we also observed that the number of neurons in the network has also a significant impact over the training and testing errors.

1. Introduction

The creation and performance of early popular music were mostly commercial, and it was carried out in cities and towns, which was different from folk music with strong rural color. At the same time, it does not have the standardization and stability of art music [1]. These in early days, in many cases, were just oral. Therefore, some people say that popular music is different from art music and folk music. This, in fact, generally refers to a kind of music that is easy to understand, relaxed and lively, and easy to spread and has a large audience. Some people say that some particular music is "popular music" [2]. Music genre is an important label to describe music. Music tags play a virtuous part in pinpointing and separating digital music resources [3]. Therefore, from a huge amount of musical data, their identification and classification have become more daunting. Facing the enormous music catalogue, depending on manual explanation for classification will devour significant computational costs, resources, and time. Moreover, we believe that they will still not be able to meet the needs of the current times enriched by big data, Internet of things, and people's increasing interest in music. Therefore, music classification has gradually become a research hotspot.

At present, scholars in related fields have made theoretical research on the classification of music themes. For example, the authors in [4] proposed an engine system for classifying genres, which aims to replace these features by a new model. The model can also recommend music from vocal music that has been extracted from online music. Their experimental results show that this method not only has certain efficiency but also can effectively modulate speech pitch and construct separation masking based on neural recursion. It should be kept in mind that the voice signals mixed with music can be screened and deleted. The music pitch classification method based on the RNN model can improve the time trajectory of speech and music pitch values. Moreover, this can also determine that the unknown continuous pitch sequence belongs to speech or music. This method has significant classification performance without losing speech noise separation performance. Nevertheless, the previously mentioned approaches still have some

complications, such as low classification precision, poor effect, and lengthy computational time.

In order to solve the above complications, a classification method of music genres based on deep learning is proposed in this paper. Using deep learning, the data preprocessing is used to filter the music signals. Furthermore, using a fully connected neural network structure, the extraction of music genre features is completed. Finally, the attention mechanism is used to design a music genre classification network model. The music genre classification effect of the suggested method is better than those of other approaches, which can effectively improve the classification accuracy of the music genre. Moreover, our approach shortens the classification time significantly. The main contributions are as follows:

(i) We study the classification of the design structure of music signal channel, and the connected neural network associated with music is designed.

(ii) According to different music sequence measurements, the feature sequence mechanism of music design feedback optimization is studied.

(iii) The type probabilities of different calculated orbits are measured by softmax function, and the function value of cross loss is obtained.

(iv) Finally, an Adam optimization algorithm is used as the optimization algorithm of network model, and an independent adaptive learning planning rate is designed.

The remainder of the paper is organized as follows. In Section 2, we briefly discuss the basic theory of deep learning. Neural and back-propagation (BP) networks along with activation functions are discussed. In Section 3, fundamentals of music signal analysis are illustrated. In the fourth section, we discuss the classification of music genres and feature extraction and propose a neural network model. Experimental discussion and results are presented in Section 5. Finally, Section 6 summarizes the paper and presents directions for future research.

2. Basic Theory of Deep Learning

Deep learning is a branch of machine learning that deals with learning algorithms using deep neural networks. In fact, deep learning methods are developed from artificial neural networks (ANNs). It should be noted that ANNs are the most commonly used and representative model structure in the field of machine learning. Deep neural network (DNN) is a neural network, which is formed from the interconnection of various neurons and weights and may have many hidden layers and neurons [5]. Deep learning can learn higher-level feature expression from complex and large samples.

2.1. Neural Networks. Deep learning is developed from artificial neural networks. Furthermore, neural networks are abstracted from the structure of biological neural networks. In the network, information is transmitted and activated through the interconnection between basic units, known as neurons, which in fact imitates the process of information transmission between the biological neurons [6]. The basic unit of the neural network is called neuron, and several neurons are connected with each other in such a way that communications occur among them [7]. The basic structure of the neuron is as shown in Figure 1.

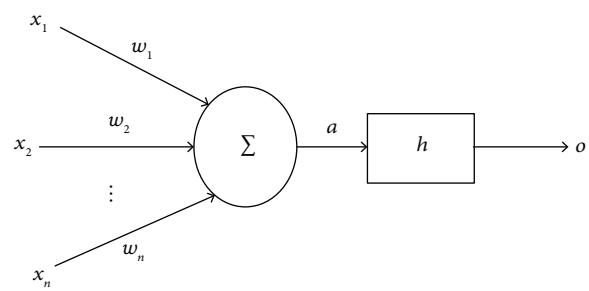

Figure 1: The neuron structure diagram.

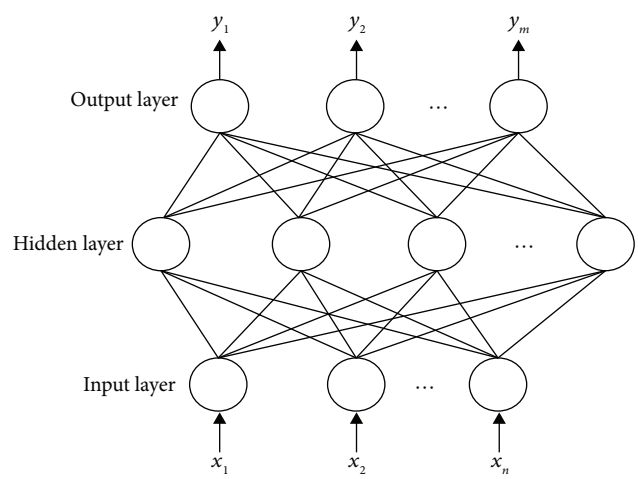

Figure 2: Structure diagram of a fully connected neural network.

In Figure 1, x_1 is the input signal, and the arrow starting from the input signal represents the connection. Each connection corresponds to a particular weight w_1. After the input signal passes through these connections, it is weighed and summed to obtain a (a usual output of the hidden neurons). Finally, the previous output goes through a nonlinear function in order to get output o. It should be noted that the nonlinear function h is called the activation function that is used to tune the performance of the network [8]. The process of neuron input to output can be described by mathematical expression as follows:

$$o = h\left(\sum_{i=1}^{n} x_i w_i + b\right). \tag{1}$$

In formula (1), b is the bias term of the neuron. Multiple neurons with the same inputs form a hidden layer. The input of one layer of neurons is used as the input of the next layer of neurons, and the basic neural network is formed according to this connection method. The input of a neuron can come from either the input signal or the output of other neurons [9]. The structure of the fully connected neural network is shown in Figure 2.

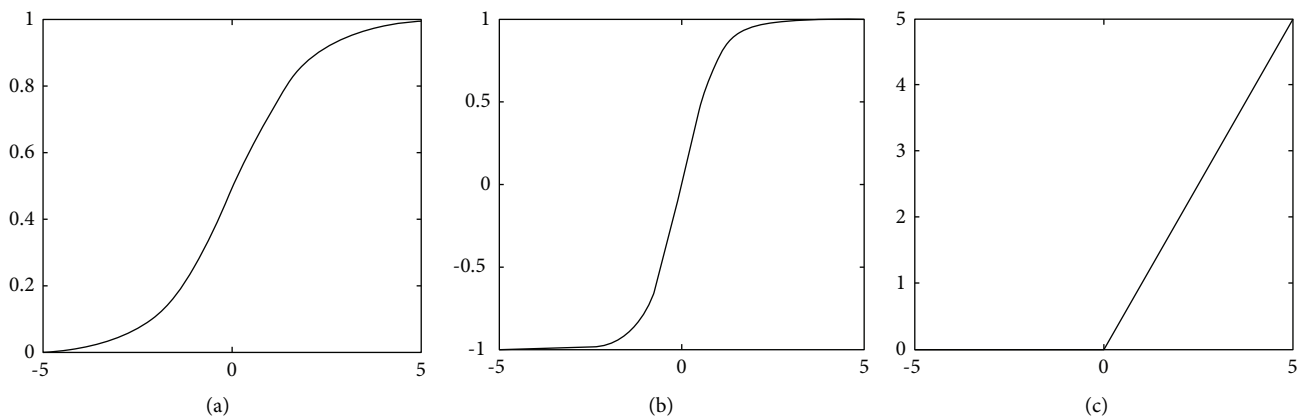

Figure 3: Three activation functions and images. (a) Sigmoid. (b) tanh. (c) ReLU.

From bottom to top, as shown in Figure 2, the input layer takes inputs, passing through several neuron layers, and the output layer creates the output. The network structure, in Figure 2, has only one hidden layer, and this type of neural network is also called a single hidden layer feedforward neural network. In deep learning, multiple hidden layers can also be set, and each hidden layer is set with a different number of neurons according to the actual situation to improve the learning capability. The connection weight matrix of each layer and the previous layer is multiplied by the output value of the neuron of the previous layer, and the bias term of this layer is added to obtain a linear output. Subsequently, the obtained linear output then passes through the activation function of this layer performing nonlinear transformation to get the output of this layer of neurons [10]. The process of neurons in each layer from receiving input to calculating output can be described by a calculation formula as follows:

$$\begin{aligned} z^l &= W^l a^{l-1} + b^l \\ a^l &= f^l\left(z^l\right). \end{aligned} \tag{2}$$

In formula (2), z^l is the linear output vector of neurons in layer l, which is calculated from the output vector a^{l-1} of neurons in layer $l-1$, the connection weight matrix W^l of layer l, and the bias term b^l of layer l. Furthermore, a^l is the nonlinear output vector of the l layer neuron obtained by the linear output z^l of layer l neuron through the activation function $f^l(\cdot)$ of layer l.

Let us again refer to the basic architecture of the neural network, as shown in Figure 2, starting from the input layer, along the direction from input to output. For example, according to the above process, a series of linear and activation operations are carried out for the input vector, connection weight matrix, and offset term of each layer [11]. All these parameters are calculated layer by layer until the target prediction result is obtained at the output layer. This process is a forward propagation process.

2.2. Back-Propagation (BP) Algorithm. The input layer, hidden layer, and output layer are the three components that make up the front end, middle, and end of the BP neural network. It is assumed that $x0 = -1$; the beginning of the imported input is the input vector, whose formula is $x = (x1, x2, \ldots, xi, \ldots, xn)T$; the middle of the neural network is the hidden layer, which will slow down training. The output vector is the result of the generated data, and its formula is $y = (y1, y2, \ldots, yi, \ldots, yn)T$. $y0 = -1$ can be provided as an additional assumption. The algorithm is a part of a unique programme, and, right now, one of the most cutting-edge fields is neural network. The result of combining the two is BP neural network. The topology of the BP neural network is shown in Figure 3. This research employs the modified BP neural network model to evaluate music classification, which can successfully eliminate the difficulties of instability and slow convergence of the classic model and can comprehensively improve the accuracy of the evaluation findings [12]. Topological structure of BP neural network model is shown in Figure 4.

In this first step, we calculate the error of the output layer according to the error loss function and then transfer it layer by layer to the middle layers in some form and update the parameters of each layer [13, 14]. Through continuous iteration, the error of loss function calculation is minimized and the parameters converge. The back-propagation algorithm adopts the gradient descent method, as illustrated in equation (3), to update the parameters:

$$\begin{aligned} w_{ij}^l &= w_{ij}^l - \eta \nabla w_{ij}^l \\ b_i^l &= b_i^l - \eta \nabla b_i^l. \end{aligned} \tag{3}$$

In formula (3), η is the learning rate, and ∇w_{ij}^l and ∇b_i^l are the gradients of the error loss function to the connection weight w_{ij}^l and the paranoid term b_i^l, respectively. It can be seen that the key of the back-propagation algorithm is to find the gradient of the error loss function to the parameters [15]. The calculation process is given in the following steps.

Step 1: Calculate the loss error according to the target prediction and expected output of the output layer using the following equation:

$$L = \gamma\left(a^N, y\right). \tag{4}$$

In formula (4), L is the loss error, a^N is the target prediction vector of the output layer, y is the target expectation vector, and the function $\gamma(\cdot)$ denotes the loss function.

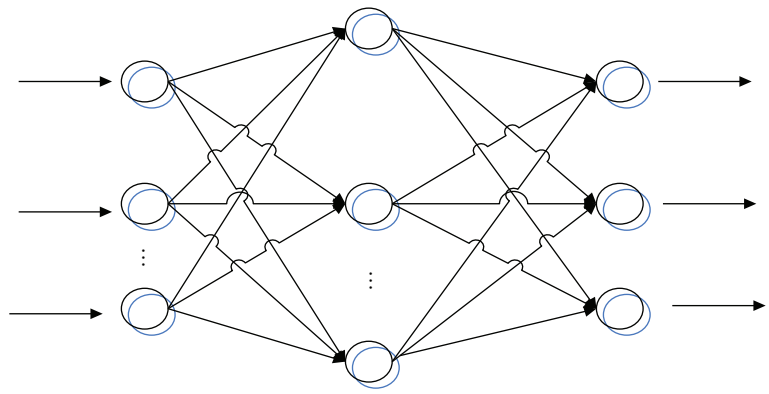

Figure 4: Topological structure of BP neural network model.

Step 2: Calculate the error term δ^l of layer l in the network according to the error loss L using the following equation:

$$\delta^l = \frac{\partial L}{\partial z^l} = \frac{\partial L}{\partial a^l}\frac{\partial a^l}{\partial z^l}. \tag{5}$$

Step 3: Calculate the error term of neuron i in layer l according to the chain rule, as illustrated in the following equation:

$$\delta_i^l = \frac{\partial L}{\partial z_i^l} = \sum_j \frac{\partial L}{\partial z_j^{l+1}}\frac{\partial z_j^{l+1}}{\partial z_i^l} = \left(\sum_j \delta_j^{l+1} w_{ij}^{l+1}\right) g_l'\left(z_i^l\right). \tag{6}$$

It can be seen from formula (6) that the error term of layer l is affected by the error term of layer $l+1$. In other words, the error of the network will propagate in the opposite direction layer by layer through the back-propagation algorithm.

Step 4: Calculate the connection weight of each layer and the gradient of the bias term according to the error term using the following equation:

$$\begin{aligned} \nabla w_{ij}^l &= \frac{\partial L}{\partial z_j^l}\frac{\partial z_j^l}{\partial w_{ij}^l} = \delta_j^l a_i^{l-1}, \\ \nabla b_i^l &= \frac{\partial L}{\partial z_i^l}\frac{\partial z_i^l}{\partial b_i^l} = \delta_i^l. \end{aligned} \tag{7}$$

As can be seen from formula (7), the gradient of the current layer connection weight w_{ij}^l strongly depends on the error term of the current layer neuron and the output of the previous layer neuron. Moreover, it can also be observed that the gradient of the current layer bias term b_i^l depends on the error term of the current layer neuron. Through substituting the above calculation results into formula (3), the parameter update of each round of the training process can be completed.

2.3. Activation Functions. The activation function achieves delinearization, turning the neural network into a nonlinear model and bringing the network model the ability to solve linear inseparable problems [16]. There are various activation functions that are related to neural network and each function can be replaced with another one in order to boost the accuracy of the model. Few of the well-known and largely used activation functions comprise the tanh function, ReLU (Rectified Liner Units) function, sigmoid function, and the softmax function. Among these, the *softmax* function is often used in the classification tasks [12, 17]. It should be noted that an appropriate activation function is selected according to the needs of the task and the characteristics of the network layer. The three activation function images are illustrated in Figure 3.

In the next discussion, we offer a brief description and mathematical model of each activation function. In the later sections, we will demonstrate that these functions have impacts on the network accuracy and prediction outcomes.

(1) tanh: the tanh function is a hyperbolic tangent function, which maps variables to the values among the range $[-1, 1]$. However, the tanh function has the problem of gradient saturation; that is, the derivative of the function at both ends is almost zero. This easily causes the problem of gradient disappearance in the training process of the neural network back-propagation, which makes the training speed of the network model very slow or difficult to converge. The function's mathematical expression is given in the following equation:

$$f(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}. \tag{8}$$

(2) Sigmoid: the sigmoid function image is similar to the tanh function, and the problem of gradient disappearance is also prone to occur. The function's mathematical expression is given in the following equation:

$$f(x) = \frac{1}{1 + e^{-x}}. \tag{9}$$

(3) ReLU: the ReLU function is a linear rectification function and a nonsaturated activation function, which can solve the problem of the disappearance of the gradient caused by the derivative tending to zero. The ReLU function sets the negative value to 0 and performs truncation processing. The ReLU function is easier in the process of derivation calculation and can speed up the convergence speed of the network model [18]. The mathematical expression of the ReLU function is given by the following equation:

$$f(x) = \max(0, x). \tag{10}$$

(4) Softmax: the softmax function is generally used in the output layer of the neural network to complete the classification task. In the multiclassification process, the main task and function of the softmax function is to use the original output, calculate a new output, and map the value range to [0, 1]. In this way, the output of the neural network becomes the probability distribution of the target label. The function's mathematical expression is illustrated in the following equation:

$$f(x_i) = \frac{\exp(x_i)}{\sum_k \exp(x_k)}. \tag{11}$$

3. Fundamentals of Music Signal Analysis

3.1. Overview of Music Genres. Since the emergence of human beings, music has developed with the evolution of human beings. Under the influence of different periods, regions, nationalities, and cultures, it has gradually formed some unique musical classic characteristics in musical thought, creative principles, artistic personality, and means of expression and techniques, and music types with different styles appeared. These types can be called music schools. Popular music genres include classical, jazz, blues, hip-hop, rock, country, pop, and metal [19, 20]. There is no strict classification standard for the classification of music genres, which is subjective. Music works of the same genre have similar artistic styles.

3.2. Music Features. The features and characteristics of the music genre can be divided into three different types: (i) time domain characteristics, (ii) frequency domain characteristics, and (iii) cepstrum domain characteristics.

3.2.1. Time Domain Characteristics. Time domain features include zero crossing rate (ZC3) and short-time energy (STE). These features can be extracted directly from the waveform of the original signal. The processing process is simple and requires less mathematical calculation. They are widely used in the research of music classification tasks [20, 21]. The two common time domain features are described in detail below:

(1) Short-time energy: Short-time energy is the sum of energy in a small window, reflecting the change range of music signal over a period of time. It should be noted that it is generally used to judge the silence in a piece of music, carry out endpoint detection, and identify the beginning, transition, or end of music signal [22]. The calculation formula for the short-time energy is given by the following equation:

$$E_n = \sum_{k=-\infty}^{\infty} [x(k)\omega(n-k)]^2. \tag{12}$$

In formula (12), $\omega(n-k)$ represents "window function." The more popular window functions used to calculate short-time energy include "rectangular window" and an improved raised cosine window, "Hamming window" [23]. The calculation formula for window function is given by the following equation:

$$\omega(n) = \begin{cases} 1, & (0 \le n \le N-1), \\ 0, & \text{otherwise}, \end{cases}$$

$$g(n) = \begin{cases} 0.54 - 0.46\cos\left[\dfrac{2\pi n}{(N-1)}\right], & (0 \le n \le N-1), \\ 0, & \text{otherwise}. \end{cases} \tag{13}$$

In formula (13), N represents the length of the window.

(2) Short-time zero crossing rate: If the adjacent voice signal samples carry the opposite algebraic symbols, it is considered that zero crossing will be produced. The level of zero crossing rate directly reflects the number of high-frequency components of music signal. Short-time zero crossing rate is commonly used to detect silent frames in voice time domain analysis. The calculation method of this feature is given by the following equation:

$$\text{zerocross} = \frac{1}{2}\sum_{m=0}^{N-1} \left|\text{sgn}[x_n(m)] - \text{sgn}[x_n(m-1)]\right|. \tag{14}$$

In formula (14), $x_n(m)$ represents a discrete speech signal, and $\text{sgn}[\cdot]$ is a special function used to represent algebraic symbols. The definition of the function that denotes the algebraic symbols is given by the following equation:

$$\text{sgn}[x] = \begin{cases} 1, & (x \ge 0), \\ 0, & (x < 0). \end{cases} \tag{15}$$

3.2.2. Frequency Domain Characteristics. Common frequency domain features include spectrum centroid (SC), spectrum energy (SE), spectrum bandwidth (SB), and spectrum traffic (SF). The description and calculation

formulas of several common frequency domain features are listed below.

(1) Spectrum centroid (SC): The spectrum centroid is a commonly used measure. The size of this value represents the size of the frequency component of the music signal. The larger the value, the more high-frequency components and vice versa. The calculation formula is illustrated as follows:

$$SC = \frac{\sum_{\omega=l_0}^{h_0} \omega |F(\omega)|^2}{\sum_{\omega=l_0}^{h_0} |F(\omega)|^2}. \tag{16}$$

(2) Spectrum energy (SE): The frequency domain feature is used to characterize the frequency domain energy of a frame signal of music. The calculation formula for the spectrum energy is as follows:

$$SE = \sqrt{\frac{1}{h_0 - l_0} \sum_{\omega=l_0}^{h_0} |F(\omega)|^2}. \tag{17}$$

(3) Spectrum traffic (SF): The spectrum traffic is a dynamic feature that represents the spectrum of the music signal. In fact, it is the sum of the squares of the signal differences of all adjacent frames in a discrete frequency domain music signal. The calculation formula is given as follows:

$$SF = \frac{1}{h_0 - l_0} \sum_{\omega=l_0}^{h_0} |F(\omega + 1) - F(\omega)|^2. \tag{18}$$

In the three above formulas, $F(\omega)$ represents the Fourier transform of each frame of signal. Furthermore, l_0 and h_0 represent the maximum frequency and minimum frequency of a piece of music in the frequency domain signal, respectively.

3.2.3. Cepstrum Domain Characteristics. The music signal is transformed into frequency domain through Fourier transform, and the frequency domain characteristics are obtained through mathematical calculation and analysis, as discussed in previous sections. Then, take the logarithm of the music spectrum signal and perform the inverse Fourier transform. The audio signal in the frequency domain will be converted to the cepstrum domain, so as to obtain the cepstrum domain characteristics [24, 25]. The most common cepstrum domain features and related formulas are listed below:

(1) Mel frequency cepstral coefficient (MFCC): It is one of the most commonly used cepstral domain features, which can well represent the audio signals. The Mel frequency cepstrum coefficient can transform nonlinear relationship into linear relationship. The calculation step of the MFCC is through pre-emphasis, framing, windowing, fast Fourier transform, and taking the absolute value or the square value. Through the triangular band-pass Mel frequency filter bank, the logarithm of the output energy of the filter is taken and DCT inverse transformation is performed to obtain the characteristics of the dynamic Mel frequency cepstrum coefficient [26]. The relationship between the mel frequency represented by $\mathrm{mel}(f)$ and the linear frequency represented by f is given by the following equation:

$$\mathrm{mel}(f) = 2595 \times \log_{10}\left(1 + \frac{f}{700}\right). \tag{19}$$

(2) Linear prediction and cepstrum: Combining the two principles of linear prediction and cepstrum, the all pole model function is defined as illustrated in the following equation [27]:

$$H(z) = \frac{1}{1 - \sum_{k=1}^{p} a_k z^{-k}}. \tag{20}$$

In formula (20), a_k and p represent prediction coefficient and prediction order, respectively. Assuming that $h(n)$ represents the impulse response of the original music signal without preprocessing and $H(z)$ represents the system function, the process of obtaining the cepstrum is to calculate the logarithm of $H(z)$ first and then perform the inverse transformation. The calculation process is given by the following equation:

$$\lg H(z) = \widehat{H}(z) = \sum_{n=1}^{\infty} \widehat{h}(n) z^{-n}. \tag{21}$$

4. Classification of Music Genres

Grounded on the deep learning-based music genre classification method, in fact the music genre characteristics are extracted by preprocessing the musical signals. Furthermore, the music genre classification neural network model is planned according to the fully connected neural network structure. According to the characteristic sequence of the input music genre, the attention mechanism is researched, and the classification network of this article is designed using the attention mechanism to realize the classification of music genres.

4.1. Music Signal Preprocessing. Preprocessing the music signal is a very important stage in the music genre classification method. The preprocessing can make the next extracted features more effective. Moreover, less useful signals and noise can be removed to increase the prediction outcomes and accuracy. The following steps were carried out to preprocess the music signals.

(1) Preemphasis: In order to improve the high-frequency resolution of the music signal [28] and in order to perform overall spectrum analysis on the entire frequency band, the preemphasis is introduced. The preemphasis is generally achieved

through a first-order digital filter before the feature parameter extraction. The transfer function of the filter is expressed as given by the following equation:

$$H(z) = 1 - az^{-1}. \tag{22}$$

In formula (22), parameter a denotes the factor of preemphasis that is, in general, considered as a decimal digit nearby to 1. If we suppose that the worth of sample, related to the music genre signal, is $x(n)$ at time n, then the outcome after the pre-emphasis phase is as given by the following equation:

$$y(n) = x(n) - ax(n-1). \tag{23}$$

(2) Framing: In order to smoothly transition between the two frames of signals and to ensure that information is not lost, the framing phase needs to have an overlapping part of 1/3~1/2 frame length between the two frames. This overlapping fragment is entitled the frame shift. Then, the theoretical calculation formula for the number of frames of a music signal segment is computed as explained in the following equation:

$$N = \left[\frac{N_1 - N_0}{N_2 - N_0}\right]. \tag{24}$$

In formula (24), N_1 characterizes the entire span of the music signal, and N_2 symbolizes the length of the frame. Similarly, N signifies the total amount of frames, and N_0 exemplifies the frame shift.

(3) Windowing: After framing all music genre segments, in order to increase the continuity between frames, it is suggested to reduce edge effects and also reduce spectrum leakage. Furthermore, it is also essential and crucial to accomplish the process of windowing on the framed music signal. The commonly used window functions in audio signal processing include (i) Hamming window, (ii) rectangular window, and (iii) Hanning window. The three window functions are defined as follows:

$$\omega(n) = \begin{cases} 1, & 0 \le n \le M-1, \\ 0, & \text{otherwise}, \end{cases}$$

$$\omega(n) = \begin{cases} 0.5\left(1 - \cos\left(\dfrac{2\pi n}{(M-1)}\right)\right), & 0 \le n \le M-1, \\ 0, & \text{otherwise}, \end{cases}$$

$$\omega(n) = \begin{cases} 0.54 - 0.46\cos\left(\dfrac{2\pi n}{(M-1)}\right) & 0 \le n \le M-1, \\ 0, & \text{otherwise}, \end{cases} \tag{25}$$

These three window functions all have low-pass characteristics, and the main performance is determined by the attenuation of the first side lobe and the width of the main lobe. Since the boundary of the window function of the Hamming window is smooth, the first side lobe attenuation is the most severe, which can meritoriously circumvent the phenomenon of leakage [29]. Consequently, this paper selects Hamming window as the window function.

4.2. Music Feature Extraction. After preprocessing the signal of each music genre, the characteristic of the music genre, namely, MPCC, is extracted. The specific steps for extracting MPCC characteristic parameters of music genre signals are illustrated in the following steps:

(1) Accomplish the FFT transformation on every frame of the music genre signal after preprocessing to acquire the spectrum of the frequency.

(2) Proceed with the square of the modulus for the FFT-transformed spectrum, computed in previous step, in order to acquire the discrete power spectrum, denoted by $|X(k)|^2$, of every music signal.

(3) In the third step, pass the power spectrum $|X(k)|^2$ for filtering through a set of Mel filters using the following equation:

$$S(i,m) = \sum_{k=0}^{N-1} |X(i,k)|^2 H_m(k), 0 \le m < N. \tag{26}$$

(4) Finally, calculate the natural logarithm to acquire the MPCC parameters for each and every music genre signal using the following equation:

$$\text{mpcc}(i,m) = \ln S(i,m). \tag{27}$$

Subsequently, the range of the frequency in the music signal changes from a little and few hertz to thousands or kilo of hertz, and the transformation is moderately very slow. Therefore, the MPCC parameters extracted from each frame of the music genre signal in this paper are 12-dimensional.

4.3. Design of Network Model for Music Genre Classification. The neural network learning process is listed in Figure 5(a). According to the neural network structure, the design and research of music classification model is shown in Figure 5(b) [15, 16].

