Mobile Information Systems

Intelligent Sensing and Communication for Mobile Grid Information Systems

Lead Guest Editor: Xu Li
Guest Editors: Yanyi Rao and Nguyen-Son Vo

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Retracted: Financial Default Risk Prediction Algorithm Based on Neural Network under the Background of Big Data

Mobile Information Systems

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Hindawi
Mobile Information Systems
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Retraction

Retracted: Tourist Attraction Recommendation Method and Data Management Based on Big Data Analysis

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Mobile Information Systems
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Retraction

Retracted: Dynamic Fire Monitoring Analysis and Risk Assessment Based on Multisource Satellite Remote Sensing

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Hindawi
Mobile Information Systems
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Retraction

Retracted: The Impact of Artificial Intelligence and Blockchain Technology on the Development of Modern Educational Technology

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Hindawi
Mobile Information Systems
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Retraction

Retracted: Enterprise Precision Marketing Strategy and Quality Management Mobile Information System Based on Customer Satisfaction

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Hindawi
Mobile Information Systems
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Retraction

Retracted: Identification of Scientific Research Evaluation Indicators of College Teachers Based on Wireless Communication Network

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Mobile Information Systems
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Retraction

Retracted: English Language Intelligent Translation System Based on 3D Visualization Technology

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Mobile Information Systems
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Retraction

Retracted: Mechanical Motion Trajectory Control Tracking System Based on Machine Learning Algorithm

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Retraction

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Retraction

Retracted: UAV Based on Communication Network to Obtain Oil Pipeline Data and 3D Modeling

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Retraction

Retracted: Music Timbre Extracted from Audio Signal Features

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Retraction

Retracted: Psychological Counseling and Adaptive Adjustment Methods for Employment Psychological Distress Based on Intelligent Internet of Things

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Research Article

Path and Mechanism of Industrial Internet Industry Promoting the Transformation and Upgrading of Small and Medium-sized Enterprises with Artificial Intelligence

Yi He

School of Civil Engineering and Architecture, Guangxi Vocational Normal University, Nanning, Guangxi, China

Correspondence should be addressed to Yi He; 888@zcmu.edu.cn

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With the development of intelligent sensing and communication, industrial Internet of Things (IoT) networks have been widely applied in many application scenarios. As a typical application of industrial Internet of Things (IoT) networks, industrial Internet industry has attracted much attention from researchers. Specifically, in the transformation and upgrading of small enterprises in the Internet industry, their paths and mechanisms are very important. The correct path and mechanism of transformation and upgrading can promote national economic growth, strengthen market competition, enhance market vitality, and optimize economic structure. Small and medium-sized enterprises have always been the backbone of my country's economic development, especially in terms of promoting employment, promoting technological innovation, increasing national taxes, and improving people's livelihood. In this paper, when discussing the relationship between knowledge sharing and business performance of SMEs, the organization name is introduced as an intermediate variable. By combining theoretical research and empirical research, a theoretical model is established, research hypotheses are proposed, and the previous research questionnaire is used, by exploiting the intelligent sensing and communication. As a reference, a research questionnaire suitable for the reality and needs of this research was designed. On this basis, this article first has a deep understanding of the research status of comprehensive budget management at home and abroad and analyzes the innovations and shortcomings of this article in the analysis process, understands the mobile Internet, integrates budget management, and integrates information for budget management. It prove the feasibility of helping small and medium-sized enterprises to transform in the mobile Internet environment and analyzes the feasibility of implementation to help small and medium-sized enterprises; it also shows that the industrial Internet industry is helpful to the transformation of traditional industries and is conducive to the transformation and upgrading of enterprises, thereby solving the problem of high cost of building an information platform, reducing the workload of IT personnel and extending the budget Management time provides new ideas for promoting the transformation and upgrading of the Internet for small and medium-sized enterprises, which can increase the efficiency of the small and medium-sized enterprises by more than 40% and greatly increase their profits, through the intelligent sensing and communication. The research of this paper provides important guidance for the application of industrial IoT networks, especially for the intelligent sensing and communication.

1. Introduction

With the development of wireless communication and edge computing, industrial Internet of Things (IoT) networks have been widely applied in many application scenarios. As a typical application of industrial Internet of Things (IoT) networks, Industrial Internet industry has attracted much attention from researchers. Specifically, with the implementation of the "Broadband China" strategy and the rapid development of mobile smart terminals, the Internet has penetrated into all areas of the economy and society and has greatly affected people's living standards, production methods, industrial standards and service levels, and business model. "Internet +" is the improvement, update, surpassing, and gathering of Internet applications. The essence is to use Internet technology to overthrow traditional

business models and new service models in the industry. At present, traditional industrial models and business models have not integrated and penetrated the Internet. Traditional enterprises are faced with high procurement costs, difficulty in clearing inventory, insufficient user stickiness, and lack of understanding of user positioning and user needs, which have seriously affected the development of small and medium-sized enterprises.

Based on the industrial Internet industry and artificial intelligence, in the current economic growth, SMEs are still the backbone of the economy. The scale and number of SMEs are very large. Therefore, only by promoting our own sustainable development can we maintain social and economic stability and realize the well-being of the people and the country. The current dilemma is that transformation is a necessary step for the sustainable development of SMEs. If this step is not taken, the company will inevitably go bankrupt, but it is also very difficult to take this step steadily. Faced with this problem, we use Internet thinking. Conversion and renewal are the starting point for companies seeking growth. From the perspective of management concepts, after entering the Internet, many previous management models have become obsolete. In the era of rapid Internet development, the organization of the company has become difficult, and the company is implementing new innovative models, new operations, and sales. Models and new openings and construction are facing huge challenges. In the Internet age, exploring new management and operating models to replace increasingly exposed bureaucratic management methods and improving inefficient production and operating models is positive for promoting the innovation of related theories.

Starting from the industrial IoT-based upgrade path and mechanism, Ji Liuhe believes that the deep integration of Internet technology and traditional industries has become the future development trend. The application and development of the industrial Internet have created new business models and are becoming the main force in the redesign and modernization of traditional buildings. We determine the connotation of industrial Internet and business models, select the innovation process of business models, theoretically analyze network results and industrial Internet platform models, explore the deep integration mechanism of the Internet, build traditional companies, and establish the Internet, and establish the Internet, technological innovation, and business models. However, Internet technology needs strong algorithm support and also needs continuous improvement and optimization before it can be put into use [1]. Zhu Xiaojing believes that the Internet is a product of the deep integration of a new generation of information and manufacturing technology. The Industrial Internet is an effective choice for the transformation and modernization of manufacturing companies. Manufacturing clusters have a huge advantage in the development of the Industrial Internet. In promoting the development of the Industrial Internet, cluster companies still face difficulties in knowledge, talent, capital, and information security. The government should increase support to encourage the widespread use of the industrial Internet in