The input of the input layer processes the music signal through preemphasis, framing, and windowing to extract music genre features. The music genre feature sequence, extracted from the input layer, is their features learned. Similarly, the influence on the current time state is calculated from the future and the past, respectively. The feature representation $H = \{H_1, H_2, \ldots, H_L\}$ is obtained and combined with the context semantic information, which is input into the attention mechanism network. The attention

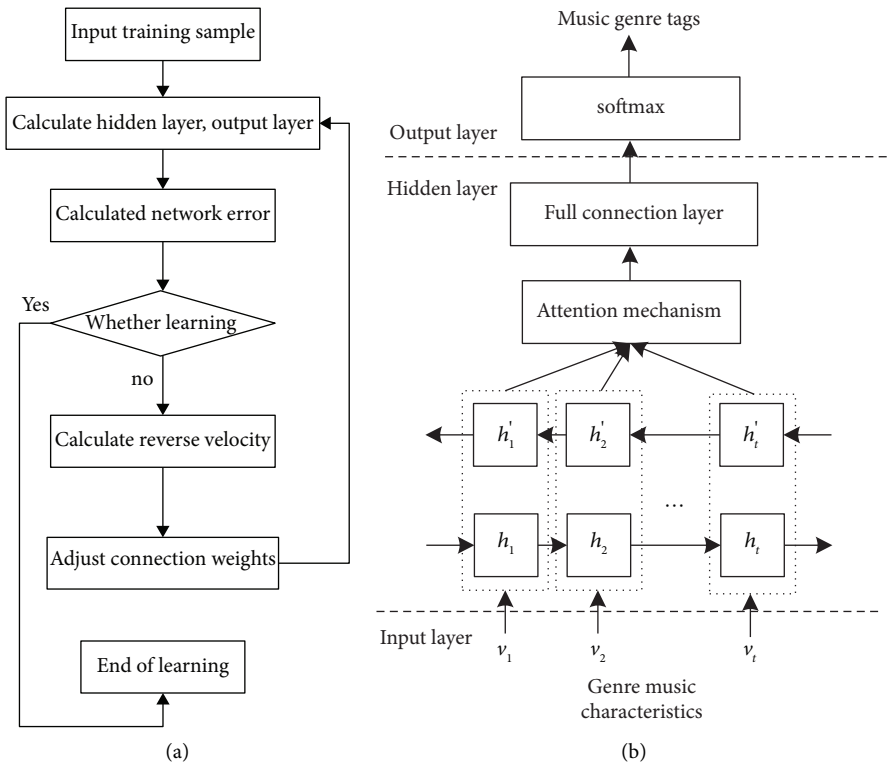

Figure 5: (a) Neural network learning flow chart; (b) structure diagram of music genre classification network model.

mechanism network learns the input feature representation H and obtains the corresponding attention probability distribution [14]. Subsequently, it multiplies each attention probability by its corresponding feature vector and finally obtains the music genre feature vector representation v. The attention process is given as follows:

$$e_t = \tanh\left(WH_t + b\right). \tag{28}$$

In the above formula, e_t is the attention score of the feature vector H_t at time t in the feature representation H. In the next phase, the activation function softmax is applied, as given by equation (28), to compute v as given by the following equation:

$$\alpha_i = \text{soft}\max\left(e_i\right) = \frac{\exp\left(e_i\right)}{\sum_{k=1}^{L}\exp\left(e_k\right)}, \tag{29}$$

$$v = \sum_{i=1}^{L}\alpha_i H_i. \tag{30}$$

The output layer of the network model is defined as follows by calculating the cross-entropy loss function:

$$C = \frac{1}{n}\sum_{x} y\ \ln\left(a\right) + \left(1 - y\right)\ln\left(1 - a\right). \tag{31}$$

In the above formula, C is the loss, n is the number of samples, x is the input sample, and y and a are the output predicted value and target expected value, respectively, of input x of the network model. Note that the classification of music genres is calculated using the following equation:

$$\Delta\theta = -\alpha\frac{v_t}{\sqrt{s_t + \varepsilon}}. \tag{32}$$

In the above formula, the classification of music genres is realized through the steps described above.

5. Experimental Analysis

5.1. Experimental Environment and Datasets. In order to verify the effectiveness of the music genre classification method based on deep learning, the MATLAB 2016a programming software was used to extract the features of music signals. We build a fully connected neural network based on Theano library using the Python language. Similarly, we model training that uses the Adam optimization method as the gradient descent optimization algorithm. The learning rate is set to 0.001, and the training rounds are set to 200 rounds. All experiments are carried out and verified on the GTZAN dataset. There are a total of 1000 audio files in the GTZAN dataset. These 1000 files contain 10 genres of music, and each genre has a total of 100 samples. Note that the experiments were carried out several times and the reported results are averaged over multiple runs. In the experiments, the method of nonrepetitive random sampling is adopted, and 80% of each music genre dataset is selected. Furthermore, the distribution of the number of music genres in each

Table 1: Distribution of music genres in each category.

Music genre	Rock	Metal	Country	Classical	Blues
Training set	320	308	268	320	320
Validation set	80	78	67	80	79

Table 2: Music genre classification effect of the proposed method.

		Forecast confusion matrix (%)				
		Rock	Metal	Country	Classical	Blues
Actual confusion matrix (%)	Rock	85.07	5.97	8.96	0	0
	Metal	3.80	94.94	0	0	1.27
	Country	15.38	0	82.05	0	2.56
	Classical	2.50	1.25	2.50	92.50	1.25
	Blues	1.25	0	0	3.75	95.00

category of the training set and validation set is as shown in Table 1.

5.2. Classification Evaluation Index. We performed the music genre classification experiments on five different music genre files of rock, metal, country, classical, and blues. In fact, this is a multiclassification task, and the categories are relatively balanced. The accuracy of the sample population accuracy is expressed follows:

$$\text{accuracy} = \frac{\sum_i M(i,i)}{\sum_i \sum_j M(i,j)} \times 100\%. \quad (33)$$

In the above formula, $M(i, j)$ is the number of samples in the population.

5.3. Music Genre Classification Effect. After the music genre classification network model is trained by the proposed method, the classification performance of the music genre classification network model is evaluated by using the verification set. The results and the forecast confusion matrix outcomes for 5 files are shown in Table 2.

Analyzing the results demonstrated in Table 2, we conclude that the metal music, classical music, and blues music all successfully fit into their appropriate classification categories, with accuracy rates of 94.94 percent, 92.50 percent, and 95.00 percent, respectively. Furthermore, the rock music and country music are sometimes mislabeled. Due to the fact that some country music can be used as an accompaniment to country dancing and that some rock music is mistakenly categorized as country music, country music is often confused with rock music. The distinction between rock music and metal music is somewhat erroneous. However, the possible reason is that they both pay more attention to rhythm and are similar. In general, the proposed method is used to effectively classify the music of the above five genres, and the proposed method has a better effect on the classification of music genres.

The total number of neurons in the BP neural network has a significant impact over the training and test error. For example, as shown in Table 3, when the number of neurons increases, the training error continues to decrease, and we observed that there is a certain correlation between them. After the analysis, we concluded that 7 as the number of neurons is the most ideal measurement for our experimental setup.

Table 3: Relationship between number of neurons in hidden layer and error.

Number of hidden layer neurons	The training error	Test error
3	1.385	1.11
4	0.805	0.81
5	0.706	0.72
6	0.629	0.71
7	0.621	0.70

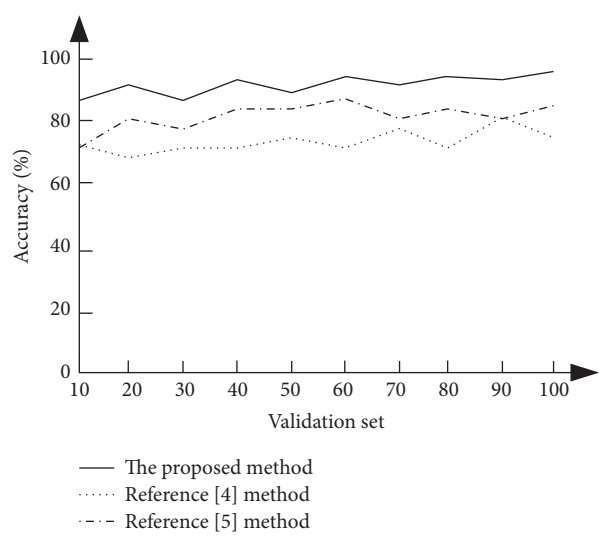

Figure 6: Comparison of outcomes of various techniques for music genre classification in terms of accuracy.

5.4. Classification Accuracy of Music Genres. The assessment outcomes and comparative study of classification precision of various music genre approaches are presented in Figure 6.

We can easily observe from Figure 6 that, under different validation sets, [4] is 73%, and [30] is 82%. The average music genre classification accuracy rate is 91%. Furthermore,

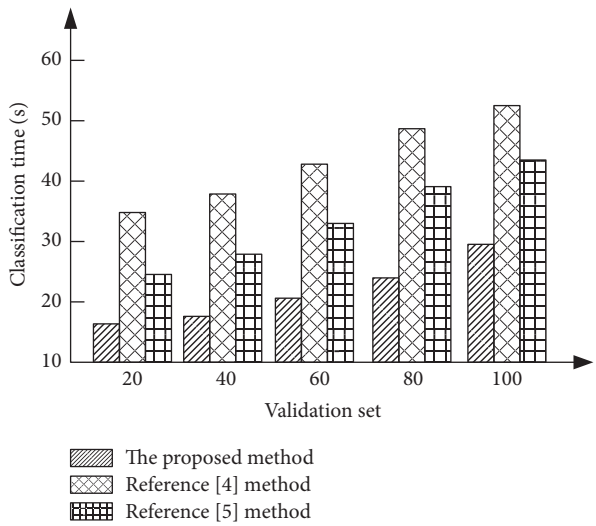

Figure 7: Comparison of outcomes of various approaches for music genre classification in terms of time.

we can also observe that, associated with the method demonstrated in [4] and the approach presented in [30], the correctness and accuracy of the proposed music genre classification method are significantly higher.

5.5. Music Genre Classification Time. The evaluation results, in terms of classification time, when the proposed approach is compared with other music genre classification techniques, are presented in Figure 7.

We can observe from Figure 7 that when the number of verification sets increases, the music type classification time of various techniques will also increase. The technique based on the deep learning algorithm, projected in this paper, has the benefits of refining the accurateness, precision, and effectiveness of the music classification.

6. Conclusions and Future Work

In this paper, a prediction method based on the deep learning algorithm was proposed, which has the advantages of refining the correctness, precision, and effectiveness of the music classification. The experimental outcomes demonstrated that the projected method has the ability to effectively improve the accuracy of the music classification and is helpful for music channel classification. Moreover, its music genre classification accuracy is high, which can effectively shorten the music genre classification time and has, therefore, a better music genre classification effect. However, because the research scope of this algorithm is not extended to the subject of finite element, the proposed method has some limitations. In the process of extracting music genre features, this paper ignores the accompaniment information of music. The main melody of the same piece of music, accompanied by different music, may present different genres and styles.

In subsequent research, we can consider combining the main melody and accompaniment of music to extract features to further improve the accuracy of classification. Moreover, advanced deep learning methods such as deep neural networks should be considered to improve the accuracy of the prediction outcome. In learning algorithms, the training is one of the activities that take significant time and can degrade the performance of the whole system. Therefore, we will consider dividing the training and prediction phases over the edge-cloud architecture so that the training may happen at the remote cloud that has usually bulk of resources. The prediction part of the algorithm should run on edge which will essentially increase the processing and response time of the system.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Research Article

A Personalized Recommendation Technique for Travel Route Based on Fuzzy Consistent Matrix

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Recommending travel routes for tourists has become a research hotspot in the present tourism industry. Various machine learning methods have been well studied for recommendation systems. However, the accuracy of these systems is not up to the expected levels. In order to increase the ranking accuracy, as well as, the recall rate of the recommended routes by the personalized travel recommendation algorithm, in this paper, a fuzzy consistent matrix technique is introduced for personalized travel recommendation systems. First of all, the user's travel interest data are obtained through the fuzzy consistency matrix. Next, the user's travel interest data are de-noised to determine the user's preferred interest points and the coverage of the user's interest points. Besides this, the constraints of the route recommendation systems have also become a research topic. Therefore, the proposed method also uses the fuzzy consistent matrix technology to determine the users' similarity and classifies the personalized recommendation algorithm. Finally, a personalized travel recommendation model is constructed to comprehend the personalized travel route recommendation. The investigational outcomes, using real datasets, illustrate that when the number of routes is 5000, then the accuracy rate of the proposed method is approximately 97.21%, and the accuracy rate of the recommendation ranking is 97.54%. We also observed that when using 60 GB of data, the recall rate of the proposed method, for personalized travel recommendation routes, can reach as high as 97.59%.

1. Introduction

In the modern ages, with the continuous advancement and popularization of information technology, especially big data and machine learning technologies, the Internet has gradually integrated into all facets of folks' life, providing many conveniences for people's study and life. However, with the rapid proliferation of network and information resources, the popular service mode of traditional websites or platforms has been difficult to keep up with the personalized pursuit of users in different scenes. Based on this, in what way to scientifically acquire the information that users are really interested in from massive resources has been urgently analyzed and solved by professionals and researchers internationally [1]. The personalized information recommendation system is used to resolve the issue that users do not know how to obtain the content they are categorically fascinated in when facing an enormous volume of information. The principle of the recommendation system is to first obtain the user's browsing record data, build its corresponding interest model, and then analyze the user's current interest preference and predict the possibility of future interest preference change through the model. Finally, the system recommends the content of interest to different users. The information of personalized recommendation system comes from and mostly depends on user interest modeling.

The research on user interest preference in the modeling stage is very important, which is unswervingly associated with the worth and importance of a recommendation system [2]. Therefore, the system can really push satisfactory projects for each user only after obtaining and fully understanding the user's interest and preference information. However, so far, user interest modeling still faces many

challenges, which can be divided into three parts: (i) the first part, users' interest preferences are often diverse, and each user may have different needs and preferences, with obvious diversity characteristics; (ii) in the second part, the user's curiosity and attention frequently fluctuate with the change (passage) of time and situation. In fact, even the same user may lead to different interest preferences in different situation environments, which has obvious changeable characteristics; and (iii) in the third part, the data information of user interest resources that can be obtained is extremely scarce [3]. Such problems have not been effectively solved, which also leads to the fact that few of the existing recommendation algorithms can really solve the two problems of user cold start and interest overfitting. In fact, this makes the efficiency and performance of the existing recommendation systems significantly low and, also, the user's experience of the system is not high.

The introduction of personalized recommendation service into the tourism industry is the trend of the development of smart tourism. Tourism is a mobile, real-time, and changeable activity. Real-time and personalized push of tourism information services of interest to users is an important way to improve user satisfaction. Tourism is an activity with a more situational interactive experience. Its personalized service should be properly combined with the user's current situation and provide users with real-time personalized and efficient recommendation service according to the user's situational conditions, which is a hot issue in the research of tourism service at home and abroad [4]. Experiments of state-of-the-art literature demonstrate that this personalized recommendation algorithm and method can resolve the issue of scarce tag data, and the recommendation performance of the trained recommendation system is significantly good as compared to other techniques. However, unfortunately, the accuracy of the personalized tourism recommendation procedure is poor [5–7].

As a result, the fuzzy consistent matrix method is introduced for the purpose of recommending personalized travel. To begin, the user's travel interest data are obtained via the fuzzy consistency matrix, and the user's travel interest data are de-noised in order to determine a particular user's preferred points of attention, i.e., POI (point of interest) and the coverage of the user's interest points. Then, the optimal route is automatically planned, and the user similarity is calculated using fuzzy consistent matrix technology. In addition, the personalized recommendation algorithm is classified. Finally, the personalized travel recommendation model is constructed to comprehend the personalized travel recommendation for routes. The major contributions of the research conducted in this study can be shortened as follows:

(1) The fuzzy consistent matrix method is introduced for personalized travel recommendation algorithm;

(2) The user's travel interest data is obtained through the fuzzy consistency matrix;

(3) The data are de-noised to determine the user's preferred interest points. We use the fuzzy consistent matrix technology to compute the users' resemblance and similarity, and classifies the personalized recommendation algorithm; and

(4) A personalized travel recommendation model is then constructed to comprehend the recommendations for the personalized travel route.

The rest of the manuscript is arranged along these lines. In Section 2, we deliberate state-of-the-art related works. In Section 3, interest analysis of tourism users based on fuzzy consistent matrix is explained in details. Along with the geographical feature, in this section, we also discuss the similarity calculation between users based on fuzzy consistent matrix. The personalized tourism recommendation algorithm based on the fuzzy consistent matrix is proposed in Section 4. Experiments using real datasets are analyzed in Section 5. At the end, Section 6 completes this paper and offers guidelines for additional work.

2. Related Work

The introduction of personalized recommendation service into the tourism industry is the trend of the development of smart tourism. Tourism is a mobile, real-time, and changeable activity. Real-time and personalized push of tourism information services of interest to users is an important way to improve user satisfaction. Tourism is an activity with more situational interactive experience. Its personalized service should be properly combined with the user's current situation and provide users with real-time personalized and efficient recommendation service according to the user's situational conditions, which is a sizzling subject in the research of tourism service at home and abroad [4]. Because user demand changes dynamically with time and scene, tourists' requirements for tourism services are generally closely related to their current scene conditions. In order to provide users with efficient recommendation applications, it is indispensable to investigate and judge the user's situation state, identify effective situation feature elements, and then provide users with a personalized recommendation list in line with their current situation features. Relevant scholars have studied this and made some progress.

Heng et al. suggested a personalized tourism recommendation procedure grounded on attribute features [8]. The algorithm considers the similarity of each attribute feature of the project and improves the calculation method of the traditional method of similarity. Moreover, it has the capability to measure the similarity from multiple dimensions. Their attained investigational outcomes indicate that the suggested algorithm can increase the superiority of recommendation, but the accuracy of personalized travel recommendation route ranking is extremely poor. Chunsheng et al. proposed the research on tourist attraction recommendation algorithm based on user online comments [9]. The authors used crawler software and Jieba word segmentation to obtain and preprocess the user's online comment information on tourist attractions. Furthermore,

they also used the emotion intensity analysis method to determine the evaluation scale of each comment relative to each attribute of scenic spots. Through this process, they calculated the user's weight on each attribute of scenic spots according to the processed online comment information. In fact, the well-known TOPSIS ranking technique is usually used to endorse users' tourist attractions. Experiments demonstrate that this algorithm can effectively determine the user's preference for scenic spots and successfully increase the correctness of scenic spot recommendation, but the recall rate of personalized tourism recommendation is low and the recommendation efficiency is low.

Zheng et al. offered the state-of-the-art research on personalized recommendation systems for traveler attractions grounded on the concept of domain adaptation [10]. By using the domain adaptation technology, an enormous amount of labeled data in other fields related to the target task are used as auxiliary data. In the next step, the recommendation model is trained to obtain a recommendation system with good performance and efficiency. The authors conducted several experiments and the acquired outcomes indicate that the offered personalized recommendation system can effectively solve the problem of scarce tag data, and the recommendation performance of the trained recommendation system is significantly good. However, the accuracy of the personalized tourism recommendation algorithm is poor [5–7]. Thus, improving the efficiency, as well as, accuracy of such recommendation systems is the focus of this research.

3. Interest Analysis of Tourism Users Based on Fuzzy Consistent Matrix

3.1. Data Denoising and Filtering. The Foursquare and Flickr social networking sites cover the check-in records of major cities in the world, and at least 10000 people in each city sign-in on the social network. In this paper, several cities are selected as the experimental data set in the two social networks. On the Foursquare data set, the data of L City are selected as the city where the check-in record belongs. In the Flickr dataset, the data of X city, Y City, Z City, and r city are selected. The POI is an abbreviation for "Point of Interest". From the perspective of the GIS (i.e., geographic information system), a POI can be a mailbox, a shop, a house, a bus station, or any other location. The location information (in terms of longitude and latitude) in the data set is an important feature to determine the user's specific location and calculate the distance between different POIs [11]. To begin, all data items in the data set that lack location information are removed. Due to the loss of location data, it is impossible to determine the location of the user's punch in record, and thus the POI accessed by the user.

In the field of personalized recommendation, location data can effectively mine users' access preferences and then better recommend POIs that meet those preferences when recommending to users [12]. Second, this paper determines the location of the user's stopover rendering to the location information of the check-in record. When the user visits a particular location, multiple check-in records will be generated. For example, when the user is in a point of interest or shopping mall, multiple record data will be generated, but multiple check-in records belong to the same location. The process of computing whether a user belongs to a particular POI or not is given as follows. We match the POI accessed by the user according to the location information of the check-in record, as shown in Figure 1 [13]. Using the position information of the POI, we set the position of the POI as the center with a radius of 200 m. In the next stage, we determine the coverage of the POI and judge whether the user's check-in location belongs to the POI by calculating the European distance between the longitude and latitude. If the check-in record is within the coverage of the POI, it is determined that the user's check-in location belongs to the POI, otherwise the user's check-in location does not belong to the POI.

If a particular user's check-in information, unfortunately, does not match the appropriate POI, that is, the distance between the location information of the check-in record and all POIs is greater than 200 m, then the check-in record is regarded as a noise point and the check-in information is removed from the user's historical check-in record set. In addition, in order to better mine user preferences, this paper removes the basically inaccessible POI from the POI set. This also ensures that redundant data are removed which basically is a preprocessing technique. This ensures that only essential and most important data are processed.

3.2. Geographical Factor Feature Analysis. Geographical location has a certain impact on users' check-in behavior. Users generally like to visit POI close to themselves. First, the user's historical TOP-K punch-in record POI is counted in the check-in records of social networks based on all of their historical check-in records. The user's access frequency to POI may serve as a proxy for their own preferences. As shown in Figure 2, the ArcGIS tool [14] visually analyses all historical information and the user's TOP-K points of interest. This time the historical access record with user ID 6715 is adopted, and the POI with user historical access frequency of TOP-10 is counted for analysis. Among them, the black triangle points represent the interest points with the user access frequency of top-10, that is, the user activity center point. The green dot indicates the user_ All history points of User_ID6715 [15].

The depiction in Figure 2 makes it clear that every interest point in the user's top 10 is scattered throughout the user's activity center, meaning that the user's actions primarily take place in and around these centers. It may be deduced that users' past actions have been concentrated in their frequent locations, and users are accustomed to accessing POI there, meaning they prefer to do so constantly [16]. The user's inclination for POI in various topographical regions can therefore be utilized as one of the benchmarks to quantify the user's inclination for the POI. Therefore, as a result, the geographical factor features and characteristics can be incorporated into the personalized recommendation model.

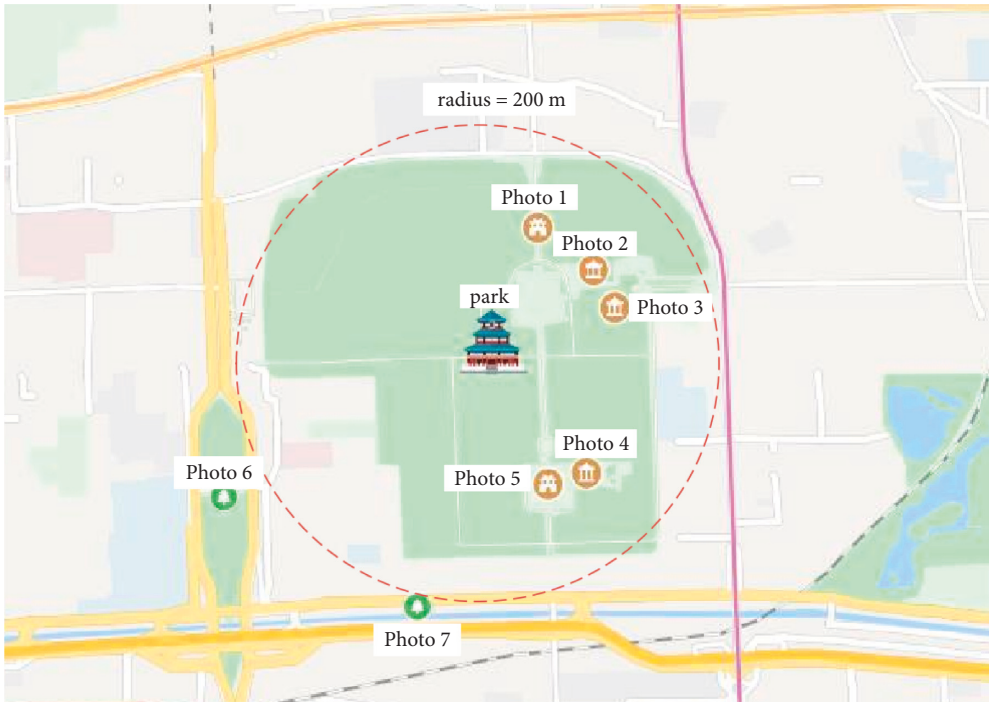

Figure 1: The POI matching diagram.

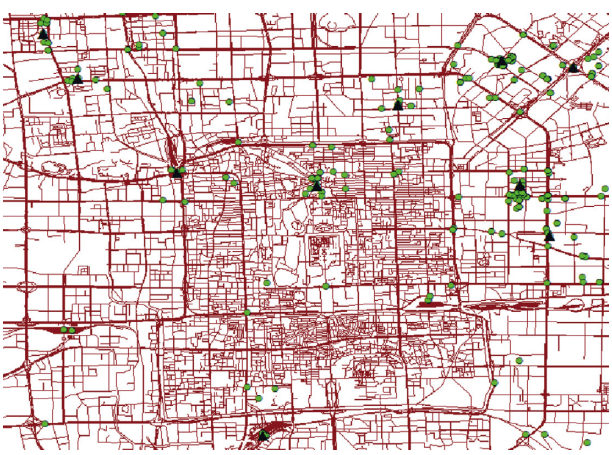

Figure 2: The distribution of interest points of users on TOP-10.

3.3. Similarity Calculation between Users Based on Fuzzy Consistent Matrix. In the process of fuzzy decision-making, when the elements are compared, the established judgment matrix is the fuzzy complementary matrix. It can be regarded as a complementary relationship that the values of the elements compared with each other satisfy and when experts compare elements, it is necessary to judge the rationality of expert judgment. If experts believe that it is more important than others, there should be more important, that is, the expert's judgment should meet the consistency [17]. In order to resolve the above difficulties, the concept of fuzzy uniform matrix is introduced.

Definition 1. If a particular fuzzy matrix that is denoted by $R = (r_{ij})_{n\times n}$ and essentially satisfy $r_{ij} = r_{ik} - r_{jk} + 0.5\,(\forall i, j, k \in I)$, then the matrix R is known as a fuzzy uniform matrix. According to the definition of fuzzy uniform matrix, it can be obtained that it has the following two properties:

(1) Fuzzy consistent matrix must be fuzzy complementary matrix [18].

It is proved that taking the fuzzy uniform matrix $T = (t_{ij})_{b\times b}$, when $k = j$, then there is $r_{ij} = 0.5, \forall j \in I$, and when $k = i$, then there is $t_{ij} = t_{ii} - t_{ji} + 0.5$, that is, there is $t_{ij} + t_{ji} = 1, \forall i, j \in I$.

(2) The difference between the corresponding elements of any two rows of fuzzy uniform matrix $T = (t_{ij})_{b\times b}$ is a constant.

It is proved that if rows i and j are arbitrarily specified, then the fixed i, i, j, $\forall k \in I$, and $r_{ij} = r_{ik} - r_{jk} + 0.5$ can be obtained from the definition of fuzzy consistent matrix. In fact, the following formula (1) is used to carry out this task.

$$\forall k \in I, r_{ik} - r_{jk} = r_{ij} - 0.5. \tag{1}$$

In the above formula (1), i, j are a fixed value, only it is taken arbitrarily, so the conclusion is tenable. At the same time, the following Lemmas 1 and 2 hold.

Lemma 1. *The lemma says that a particular matrix is a fuzzy consistent matrix if the dissimilarity amongst the analogous elements of any two rows is a fixed value [19].*

It is proved that if $T = (t_{ij})_{b\times b}$ is a fuzzy complementary matrix, there is $r_{jj} = 0.5, \forall j \in I$,. Furthermore, when $\forall i, j, k \in I$, there is $r_{ik} - r_{jk} = g$, where g is a fixed value. From the arbitrariness of k, the above formula also holds when $k = j$, so there is $r_{ij} - r_{jj} = g$, that is, $r_{ij} - 0.5 = g$, so there is $r_{ik} - r_{jk} = r_{ij} - 0.5$, which holds for $\forall i, j, k \in I$.

For the traditional reciprocal judgment matrix denoted by $T = (t_{ij})_{b\times b}$, if its weight vector is given by $W = (w_1, w_2, \ldots, w_n)^T$, then the relationship satisfied between its element characterized by r_{ij} and weight can be approximately regarded as $r_{ij} = w_i/w_j$. In other words, the relationship illustrates the weight ratio of the corresponding two elements. This should be noted that the complementary judgment matrix describes the relationship between them from another angle, that is, the difference between the weights of two elements. For any fuzzy judgment matrix, there is the following lemma w that must hold [20]:

Lemma 2. *Let $T = (t_{ij})_{b\times b}$ be a fuzzy complementary matrix and $W = (w_1, w_2, \ldots, w_n)^T$ be a nonnegative normalized vector. For a given positive number g, $\forall i, j \in I$ the following relationship holds.*

$$t_{ij} = \left(w_i - gw_j\right) + 0.5. \tag{2}$$

Then, T is a fuzzy uniform matrix.

$$\forall i, j \in I, t_{ij} = \left(w_i - gw_j\right) + 0.5, \tag{3}$$

$$\begin{aligned} &\Rightarrow \forall i, k \in I, t_{ik} = \left(w_i - gw_k\right) + 0.5, \\ &\Rightarrow t_{ik} - t_{ij} = \left(w_j - gw_k\right) = t_{jk} - 0.5, \\ &\Rightarrow t_{ij} = t_{ik} - t_{jk} + 0.5. \end{aligned} \tag{4}$$

The above equation $\forall i, j, k \in I$ is true, so T is a fuzzy uniform matrix. Calculate the similarity between users according to the above matrix to realize the personalized recommendation of user travel routes.

4. Personalized Tourism Recommendation Algorithm Based on Fuzzy Consistent Matrix

4.1. Personalized Recommendation Algorithm Classification. At present, there are several categories of personalized recommendation systems. This section briefly introduces the recommendation algorithms that need to be used in this paper. This section first introduces the two common technologies of: (i) content-based recommendation; and (ii) demographic-based recommendation. Due to the fact that the later model is used in the process of construction of model proposed in this paper and draws on its ideas, therefore it is necessary to elaborate it further [21].

4.1.1. Content-Based Recommendation. The fundamental concept behind the content-based recommendation algorithm must be to use the attributes of the recommended items. For example, when recommending a tourism item, the characteristics of the tourism item may include the style, geographical location, and other attributes of the tourism item. These attributes are used to calculate the similarity of the tourism item and list the similar tourism items of the user's favorite tourism items in history and recommend tourism projects that users have not experienced to target users [22]. In fact, the notion of content-based recommendation procedure is to mine the attribute eigenvalues of recommended items and calculate the similarity between contents according to the attribute eigenvalues. The key point of this technology is to model the attributes of items and analyze users' interests and preferences. The process of generating recommendation results in content-based recommendation algorithm is shown in Figure 3, which generally includes three steps [23]:

(1) Extract the item attribute values.
(2) Calculate the similarity between items according to the item attributes.
(3) Obtain the user's historical interest preference from the user's historical behavior data in the system,
(4) Establish the user's interest model, compare the attribute value of the item with the user's interest model.
(5) Generate a list of recommendation results.
(6) Feedback to users.

The flow chart of a typical recommendation system, i.e., content-based is shown in Figure 3.

Although the content-based recommendation procedure can quickly establish and complete the recommendation process, it only considers the attributes of the item itself, has a certain one sidedness, and the recommendation result will be rough [5, 24].

4.1.2. Recommendation Algorithm Based on Demographics. These algorithms are based on users' particular characteristics and the information which is available. The recommendation algorithm will collect the user's characteristic information, and explore the user's background and other information. In the next step, the system computes the resemblance and similarity amongst usersand recommends the items loved by the target user's neighbors to the target user [25]. The process of generating recommendation results by this technology is shown in Figure 4, which mainly comprises of three different steps:

(1) Model the user's eigenvalues, such as user's occupation, occupation, interest, and other information;
(2) Using the model, the similarity between system users is calculated and the nearest neighbor of the target user is found; and
(3) Recommend the favorite items of the nearest neighbor users to the target users.

Figure 4 shows a flow chart of recommendation based on demographics when using user characteristics for recommendation, historical behavior data, and project attributes are not required. The project can be recommended directly. However, the algorithm is relatively rough and can only make simple recommendations, which is difficult to meet the requirements of personalized tourism recommendation.

4.2. Personalized Travel Route Recommendation Algorithm

4.2.1. User Model Initialization. In this paper, the user's vector space model uses vector u' to characterize the feature vector of user u. First, the demographic attribute information

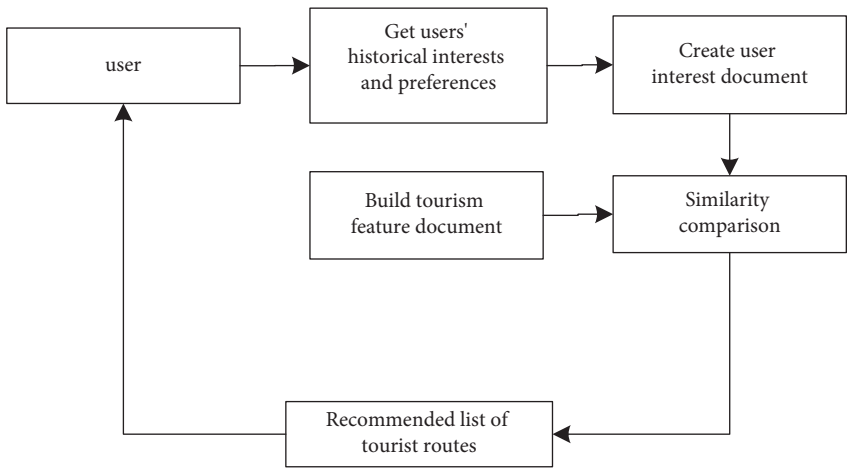

Figure 3: The flow chart of content-based recommendation system.

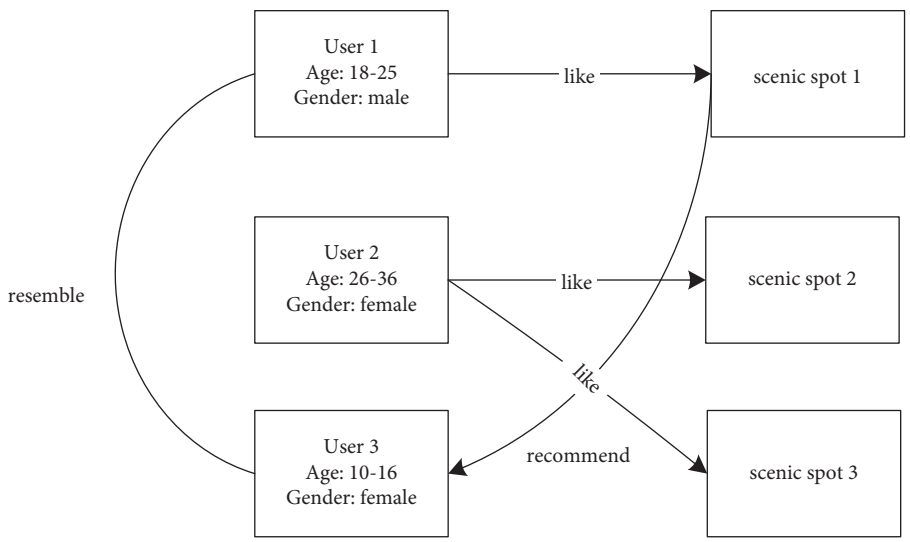

Figure 4: Flow chart for the demographic-based recommendation system.

of user u is introduced into user feature vector u'. After initialization, the user space vector is expressed as $u' = \{(b_u^1, b_u^2, \ldots, b_u^k)\}$. In the formula, each element is a basic information, out of a total of k basic information [26]. In order to solve the system cold start problem, after a particular user enters the system, let the user select the category in which the user is interested. Suppose that the interest category of a user is expressed as $Fav_u' = (m_u^1, m_u^2, \ldots, m_u^n)$, and after introducing the interest category attribute, the user's feature vector is expressed as $Fav_u' = (m_u^1, m_u^2, \ldots, m_u^n)$.

4.2.2. Modeling Users with Content Information. Content analysis enriches the user interest model by studying the user's scoring, booking, or browsing records to obtain the user's preference information. The common analysis method is TF-IDF method, which is separated into two different steps. The primary step is to segment the item, remove the stop word, merge synonyms, and get r phrases. The second step is to obtain the information value of F_{ij} according to the calculation formula (1).

$$F_{ij} = \frac{gf_{ij}}{\max_z f_{zj}} + \frac{N}{n_i}, \tag{5}$$

where N is the overall quantity of items, f_{ij} is the amount of times phrase i looks in item j, and phrase i appears in n_i items. Item j is calculated with this formula for the p phrases of each document and expressed as a p-dimensional feature vector $\{(k_1, v_1), (k_2, v_2), \ldots, (k_p, v_p)\}$. Furthermore, combined with the attribute information of the item user u likes, the attribute information $k_u' = \{(k_u^1, v_u^1), (k_u^2, v_u^2), \ldots, (k_u^p, v_u^p)\}$ of user u represented by p phrases can be obtained. When the p size is large, users have more attributes, and different attributes have different selection weights for users. If the noise attributes are considered, in addition to increasing the cost of information acquisition and the amount of calculation, it will also reduce the prediction accuracy.

Therefore, when selecting attributes, some attribute information that can better describe users' preferences should be selected [25, 27].

This should be noted that attribute selection is a heuristic learning process. According to domain knowledge or statistical knowledge, the attribute selection in this paper uses the χ^2-test method in statistics to set the classification set as D and the attribute to be detected as I_t. The relationship between attribute and category is given in Table 1.

The χ^2-test is based on the assumption that D and I_t are independent, and the following test formula (4) is given as follows:

$$\chi^2 = \sum_{I,m} \frac{\left(k_{lm} - \Pr(D = l) + n\Pr\left(I_t = m\right)\right)^2}{Pr(D = l)\Pr\left(I_t = m\right)}. \quad (6)$$

In the above formula, when χ^2 is larger, the correlation between category D and attribute I_t is higher. The calculation strategy of χ^2 is to calculate the χ^2 value of each attribute, sort it from large to small, select the top N most important attributes to model the user, and the value of N is obtained by maximizing the prediction accuracy. Through the above selection, s attributes are obtained to get the best effect, and $u_u' = \{\alpha(e_u^1, e_u^2, \ldots, e_u^k), \beta(m_u^1, m_u^2, \ldots, m_u^n), \delta(v_u^1, v_u^2, \ldots, v_u^s)\}$ are its user model.

4.2.3. User Personalized Travel Route Recommendation. There are two types of user project interaction information: explicit and implicit. Explicit behavior generally includes scoring and buying, while implicit behavior includes browsing, collecting, and sharing. This paper studies the explicit behavior of users and uses the user-item scoring matrix to model. The user project scoring matrix is given in Table 2. Note that U characterizes a particular user.

In Table 2, $S_{i,j}$ is the user's score for the project, and the scoring matrix is a $m \times n$ two-dimensional matrix. In this paper, we use the common singular value decomposition technique in order to decompose the scoring matrix into: (i) a user characteristic matrix P; and (ii) an item characteristic matrix Q, that is, $R = P^T Q$. In subsequent steps, then the scoring of the user u on item i becomes $r_{ui} = (p_u q_i)'$. The process continues to learn and obtain matrices P and Q through the random gradient descent method, and then predict score r_{ui}. The user model not only considers the basic attributes of users, but also comprehensively considers the user project interaction information, and adds the factor of collective intelligence to the user model [7]. The user u is expressed in the characteristic matrix P as: $p_u' = \{p_u^1, p_u^2, \ldots, p_u^k\}$.

In this way, we can realize the accurate recommendation of personalized tourism routes. It can be seen that our method is general and can be used in recommendation in other fields.

5. Experiments and Results

5.1. Experimental Data Description. The Flickr dataset is used in our experiments and evaluation of the proposed recommendation system. Each picture in the dataset includes a photo ID, a user ID, shooting time, geographic coordinate information, and the accuracy of geographic coordinates. This paper extracts images taken in Toronto from Flickr dataset, Budapest, Vienna, and Osaka are the four different cities marked with geographic information. The data set description is shown in Table 3.

Table 1: The attributes category and relationships.

D	I_t	
	0	1
0	K_{00}	K_{01}
1	K_{10}	K_{02}
2	K_{20}	K_{03}

Table 2: The user project scoring matrix.

	I_1	I_2	...	I_m
U_1	S_{11}	S_{12}	...	S_{1n}
U_2	S_{21}	S_{22}	...	S_{2n}
...	...	...	...	...
U_n	S_{n1}	S_{n2}	...	S_{mn}

We use the process of matching to ensure that the obtained data are preprocessed and have no duplicate entries. The preprocessed is then used to verify the proposed personalized tourism recommendation algorithm. Various valuations metrics are then used to measure the overall performance of the system in terms of prediction accuracy, sorting or ranking accuracy, and the recall ratio. In the next subsections, we briefly explain these metrics and discuss their calculation mechanism through mathematical equations.

5.2. Index Calculation

5.2.1. Accuracy. Obviously, accuracy is the most important evaluation index for recommendation system. In fact, it measures the accuracy of recommendation algorithm in predicting users' preference for recommended products. From different angles, accuracy can be divided into prediction score accuracy, prediction score relevance, classification accuracy, and sorting accuracy. The accuracy evaluation of the prediction score is the similarity between the score predicted by the algorithm and the user's actual score [6]. There are many methods to evaluate the prediction accuracy, and the most commonly used are the mean square error (MSE) metric, mean absolute error (MAE) metric, root mean square error (RMSE), and standard mean absolute error (NMAE) metric. The most commonly used is the former one and it is given by formula (5):

$$MAE = \frac{\sum_{u,i \in T} \left| r_{ui} - r_{u,i}' \right|}{|T|}, \quad (7)$$

where r_{ui} is the actual score of the user u on item i, $r_{u,i}'$ is the prediction score obtained by the algorithm, and T is the test set. The prediction accuracy of mean absolute error calculation has obvious advantages, e.g., simple calculation and uniqueness of the obtained mean absolute error. The

Table 3: Description of the flickr dataset.

City	Number of photos	Number of users	Number of POI	Number of tourism sequences
Toronto	157505	1395	39419	6057
Budapest	36000	935	18513	2361
Vienna	85149	1155	34515	3193
Osaka	39240	450	7747	1115

disadvantage is also obvious, that is, when the difference between the average absolute error of the two scenic spots is small, then the difference is not significant. In such scenarios, the MAE cannot be a good evaluation metric.

5.2.2. Sorting Accuracy. The ranking accuracy is defined as the accuracy of the ranking of the recommendation list relative to the user's real ranking of the tourist route. This index is suitable for the recommendation system that provides users with a ranking list. For example, if the top 10 scenic spots in the list are liked by users, and the user's sorting is completely different from the order given by the algorithm, then in that case the sorting accuracy will also be very low [28]. The average ranking index is used to calculate the ranking accuracy of the tourism route recommendation algorithm, which is defined as given by formula (6):

$$r_i = \frac{P_i}{M}. \tag{8}$$

In the above formula, M is the number of items not selected by the user in the training set, and P_i is the position of the item i to be predicted in the recommendation list in the test set.

5.2.3. Recall Rate. Recall rate, also known as "recall ratio", refers to the ratio of the number of recommended tourist attractions to the number of all relevant tourist attractions. In fact, it measures the recall rate of the tourist route recommendation algorithm [29]. Assuming that the set of tourist attractions recommended by the recommendation system to users is known and the set of tourist attractions actually liked by users is $T(u)$, then the recall rate of the recommendation results is defined as given by formula (7):

$$\text{Recall} = \frac{\sum_{u \in U} |R(u) \cap T(u)|}{\sum_{u \in U} T(u)}. \tag{9}$$

In this paper, the experimental verification of the proposed and other state-of-the-art recommendation systems is carried out according to the above experimental indexes and evaluation metrics.

5.3. Effect of Personalized Travel Recommendation Route

5.3.1. Accuracy of Personalized Travel Recommendation Route. In order to verify the accuracy of the personalized tourism recommended routes under different methods, the approaches proposed in [8–10] and this paper are used to verify the accuracy of the personalized tourism recommended routes. The results are shown in Table 4.

According to the analysis of Table 4, when the number of recommended routes is 2000, the accuracy of [8] is 87.52%, the accuracy of [9] is 79.52%, the accuracy of [10] is 76.52%, and the accuracy of our proposed method is 96.66%. Moreover, when the number of recommended routes is 5000, the accuracy of [8] is 72.28%, the accuracy of [9] is 73.38%, the accuracy of [10] is 88.46%, and the accuracy of the proposed method is 97.21%. These outcomes show that the accuracy of the personalized tourism recommendation route using the proposed method is significantly higher than that of other state-of-the-art methods, which shows that the personalized tourism recommendation route of this method has a better effect.

5.3.2. Ranking Accuracy of Personalized Travel Recommended Routes. In order to verify the ranking accuracy of personalized tourism recommended routes under different methods, the approaches proposed in [8–10] and this paper are adopted. The results are shown in Table 5.

According to Table 5, the ranking accuracy of personalized tourism recommended routes is different under different methods. When the number of recommended routes is 1000, then the sorting accuracy of [8] is approximately 64.65% while the sorting accuracy of [9] is 70.21%. Similarly, the sorting accuracy of personalized tourism recommended routes of the method suggested in [10] is 75.32%, while the sorting accuracy of our proposed method is 99.65%. In our empirical evaluation, we observed that when the number of recommended routes is 3000, then the sorting accuracy of the method suggested in [8] is 62.53%. Furthermore, the sorting accuracy of [9] was noted at approximately 78.52%, while the sorting accuracy of [10] was observed as high as 76.75%. This should be noted that the sorting accuracy of personalized tourism recommended routes of our proposed method is as high as 98.26%.

Furthermore, our experimental outcomes revealed that when the number of recommended routes is 6000, then the sorting accuracy of personalized tourism recommended routes of [8] is 78.54%. Similarly, we noted the sorting accuracy for [9] approximately 68.54%, while the sorting accuracy of [10] was recorded at 80.32%. The results shown in Table 5 demonstrate that the sorting accuracy of personalized tourism recommended routes of our suggested method is as high as 95.76%. To summarize our findings and results, the accuracy of personalized travel recommendation route ranking of our proposed method is significantly higher than that of other methods [8, 9], and [10], which shows that the personalized travel recommendation route ranking effect of our method is better than these closest rivals and techniques.

Table 4: Accuracy of the personalized travel recommended routes.

Number of recommended routes	Accuracy (%)			
	[8]	[9]	[10]	Proposed method
1000	88.56	78.38	72.59	93.32
2000	87.52	79.52	76.52	96.66
3000	86.43	80.31	78.23	98.27
4000	78.56	82.27	80.32	93.54
5000	72.28	73.38	88.46	97.21
6000	75.76	75.42	81.59	99.81

Table 5: The ranking accuracy of personalized tourism recommended routes.

Number of recommended routes	Ranking accuracy (%)			
	[8]	[9]	[10]	Proposed method
1000	64.65	70.21	75.32	99.65
2000	66.69	79.32	78.13	98.65
3000	62.53	78.52	76.75	98.26
4000	76.32	77.54	79.45	97.87
5000	77.54	76.54	81.67	97.54
6000	78.54	68.54	80.32	95.76

5.3.3. Recall Rate of Personalized Travel Recommended Routes. In order to verify the recall rate of personalized tourism recommendation under different methods, the approaches proposed in [8–10] and this paper are used to obtain the recall rate of the personalized tourism recommendation system. The obtained results and outcomes are shown in Table 6.

According to Table 6, the recall rate of personalized travel recommended routes is different under different methods. When the amount of data is 10 GB, the recall rate of the method proposed in [8] is 67.86%. Similarly, the recall rate of [9] was noted 66.32% and the recall rate of [10] was observed at approximately 64.32%. This should be noted that the recall rate of the personalized travel recommendation route is 98.32%. Generally speaking, with the increase of data amount the accuracy of the recommendation system increases and vice versa. For example, when the amount of data are increased from 10 GB to 30 GB, then the recall rate of the method suggested in [8] is approximately 68.62% and the recall rate of the method in [9] is 70.32%. Furthermore, the recall rate of the method proposed in [10] is approximately 66.87% while the recall rate of our proposed approach is 98.21%.

When the amount of data is 60 GB, the recall rate for the method in [8] is 71.05% and the recall rate of the proposed method in [9] is as high as 70.31%. Similarly, align with previous outcomes, the recall rate of the method in [10] is 72.61%. This should be noted that the recall rate of our proposed method is as high as 97.59%. Using these experimental outcomes, we can easily observe that our proposed method always has a higher recall rate for personalized travel recommendation routes as compared to other methods as proposed in [8, 9], and [10].

Table 6: The recall rate of personalized travel recommendation system.

Data volume/GB	Recall rate (%)			
	[8]	[9]	[10]	Proposed method
10	67.86	66.32	64.32	98.32
20	79.46	67.98	62.38	97.54
30	68.62	70.32	66.87	98.21
40	69.36	72.58	69.95	99.32
50	70.21	75.32	70.32	96.32
60	71.05	70.31	72.61	97.59

6. Conclusion and Future Work

In this paper, we proposed a personalized tourism recommendation algorithm based on the introduction of fuzzy consistent matrix. In the process, we obtained the user's travel interest data through the fuzzy consistency matrix and obtained the coverage of the user's POI. Next, we determined the user's preferred POI and conducted a visual analysis through ArcGIS tool. Third, we obtained the user's historical access frequency in order to realize the user's geographical factor feature analysis and calculate the similarity between users using the fuzzy consistency matrix technology. Finally, we build a personalized tourism recommendation model in order to realize personalized travel route recommendation. The following conclusions were drawn through experiments: (i) when the number of recommended routes is 5000, then the accuracy of our method is approximately 97.21%, which shows that the recommended routes are effective; (ii) when the number of recommended routes is 6000, then the ranking accuracy of our method is approximately 95.76%, which shows that the route ranking effect of our method is better; and (iii) when the data volume is 60 GB, the recall rate of our proposed method is 97.59%. Across several experiments, we observed that the proposed method always has a high recall rate for personalized tourism recommended routes.

In the future, we will introduce deep learning technology to further improve the recommendation quality, recall rate, and system accuracy. Furthermore, larger datasets will be used to generalize the findings of this study. This should be noted that along with the increase in data the complexity of the proposed algorithm will definitely increase. Therefore, big data technologies such as cloud computing and edge intelligence can be used to improve the response time of the recommendation system. Edge intelligence uses the state-of-the-art machine learning methods to improve decision-making power that could be of interest of the modern recommendation systems. Finally, we will continue working toward the real implementation of the proposed systems in a particular traveling and routing system [30].

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Retraction

Retracted: A BP Neural Network Model for Evaluating the Literature and Art Career of College Students' Political and Ideological Education

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Y. Jing, "A BP Neural Network Model for Evaluating the Literature and Art Career of College Students' Political and Ideological Education," *Mobile Information Systems*, vol. 2022, Article ID 3020040, 9 pages, 2022.

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Research Article

A BP Neural Network Model for Evaluating the Literature and Art Career of College Students' Political and Ideological Education

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The evaluation of the literary and artistic carrier of the political as well as the ideological education of college students is an important research topic in contemporary college education concepts. Since it consists of multiple variables, there are still many difficulties in evaluating the ideological productivity of college students. The same statement is true for political education as well. This paper builds a model for the literary and artistic carrier of the political as well as the ideological education of college students based on the backpropagation neural network (BPNN) structure. Furthermore, we study the current status of the literary and artistic carrier of the political along with the ideological education of college students. This paper implements the BP neural network to model the literary and artistic carrier of college level graduate students' political and ideological education in order to analyze the dynamics of contemporary college students' ideological differences. Finally, we provide an adequate theoretical basis for inquiry, from qualitative description to quantitative analysis. The suggested approach may successfully avoid the old model's instability and sluggish convergence issues as well as significantly increase the correctness of the evaluation findings for literary and artistic carrier of the political as well as the ideological education of college students.

1. Introduction

The backpropagation (BP) neural network is a type of multilayer feedforward neural networks in the field of artificial neural network (ANN) when taken within the context of artificial intelligence (AI). The network output error is used in the gradient descent approach to alter and adjust the network connection weights and lessen, as much as possible, error modulation. People's ideological status has demonstrated traits of diversification, complication, differentiation, and personalization against the backdrop of ongoing globalization, rapid advancement of information technology, and ongoing deep reform and opening up. This has presented challenges to the conventional mode of political as well as the ideological education method in a number of ways. It renders conventional educational approaches ineffective, sluggish, simplistic, and full of tiredness, making it challenging to address the intricate political along with the ideological issues facing modern society [1]. In [2], the authors have tried to develop abilities that exhibit a holistic development of morals, intelligence, and art in the modern context of the diversified development of colleges and universities. The different sorts of college student communities are examined, and the primary purposes and practical importance of the college student community are clarified [3].

Based on a thorough examination of WeChat's attributes and capabilities, the authors in [4] evaluated how to utilize WeChat to its fullest potential for college students' political and ideological education. The classification model is developed by the logistic regression approach using the prior student data in order to assess the students' political as well as the ideological health [5]. Yang et al. [6] made a contribution to colleges and universities in the new age by "educating individuals for the party and fostering talents for the country." The enactment of the party's educational strategy, the accomplishment of the essential and vital job of cultivating moral individuals, and the education of skilled and competent builders and dependable socialists with Chinese individualities who are professional and have both

aptitude and political uprightness as well as comprehensive development people are all made possible by the ideological education of college students (CSs) carried out with the aid of BD technology. The goal of Yang et al. [7] is to study the function of BD in the process of carrying out targeted political as well as ideological education for CS. It is utilized to highlight the up-to-date issues come across in the study.

First, the fundamental guidelines for building assessment models of university students' political as well as the ideological learning are presented in [8]. Furthermore, in light of the deficiencies of assessment goals, single assessment approaches, shortage of applicability of assessment indicators, and bias of assessment benchmarks are presented in assessment systems. The application of machine learning, big data, mobile Internet, and cloud-edge technology in the teaching rehearsal of political along with the ideological course in universities and colleges can increase the affinity of both political as well as the ideological course. Similarly, according to the work demonstrated in [9], investigation of the requirement, teaching techniques, and teacher-student characters of the application of mobile Internet and big data technology in the teaching rehearsal of political as well as the ideological course are demonstrated. Moreover, the work demonstrated in [10] is another influential piece that addresses similar concepts.

In this research, we construct a model grounded on the well-known BP neural network architecture while enhancing the performance of conventional BP neural network. Moreover, we briefly discuss the idea and model of artificial neural networks. We then go into how the BP neural network model was put to use in assessing the literary and aesthetic components of college students' political as well as the ideological education. In this study, the literary and artistic carriers of college students' political as well as the ideological education are evaluated using an improved BP neural network model [11]. By doing so, the paper successfully avoids the unsteadiness and sluggish convergence issues with the outdated model and substantially increases the correctness of the assessment findings. In terms of literary and artistic carriers of the political as well as the ideological education of college students, the significant innovations of the research done in this paper can be summed up as follows:

(1) We give a thorough explanation of the BP neural network's concept, topology, and network structure so that we can understand it in its entirety.

(2) We construct a BP neural network model and assess literary and artistic carrier of the political as well as the ideological education of college students based on the model.

(3) We study the current status of the literary and artistic carrier of the political along with the ideological education of college level graduate students.

The remainder of the paper is arranged as follows. We discuss The basic principles of the BP neural network in Section 2. In Section 3, model establishment and analysis is discussed, and conclusion and future work in are given in Section 4.

2. The Basic Principles of the BP Neural Network

2.1. The Model of BP Neural Network. The BP network uses back-up advertising algorithms, usually comprising an input layer, a hidden layer or several hidden layers depending upon the depth of the network model, and an output layer. In fact, in the model structure, information is transmitted from the input network layer to the hidden layer and, subsequently, to the output layer. If in case there is an error, then the error is reversed among the output of the output layer and the anticipated output. The basic structure of the BP network model is shown in Figure 1.

Regarding the selection of the activation function, if the output layer uses the sigmoid function, then the output is between [0, 1]. However, if in case a linear Pauline function is used, then the output can take any value [12]. The expression of the sigmoid function is given by $y = 1/1 + e^{-x}$, and its figure is shown in Figure 2.

2.2. The BP Neural Network Algorithm. We assume that there is only a single hidden layer in our proposed network model [13]. Furthermore, let us assume that i, j, and k inputs represent neurons in the hidden and output layers, and we input the jth neuron in the hidden layer. This relationship is mathematically modelled as

$$s_j = g\left(\mathrm{net}_j\right). \tag{1}$$

The input of the neuron in the output layer is given by

$$\mathrm{net}_k = \sum_j^m w_{kj} s_j. \tag{2}$$

Therefore, the final output is represented by y_k and is given by

$$y_k = g\left(net_k\right), \tag{3}$$

where g is the sigmoid function and is mathematically defined as

$$g(x) = \frac{1}{1 + e^{-(x+\theta)}}, \tag{4}$$

where θ is the threshold and the final output of the BP network model is characterized in the following formula:

$$s_j = \frac{1}{\left(1 + e^{\left(-\left(\sum_i^n w_{ji} x_i + \theta_j\right)\right)}\right)}. \tag{5}$$

The output s_j is given in formula (6) which is obtained by putting the values of formula (5) into formula (3):

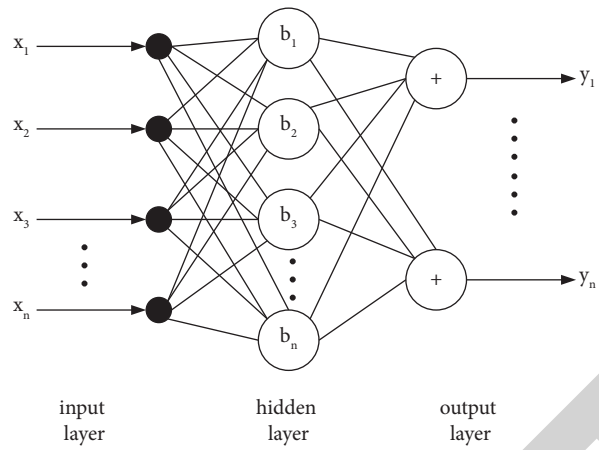

Figure 1: The BP network structure.

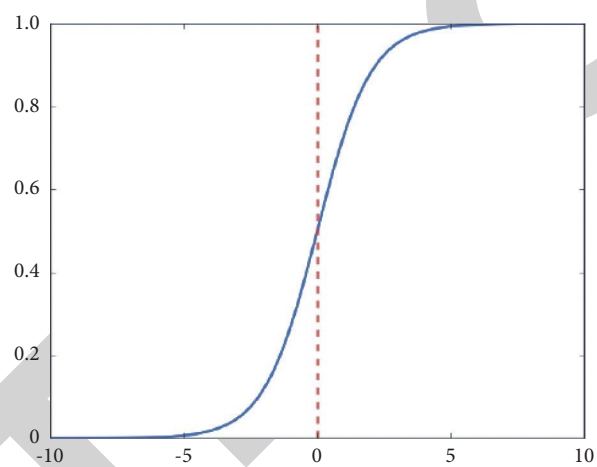

Figure 2: The sigmoid activation function.

$$y_k = \frac{1}{\left(1 + e^{\left(-\left(\sum_j^m w_{ki} s_j + \theta_k\right)\right)}\right)}. \tag{6}$$

The BP network background advertising algorithm idea can significantly minimize the error function. In the error return process, y_k is the true output of the kth node, t_k is the desired output, and the error function is given by

$$E = \frac{1}{2} \sum_k^p (t_k - y_k)^2. \tag{7}$$

2.3. Evaluation Metrics. We use three evaluation metrics, i.e., accuracy, recall rate, and $F1$ value to measure the prediction performance of the proposed BP network model.

2.3.1. Accuracy. By dividing the total number of texts by the number of texts for which accurate predictions were produced, the accuracy rate is determined [14]. (8) can be used to define and estimate the accuracy rate.

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}, \tag{8}$$

where TP stands for true positive, TN stands for true negative, FP stands for false positive, and FN stands for false negative.

2.3.2. Recall Rate. The recall rate is defined as the number of texts that are correctly identified as belonging to a positive class and as a percentage of all texts that are expected to do so [15]. It can be explained as given by

$$\text{recall} = \frac{\text{TP}}{\text{TP} + \text{FP}}. \tag{9}$$

2.3.3. The F1 Value. The $F1$ value is a specific kind of assessment index that fully takes into account both the

precision rate and the recall rate [16]. The predictive technique is superior and vice versa when the $F1$ value increases. The following equation can be used to define the $F1$ value:

$$\mathrm{F1} = \frac{(2 * \text{accuracy}) * \text{recall}}{\text{accuracy} + \text{recall}}. \tag{10}$$

We particularly assess the effectiveness of the suggested classification model using these evaluation metrics for each class for classification accuracy, recall, and $F1$ value.

3. Model Establishment and Analysis

Evaluating the political as well as the ideological educational status of college students is primarily a matter of identifying patterns, that is, comparing the actual monitoring result evaluation standards with the evaluation system of the political as well as the ideological educational status of college students. The result of identifying the BP artificial neural network model, i.e., the corresponding assessment of the students' political as well as the ideological educational status, is the level of environmental quality corresponding to the nearest standard value array to assess the political as well as the ideological educational status of college students [17].

The BP neural network, a multilayer feedforward neural network, offers excellent non-linear mapping capabilities. The internal neurons are not connected to any layer of the neural network model, rather only nearby neurons are connected to each other. Hidden layer, input layer, and output layer are the parts of neurons. The objective function in a standard BP neural network learning method is the sum of squares of network errors, and the gradient algorithm is used to determine the least value of the objective function. Error rectification is the guiding principle. The network error is output using the gradient descent approach, which also implements backpropagation and modifies and adjusts the network connection weight. Figure 3 shows the neural network learning process after minimizing error modulation [18].

3.1. The Patriotism Model of Literature and Art Careers. This paper uses a three-layer BP neural network with 20 neurons in the middle layer. If the training step scale in this paper is set to 100, the error accuracy of the network model training is 0.002 and the post-training output results are satisfactory and relatively satisfactory. The program in the MATLAB software is as follows:

(i) P = [0.7 0.3 0 0; 0.5 0.4 0.10; 0.5 0.5 0 0; 0.3 0.2 0.4 0.1; 0.4 0.4 0.20; 0.1 0.5 0.3 0.1; 0.4 0.3 0.1 0.2; 0.30.60.1 0; 0.34 50 0.6 0]; >>T = [0 1; 0 1; 0 1; 1 0; 1 0; 1 0; 1 0; 1 0]; >>P'; >>T = T; >> net = newff (minmax (P), [2, 19], I′ tansig', logsig', 'trainlm');

(ii) >> net.trainParam.epochs = 100;

(iii) >> net.trainParam.goal = 0.0014;

(iv) >> net = train (net, P, T);

(v) P_ _test = [0.4 0.4 0 0; 0.2 0.8 0.2 0]'

(vi) >> Y = sim (net, P. test)

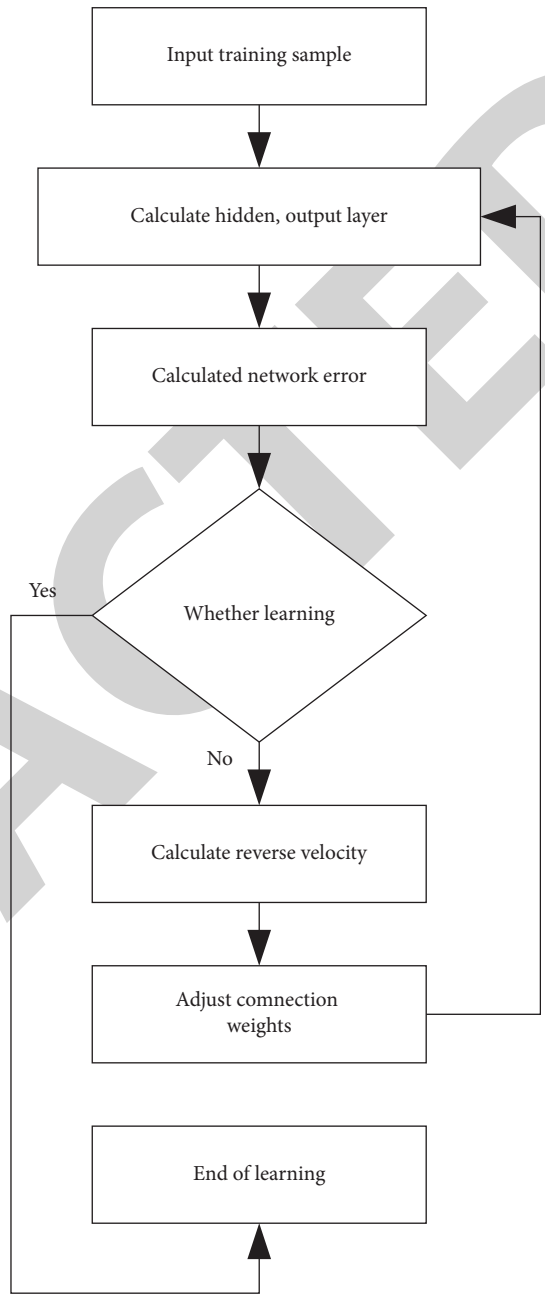

Figure 3: Neural network learning flowchart.

(vii) Y =

(viii) 0.0000

(ix) 1.0000

(x) 0.9989

(xi) 0.0014.

The actual accuracy of the test and the reference error accuracy are shown in Figure 4. As shown in the figure, the test results meet the requirements after 14 steps.

The weights input to the input layer during network training are shown in Table 1.

The weights input to the output layer during network training are shown in Table 2.

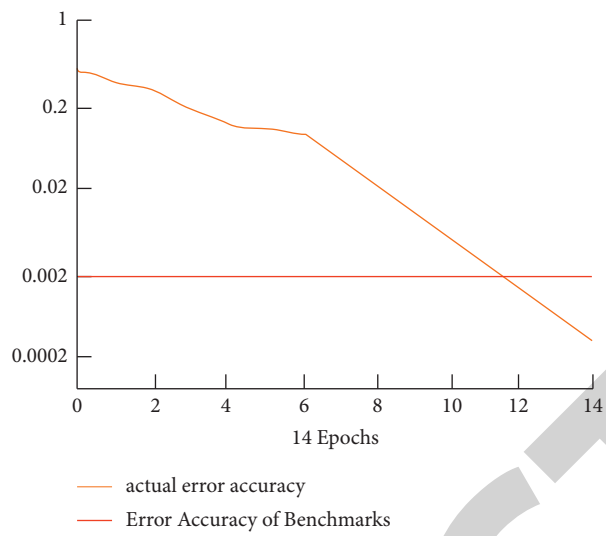

Figure 4: Error accuracy of the model.

Table 1: Weights of the input layer.

7.3676	6.7460	2.3132	−14.8766	1.7256	9.3173	10.1660	−3.5217
2.2961	−3.2459	12.6376	4.9848	6.4536	−0.7091	8.0472	6.9200
−1.3416	−13.4564	5.8914	2.2320	−5.3377	6.0507	8.6658	−10.6664
3.6785	5.9507	−11.6827	9.6164	1.1409	4.2388	−11.6314	−12.3859
−1.1803	12.8118	5.5029	11.0229	5.4328	0.2668	11.4821	−6.7897
6.2897	−4.1297	−8.6129	−6.8403	−3.1781	10.9147	7.5309	−5.4834
2.4587	−9.3093	−4.5662	−18.4676	5.1269	1.8168	−9.4137	15.7556
−4.9813	−4.8113	6.6864	−15.6568	5.6251	1.6632	−8.7323	16.8907

Table 2: Weights of the output layer.

−2.5391	0.3575	−0.8567	−0.1907	1.8130	−1.0057	−0.3211	0.4689
3.1670	2.1021	1.5061	0.5655	−2.9186	0.3298	−0.1584	−0.6670
−2.5391	0.3575	−0.8567	−0.1907	1.8130	−1.0057	−0.3211	0.4689
3.1670	2.1021	1.5061	0.5655	−2.9186	0.3298	−0.1584	−0.6670
−2.5391	0.3575	−0.8567	−0.1907	1.8130	−1.0057	−0.3211	0.4689
3.1670	2.1021	1.5061	0.5655	−2.9186	0.3298	−0.1584	−0.6670
−2.5391	0.3575	−0.8567	−0.1907	1.8130	−1.0057	−0.3211	0.4689
3.1670	2.1021	1.5061	0.5655	−2.9186	0.3298	−0.1584	−0.6670
1.5876	−1.1987	1.1235	3.5891	1.5421	−1.6895	0.9671	1.7012
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−2.9912	−0.3013	0.6122	−3.8971	−2.1465	0.0587	−1.9268	−0.6451
−0.6354	1.2891	0	0	0	0	0	0

According to the survey data, the results obtained after the online training show that the patriotic political beliefs of college students are positive and healthy. Furthermore, they are optimistic about the social situation in the Republic of China and the situation they face, especially those who are concerned about social hotspots. However, the independence, choice, variability, and difference in the ideological activities of some students have clearly improved and the influence of various political, ideological, and cultural influences has increased significantly.

3.2. Moral Idea Model of Literature and Art Careers. In this article, the training steps are set to 100, and the error accuracy of the network model training is 0.002. Outcomes after training show that college students have strong

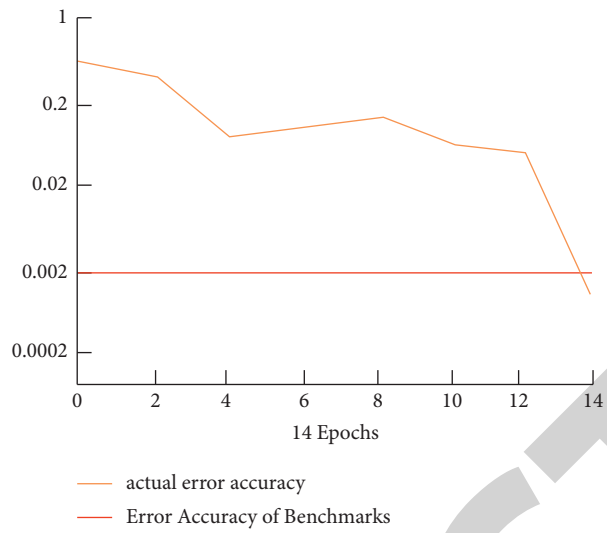

Figure 5: Error accuracy of the model.

Table 3: Weights of the input layer.

6.04885	3.72024	2.24081	1.12211	11.8194	−1.01276	−4.74083	−5.35803
10.89497	10.30148	9.61658	−8.4031	8.38868	6.61068	6.58202	4.26048
3.27458	6.04277	−5.18018	−2.73316	−16.579	−1.22214	−1.31496	2.01035
−2.90705	−8.74892	15.78325	−3.47418	13.19126	−1.59275	4.01227	1.07633
5.26108	2.94701	18.15992	6.18717	11.54132	5.1998	−3.20252	6.24576
−7.3828	−4.03316	−7.47613	−8.47961	12.57663	−7.19551	8.04153	−7.7778
9.44116	−7.45209	−2.26017	6.6755	−1.40548	4.13559	6.45987	−2.56684
11.20591	−3.83321	−8.25948	3.29138	−7.57593	7.40503	−1.05792	2.45248

Table 4: Weights of the output layer.

0.22573	−0.03089	−0.62916	−1.39002	−0.90343	1.45663	−0.7676	−0.1165
0.0025	0.20163	−0.25954	−0.04103	2.15207	0.53647	−1.52321	−0.05108
0.84457	0.57801	−0.55455	−0.31738	−1.4757	0.19498	−0.76045	0.55839
−1.30605	0.68744	−0.08132	−0.47084	0.84694	0.04539	−1.0064	−0.38912
0.99988	−0.11157	−0.04137	−1.3391	1.78616	−0.01061	−1.18454	0.95058
0.19114	−1.04189	0.56102	−1.44906	0.43575	2.80189	1.92293	−2.07846
0.41613	−0.44639	−0.91885	1.07607	1.50254	1.95454	−0.09109	0.45215
0.48692	−0.24985	−1.68021	−0.34228	−2.14601	0.86631	1.20702	0.42063
0.05008	−0.14151	-0.82789	−1.61919	0.37738	0.62707	0.88191	0.26026
2.2748	1.43447	1.7732	−0.02147	2.54335	−0.4241	−0.20788	0.34809
−0.41439	−1.60332	−1.09206	−0.68144	0.40043	−1.36376	2.23108	−0.43029
−1.01772	−1.09372	0.89603	−0.50595	−0.87311	0.93515	0.72299	−1.26683
−1.06426	0.83431	-0.14861	−1.56036	−0.86864	−1.12675	1.36848	−0.31647
−1.11885	1.83703	0.49612	1.08022	−0.12933	−1.06788	−1.29981	−0.11329
−0.10704	0.1113	−0.40218	1.43299	−0.1705	−1.87078	0.8331	1.00442
−0.24762	0.3619	2.29663	2.52692	1.07595	0.9462	0.07523	0.97375
0.42349	0.55768	−0.13797	−1.41793	−0.70576	0.87428	−1.39419	−1.60202
−0.26269	−0.51762	0.78542	1.21152	0.56807	0.69691	−1.83565	−1.97498

ideological and moral concepts. The program in the MATLAB software is as follows:

(i) P = [0.8 0 0 0.1; 0.8 0.2 0 0; 0.9 0 0 0.2; 0.8 0.1 0 0; 0.8 0 0.1 0; 0.9 0.2 0 0; 0.4 0.5 0.2 0; 0.9 0.2 0.2 0; 0.5 0.2 0.1 0; 0.2 0.5 0.3 0; 0.6 0.4 0.2 0; 0.4 0.1 0.2 0];

(ii) T = [0 1; 0 1; 0 1; 0 1; 0 1; 0 1; 1 0; 10; 1 0; 10; 1 0; 1 0];

(iii) $P = P'$;

(iv) >> $T = T'$;

(v) >> net = newf (minmax (P), [4, 20], 'tan-sig' log-sig', trainlm');

(vi) >> net.trainParam.epochs = 100;

(vii) net.trainParam.goal = 0.002;

Table 5: Weights of the input layer.

−10.2685	−4.8812	−11.0432	8.5458	−16.2349	1.5714	6.4851	−1.3277
11.0055	−3.6714	15.3104	1.1071	−14.2671	−8.9461	−2.3404	−4.7309
−6.4599	−7.3809	−8.6406	−8.0818	6.9495	10.0914	−1.0865	−9.0226
−5.4358	2.6676	7.9580	−7.6349	−8.0096	−18.2486	−10.1283	7.6802
−8.6268	−2.4587	−9.1686	−12.3538	1.3491	−8.3351	−12.0357	−6.1084
−2.9058	−1.5327	−2.6401	10.4688	−2.1581	−6.1432	1.0494	10.0883
1.5016	1.1871	−3.2485	−9.3791	−5.9565	−1.8321	−10.2374	17.0144
−4.4741	1.1297	−1.4010	11.7655	−1.1020	3.5183	−10.5253	13.4325

Table 6: Weights of the output layer.

0.2587	1.3039	−2.0412	1.0624	−0.3185	1.5132	−0.1739	0.8385
−0.3723	−0.4344	−0.2955	−1.9166	−1.2622	−0.3775	1.2976	0.3699
0.4148	0.2760	2.2330	−1.4782	−1.5535	−0.5334	1.4785	2.2711
−0.1677	−0.7346	0.1404	0.1340	0.8468	0.6383	1.7941	0.4387
0.2147	0.9603	0.0436	1.3116	0.3209	−0.3078	−1.5502	−1.5503
−1.1838	−1.2842	0.4377	−1.2849	−1.1625	−0.2893	2.0491	−0.1560
1.3069	0.0470	1.7865	−0.2858	1.0079	0.9097	−1.6071	−0.7772
2.4971	0.5390	−0.9341	−0.6938	−0.3640	−0.0792	−1.5120	−0.9671
−0.7886	0.4177	−0.2681	−0.0839	−0.5934	−0.7231	0.2972	0.3353
0.2918	0.8025	0.5843	1.5742	−2.2164	−1.7408	−2.1675	−0.1958
−2.0408	0.3499	−0.8359	−2.2153	0.2272	0.8622	−0.8025	0.4036
−1.5150	−0.3144	0.1833	0.3971	0.9109	0.9232	1.1224	−0.9528
1.3664	0.6800	0.6865	−0.6987	−0.1001	−1.7787	0.9875	0.2162
0.3475	−0.2403	1.1430	0.7008	0.8143	0.0297	−0.3305	0.7893
0.9255	−2.1345	−1.6414	−1.1673	−1.0571	0.2663	1.0766	−0.9000
−1.1458	1.4958	−1.3619	0.5228	0.0679	−1.8427	−0.2770	−0.0372
0.0948	0.3928	−0.1448	0.9659	0.1533	0.5714	−2.6806	0.8984
−1.8176	0.0272	0.2209	−1.9536	−0.8938	−0.6577	1.1292	−1.0603

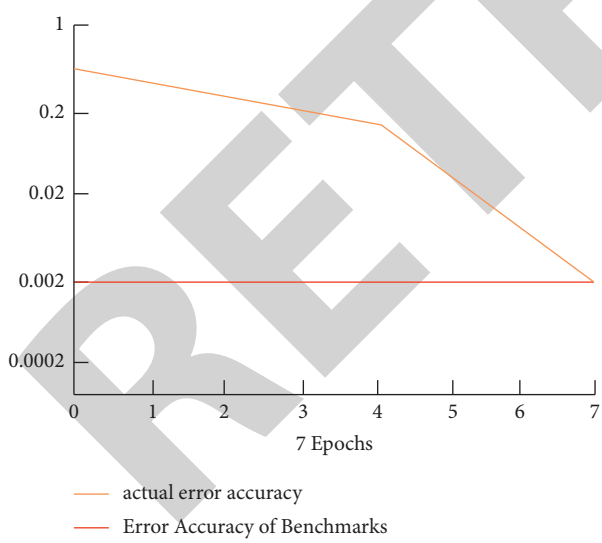

Figure 6: Error accuracy of the model.

(viii) net = train (net, P, T);

(ix) P_ _test = [0.8 0 0.1 0; 0.8 0.2 0.4 0]';

(x) >> Y = sim (net, P._test)

(xi) Y =

(xii) 0.0216, 1.0000

(xiii) 0.9764, 0.0000.

The actual accuracy of the test and the accuracy of the reference error are shown in Figure 5. As shown in the figure, the test results meet the requirements after 14 steps.

The weights input to the input layer during network training are shown in Table 3.

The weights input to the input layer during network training are shown in Table 4.

According to the survey, the results obtained after the network training show that college students have strong moral values, love for the motherland, and desire to be talented and aggressive. They are full of ideals, active in thought, and willing to accept new things. They care about their own development, practical instincts, and personal utility consciousness coexistence. At different levels, however, there are issues such as poor moral cultivation and self-control, poor understanding of ambition, poor sense of integrity, lack of social responsibility, weakened spirit of hard work, lack of unity and cooperation, and poor mental quality.

3.3. The Ideal and Belief Model of Literary and Artistic Careers. In this article, the training steps are set to 100, and the error accuracy of the network model training is 0.002. Out-of-pocket results after training show that college students have strong ideals. The program in the MATLAB software is as follows:

(i) P = [0.8 0.1 0 0; 0.4 0.1 0.2 0.1; 0.8 0 0.1 0.1; 0.6 0.2 0.1 0; 0.4 0.1 0.1 0; 0.8 0.1 0.1 0; 0.9 0 0.1 0; 0.9 0.2 0 0; 0.6 0.3 0 0; 0.9 0.1 0 0; 0.2 0.9 0 0; 0.4 0.1 0.3 0.2; 0.2 0.6 0 0.2; 0.5 0.2 0.3 0; 0.5 0.4 0.1 0; 0.5 0.3 0.2 0; 0.4 0.1 0 0.2];

(ii) >>T = [0 1; 0 1; 0 1; 0 1; 0 1; 0 1; 0 1; 0 1; 0 1; 0 1; 1 0; 1 0; 1 0; 1 0; 1 0; 1 0; 1 0];

(iii) PP';

(iv) >> $T = T$;

(v) >> net = newf (minmax (P), [4, 20], {tan-sig', logig'rainlm');

(vi) >> netrainParam.epochs = 51000;

(vii) net.trainParam.goal = 0.002;

(viii) net = train (net, P.T);

(ix) P_ test = [0.6 0.1 0.2 0; 0.1 0.4 0.5 0.1 1]';

(x) >> Y = sim (net, P. _test)

(xi) Y =

(xii) 0.0078

(xiii) 1.0000

(xiv) 0.9892, 0.0000.

The actual accuracy of the test and the accuracy of the reference error are shown in Figure 6. As shown in the figure, the test results meet the requirements after 14 steps.

The weights input to the input layer during network training are shown in Table 5.

The weights input to the input layer during network training are shown in Table 6.

This proposed technique is applied to the collected data, and the results are used to strengthen and guide the life confidence of college students. The confidence level of contemporary college students is generally good and it is a stage of development from a low level of irrational belief to a high level of rational belief. But it is undeniable that there is a certain degree of trust crisis among university students, which is mainly expressed in pluralism, variability, irrationality, non-scientificization, and secularization.

4. Conclusions and Future Work

In this paper, we implemented the BP neural network to model the literary and artistic carrier of college students' political and ideological education, to analyze the dynamics of contemporary college students' ideological differences, and to provide an adequate theoretical basis for inquiry, from qualitative description to quantitative analysis. We provide quantitative analysis and calculation methods for student-specific questions in this paper. The entire evaluation findings of college students' political and ideological education grounded on the model of the well-known BP neural network are acquired through empirical analysis. The outcomes are more reliable, and it is now a more popular method for assessing college students' political as well as the ideological education through literature and arts. On the other hand, nothing is known about Chinese education quality. The model of the BP neural network, which is developed and suggested in this research study, is purely hypothetical and has not seen extensive use in real-world applications. Later on, it needs to be practiced and put into use. These restrictions will be the main area of our forthcoming study. We will further take into account more sophisticated procedures, for instance, the CNN, GCN, and the attention networks [21].

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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Research Article

Application of the R-Tree Clustering Model in Medical Information Retrieval

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Hospitals produce a large amount of medical information every day. In the face of medical big data, the existing data processing methods cannot meet expectations and need to be continuously optimized. In the database system, when the stored objects are very large, and then the efficiency of data retrieval is a major bottleneck, therefore restricting the application of medical information. For that reason and to improve the efficiency of information retrieval, it is necessary to add an index to the information object and filter the dataset participating in the connection retrieval through the index. In this paper, an information retrieval technique grounded on the R-tree clustering model index is proposed for massive hospital information. The R-tree clustering model is constructed in massive hospital information by using the dynamic determination clustering center (DCC) algorithm. Finally, the superiority of the method is proved by simulations. The experiments and empirical evaluation show that the proposed R-tree clustering model index significantly improves data retrieval efficiency.

1. Introduction

With the prompt growth of medical diagnosis technologies such as medical and health information systems, Internet of things, big data, and high-throughput sequencing, the medical and health field is gradually entering the "big data era" [1]. Using big data and Internet of things can improve medical quality and solve current problems, but its unique characteristics (large quantity, fast growth, various types, and difficult to determine accuracy) also pose challenges to technology and management. Since many hospitals have digitized their administrative and treatment procedures, the generation speed and quantity of data exceed the limitations of traditional data processing software [2]. Complex data forms greatly increase the difficulty of storing, mining, and analyzing data. In the database system, when the stored objects are very large, the efficiency of data retrieval is an important bottleneck that limits the application of medical information [3, 4]. Therefore, improving the information retrieval ability in the context of medical big data is of prodigious importance to develop and enhance the level of medical services and encourage the construction of medical informatization. The medical big data includes basic data such as electronic medical records, residents' behavioral health, detection reports, diagnosis and treatment data, medical images, economic data, and medical management. In fact, it is characterized by large scale, fast growth, diverse structure, and high application value.

In order to acquire the required statistics from the massive medical data, retrieval technology must be used as a support [5]. At present, there are many methods for database indexing, such as fixed grid method [6], quadtree method [7], and R tree (and its variants) [8] index. Because the R-tree clustering model index has the advantages of dynamic, great efficiency, and great aggregation, therefore, it has become one of the maximum extensively used and well-established index technologies in the literature [9, 10]. According to the characteristics of various types of medical data and large amount of data, combined with the R-tree clustering model index, this paper proposes a method to quickly retrieve and process medical data. The proposed method uses the R-tree clustering model to retrieve medical data through the R-tree

clustering model index, so as to increase the efficiency of the information retrieval system.

In the face of medical big data, the existing data processing methods cannot meet expectations and need to be continuously optimized. In the database system, when the stored objects are very large, the efficiency of data retrieval is a major bottleneck which, in fact, restricts the application of medical information. Therefore, it is necessary to add an index to the information object (within the large database) and filter the dataset participating in the connection retrieval through the index to increase the effectiveness of the information retrieval system. The major contributions of this research are as follows:

(i) A retrieval method based on the R-tree clustering model index is proposed for massive hospital information

(ii) The R-tree clustering model is constructed in massive hospital information by using the dynamic determination clustering center (DCC) procedure

(iii) The model of the R-tree clustering index improves data retrieval efficiency

The remaining of the manuscript is organized in the following manner. The establishment of an R-tree clustering model is discussed in section 2. Moreover, a dynamic algorithm is demonstrated that can determine the centers of the clusters. In section 3, the proposed algorithm is tested in terms of its application simulation in medical information retrieval. Finally, section 4 summarizes the paper and gives some insights into future research.

2. Establishment of the R-Tree Clustering Model

2.1. A Dynamic Algorithm for Determining Cluster Centers. In order to accomplish an effective contact to large-scale data, this paper uses the clustering model based on the R-tree clustering model index to retrieve data from the medical information system. Setting the clustering center in advance will cause the final clustering result to differ from reality when building the R-tree clustering model if the data distribution rule is unknown. Therefore, affecting the efficiency of the index of the constructed R-tree clustering model [6, 11]. This study introduces the DCC approach to build an R-tree clustering model, efficiently determining the clustering center [12].

Definition 3.1. Set the distance index of measuring adjacent objects as r [13], expressed as the following formula:

$$R = \frac{1}{\sqrt{(m/D)}}. \tag{1}$$

In formula (1), m is the quantity of spatial data, D is the given spatial area range, and d_i denotes the space from data to i. In case $d_i \leq R$, then mark i as the contiguous entity of data. Similarly, if $d_i > R$, then mark i as a noncontiguous entity of data [14, 15].

Given that $r_1, r_2, \ldots, r_m$ is a set of R^d spatial data of m, and c_l is the center of the cluster l, at that point the distance function, i.e., distance among r_i and c_l can be expressed as expressed by the following formula:

$$d(r_i, c_l) = \sqrt{\left(r_i^1 - c_l^1\right)^2 + \left(r_i^2 - c_l^2\right)^2 + \cdots + \left(r_i^d - c_l^d\right)^2}. \tag{2}$$

Let the sample of class l be expressed as the following formula:

$$S_l = \{c_{l1}, c_{l2}, \ldots, c_{\ln}\}. \tag{3}$$

If formula (3) contains n data, the average point of this category is expressed as the following formula:

$$c_l = \left(c_l^1, \ldots, c_l^k, \ldots, c_l^d\right). \tag{4}$$

In formula (4), c_l^k is the k attribute of c_l, which is expressed as the following formula :

$$c_l^k = \frac{r_{l1}^k + r_{l2}^k + \cdots + r_{\ln}^k}{n}. \tag{5}$$

When choosing a cluster center, initially acquire the value point (mean), denoted by c_l, of the data in the class [16, 17]. In the next stage, calculate the distance between the mean value point and other data, and obtain the adjacent objects of c_l while agreeing to the distance index R. In the third stage, compute the value point (mean), denoted by $c_l^{'}$, of the adjacent objects. Finally, choose the spatial data which is the nearby to the $c_l^{'}$ as the cluster center. The final stage is expressed mathematically as given by the following formula:

$$r = \arg\min\left(c_l^{'}, r\right), \quad r\{r_{l1}, r_{l2}, \ldots, r_{\ln}\}. \tag{6}$$

In algorithm 1, the first line is the process of calculating the mean point, and c_l is the cluster center. Lines 2–7 get all neighboring objects. Line 3 calculates the distance between each spatial data and c_l. If it is a neighboring object, it is put into the set M (lines 4–6). Line 8 calculates the mean point $c_l^{'}$ of adjacent objects in the set M. In line 9, find the data closest to $c_l^{'}$ in the spatial data as the cluster center r_c. If r_c is not unique, the cluster measure function is used to compare it, and the number with the smallest convergence value is selected as the cluster center.

2.2. Constructing the R-Tree Clustering Model. By means of the dynamic R-tree clustering model and the proposed algorithm, the sensible leaf nodes are interleaved into the destination object. Furthermore, the above dynamic determination clustering center algorithm is used to build, so as to realize the dynamic optimization of the R-tree clustering model at a large-scale [18, 19]. For the generation of the R-tree clustering model for any spatial data set, the main process is as follows: first, the minimum boundary rectangle is established for all spatial objects. Then, the base rectangle is grouped according to the DCC algorithm. For example, in Figure 1(a), we first select R12 which, in fact, is nearby to the average point as the preliminary clustering center, and then $k = 1$. Then, we select R19 which is the farthest from R12, and R8 which is the farthest from R19, as clustering centers and start clustering [20].

Input: mR^d space data $S = \{r_1, r_2, \ldots, r_n\}$
Output: cluster center r_c
(1) $c_l = (c_l^1, \ldots, c_l^k, \ldots, c_l^d)$;
(2) for $i = l$ to m do
(3) Computing $d(r_i, c_l)$;
(4) if $d(r_i, c_l) < R$;
(5) $r_i \in M, M = \{r_b | d(r_b, c_l) \leq R, b \leq i\}$;
(6) end if
(7) end for
(8) Computing c_l^i;
(9) $r_c = \arg\min(d(r_c, c_l^i)), r_c \in S$;
(10) Output cluster center r_c

Algorithm 1: Build algorithm 1: DCC.

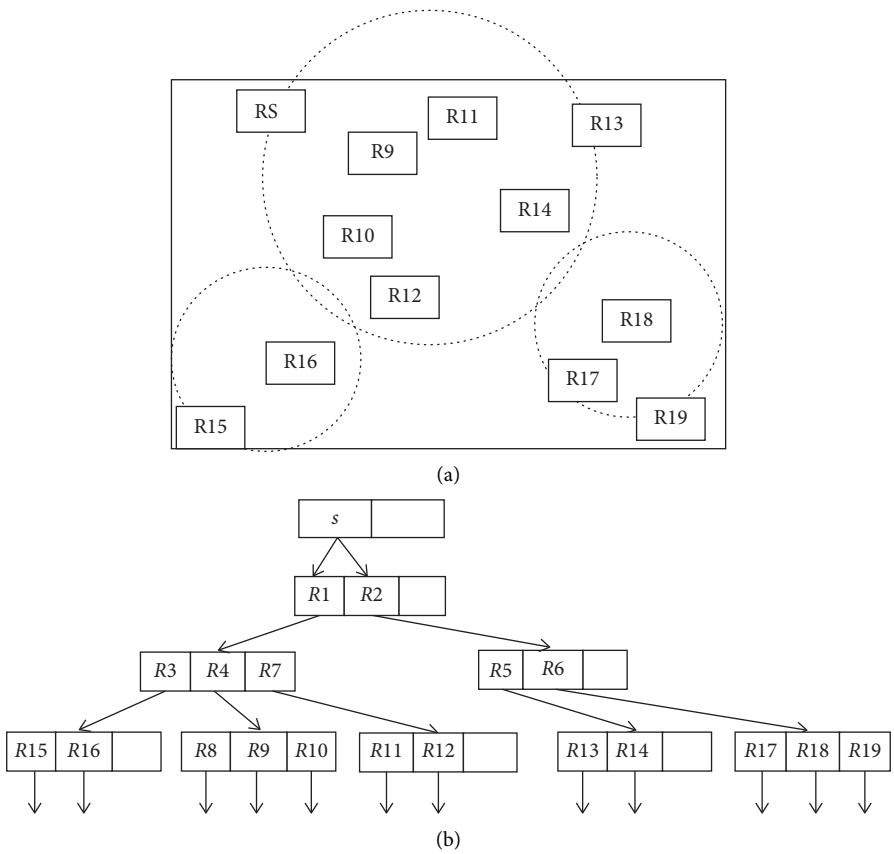

Figure 1: Hierarchy and its R-tree index. (a) Three cluster centers. (b) Record in table.

The R13, R14, R17, and R18 are divided into R19, and R9, R10, R11, R12, R15, and R16 are divided into R8. At this time, two clusters ($k = 2$) are formed, and the cluster center along with the cluster measurement function are computed. Subsequently, we select the cluster having the biggest radius and its cluster center R12 from the two clusters. Then, we select R15 which is the farthest from R12, R11, and R18 which are the farthest from R15 as the cluster center for reclustering. After that, we then calculate its cluster center and cluster measurement function (at this time, $k = 3$). In a cycle, the value of k upsurges as far as the converge of the clustering function occurs. Finally, a rectangle comprising entirely spatial objects in the whole area is shaped to obtain the R-tree clustering model. The entire process is shown in Figure 1(b).

Algorithm 2 is the process of constructing the R-tree clustering model through the DCC algorithm. The first line clusters the data, and the second to fifth lines construct the subtree layer-by-layer from the root.

2.3. Information Retrieval. A whole index establishment, retrieval, and node deletion mechanism is built into the R-tree clustering model itself. The R-tree clustering model

```
Inputs: S = {r_1, r_2, ..., r_n}
Outputs: root
M = DCC(S);
for i = 1 to j do
    root ⟶ child(i) = M_i;
    Construction_R(root ⟶ child(i), M_i);
end for
```

Algorithm 2: The build algorithm 2: Construction_R.

```
Inputs: N denotes the type of the R-tree
  W is the rectangle of request.
Outputs: return a suitable rectangle for the input W
if level of N = 0 then
    return 0;
else
    for j = 1, 2, ..., n do
        if W intersets with the N.MBR then
            R_Search (W, N.p_j);
        end if
    end loop
  end if
  return the data rectangles for W.
```

Algorithm 3: The build algorithm 3: R_Search.

index is used to obtain the geometric data from the database [21]. The R-tree clustering model index can be created in the database to significantly increase the speed of multi-user data retrieval.

Algorithm 3 is used to discover all the data rectangles overlapping WN in the R-tree clustering model along with the root node N.

3. Application Simulation in Medical Information Retrieval

3.1. Simulation Parameters. In this paper, the R-tree clustering model is built in the medical record management system for simulation to verify the system performance after the integration of R-tree. Compared with the hash index [22, 23], the multidimensional analysis of the system performance in various cases is carried out. IoT devices are the infrastructure for hospitals to collect data. Health information gathered by medical wristbands is one example of a group of devices that each have their own management server for. The volume of data affects the size of R-tree. Set T as the data volume and W is the network bandwidth resource [24]. N represents the number of searches and Q represents the search complexity. The simulation variable α represents the available bandwidth and β represents the workload. Relevant parameter settings of simulation are shown in Table 1.

3.2. Simulation Results. In order to study the influence of network status and the task size on the index of the R-tree clustering model, the simulation parameters set in this paper are: ① $\alpha = 0, \beta = 0$ (that is, the network is idle and the task is small), and the results are shown in Figure 2. ② $\alpha = 1, \beta = 0$ (that is, the network is busy and the number of tasks is small), and the results are shown in Figure 3. ③ $\alpha = 0, \beta = 1$ (that is, the network is busy and the number of tasks is small), and the results are shown in Figure 4. ④ $\alpha = 1, \beta = 1$ (that is, the network is busy with a large number of tasks), and the results are shown in Figure 5. The ordinates are all simulation times.

Table 1: The experimental parameters and their values.

Parameter	Numerical value
W	100 MB
T_1, T_2	0.47 MB, 4.48 MB
N_1, N_2	5,549, 12,068
Q_1, Q_2	1, 4
$\alpha = 0$	100 MB
$\alpha = 1$	50 MB
$\beta = 0$	$T_1 + N_1 + Q_1$
$\beta = 1$	$T_2 + N_2 + Q_2$

3.3. Discussion. The retrieval time of the system using the R-tree clustering model was observed, initially, slower than the hash index, i.e., in particular, when the task volume is modest, but over time, the system speed is noticeably increased (as shown in Figures 2 and 3), especially when the network is idle (as shown in Figure 2). This paper analyzes the reasons for this result: the system deploying the R-tree

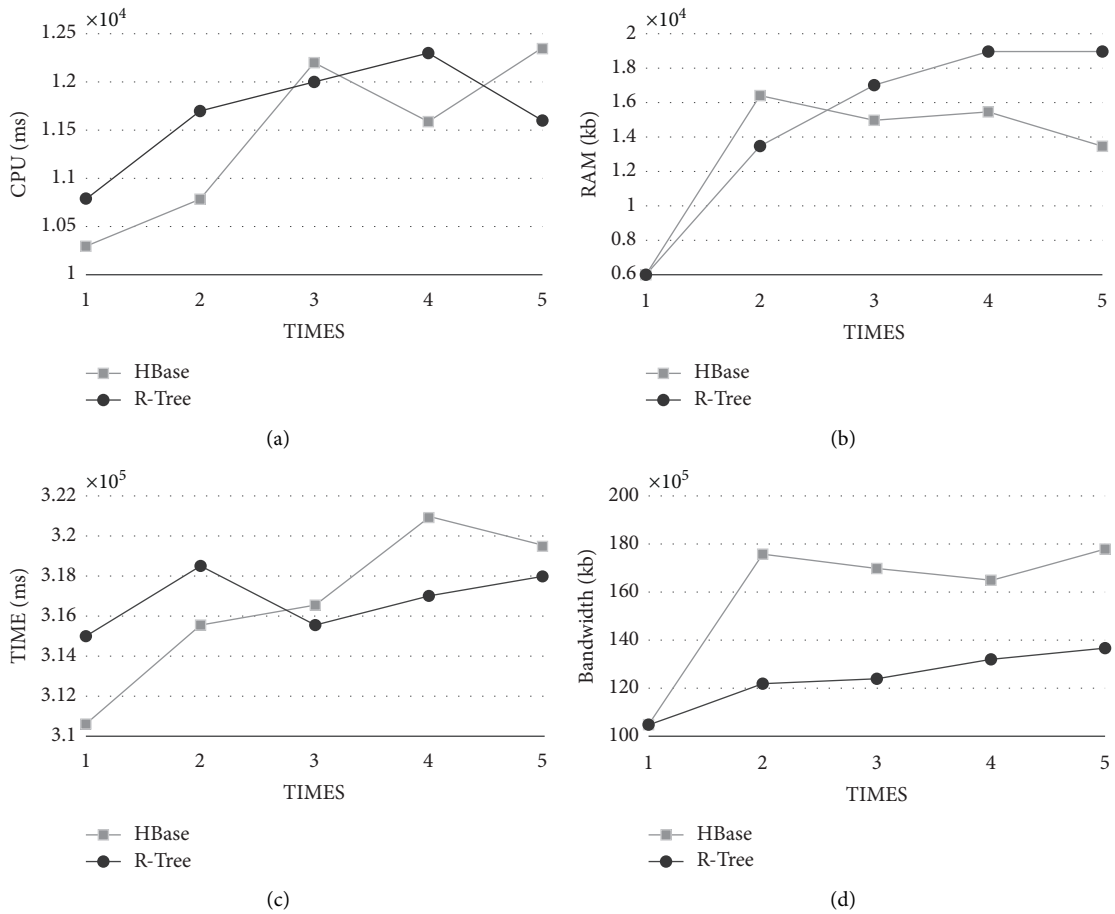

Figure 2: The R-tree index effect in terms of CPU running time, RAM usage, system running time, and bandwidth ($\alpha = 0, \beta = 0$). (a) CPU running time. (b) Ram occupancy. (c) System runing time. (d) Bandwidth.

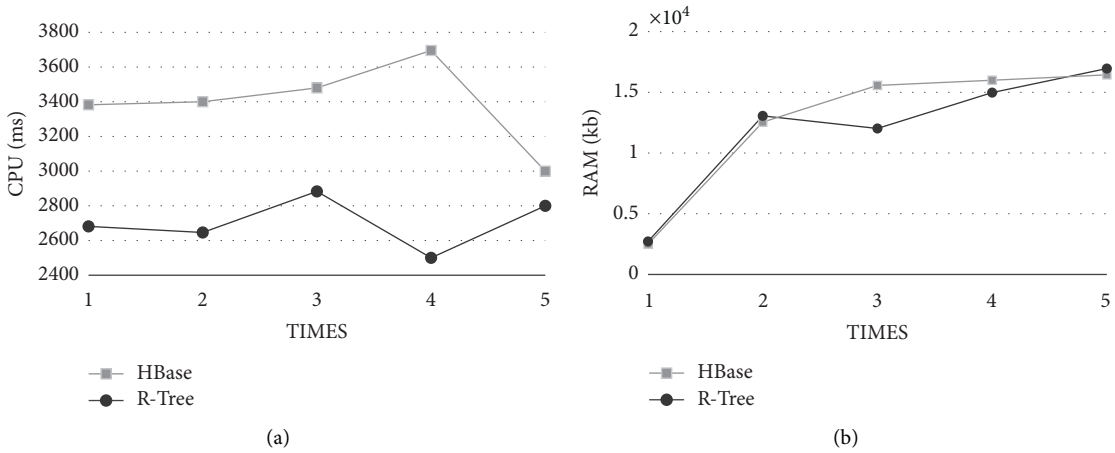

Figure 3: Continued.

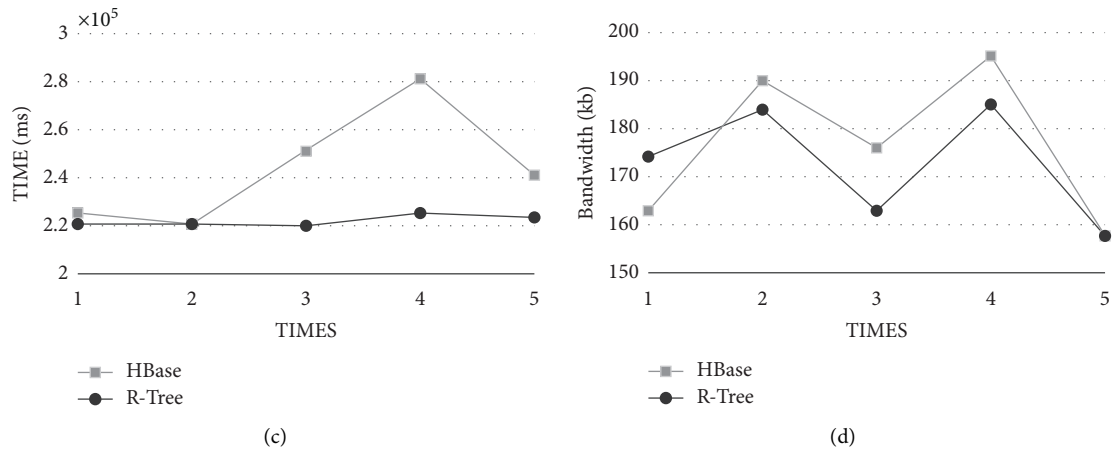

Figure 3: The R-tree index effect in terms of CPU running time, RAM usage, system running time, and bandwidth ($\alpha = 1, \beta = 0$). (a) CPU running time. (b) Ram occupancy. (c) System runing time. (d) Bandwidth.

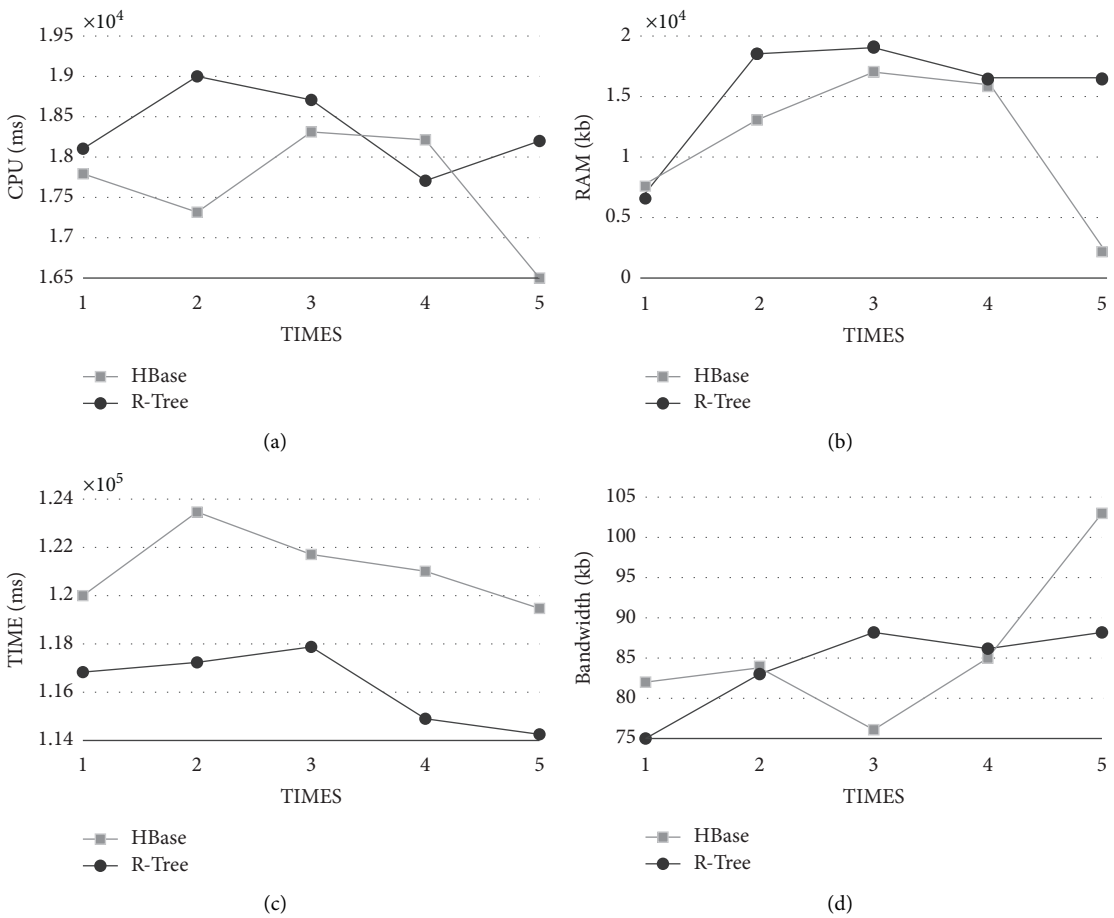

Figure 4: The R-tree index effect in terms of CPU running time, RAM usage, system running time, and bandwidth ($\alpha = 0, \beta = 1$). (a) CPU running time. (b) Ram occupancy. (c) System runing time. (d) Bandwidth.

clustering model needs to establish the R-tree at the beginning of retrieval. The time complexity of R-tree built by implementing the proposed techniques and algorithms is $O(n^k \times t)$, where k represents the total amount of clusters, n represents the total amount of data, and t characterizes the total number of iterations. Furthermore, the hash index method computational complexity is $O(1)$. Therefore, at the beginning of system operation, the R-tree clustering model index was observed significantly slower than the hash index. However, the R-tree clustering model created

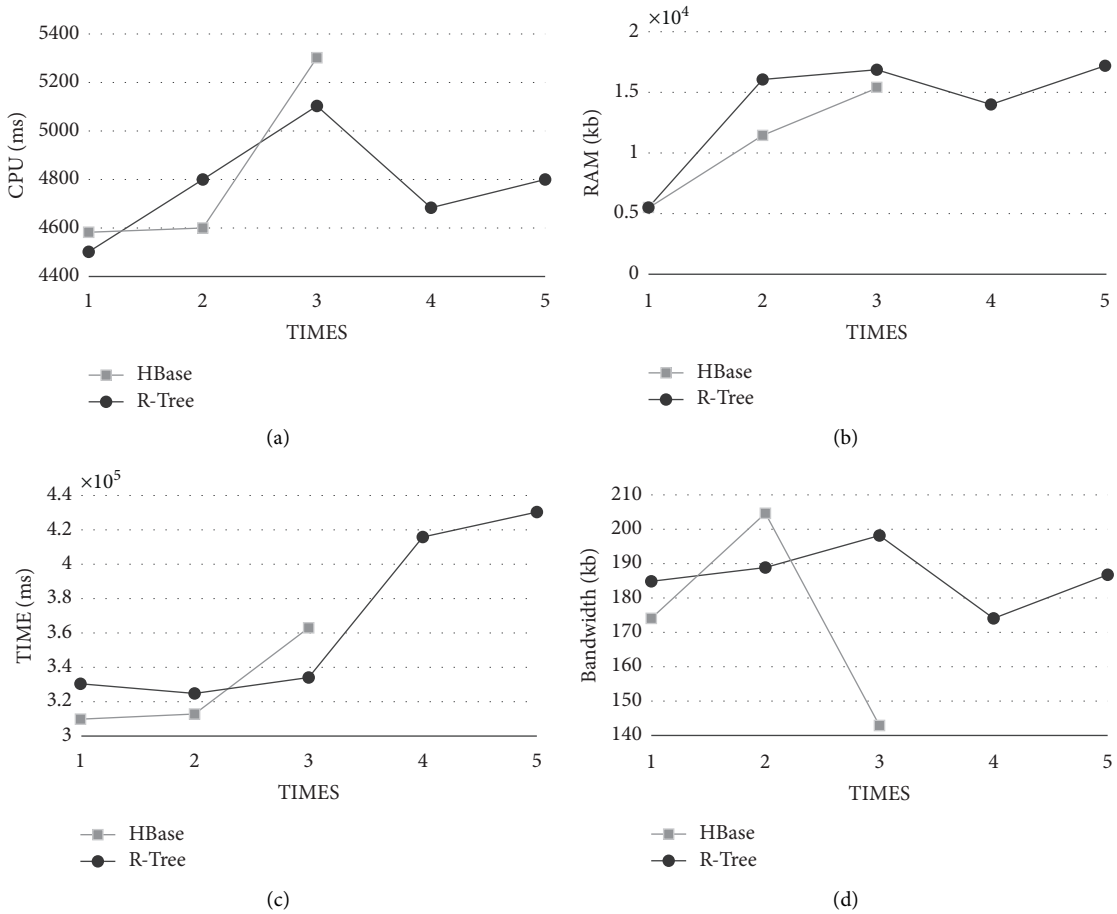

Figure 5: The R-tree index effect in terms of CPU running time, RAM usage, system running time, and bandwidth ($\alpha = 1, \beta = 1$). (a) CPU running time. (b) Ram occupancy. (c) System runing time. (d) Bandwidth.

and proposed in this paper can effectively reduce the coverage and overlap amongst MBRs. Moreover, it can make the generated tree dense and have less multipath retrieval, and improve the retrieval efficiency. After the system runs for a period of time, the retrieval efficiency of the R-tree clustering model is significantly higher than that of the hash index [25].

When the quantity of tasks is huge, then the performance and quality of the proposed system for using the R-tree clustering model is significantly better than that of the hashing method (as shown in Figure 4), specifically when the communication link of the network is full of activity (as shown in Figure 5). When the network is busy, the system that deploys the hash index crashes and cannot run after several simulations, resulting in the failure of subsequent simulations. However, the system that employs the R-tree clustering model can still perform subsequent operations. This is because of R-tree, the more times it is searched, the more data it contains and the more search paths it has, thus affecting the retrieval response time. When the amount of data is enormous, it will have a negative effect on the system performance after operating for a while, since the creation and maintenance of hash tables places a heavy demand on the computational performance of the computer.

3.4. Computational Complexity. The time complexity of R-tree built by implementing the proposed techniques and algorithms is $O(n^k \times t)$, where k represents the total amount of clusters, n represents the total amount of data, and t characterizes the total number of iterations. Furthermore, the hash index method computational complexity is $O(1)$. Therefore, at the beginning of system operation, the R-tree clustering model index was observed significantly slower than the hash index. However, the R-tree clustering model created and proposed in this paper can effectively reduce the coverage and overlap amongst MBRs. The complexity of the proposed method increases along with increase in the number of clusters, amount of data, and the index system.

4. Conclusions and Future Work

Although, data retrieval is frequently a significant bottleneck, the Internet of things and big data technologies have considerable potentials for applications in the domain of material management, hospital personnel, and the development of medical technologies. In order to upsurge the usefulness of applications and the advantages of medical information technology, data exchange, and efficient retrieval must be realized. In this paper, a new retrieval technique grounded on the R-tree clustering model index is

suggested for medical data with various types and large amounts of data. Firstly, the medical data is clustered and divided by the dynamic determination of cluster center (DCC) algorithm. By selecting the optimized cluster center, the data in the same subspace are clustered under the same subtree. Furthermore, a layer-by-layer effective R-tree method is constructed from root nodes to leaf nodes. The medical data is retrieved through the R-tree clustering model index to increase the efficiency of the information retrieval system. Then, the experiments were carried out in the area of the hospital information system. As a final step, the system quality of service and performance was assessed under various network tasks and states. Through comparing with the system performance after deploying the hash index, it was empirically proved and validated that the proposed method significantly improves the information retrieval efficiency of the system.

From our experimental outcomes, it can be seen that the index structure of the R-tree clustering model is constructed, layer-by-layer, from top to bottom through dynamically determining the clustering center using the algorithm proposed in this paper. We noted that the proposed system can effectively improve the information retrieval efficiency of medical information by deploying the R-tree clustering model in the medical information system. However, due to the large amount of computation when clustering data with the clustering algorithm, the CPU utilization is too high when the retrieval task is small. Therefore, future research also needs to select the appropriate model according to the actual data characteristics, and use the data mining algorithm to study the more universally applicable retrieval methods. Furthermore, the recent advancement of the edge-cloud servers setting can also be used to improve the CPU running time of the proposed algorithm. In that context, the database should be placed on a cloud server, while the information retrieval module related to the clustering will be implemented over the cloud. On the edge, each hospital will run the patient monitoring system that will optimize the patient statistics based on the data stored on the cloud. In ongoing work, we plan to implement the proposed R-tree clustering information retrieval method over the edge cloud. Finally, the deep learning network can also be integrated to further optimize the parameters and data.

Data Availability

The data used to support the findings of this study are available within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Surface Movement and Deformation Law Caused by Different Coal Pillar Stagger Distances in Strip Filling IoT-Enabled Sustainable Mining

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Most of the mines in the middle and lower reaches of the Yellow River Basin in China have the occurrence characteristics of multiple coal seams, and the mining is easy to cause damage to the ecological and human settlement environments. Mine monitoring methods, using Internet of Things (IoT) and machine learning, pursue to develop a suitable atmosphere to avoid similar damages and mine closure with supreme efficacy. Accurate monitoring methods reduce these damages and optimize mining. Strip filling mining is characterized by high efficiency, reliability, and low cost, which provides a good technical support for mining damage control. However, how to reasonably layout the working face under multicoal seam conditions and the law of surface movement under different coal pillar stagger distance need to be studied. Based on the geological and mining conditions of a mine in Shandong Province, through numerical simulation and theoretical analysis, this article studies the influence of coal pillar stagger distance on surface movement of multicoal seam strip filling mining. The study reveals mechanism for surface cooperative deformation under different coal pillar stagger distances. Furthermore, an IoT, cloud computing, and data aggregation based architecture is offered in order to support the development of a digital and sustainable mining platform. The results show that the surface subsidence is positively correlated with coal pillar stagger coefficient and mining layers. When the stagger coefficient $s \geq 0.75$, then the surface subsidence and horizontal movement are less affected by the change of coal pillar stagger coefficient. The relationship between surface subsidence ratio and coal pillar stagger coefficient, in multicoal seam strip filling mining, is a power function. The subsidence ratio observed was 0.21–0.32, and the horizontal movement coefficient is about 0.09. The fitting empirical formula of surface subsidence ratio and coal pillar stagger coefficient, in this particular mining area, is established through various machine learning methods. Under the mining conditions of gently inclined coal seam, the surface subsidence can be slowed down to a certain extent by the arrangement of working face along incline direction. Through plausible assumption, our experimental outcomes demonstrate that the proposed prototype can improve the prediction accuracy and model execution times, from 14.2% to 18.9%, through the data aggregation method.

1. Introduction

The Yellow River Basin is rich in coal resources, which is the most significant base of coal production in China and also an important ecological barrier in China [1]. However, the exploitation of an enormous number of coal resources inevitably consequences to a series of ecological environmental damages and human settlement environmental damages. In particular, the repeated disturbance, long duration, and large destructiveness of multicoal seam mining are some of the common damages, which have a great negative impact on local people and ecological environment [2]. Source subsidence control mining and environmental posttreatment are the keys to ensure green and sustainable development of human settlements and ecological environment in mining areas. In fact, the former one is the most direct and important technical approach. Many researchers have accomplished relevant research work. The essence of source

subsidence control mining is to use "three under" coal mining technology to control strata, including strip mining, filling mining, and so on.

As a partial mining technology [3], strip mining has good subsidence control effect and is widely used. Zou et al. [4] proposed the three-dimensional layered medium theory of strip mining and the main control factors of surface movement control, and established the elastic mechanics model of strip mining. Similarly, Wang et al. [5] extended the work for the limitations of the application of A. H. Wilson design theory, given that the formula is not constrained by geological mining conditions. Guo [6] proposed the probability integral superposition prediction method of full-mining multiface according to the characteristics of deep large mining width strip mining. The proposed prediction methods can more accurately predict the deformation and surface movement of deep strip mining. Yu et al. [7, 8] established the strip coal pillar nonuniform stripping model, and proposed the strip coal pillar long-term stability field evaluation method. Strip mining is also the main technical means of multicoal seam mining. Moreover, Deng et al. [9] studied the connection among the spatial position of multicoal pillar and the movement of overlying strata and surface, and gave the corresponding functional relationship. Similarly, Zhang [10] used the method of similarity and numerical simulations in order to reveal the regulation of rocks, deformation, and surface movement in multiseam strip mining process.

Filling mining is a mining technology that replaces coal pillar by filling body [11], which can effectively alleviate surface subsidence and deformation. Zhang et al. [12] constructed the in situ filling mining mode of coal gangue underground sorting based on underground sorting. Moreover, Guo et al. [13] proposed a new idea of three-step mining subsidence control: strip mining-grouting filling consolidation goaf-residual strip mining. Dai et al. [14] and Guo [14, 15] proposed a subsidence control mechanism of mining that is coordinately mixed with keeping and backfilling, and given the corresponding surface subsidence prediction formula. Based on the change of filling position and filling material elements, Xu et al. [16, 17] proposed the strip filling technology in goaf. The isolated grouting filling technology in separated strata and the grouting filling technology in caving zone of strip mining are suggested. Combined with the key strata theory, the control mechanism of strata in partial filling mining was revealed. The field practice shows that strip filling is an efficient and low-cost filling coal mining technology [18].

In summary, the strip mining resource recovery rate is low, while the filling mining cost is high. Therefore, the reliability of overburden strata control needs to be improved. The strip filling mining combines the benefits of filling mining and strip mining. Through reasonable design and layout of the coal pillars, filling working face, and caving working face, this not only ensures the resource recovery rate, but also achieves the goal of protecting human settlements and ecological environment. Moreover, appropriate monitoring systems will ensure safety in mines, avoid damages, and mine closure [19, 20]. The efficiency of the monitoring system in such environments is of utmost importance. Nevertheless, it has good technical advantages, but it is still widely used in single coal seam. However, most of the production mines in the lower and middle reaches of the Yellow River have the occurrence characteristics of multicoal seams, and there are many ground buildings. After the completion of the first coal seam mining, it is worth exploring how to reasonably arrange the lower coal seams mining to realize the effective control of strata and surface movement and reduce the disturbance to buildings. Therefore, this article take the geological and mining conditions of a mine in the middle and lower reaches of the Yellow River as the research background and investigate it through numerical simulations. Combined with the mechanical structure and movement law of strata in multicoal seam strip filling mining, the surface cooperative deformation mechanism of "large mining thickness under insufficient mining" with small coal pillar stagger distance and "small mining thickness under sufficient mining" with large coal pillar stagger distance is revealed.

Based on the characteristics of multiseam mining and the spatial stagger relationship of coal pillars between coal seams in strip filling mining, the surface movement law and cooperative deformation mechanism of strip filling mining under different coal pillar stagger distance are studied. This can also provide reference for safe and efficient green mining of multiseam in the lower and middle reaches of the Yellow River. In this article, an IoT and cloud computing based architecture is offered in order to support the development of a digital and sustainable mining platform. Moreover, mine monitoring methods, using Internet of Things (IoT) and machine learning, pursue to develop a suitable atmosphere to avoid damages and mine closure with supreme efficacy. Accurate monitoring methods reduce these damages and optimize mining. The key contributions of the research carried out in this article are as follows:

(i) We investigate the influence of coal pillar stagger distance on surface movement of multicoal seam strip filling mining

(ii) We propose a mechanism of surface cooperative deformation under different coal pillar stagger distance

(iii) A data aggregation method is suggested that runs on the edge device and send only important data to the cloud for storage

(iv) An IoT and cloud computing-based architecture is offered in order to support the development of a digital and sustainable mining platform

The rest of the article is systematized in the following manner. In Section 2, we discuss related materials and research methods that will familiarize the readers with the research field being investigated in this article. The UDEC numerical simulation and the essential toolkits are illustrated in Section 3. A machine learning framework based on the edge computing system is proposed in Section 4. Furthermore, a data aggregation method is suggested that process the collected data and saves the required data.

Section 5 demonstrates the obtained results. The major outcomes of our research are summarized in Section 6. To end with, Section 7 concludes the article and provides few guidelines for future research.

2. Materials and Methods

2.1. Overview of the Study Area. The mine in the study area belongs to a mine in Shandong Province. The terrain in the mine field is flat, coal retention rate under village reached 100%, and the relocation is difficult. The main coal seams are 5# coal, 8# coal, and 12-1# coal, and the coal thickness is 2.95 m, 3.94 m, and 2.95 m. The coal seam spacing is 49 m and 43 m. The interval strata are mainly fine sandstone and sandy mudstone. The coal seam dip angle is about 10°, the loose layer thickness is 80 m, and the mining depth is 491–723 m.

According to the calculation method of each working face size of single coal seam mining unit [15], combined with the geological and mining conditions and actual production benefits in the study area, the optimal widths of caving working face, filling working face, and reserved coal pillar of each mining unit of 5# coal in the first coal seam were determined as 80 m, 90 m, and 70 m, respectively. The first mining unit was completed between January 2018 and June 2020.

At the same time, the surface movement was observed, and the layout of the observation station is shown in Figure 1. The measured outcomes show that the largest subsidence of the surface movement surveillance station of the inclined main section is positioned on the side of the partial caving face above the mining unit. As shown in Figure 2, the largest subsidence value of the surface is 152 mm, and the subsidence ratio under the geological and mining conditions in this area is about 0.05, which has little effect on the surface movement, and there is no apparent destruction to the surface buildings during mining.

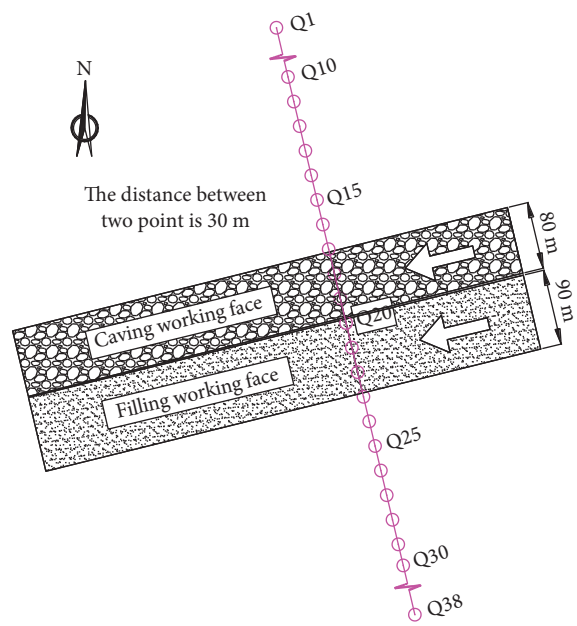

Figure 1: Observation station layout.

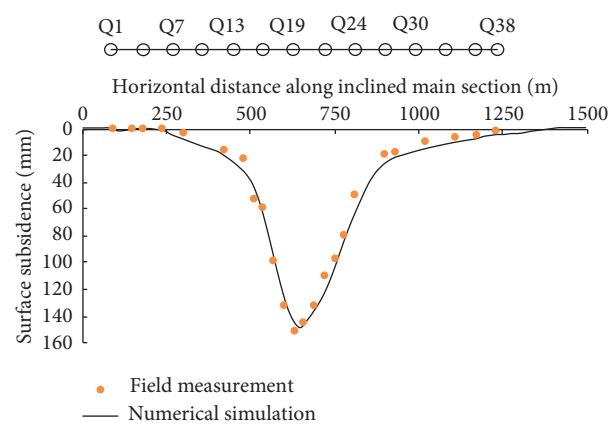

Figure 2: Comparison of field measurement and numerical simulation subsidence results in 5# coal mining (surface subsidence is measured in millimeter, and the distance is measured in meters).

2.2. Surface Cooperative Deformation Mechanism under Different Coal Pillar Stagger Distances. The staggered arrangement of coal pillar in multicoal seam strip filling mining includes multiple mining units of different coal seams, and each mining unit contains three components, namely caving face, filling face, and coal pillar. Coal pillar stagger arrangement according to the coal pillar stagger distance can be divided into coal pillar normal alignment, coal pillar part stagger, and coal pillar completely stagger, the specific arrangement is shown in Figure 3. The normal alignment arrangement of coal pillar is characterized by the alignment of coal pillar, filling working face, and caving working face of multilayer coal along the normal direction of coal seam [21]. In the layout mode of partial staggered coal pillar, the coal pillar, filling face, and caving face of multilayer coal are less than one coal pillar width transversely out of the upper coal; in the coal pillar completely staggered layout mode, the coal pillar, caving working face, and filling working face of multilayer coal are transversely deviated from a coal pillar width than the upper coal seam. In order to facilitate the study, based on the layout mode of coal pillar normal stagger change, the stagger degree is represented by coal pillar stagger coefficient s, and s is the ratio of coal pillar stagger distance l to coal pillar width a, the expression is $s = l/a \in [0, 1]$.

Overburden strata movement and surface subsidence are interrelated as a whole [22], and surface subsidence is the appearance of the movement and deformation of overlying strata in the surface. Strata movement includes arch, beam, and other structural forms [23, 24]. Different coal pillar stagger layouts have different mechanical bearing structures, and the surface movement characteristics will also be different.

The control of stagger layout mode on overlying strata and surface movement includes two dimensions, horizontal and vertical. In the horizontal direction, it shows that with the growth of stagger distance, the sufficiency of multicoal

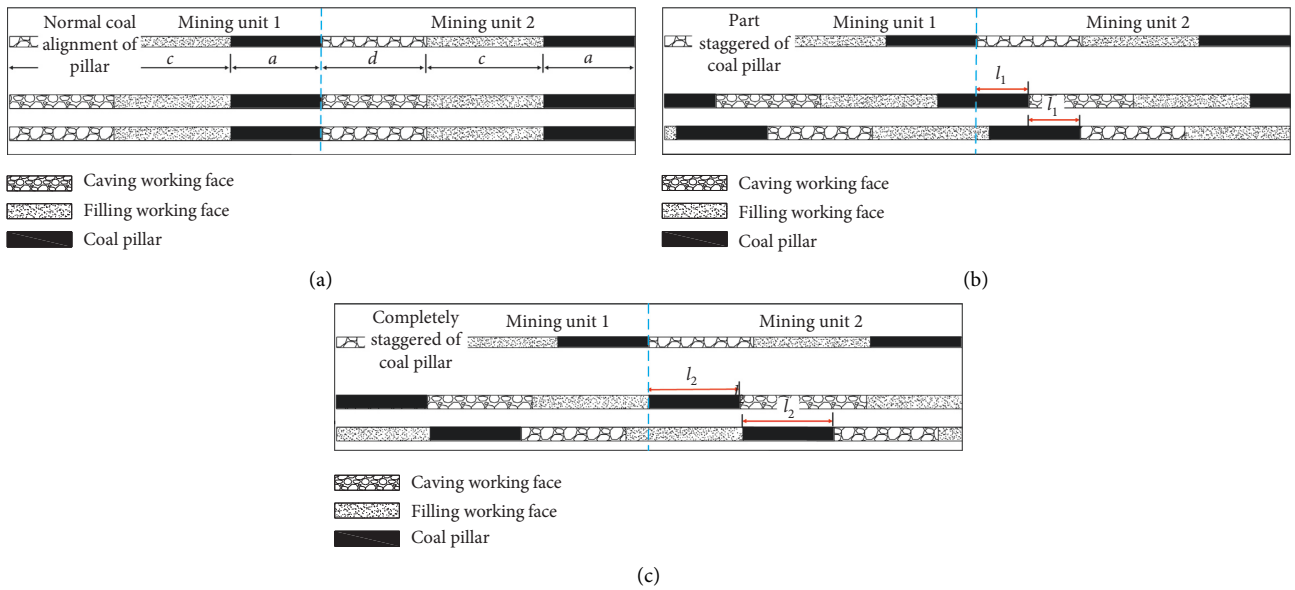

Figure 3: Diagram of the layout pattern of different coal pillar stagger distances.

seam mining increases. Vertically, the sequential layout of "coal pillar-filling working face-caving working face" avoids the large area suspension of roof. The smooth transition from coal pillar to caving working face can meritoriously diminish the separation space of the main key layer, and avoid the sudden chain failure instability of "domino effect" of the main key layer due to stress concentration. When the coal pillar is arranged in alignment or the stagger coefficient is small, the combination of coal pillar and filling body forms an effective bearing on the overlying strata, which blocks the connectivity of the caving areas on both sides. Multiple sets of stress arches are formed above the caving and filling working face, which are divided into multiple insufficient mining units.

At this time, the control effect on the surface is the best. With the increase of stagger distance, the effective combination of coal pillar and filling body support width decreases gradually, the sufficiency of mining increases, and the control effect of the surface is weakened. When reaching a certain critical value, the combination of coal pillar and filling body loses the main bearing function, and the mining units are connected to the rock failure zone, forming a flat arch across the three mining units above the mining area. At this time, the span and deflection of the main key layer are significantly increased, and the contact with the lower rock mass. The stress state of the overlying strata is changed from the local stress of the combination of coal pillar and filling body to the overall stress of the goaf [25]. The multiple mining units in the lateral space basically achieve sufficient mining, but are limited by the longitudinal comprehensive mining thickness. The separation space under the key layer is not enough to lead to structural breakage and can still play a role in controlling surface subsidence. The stagger distance continues to increase, similar to the sufficient mining stage of the working face, the surface subsidence changes little until it reaches the maximum.

The surface cooperative deformation mechanism of multilayer coal strip filling mining is shown in Figure 4. Affected by repeated mining of multiple coal seams, the strata and surface above the mining face experience multiple subsidence and the surface subsidence is the superposition of surface subsidence of each mining face in adjacent mining units of different coal seams. As shown in Figure 4(a), when the coal pillar is arranged in a normal alignment, the goaf of the narrow caving face on both sides is effectively blocked by the combination of coal pillar and filling body. After the multilayer coal mining, it is equivalent to a mining unit with the same thickness or slightly larger than the sum of the mining thickness of each coal seam in space, forming a "large mining thickness of insufficient mining." However, the layout mode of fully staggered coal pillars (Figure 4(b)) is adopted. In this layout mode, the combination of coal pillar and filling body between coal seams loses the bearing capacity [26].

The damage to rock strata after multilayer coal mining is equivalent to a mining unit with large mining width and small mining thickness in space [27]. In other words, each caving face connected horizontally staggered arrangement forms a working face with large mining width, and the overall formation of "sufficient mining with small mining thickness." Simultaneously, with the growth of the coal seam stagger coefficient, the subsidence gradient of the surface basin is gradually reduced. When the stagger coefficient is large, the tensile and compression deformation area is superimposed after mining between coal seams, and the surface deformation value of the central goaf is small, which is beneficial to the safe use of buildings. The partial stagger arrangement is in the transition stage of the above two cooperative deformation structures from overburden to surface.

3. UDEC Numerical Simulation

3.1. Principles of the UDEC. The UDEC is a two-dimensional discrete element numerical simulation software developed by ITASCA for the treatment of discontinuous media, all

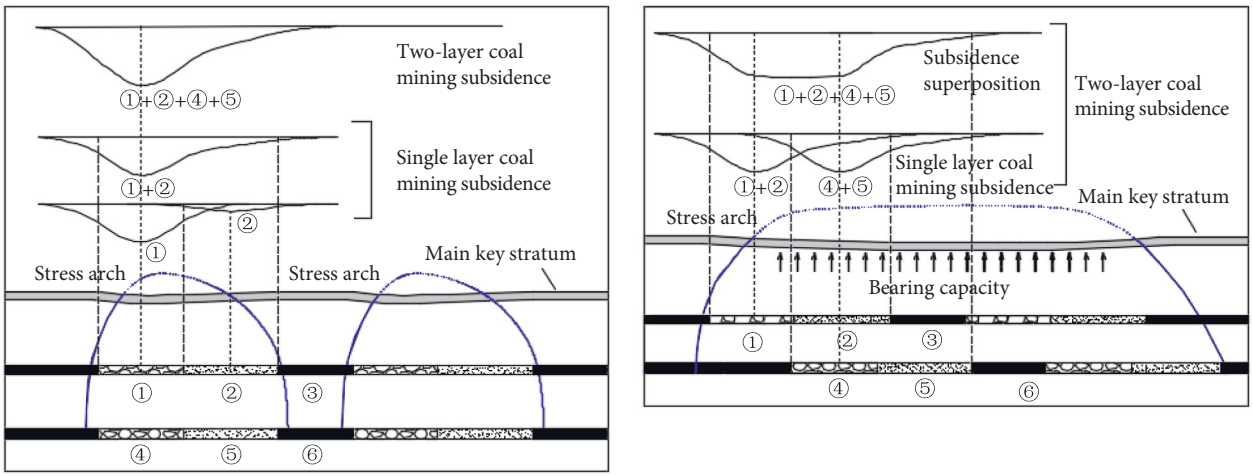

Figure 4: Surface cooperative deformation mechanism under different coal pillar stagger distances. (a) Normal alignment of coal pillars ($s = 0$). (b) Completely staggered coal pillars ($s = 1$).

known as Universal Distinct Element Code. In fact, the UDEC can be used to mimic and simulate the reaction of discontinuous media (for instance, joints in rock mass) under static or dynamic loads. The discrete block set is used to represent the discontinuous medium, and the boundary surface between blocks is used to represent the discontinuous surface, allowing large displacement and rotation of blocks along the discontinuous surface, which can be used to simulate the displacement phenomenon that may occur at the discontinuous geological interface. In the recent years, UDEC has developed one of the most effective tools to investigate the mining subsidence problem [28].

3.2. Establishment of the Model. The UDEC software was used in the numerical simulation, and the geological and mining conditions of a mine in Shandong Province were taken as the prototype. According to the distribution of rock strata exposed by the mine drilling, the appropriate simplified modeling was carried out. The model size is 1800 m × 800 m, and the actual development and distribution of the discrete element block reference rock are divided into 20,550 units.

In the proposed model, three mining units are arranged for each layer of coal. The caving face, filling face, and coal pillar width of the first coal mining unit are the actual mining size of 5# coal, 80 m, 90 m, and 70 m, respectively; the mining sequence between coal seams is first up and then down, and the working face is first filling working face and then coving working face in the same group of mining units. The geometric model for numerical simulation of coal pillar normal alignment layout is shown in Figure 5. In the next subsections, we briefly elaborate the establishment of the proposed model.

3.2.1. Determination of Key Mining Parameters of Filling Working Face. In deep filling mining face, the filling rate and compaction rate of filling materials have a direct impact on the bearing capacity of column filling combination [29, 30], and it is also the key to control the deformation of strata and surface movement. Referring to the actual situation of the existing working face filling mining in the mining area, the simulation filling rate is 80% and the compaction rate is 85%.

3.2.2. Constitutive Model and Boundary Conditions. According to the material difference and the characteristics of UDEC software, the Mohr-Coulomb model reflecting the shear failure characteristics of the material is selected for the loose layer and the coal and rock mass in the model, and the double-yield model reflecting the low-bond granular material is used for the filling body [15]. The surface contact Coulomb sliding model is selected for the joints. The upper boundary of the model is a free surface, and the left and right boundary conditions are applied to limit the horizontal displacement. The lower boundary is a fixed support, and the displacement in the horizontal and vertical directions is limited. The initial stress field is the self-weight stress of the stratum.

3.2.3. Determination of Numerical Simulation Parameters Based on the Mined Working Face. Based on the laboratory mechanical measurement, the mechanical as well as the physical characteristics and parameters of rock mass and coal are determined through comprehensive comparison with the measurement of field of the mining face. Combined with laboratory measurements and empirical parameters, the mechanical and physical factors and parameters of numerical simulation rock mass and coal are preliminarily determined. The obtained outcomes are illustrated briefly, as shown in Table 1; and the model of 5# coal seam mining unit 1 excavation is the most effective.

Figure 2 shows the comparison of the subsidence results of field measurement and numerical simulation after 5# coal mining.

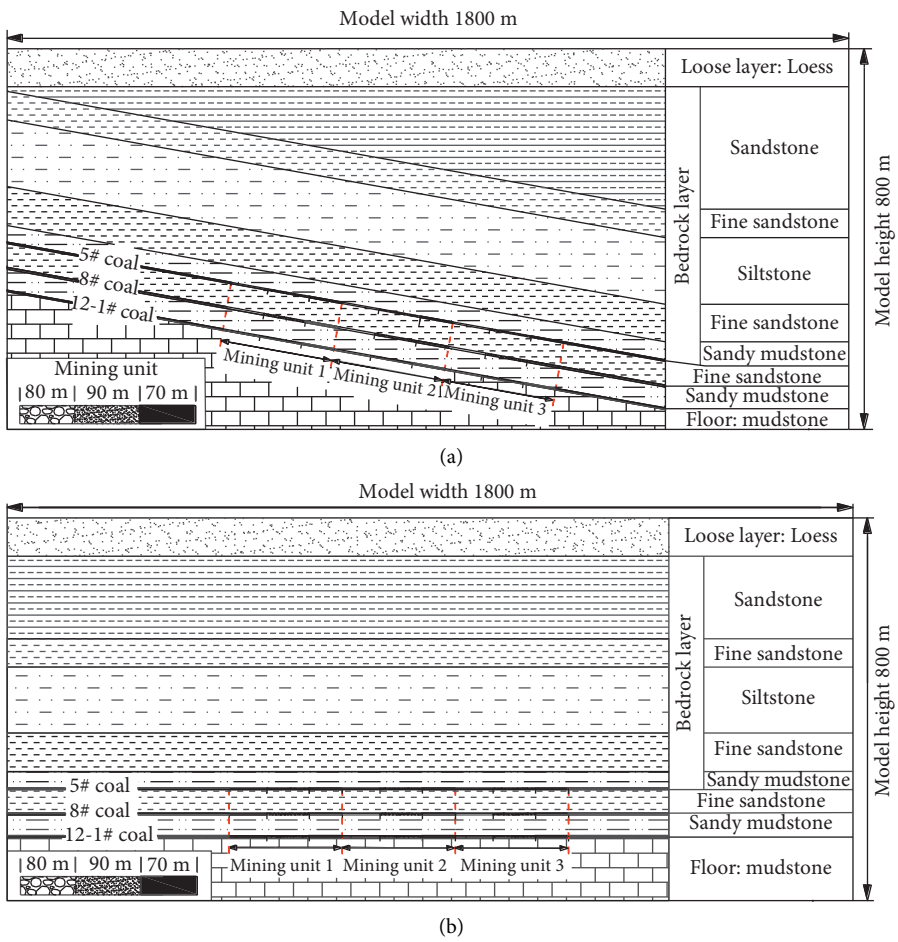

Figure 5: Geometric model for numerical simulation of the coal pillar normal alignment layout. (a) Arrangement along the inclination ($\alpha = 10^{\circ}$). (b) Arrangement along the strike of coal seam ($\alpha = 0^{\circ}$).

Table 1: The mechanical and physical parameters of the coal rock in the UDEC model.

Lithology	Thickness (m)	Density ($kg \cdot m^{-3}$)	Bulk modulus (GPa)	Shear modulus (GPa)	Cohesion (MPa)	Friction angle (°)	Tensile strength (MPa)
Loess	80	1800	0.67	0.3	0.20	20	0.12
Sandstone	183	2462	15.7	5.9	0.25	31	0.20
Fine sandstone	59	2662	35.2	7.4	0.38	34	0.21
Siltstone	138	2627	26.4	5.1	0.48	34	0.24
Fine sandstone	81	2662	35.2	7.4	0.38	37	0.21
Sandy mudstone	34	2500	9.14	2.1	0.57	35	0.45
5# coal	2.95	1400	0.90	0.8	0.28	25	0.10
Fine sandstone	49	2500	9.14	1.9	0.38	35	0.21
8# coal	3.94	1400	0.90	0.8	0.28	25	0.10
Sandy mudstone	34	2500	9.14	2.1	0.57	35	0.45
12-1# coal	2.95	1400	0.90	0.8	0.28	25	0.10
Mudstone	143	2700	45.1	7.8	0.60	30	0.24

It can be seen from Figure 2 that the simulated maximum subsidence value of the surface is 148 mm, which is close to the field measured maximum subsidence value. The mean error between the simulated subsidence and the field measured surface is 10.2 mm, and the relative error is 6.7%, which verifies the mechanical parameters of the numerical model and the reliability of the simulation calculation. Therefore, this set of parameters is adopted in the

subsequent excavation of other mining units of 5# coal and other simulation schemes.

3.3. Numerical Simulation Scheme. Multiple coal seam mining involves many geological mining factors, such as mining thickness, mining depth, coal seam spacing, and overburden lithology. For specific projects, the geological conditions are fixed. Therefore, in order to study the law of strata and surface movement of different coal pillar offset modes in multiseam strip filling mining, this section changes the normal stagger distance of coal pillars on the basis of the strip filling mining of single coal seam, and establishes the simulation schemes of different coal pillar stagger layouts ($s = 0$, 0.25, 0.5, 0.75, 1) when the multicoal seam mining is arranged along the strike ($\alpha = 0^\circ$) and along the incline ($\alpha = 10^\circ$).

4. Internet of Things (IoT) and Cloud-Based Monitoring and Prediction System

The prominence of the IoT, cloud computing, and communication technologies in sustainable mining platform cannot be exaggerated. In fact, this setup can deliver connectivity between various sensing, data collection units, and monitoring modules of the IoT prototype and, therefore, could allow real-time decision making through integration of various components. The most popular methods for avoiding mining dangers and equipment damage are monitoring and early warning. IoT-based monitoring devices now provide extensive data, thanks to the growth of the IoT and edge computing, improving the accuracy and efficiency of early warning and mining monitoring. Additionally, IoT monitoring data might be directed to a remote centralized cloud facility for computational processing in order to produce reliable data sources for timely warning. Nevertheless, the overwhelming volume of IoT devices uses up the majority of the cloud center's resources, lengthening the time it takes to analyze data. Furthermore, a constrained bandwidth prevents the transmission of a lot of monitoring data. As a result, cloud computing occasionally falls short of the real-time demands of prompt and timely warning. Monitoring data may be processed quickly with edge computing technology since it processes data more locally than at a centralized cloud center. The wide-ranging prototype of edge-based IoT data mining for prevention, particularly monitoring and timely warning, is shown in Figure 6 [31].

Usually, edge servers reside between the client and the cloud that play a major role when latency and speed of the decision making is important. For example, in the case of prediction, the training module will learn from the huge amount of data that is not possible at the client or edge. Similarly, when collecting the data, it might not be possible to store all the data on the client or edge. Therefore, the mining and geological data can be stored over the cloud and can be accessed through any communication medium. In fact, this architecture can be used as part of the monitoring system in any physical mining cite for human and environmental safety.

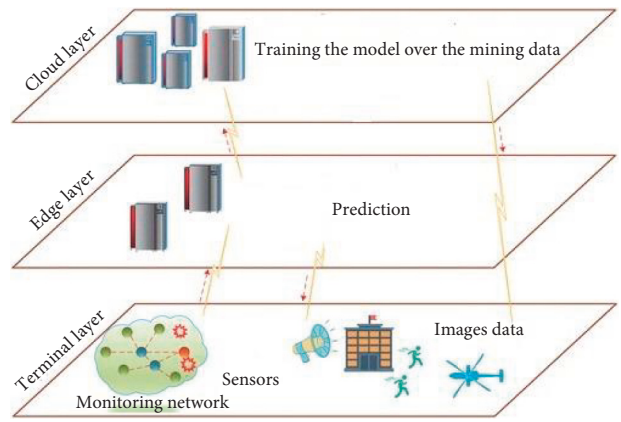

Figure 6: IoT edge mining monitoring and data processing system.

The above IoT edge architecture is then used to implement the deep learning method as shown in Figure 7. Deep learning techniques are very time-consuming, in particular, when images data are taken into account. Literature suggests that deep learning method such as GCN (graph convolutional network) is largely used in scenarios when the data are mentioned in images, and that is the case in mining. Therefore, to reduce the prediction time, the training may happen at the cloud that are resource rich, while the prediction module can be executed in the edge that has limited resources. Note that, images data are collected through camera and sensors. To further improve and clean the data, data fusion and aggregation methods can be used to reduce the amount of data. Such prediction decisions can be either related to human safety or environmental disasters which may occur in the mining cites. Deep learning models are time-consuming and it may take quite long. Therefore, the proposed IoT edge platform can be used to expedite the decision making. This should be kept in mind that failure to deliberate the observing in active working face, goaf, and other areas in mining decisions consequences in mining accidents.

4.1. The Data Aggregation Method. The proposed edge model can further be enhanced through using an aggregation method. This is due to the fact that edge resources are small and cannot process huge data. Therefore, it would be essential to reduce the amount of data. However, the aggregation algorithm reduces the data points, therefore, less data means lower accuracy and vice versa. Initially we gather data and process it grounded on the proposed data aggregation system. In fact, numerous IoT devices that can quantify and monitor the physical mining environment and observe real-time environment deviations make up the terminal layer as shown in Figure 6. Data that have been gathered by multiple sensors that are positioned over similar areas may be redundant. Only meaningful data must be stored, which requires a procedure. The IoT ecosystem uses a large number of sensors to gather data, and the reporting

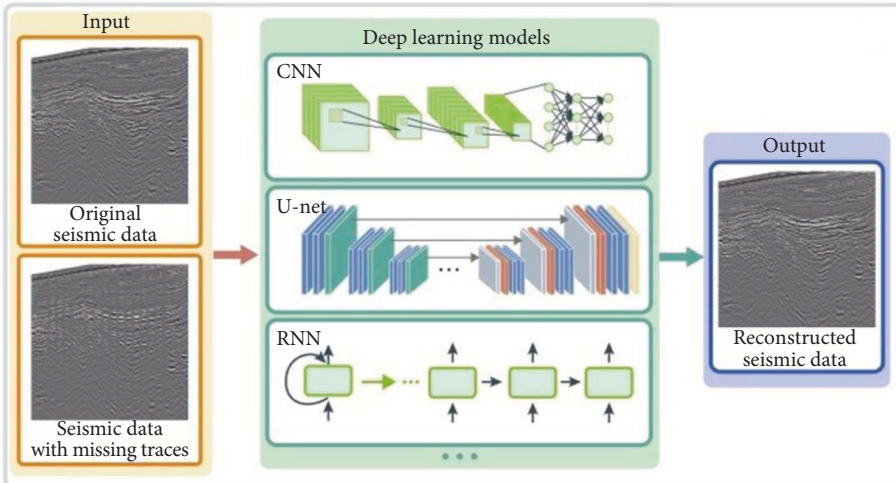

Figure 7: Deep learning model for training and prediction for mining monitoring [31].

area is expected to commonality. Due to this commonality, identical, pointless data may be gathered, which may place a strain on the server or other storage medium. Subsequently, this may also lead to strain the machine learning algorithm. Time spent training and hence predicting can be squandered in addition to latencies lengthening. Due to network congestion and prediction process impairment, the massive amount of data collected may contain duplicate values. Duplicate data must therefore be eliminated using a process. One of the i or j values is maintained while the other is eliminated if the ratio of $D_{\min}$ to $D_{\max}$, as illustrated by Equations (1) and (2), respectively, is less than the predetermined threshold value, indicating that the data are identical. Both data points must be included throughout the assessment process if the ratio of $D_{\min}$ and $D_{\max}$ is larger than or identical to certain predefined threshold value, indicating that the data are divergent.

$$D_{\min} = \sqrt{\left(\min_j - \min_i\right)^2} \text{ for all } i, j = 1 \ldots n, \tag{1}$$

$$D_{\max} = \sqrt{\left(\max_j - \max_i\right)^2} \text{ for all } i, j = 1 \ldots n. \tag{2}$$

The best time for aggregation is during the data collection phase. The technique and the pseudocode for aggregating data points are demonstrated in Algorithm 1. We calculate the Euclidean distance for each data point through step 1 to step 4. In steps 5–7, we compare the data point's value to a threshold value that has been predetermined. In case if the given conditions are satisfied, then the data point is eliminated; if not, then the algorithm continues on to the subsequent data point. Note that this is significant to remember that the datasets must be standardized before the Euclidean distance metric can be applied. A streamlined normalizing function must be used to ensure the application of the aforementioned distance metric. In this research, we used the normalizing technique outlined by

$$M_i^{\text{norm}} = \frac{M_i - M_{\min}}{M_{\max} - M_{\min}}, \tag{3}$$

where M_i^{norm} is a normalized value for M_i and $M_{\min} M_{\max}$ are the smallest and largest values through all data points, correspondingly. For instance, we might use $M_{\min} = 0$ and $M_{\max} = 1$ to normalize the supplied data points in a dataset within the range of 0 and 1. In this method, the threshold should be appropriately defined since it will affect the ratio of the discarded data. The above method is largely used due to its lower computational costs and we believe that the edge resources are quite enough to run this algorithm.

5. Results and Discussion

From Figures 8 and 9, it can be seen that when the coal pillar is arranged in normal alignment, that is, when $s = 0$, the subsidence of rock in each caving-filling working face propagates independently to the surface. The overlying strata subsidence above the coal pillar is slight, indicating that the coal pillar itself is stable due to the lateral protection of the filling body, which can support the roof and isolate the adjacent caving-filling working faces. At this time, the surface subsidence above the coal pillar is smaller than that of the caving-filling working face, and the central subsidence basin is wavy, with the maximum subsidence value of 2066 mm.

When the coal pillar stagger coefficient $s = 0.25, 0.5$, with the increase of coal pillar stagger coefficient, the superimposed area of coal pillar in upper and lower coal seam decreases, and the strata movement in the adjacent caving-filling working face is gradually connected to each other. The subsidence range of rock is getting larger and larger, and the subsidence value increases. The strata above the coal pillar is affected by the caving-filling working face on both sides, and the subsidence difference between the rock above the coal pillar and the caving-filling working face is reduced. The isolation effect of the coal pillar is weakened. In terms of

Input: Original dataset denoted by points P_i and P_j
Output: Refined dataset denoted by two points P'_i and P'_j
(1) for each element i, j in P_i, P_j
(2) if $j \leq i$ or $i \notin P_i$ or $j \notin P_j$
(3) Do nothing [no duplicate data]
(4) end if
(5) $E_d(P_i, P_j) = \sqrt{(p_{ik} - \min_{jk})^2}$ where $p_{ik} \in P_i$ and $p_{jk} \in P_j$
(6) if $E_d(P_i, P_j) \leq T_d$ then
(7) Discard either P_i or P_j, to form P'_i or P'_j
(8) end if
(9) return P'_i or P'_j

Algorithm 1: The data aggregation algorithm based on the Euclidian distance.

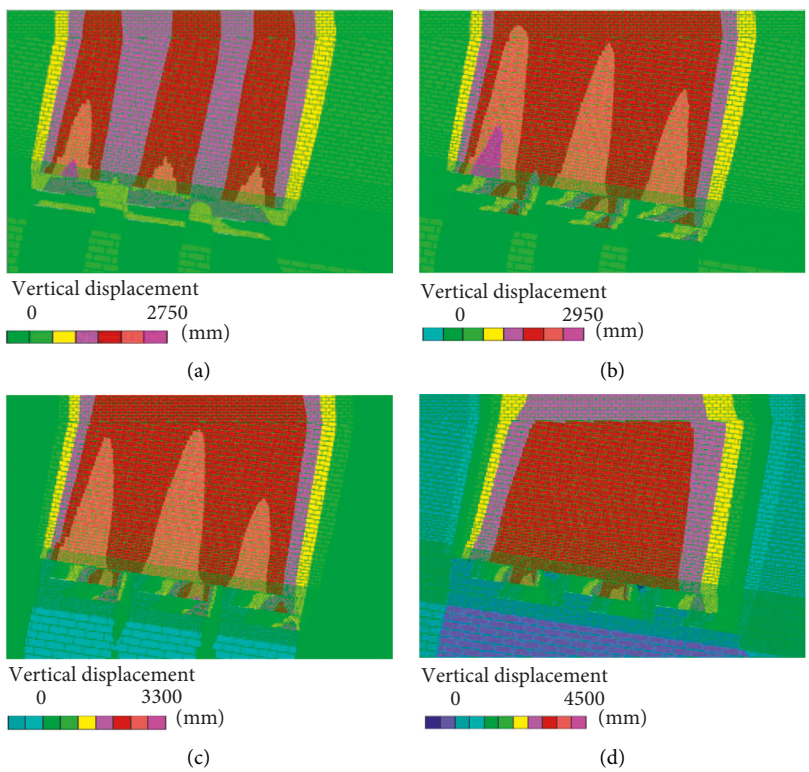

Figure 8: The vertical displacement nephogram of strata on numerical simulation scheme (for $\alpha = 10^\circ$ and $s = 0$, 0.25, 0.5, 1). (a) $s = 0$. (b) $s = 0.25$. (c) $s = 0.5$. (d) $s = 1$.

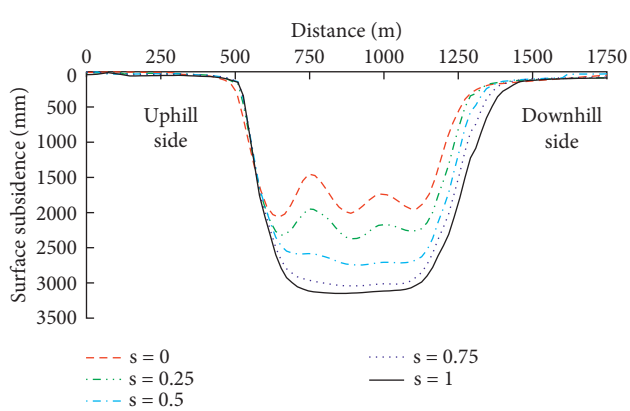

Figure 9: Surface subsidence curve of mining with staggered layout mode (surface subsidence is measured in millimeter, and the distance is measured in meters).

surface subsidence, with the increase of the coal pillar stagger coefficient, the surface subsidence values of the caving-filling working face and above the coal pillar increase. At the same time, the subsidence gradient at different positions in the center of the basin decreases, and it begins to transform from wavy subsidence to uniform subsidence.

When the coal pillar stagger coefficient $s = 0.75$, 1, the coal pillar stagger coefficient continues to increase, the adjacent strata movement area overlaps on the mining face, the "pointed tower" subsidence area on the mining face with small coal pillar stagger disappears, and the subsidence of each rock layer above the central mining area tends to be consistent, and the subsidence range and subsidence value of the rock continue to increase. The center of the surface subsidence basin completely becomes uniform subsidence. When the coal pillar stagger coefficient $s = 1$, the surface subsidence reaches the maximum of 3149 mm.

5.1. Impact of the Number of Coal Seams Mined on Surface Movement. The surface movement law changes with the increase of coal seam number under different coal pillar normal offset layout mode. The maximum surface subsidence and the maximum horizontal movement of the three-layer coal after mining in turn under different coal pillar normal stagger layout modes are shown in Figure 10.

From Figure 8, it can be seen that the maximum subsidence value and maximum horizontal movement value of the surface increase with the increase of mining layers. When the coal pillar is normal aligned, the maximum surface subsidence value is 575 mm and the maximum horizontal movement is 154 mm after the first coal seam 5# coal mining. With the mining of 8# coal and 12-1# coal, the cumulative mining thickness of coal seam increases, and the maximum surface subsidence and maximum horizontal movement increase. At this time, the maximum surface subsidence value of coal pillar normal alignment ($s = 0$) is 2066 mm, and the maximum horizontal movement is 187 mm. When the coal pillar is completely staggered ($s = 1$), then the supreme surface subsidence is approximately 3149 mm, the supreme horizontal movement is 255 mm, and the maximum surface subsidence rises by 1491 mm and 2574 mm, respectively.

Combined with the analysis in Figures 6 and 8, it can be comprehended that under different coal pillar normal offset modes, the increase in the number of coal seams has different effects on surface movement. After the first floor 5# coal mining is completed, with the mining of 8# coal and 12-1# coal, there are many disturbances on the surface and the movement deformation value increases. When the offset coefficient $s < 0.75$, the mining area is relatively concentrated in the longitudinal direction, showing the characteristics of insufficient mining, and multiple small basins are formed on the surface. When the coal pillars are aligned in the normal direction, the surface subsidence rate of multicoal seam mining is only 0.210. When the stagger coefficient $s \geq 0.75$, the multilayer coal mining face overlaps in the longitudinal direction

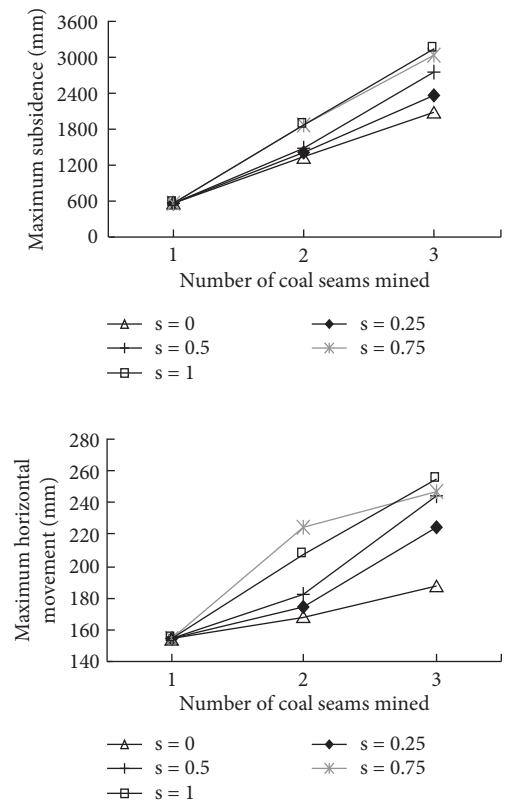

Figure 10: Relationship between the maximum surface movement and the number of mining layers under layout patterns of different staggered coal pillars (horizontal coordinates 1 for mining 5# coal single layer; 2 for mining 5# coal and 8# coal two layers; 3 for mining 5# coal, 8# coal, and 12-1# coal three layers).

and the subsidence area is gradually connected. The adequacy of horizontal mining increases, and the maximum subsidence value of the surface is large, showing the characteristics of "full mining." The surface subsidence curve is connected from multiple small basins to the overall subsidence basin. The surface subsidence ratio of each staggered layout mode of multicoal seam strip filling is 0.21–0.32, which is smaller than that of multicoal seam caving mining ($q_c = 0.6$) [32], effectively alleviating the surface subsidence and beneficial to the protection of surface buildings.

5.2. Influence of Coal Pillar Stagger on Surface Movement. With the increase of coal pillar offset coefficient, the changes of surface subsidence rate and horizontal movement coefficient after three-layer coal mining are shown in Table 2.

When the normal alignment of coal pillars $s = 0$, the surface subsidence ratio is the smallest. After the three-layer coal mining, the surface subsidence rate is 0.210. When the coal pillars are completely staggered, namely $s = 1$, the surface subsidence rate is the largest, and the subsidence rate is 0.320, which is 1.5 times that of the normal alignment of coal pillars.

Combined with Table 2 and Figure 11, it can be seen that the maximum surface subsidence value and subsidence rate

Table 2: Surface movement value of strip filling mining in multiseam with different coal pillar normal direction staggers ($\alpha = 10^{\circ}$, $q = W_{max}/M\cos\alpha$, $b = U_{max}/W_{max}$).

Coal pillar stagger coefficient	Maximum subsidence W_{max} (mm)	Subsidence ratio q	Maximum horizontal movement U_{max} (mm)	Horizontal movement coefficient b
$s = 0$	2066	0.210	187	0.09
$s = 0.25$	2371	0.241	238	0.10
$s = 0.50$	2745	0.279	245	0.09
$s = 0.75$	3041	0.309	247	0.08
$s = 1$	3149	0.320	255	0.08

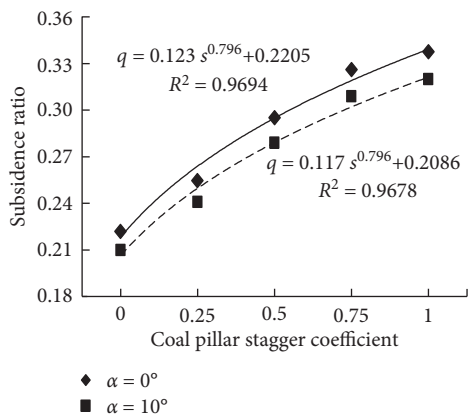

Figure 11: Relationship between subsidence ratio and coal pillar stagger coefficient (fitted with power function having 96.78% and 96.94% accuracies).

are positively correlated with the coal pillar offset coefficient. The relationship between surface subsidence rate and coal pillar offset coefficient is approximately a power function. The surface horizontal movement coefficient increases first and then decrease with the increase of coal pillar offset coefficient, and gradually tends to be stable, about 0.09. Under the geological and mining conditions of the mine, when the offset coefficient reaches a certain value ($s \geq 0.75$), the surface subsidence and horizontal movement are less affected by the change of coal pillar offset. Through regression analysis, the empirical relationship between surface subsidence ratio and coal pillar offset coefficient in multiseam strip filling mining is established: $q = 0.117s^{0.796} + 0.2086$, the goodness of fit $R^2 = 0.968$.

5.3. Difference of Surface Subsidence along Strike and Inclination of the Working Face. The numerical simulation outcomes illustrate that the whole influence range of multicoal seam strip filling mining surface is minor or tiny, and the subsidence is mainly concentrated in the mining area along the normal direction. Among them, the subsidence basin after the mining of the working face is symmetrically distributed along the strike. When the working face is arranged along the incline direction, then the steep degree of the uphill direction is slightly larger than that of the downhill direction. However, the settlement range is smaller than that of the downhill direction, as presented in Figure 9.

Figure 11 presents the surface subsidence ratio of mining with various stagger coefficient of coal pillars along the strike and inclination of the working face. We can clearly observe from the figure that the surface movement law of the working face along the strike ($\alpha = 0^{\circ}$) and along the inclination ($\alpha = 10^{\circ}$) is the same under different coal pillar normal stagger modes, and the subsidence ratio and coal pillar stagger coefficient are in a power function relationship. On the settlement value, the surface subsidence along the strike arrangement is larger than that along the inclination, and the surface subsidence rate increases by about 7%. It indicates that under the condition of gently inclined coal seam, the layout of working face along the incline direction will slow down the surface subsidence to a certain extent. This is consistent with the idea that the mining area chooses the mining plan along the inclination.

5.4. Results of the Machine Learning and Aggregation Methods. We implemented three different machine learning algorithms, that is, CNN, RNN, and U-net [33], where the training happens on a cloud and prediction at the edge. The U-net method is implemented along with the attention mechanism. The outcomes of different approaches and their accuracies with and without the aggregation method are given away in Figures 12 and 13, one-to-one. As shown in Figure 12, for various algorithms, the aggregation method considerably diminishes the model execution times. For training period, we observed approximately 38.8% to 40.9% improvement. Similarly, for prediction period, the improvement was observed up to 14.2% to 18.9%. Note that the time is represented in seconds. Nevertheless, neither CNN nor U-net could reduce the prediction times significantly and they produced almost comparable outcomes. As shown in Figure 13, the aggregation methodology formed worst outcomes in terms of prediction precision and correctness, that is, MAPE and RMSE metric values. However, the RNN approach produced comparable results. This shows that, for RNN, our proposed method has significantly learned well even from the small-scale dataset. This also demonstrates that when the data are less, the accuracy of the learning approach will be small and vice versa. The MAPE values are mentioned in percentage (%), while the RMSE factor denotes a number. The minor values exemplify a higher precise system, while the bigger values denote less accuracy.

6. Major Findings

The following are the major findings of our research:

(i) The surface cooperative deformation mechanism of different coal pillar stagger distance in multicoal

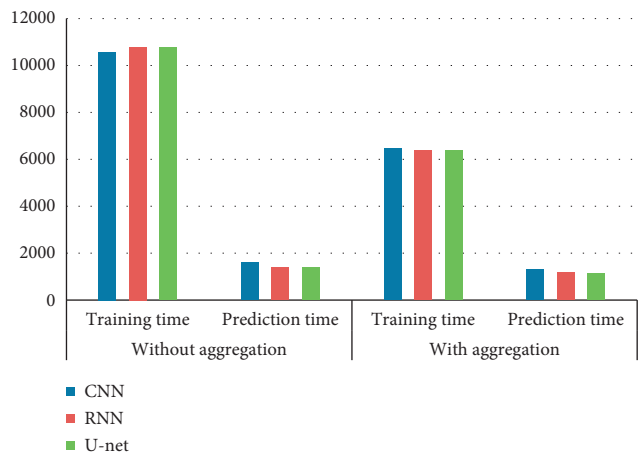

Figure 12: Comparison of training and prediction times for three different algorithms with and without the aggregation technique.

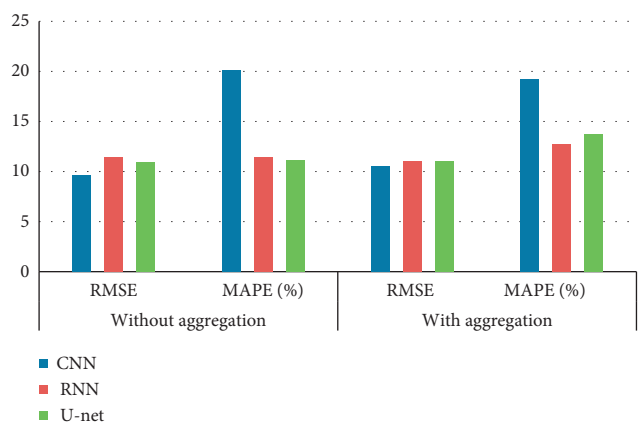

Figure 13: Accuracy of the three machine learning methods in terms of RMSE and MAPE with and without the aggregation technique.

seam strip filling mining is revealed. Through the coordination of the spatial positions of multiple mining units, the effective bearing structure of the combination of coal pillar and filling body is formed. Furthermore, the mining space of the upper and lower coal seams is controlled, so as to reduce the movement space of the main key strata and control the surface subsidence. Acting on the surface, the movement and deformation characteristics of "large mining thickness under insufficient mining" with small coal pillar stagger distance and "small mining thickness under sufficient mining" with large coal pillar stagger distance are formed.

(ii) Using the method of numerical simulation, the influence of different coal pillar stagger distance in multiseam mining on surface movement is studied. Surface subsidence is positively correlated with coal pillar stagger coefficient and mining layers. With the increase of the normal stagger of coal pillar, the support width of the effective combination of coal pillar and filling body decreases, and the sufficiency of horizontal mining increases. The overlying strata subsidence on each caving-filling working face gradually tends to be uniformly transmitted from independent propagation. The central surface subsidence basin changes from wavy subsidence to uniform subsidence, and the subsidence gradient and deformation value decrease.

(iii) The surface subsidence ratio of multicoal seam strip filling mining is power function with the coal pillar stagger coefficient, the subsidence ratio is about 0.21–0.32 and the horizontal movement coefficient is about 0.09. When the coal pillar is aligned, namely $s = 0$, the maximum surface subsidence is 2066 mm and the control effect is the best. When the stagger coefficient $s \geq 0.75$, the surface subsidence and horizontal movement are less affected by the change of coal pillar stagger. Regression analysis established the fitting formula of surface subsidence ratio and coal pillar stagger coefficient.

(iv) The mining conditions of gently inclined coal seam and the arrangement of working face along the incline direction can slow down the surface subsidence to a certain extent, which is beneficial to the protection of surface buildings.

7. Conclusions and Future Work

Mine monitoring methods, using Internet of Things (IoT), pursue to develop a suitable atmosphere to avoid damages and mine closure with supreme efficacy. Accurate monitoring methods reduce these damages and optimize mining. Strip filling mining is characterized by high efficiency, reliability, and low cost, which provides a good technical support for mining damage control. However, how to reasonably layout the working face under multicoal seam conditions and the law of surface movement under different coal pillar stagger distance need to be studied. Based on the geological and mining conditions of a mine in Shandong Province, through numerical simulation and theoretical analysis, this article studies the influence of coal pillar stagger distance on surface movement of multicoal seam strip filling mining and reveals the mechanism of surface cooperative deformation under different coal pillar stagger distance. Furthermore, an IoT and cloud computing based architecture is offered in order to support the development of a digital and sustainable mining platform. The results show that the surface subsidence is positively correlated with coal pillar stagger coefficient and mining layers.

In the future, we will consider deep leaning approaches, such as graph convolutional network (GCN), that are more suitable for the mines and the monitoring systems that are operating there. Nevertheless, we witnessed that the activation function which was used in this article cannot stimulate all neurons that leads to limited precision and accuracy. Consequently, the search for the optimal activation function and the optimization of the model structure are further research work. Similarly, we will investigate the impacts of the activation functions which is used along with

the deep learning methods. Moreover, robust data reduction or aggregation methods should be investigated to improve the performance of the proposed system.

Data Availability

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also form part of an ongoing study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Volleyball Movement Object Detection and Behavior Recognition Method of Artificial Neural Network

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Movement object detection method is the basis and key of the modem intelligent video surveillance system. It combines advanced technologies in many fields, such as artificial intelligence, image processing, and pattern recognition, and is the research area of computer vision technology. Therefore, it is important to explore the motion detection and target recognition algorithms. The data collection method has concluded that $T > 60$ is absent from four different videos. The T value is traversed from 0–255 to select the largest T value as the split threshold. Through the analysis, the range of the threshold selection can be reduced to 0-60, thus improving the operational efficiency.

1. Introduction

More than 80% of people's information about the world comes from visual information. Vision is an indispensable part of intelligent or autonomous systems in manufacturing, inspection, medical diagnosis, military, and other application fields. Visual information is an important way for people to perceive the world. Computer vision is the technology of acquiring, processing, and analyzing visual image information by computer simulating human visual perception abilities. It emerged in the 1980s but has evolved greatly in recent decades, and it has developed new concepts, methods, and theories. It has been widely used in robotics, medical image analysis, aerospace, public safety, and many other fields.

Motion detection, as a subfield of image processing and computer vision, is essential in both the theory and practice of computer vision. Due to the limitation of computer hardware, one can often only process the area of interest in the image to ensure the real-time performance of the algorithm. For video image sequences, the areas of interest are generally motion target areas (such as pedestrians and cars). Therefore, the motion object detection algorithm is widely used, has become one of the difficulties and hot spots in the field of computer vision, and has attracted more attention from scholars from all over the world.

Rapid and accurate detection of mobile targets by computer video analysis, without human intervention, can further analyze and judge the next step of the target. When a dangerous situation occurs, it makes a fast and accurate judgment, so it is often used in the field of intelligent transportation, security, and other intelligent video processing. Movement object detection and recognition constitute the most basic and key part of the video surveillance system, and the detection effect will directly affect the subsequent processing. In reality, the monitoring scene is often complex and changeable: shadow, light transformation, local occlusion, target scale change, and so on bring great challenges to the detection and identification of moving targets. Researchers conducted in-depth research on the detection and recognition algorithms of motor targets and proposed improvements to the related algorithms. They proposed a new motion object detection and recognition method, which has good recognition performance in complex and changeable background conditions and meets the requirements of the real-time algorithm. And they

applied the algorithm in the video monitoring system of the tram track crossing to ensure the safe operation of the trams at the track crossing.

2. Related Work

This paper studies some techniques based on artificial neural network, volleyball moving target detection, and behavior recognition methods, which can be fully applied to the research in this field. Ko and Chen believed that the neural network manipulation system is obtained by fitting the data generated by the best manipulation simulation [1]. Goh considered a neural network to be an information processing system whose structure is basically a biological system that mimics the brain [2]. Zhao and Ding discussed the stochastic Cohen–Grossberg neural network with time delay, by constructing a suitable Lyapunov function and adopting the semimartingale convergence theorem to ensure the stability of the network [3]. Alanis and Alma presented the results of using the training algorithm for recurrent neural networks based on extended Kalman filtering [4]. Chen et al. proposed an adaptive neural network (NN) consensus control method for a class of nonlinear multiagent systems with state delay [5]. Jiang et al. proposed a novel unified framework that jointly exploits feature relations and category relations to improve classification performance. Specifically, these two types of relationships are estimated and exploited by imposing regularization during the learning process of deep neural networks (DNNs) [6]. Perna and Rocca proposed a strategy for choosing the size of hidden layers in a feed-forward neural network model, based on a comparison of the out-of-sample predictive capabilities of different models under a specific loss function [7]. Zhang et al. studied the delay-dependent stability of generalized continuous neural networks with time-varying delays. A new Lyapunov–Krasovskii function (LKF), which takes into account more information about the activation functions and delay upper bounds for delayed neural networks, was developed [8]. Ge et al. focused on the asymptotic stability of neural networks with time-varying delays and derived a new stability criterion by employing a new Lyapunov–Krasovskii function and integral inequality [9]. Liu et al. proposed a visual analysis method to better understand, diagnose, and refine deep neural networks [10]. Pimenta et al. investigated the incidence and risk factors of volleyball injuries among elite Brazilian volleyball players [11].

3. The Method of Volleyball Moving Target Detection and Behavior Recognition Based on Artificial Neural Network

3.1. Classification of Artificial Neural Networks. The 1940s opened the era of modern neural network research. A psychologist and mathematician first proposed a simple network model called the MP model. The scientist is from Chicago, USA. The MP model is an abstract and simplified model constructed according to the structure and working principle of biological neurons. It is actually modeling of a single neuron. Although the network model he proposed is very simple and can only perform simple operations, it has pioneering significance in neural network research and has laid a foundation for further research.

Artificial neural network is an algorithmic mathematical model that imitates the behavioral characteristics of animal neural networks and performs distributed parallel information processing. The distributed processing structure of neural networks and their ability to learn and generalize enable them to solve complex problems that are currently difficult to grasp. In summary, the neural network has the following characteristics: 1. Nonlinearity: the neural network is composed of a large number of nonlinear neurons, which has inherent nonlinear characteristics, and can solve very complex and highly nonlinear pattern recognition problems on the boundary of the segmented image space. 2. Parallelism: each unit of the network is an independent computing unit, and all its calculations can be carried out independently, while large-scale interconnected complex neural networks are calculated in parallel. 3. Self-organization and self-learning: the neural network is similar to the human brain and has a learning function, and its knowledge acquisition work is much simpler than the current traditional artificial intelligence method. 4. Fault tolerance: in the neural network system, each weighting factor stores different information or knowledge; that is, the information or knowledge is stored in the neural network in a distributed manner [12].

Neural networks have different classifications, and biological nervous systems with different levels of simulation and abstraction are represented by them from different perspectives. Therefore, artificial neural networks can also be classified from different angles, such as the following: 1. Classification into connected networks and decentralized networks, deterministic networks, and arbitrary networks is based on network performance. 2. They are classified into networks without teaching and networks with teaching, based on the perspective of reading. 3. They can be classified into higher-order nonlinear correlation networks and first-order linear correlation networks, based on the properties of adjacent synapses. 4. According to the structure of the network, they can be further divided into recurrent networks, neural network, and neural networks of arbitrary structure, as shown in Figure 1.

In the forward neural network, in the process of calculating the output value, the input value propagates forward layer by layer from the input layer unit and finally reaches the output layer through the hidden layer to obtain the output. Forward neural networks are usually used in the field of simulation and function approximation. Commonly used networks are wavelet network, RBF (radial basis function) network, GRNN (generalized regression neural network), MLP (multilayer perceptron) network, BP network, etc. The recurrent network is mainly used to solve optimization problems, and its representative is the Hopfield network [13].

3.2. The Method of Volleyball. Volleyball is one of the ball sports. The court is rectangular with a high net in the middle. Both sides of the game (six players per side) occupy one side of the court. The players hit the ball into the net with their

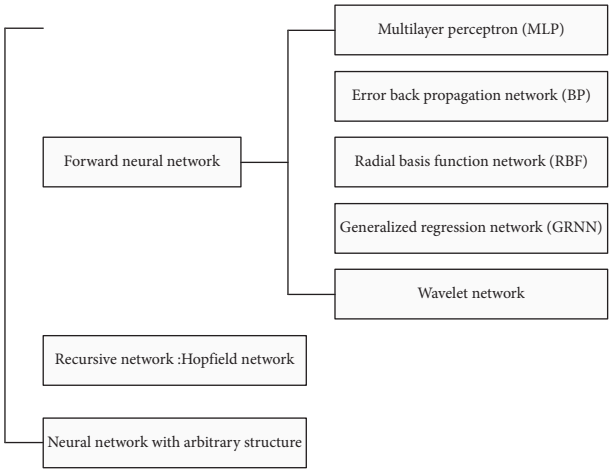

Figure 1: Classification of classical neural networks.

hands. Since its inception, volleyball has shown strong vitality because of its unique competition rules and sports characteristics. Since its introduction into China in 1905, it has been well promoted and developed and has made significant contributions to the development of Chinese sports. Volleyball has won a total of nine world championships for China. Volleyball has not only brought golden trophies to the Chinese people, but also inspired the tenacious fighting spirit of generations of Chinese people. On the other hand, the development of Chinese volleyball has also promoted the development of its own techniques and tactics, such as "back flying," "fast ball," "floating ball," and other technologies invented in China, which enriches the technical and tactical content of sports and creates a flexible and changeable play system. Volleyball now has a large influence all over the world, and various international and commercial events continue to emerge. The big reason for this is that the constant revision of competition rules has adapted to the development needs of sports in different periods, and some forward-looking competition rules have been revised to provide directional guidance for the development of sports. The research methods for volleyball are as follows.

Literature Data Methods. According to the research content of this article, we searched and read the materials related to volleyball in the university library, CNKI, VIP Information Network, and Wanfang Paper Database [14].

Mathematical Statistics. An in-depth analysis of the evolution of volleyball rules was carried out with and a clear understanding of the changes at each stage. It also explains how changes to the rules of volleyball have had a large impact on the technical and tactical aspects of the sports and on the development of volleyball.

Logic Comparative Analysis Method. By sorting out the collected volleyball competition rule data, the changes of volleyball competition rules and the specific situation of sports development in each period are classified and summarized. The collected documents of volleyball competition rules and sports development in various periods are logically compared and analyzed by methods such as induction, classification, comparison, and deduction.

3.3. Methods of Target Detection and Behavior Recognition. Segmenting and extracting useful information such as continuously moving objects or colors, contours, and shapes from continuous video sequences are moving target detection. The flowchart of moving target detection is shown in Figure 2.

Moving object extraction is a simple image segmentation. Image segmentation is the technology and process of dividing an image into several specific areas with unique attributes and proposing interesting objects. It is a key step from image processing to image analysis. The motion of objects can only be represented in a continuous stream of images, such as video streaming. Moving object extraction is also a process of difference detection, which mainly includes finding and extracting the differences due to the motion of objects [15].

Inter-frame Difference Method. The most commonly used moving object detection and segmentation method is to use the temporal dependence of the image sequence to detect moving objects according to the changes between the images. This method works well for the detection of small changes in the background.

Background Difference Method. It is a method to detect moving objects by comparing the current frame in an image sequence with a background reference model, and its performance depends on the background modeling technique used. After the image is collected by the camera device, the image is preprocessed by converting the dynamic image sequence, and finally the foreground target is extracted by background modeling. The background difference method process is shown in Figure 3.

The background difference method is simple and easy to implement, and it has the advantage of fast operation speed. In most scenes, the detection results are relatively complete and the outline is clear, so it has become the most popular and widely applicable moving target detection algorithm. However, this algorithm requires the camera to be stationary when detecting moving objects, and there are differences in the gray levels of foreground and background pixels. In addition, the detection results of this method are prone to noise and cannot cope well with scene changes, resulting in inaccurate detection results. Based on such problems, scholars in various countries have done a lot of research to improve the accuracy of algorithm detection results, such as mixed Gaussian model method and single Gaussian model method, nonparametric model method, and Kalman filter and Wiener filter based on prediction method. However, the most widely used and the best effect is the Gaussian model [16].

Mixture Gaussian Background Modeling Method. It uses sampling statistics to represent the background, and the effect is better in the background modeling algorithm. The

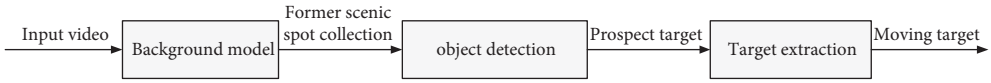

Figure 2: Flowchart of moving target detection.

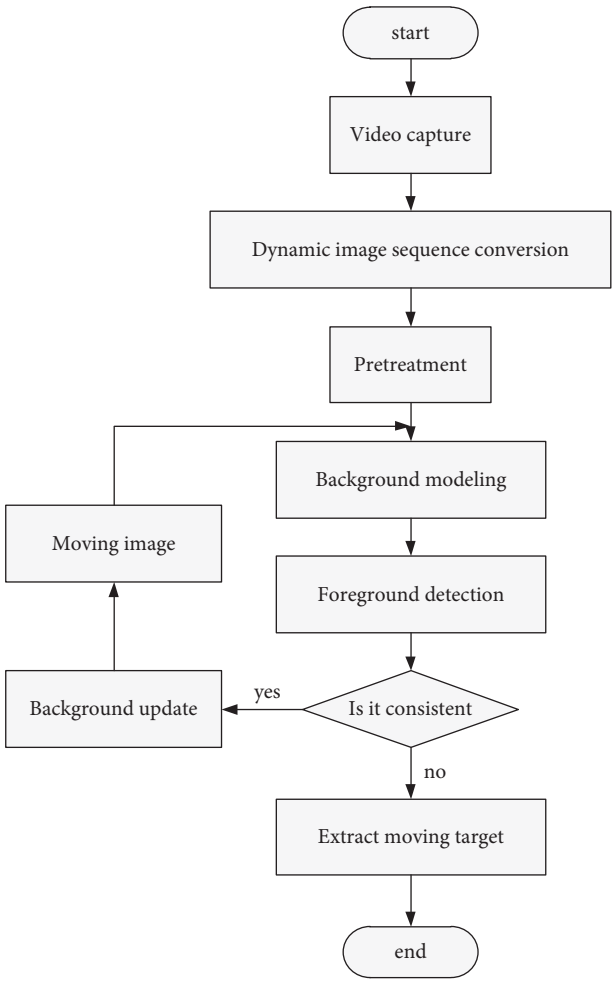

Figure 3: Background difference method.

moving object is also highlighted by subtracting the current image from the background image. Therefore, many scholars believe that the mixed Gaussian background modeling method is also a kind of background subtraction.

Event recording and analysis, that is, capturing events of interest and analyzing or understanding the behavior of objects, constitute one of the most important areas of third-generation video surveillance systems. Because of the simplicity of the analysis method, the ability to systematically analyze accidents at present is also very limited. Behavioral understanding includes the analysis and recognition of movement patterns (people or vehicles) and provides high-quality descriptions of target behaviors and interactions. It can be simply viewed as a problem of classifying time-varying features by comparing an unknown measurable sequence to a reference set of labeled sequences of typical behavioral targets. The basic principle of intelligent video surveillance is shown in Figure 4.

Motion detection and tracking are two basic technologies of intelligent video surveillance systems. Motion detection is the process of detecting changes in the position of an object relative to its surroundings, or changes in its surroundings relative to it. Motion detection and tracking form the basis for subsequent advanced processing and analysis applications, such as semantic indexing, event retrieval, action analysis, behavior detection, intelligent alarming, and compressed video formation coding, which are important for the use of automated and real-time video surveillance technologies [17].

"Background Subtraction" for Moving Object Detection. Despite the noise, the scene background is more stable and less volatile than the changing shape of moving objects in the real scene. The technical principle of "subtracting the background" is shown in Figure 5.

The "background subtraction" technology is a widely used method in the current moving target detection technology. While the principle behind background reduction is simple, the way in which the background model is created and updated is essential because it has a direct impact on the ability of the background model to adapt to changes in lighting, background disturbances, etc. Illumination changes include continuous illumination changes (usually outdoors) and sudden illumination changes (such as lights turning on and off indoors, or clouds on a sunny day outdoors), while background disturbances include global background disturbances (for example, when the camera is slightly shaken by the wind blowing outdoors) and local background disturbances (such as tree trunks, leaves, and their shadows, or when outdoor puddles are blown by the wind), which are the main factors that change the background pattern [18].

4. Experiment of Volleyball Moving Target Detection and Behavior Recognition

4.1. Experimental Study Results of Volleyball. Volleyball is a recreational game designed for adults to train. Initially, there were no technical content and no uniform rules of competition. With the improvement of volleyball's technical and tactical level and the increasingly obvious tendency of competition, some countries have established volleyball associations and officially announced the general rules of volleyball competition. The evolution of volleyball court area and number of people is shown in Table 1.

It can be seen from Table 1 that the size of the volleyball court depends on the responsibilities of the players on the court. The larger the court, the greater the responsibility of each player. A properly sized court makes offense and defense easier. Typically, the relative length changes more than the width. After years of research, the results show that the

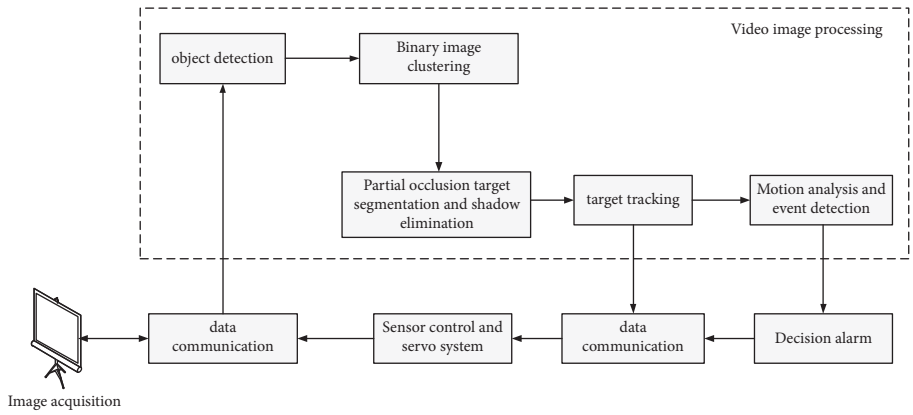

Figure 4: Basic principles of intelligent video surveillance.

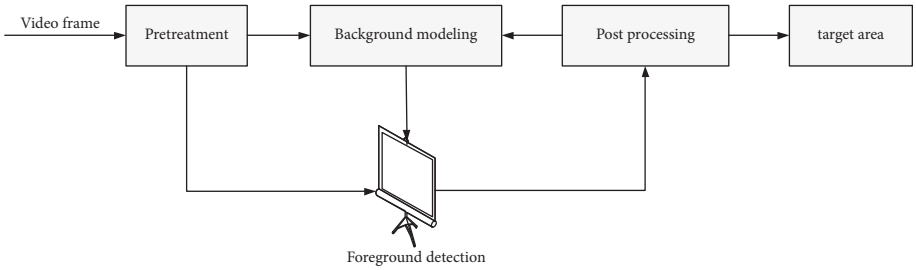

Figure 5: The principle of "background subtraction" technology.

Table 1: The evolution of volleyball court area and number of people.

Particular year	1896	1897	1912	1913	1917	1918	1922	1923	1950–present
Number of participants	Arbitrarily	Arbitrarily	9	16	9	6	6	6	6
Site area	7.62 * 15.24	7.63 * 15	10.76 * 18.3	12.192 * 24.3	11 * 22	9 * 18	18.29 * 9.14	18.2 * 9.1	9 * 18

current field size of 18×9 meters is suitable, which is also more conducive to the level of players and the distribution of attention [19]. The evolution characteristics of volleyball nets are shown in Table 2.

As can be seen from Table 2, with the increasing popularity of volleyball, the net height, especially for male players, is also increasing. Therefore, the old volleyball net does not meet the height requirement. The height of the net is too low, so the ball is more likely to be smashed, which is not conducive to the defense of the volleyball player during the game, nor does it reflect the actual level of the volleyball player. Now, men's and women's volleyball nets have reasonable heights to accommodate human physiology and promote offensive and defensive balance. The evolution characteristics of barrier-free areas are shown in Table 3.

In addition to the volleyball court, another important area is accessibility, which is an area of space that includes the area around the court and the area above the court. Table 3 clearly shows the evolution history of the barrier-free zone and its site size. On the whole, the unobstructed area will become larger and larger, which enables players to fully develop their potential in attack and defense, and can ensure the full play of techniques such as strong jumping and receiving [20]. The establishment of the sign pole and the distance between the sign poles at both ends are shown in Figure 6.

The sign poles are two flexible poles, 1.80 meters long and 1 centimeter in diameter, made of fiberglass or similar materials. The two marker rods are, respectively, arranged on different sides of the net along the outer edge of the marker band. It can be seen from Figure 6 that there were no sign poles in the early competition venues, and the sign poles did not appear until 1968, when the distance between the two sign poles was 9.40 meters. After practical application, in 1976 and 1979, the width between the two ends was fixed after the pole was moved inward twice by 20 cm, and the width between the two poles is still 9 meters. Signposts are set up to limit offense. Through the two inward shifts of the sign bars at both ends, we can see some ideas for the revision of the rules of volleyball competition, that is, to make up for the weak defensive strength by restricting and narrowing the scope of the attack, to maintain the relative balance of the offensive and defensive forces, to make the volleyball game develop healthily. The number of volleyball serves and attempts are shown in Figure 7.

Table 2: Evolution characteristics of volleyball nets.

Category	1896	1900	1912	1917	1918	1924	1950	1954–present
Net height (male)	1.94	2.14	2.31	2.41	2.44	2.44	2.44	2.44
Net height (female)		2.11	2.11	2.11	2.11	2.31	2.24	2.25

Table 3: Characteristics of evolution of barrier-free areas.

Year	1896	1955 (m)	1956 (m)	1980 (m)	1994 (m)	1995–present (m)
Height from the ground	Arbitrarily	6	8	13.5	13.5	13.5
Length from end line	Arbitrarily	4	4	9	10	10
Distance from edge line	Arbitrarily	4	4	6	7	10

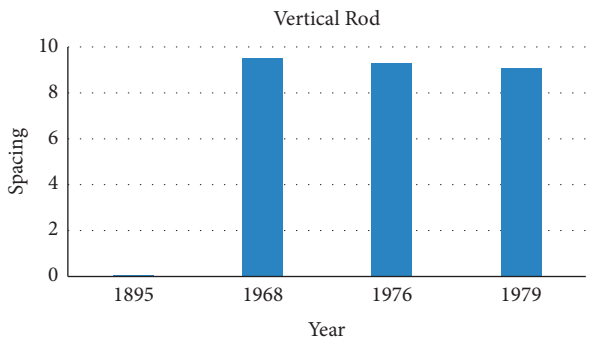

Figure 6: The establishment of the signpost and the distance between the signposts at both ends.

From Figure 7, from 1900 to 1998, serving attempts were allowed, which had two benefits for the serving side: (1) The serving side can use the serving to try to fake the opponent to disrupt its defensive rhythm. (2) If the server throws the ball into the air, seeing that the height of the throw may lead to a failure of the serve, he/she can catch the ball and serve again. However, this did not please the receiving team and caused a delay in the game. It was not until 2000 that serve attempts were banned, and with the introduction of the point-per-ball rule, the serving technique became more important. Therefore, players and coaches pay more attention to the practice of serving skills. After all, the serve is the start of the offense, a strong or difficult serve can destroy an opponent's first pass or direct score, and a good or bad serving technique affects the outcome of the game.

4.2. Experiments on Moving Target Detection and Behavior Recognition. The key of the background difference method in moving target detection is whether it can accurately model the complex background. A reliable and effective background model is directly related to the final result of detection and monitoring. However, in real-world scenes, weather, lighting, and clutter can cause changes in the scene background, which can make background modeling very difficult. Although there is no background modeling algorithm that can model any scene accurately and effectively, thanks to the rapid development of mathematics, computer vision, biomedicine, and other related disciplines, the background difference algorithm has also made rapid progress in recent decades, and the algorithm has been improved day by day.

The current background difference method can be mainly divided into the following categories according to the difference of the background model:

(1) Parametric and nonparametric modeling. Before establishing the parametric background model, it is first necessary to assume the pixel distribution model of the background; afterwards, these parameters are initialized in the process of establishing the background model, and the parameters are updated with the new input image in the process of updating the background model.

(2) Iterative and non-iterative modeling. Non-iterative methods need to store video images over a period of time to build and update the background model. The simplest non-iterative background model is the median filtered background model. The basic principle of median filtering is to replace the value of a point in a digital image or digital sequence with the median value of each point value in a neighborhood of the point, so that the surrounding pixel values are close to the true value, thereby eliminating isolated noise points.

(3) Pixel-level and region-level modeling methods. Most of the current background modeling methods are based on pixel-level background models; that is, each pixel is regarded as independent. The advantage is that the method is simple and easy to implement, but it ignores the connection between pixels and is prone to noise and holes.

Fixed background motion detection algorithms assume that the background does not change for a long period of time, and the range of motion is determined on this basis. However, in fact, even in the indoor environment, there are interferences caused by various changes such as light, so the method of fixing the background has great limitations. The choice of the adaptive threshold can be improved by experimenting with different videos, observing the value of the putative adaptive threshold T, and building a histogram of the region where it is located. The histograms of different video sequence adaptive thresholds T are shown in Figures 8 and 9.

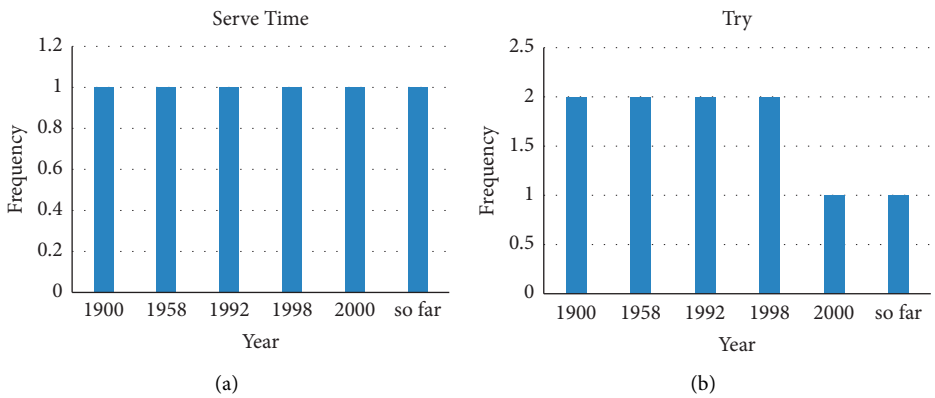

Figure 7: Volleyball serves and attempts.

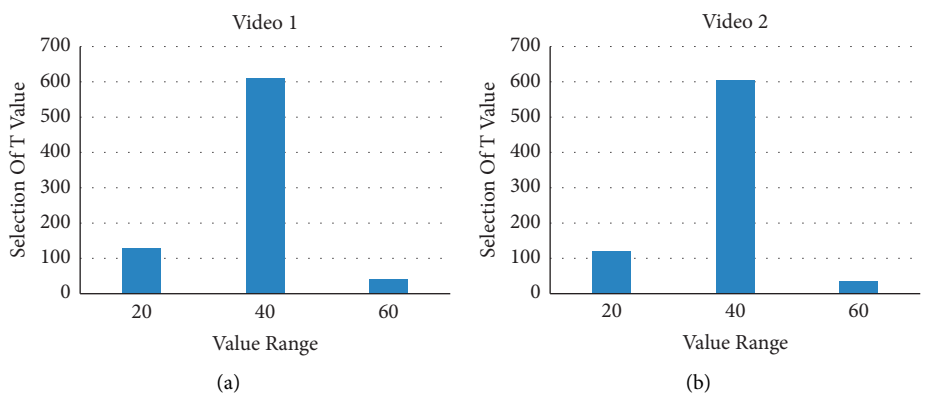

Figure 8: Histogram 1 of adaptive threshold T for different video sequences.

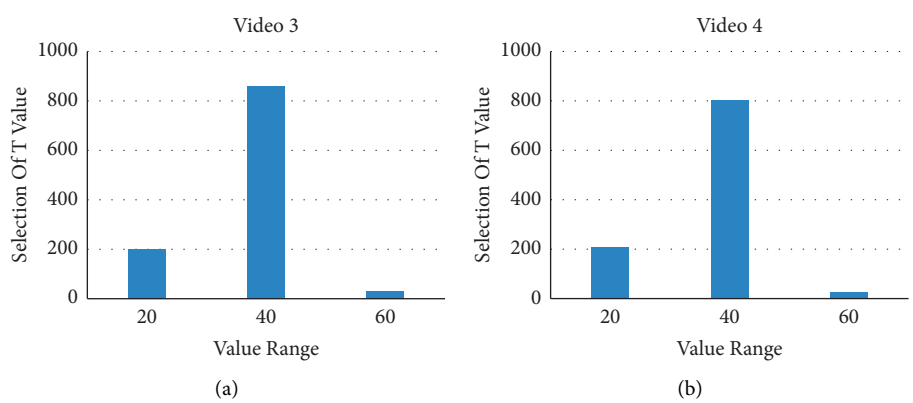

Figure 9: Histogram 2 of adaptive threshold T for different video sequences.

The histograms of the adaptive threshold T for four different video sequences show that the value of T is in the range (0, 60); i.e., there is no case of $T > 60$. Based on the analysis of the T values of a large number of video sequences, the maximum interclass difference method algorithm selects the T value in the range of 0 to 255 and thus selects the highest value as the segmentation threshold. Through the above analysis, the selection range of the threshold can be narrowed to 0-60, thereby improving the efficiency of the operation.

5. Volleyball Moving Target Detection and Behavior Recognition Based on Artificial Neural Network

5.1. Algorithm of Artificial Neural Network. One of the most important reasons that affect neural networks is the activation function of the neuron that represents its properties. The transformation functions applied to neurons in the BP algorithm have to be read everywhere. Sigmoid functions are commonly used, including tan-sigmoid and log-sigmoid

functions. Different types of neural networks have different activation functions. The following are commonly used activation functions in BP networks:

(1) A linear function with a very wide range of output values is usually used to approximate the activation function of the output layer of a neural network.

(2) S-shaped function is a kind of characteristic function of S-shaped curve with high gain in the middle, low gain at both ends, which is suitable for processing small and large signals. It corresponds to the excitation mechanism of biological neurons, so it is widely used in BP networks.

Which conversion function is used depends on the relationship between the input and output. When the output value does not contain negative values, the log-sigmoid function is used, and when the output value contains negative values, the tan-sigmoid function is used. The log-sigmoid function and tan-sigmoid function expressions are as follows:

$$f(x) = \frac{1}{1+a^{-x}} f(x) \in (0,1),$$
$$f(x) = \frac{a^x - a^{-x}}{a^x + a^{-x}}, f(x) \in (-1,1). \tag{1}$$

(3) The Gaussian function is also widely used in neural networks because it can naturally reduce the input space and improve the convergence speed of the gradient waste method. The expression of the Gaussian function is as follows:

$$f(x) = a^{(x-c)^2/2\sigma^2}. \tag{2}$$

The two function parameters are c and σ, which are often in standard form in applications, as shown in the following formula:

$$f(x) = a^{-x^2}. \tag{3}$$

(4) The above equation uses a periodic function, where f(x) has the differentiable and continuous characteristic

$$f(x) = f(x) \cdot [1 - f(x)]. \tag{4}$$

The perceptron is a single-cell neural network processor based on the MP model, which has the basic properties of neurons. The mathematical model can be summarized as follows:

(1) The operating system of the perceptron is a single-output, multi-input system. Its operating characteristics represent a neuron, and the equation of its input state vector is as follows:

$$a^n = (a_1, a_2, ..., a_n), \tag{5}$$

where each input component a_i is the state of the i-th neuron, denoted as follows:

$$b^n = (b_1, b_2, ..., b_n), \tag{6}$$

where b^n is the weight vector, where b_i is the link weight coefficient between the i-th neuron and the perceptron.

(2) The output data of the perceptron is equivalent to the state data of the perceptron. The vector a^n represents the state of its input, which is determined by the threshold represented by h and the weight vector represented by b^n. Therefore, it can be expressed as follows:

$$z = T(b^n, h, a^n). \tag{7}$$

The operation function is represented by $T(\cdot)$. The perception function of the first layer, which is easier to see, can be expressed as follows:

$$z = f\left(\sum_{i=1}^{n} b_i a_i - h\right). \tag{8}$$

In the single increasing function of the above formula, $f(u)$ is used as the excitation function that is bounded between −1 and +1. And we get the following formula:

$$u = u(a^n, b^n, h) = \sum_{i=1}^{n} b_i a_i - h, \tag{9}$$

where u is the integration function of the perceptron.

5.2. Target Detection and Behavior Recognition Algorithms. A 3D scene model can be seen as a mathematical model. 3D models are usually created using specialized software, such as 3D modeling tools, but can also be created using other methods. A 3D model in a Cartesian coordinate system was used in the study. Since the shape of stereoscopic objects is considered constant over time, the structure of 3D objects in a scene is stereoscopic. And it can be represented as a combination of the relative positions of groups of 3D points that remain constant in time, representing part of the plane, the invisible plane, or the outer surface of the object. A 3D coordinate vector and its transformation are used to resolve the motion and position of each densely packed object.

The simulation model of the table injection transformation can represent the three-dimensional position of the rigid body, which can only be realized on the basis of the Cartesian coordinate system. Its expression is as follows:

$$N' = RN + T, \tag{10}$$

where N and N' are based on coordinates representing the center of rotation of a fixed point relative to T and T', and

$$N = \begin{bmatrix} n \\ m \\ z \end{bmatrix}, N\prime = \begin{bmatrix} n' \\ m' \\ z' \end{bmatrix}. \tag{11}$$

The three-dimensional transformation vector is represented by T, and the 3 * 3 rotation matrix is represented by R; namely,

$$R = \begin{bmatrix} 1 & -\Delta\theta_n & \Delta\theta_m \\ \Delta\theta_n & 1 & -\Delta\theta_z \\ -\Delta\theta_m & \Delta\theta_z & 1 \end{bmatrix}. \tag{12}$$

The projection forms a mapping table from four-dimensional space to three-dimensional space because a two-dimensional projection of the three-dimensional space scene evolves when the camera is acquired. This is a video imaging system, and its mapping table can be expressed as the following equation:

$$\begin{aligned} f : R^4 - > R^3, \\ (n, m, z, t) - > (n_1, n_2, t), \end{aligned} \tag{13}$$

where (n, m, z, t) are the three-dimensional global coordinates, (n_1, n_2) is the coordinates of the projected two-dimensional image plane, and t is a continuous time variable. The formula of the model parameters is repeatedly calculated, and then the parameters are solved, so that the parameters can be applied to the image for global motion compensation.

Kalman filtering is a recursive method for solving the linear filtering problem of discrete data. Kalman filtering uses a set of formulas to estimate the covariance correction and reduces the covariance estimation error. The discrete process of $m \in R^y$ in the state variable is estimated based on the Kalman filter. The motion of the system is described by the following differential equations:

$$m_k = Am_{k-1} + Bu_{k-1} + \omega_{k-1}. \tag{14}$$

We define observation variable $z \in \mathfrak{R}^x$, and the system observation equation is as follows:

$$z_k = Hm_k + v_k. \tag{15}$$

Among them, m_k and m_{k-1} are the system state vectors at time k and time $k-1$, respectively; A is called the state transition matrix; and B is called the control matrix, which is also assumed to be a constant. Random signals v_k and ω_k represent process excitation noise and observation noise. Assuming that they are independent of each other, the normally distributed white noise distribution is as follows:

$$\begin{aligned} p(\omega) - Y(0, Q), \\ p(v) - Y(0, R). \end{aligned} \tag{16}$$

In a real system, the observation noise represented by the covariance matrix R and the process noise represented by the covariance matrix Q may change during the iterative calculation process.

The observation refresh equation and the time refresh equation constitute the Kalman filter. The measurement update equation in one of these two parts is responsible for feedback, that is, combining previous estimates with new measurements to achieve improved subsequent estimates. The time update equation is responsible for deriving the values of the current state variable and the estimation error variable to obtain a previous estimate of the next state. The error correction equations can also be considered as measurement update equations, and the prediction equations can also be considered as time update equations. The final estimation algorithm becomes prediction: an improved algorithm with a numerical solution.

6. Conclusions

In today's society, the importance of volleyball is no longer limited to sports and play but is increasingly integrated into people's daily life and social sports culture. The continuous development and changes of society will inevitably lead to changes in people's cultural and psychological concepts and needs in the field of sports, and increasingly people play volleyball. They are no longer willing to sit in the stands as spectators but prefer to play volleyball by themselves, experience the joy of volleyball, and move their bodies. They also hope to be inspired by volleyball in sports through the social and cultural value of volleyball, experience the social and cultural significance of volleyball, and realize themselves. Volleyball culture has important social values that can fulfill their cultural goals. The research on the method of volleyball moving target detection and behavior recognition by artificial neural network is also of great significance for promoting the current scientific development.

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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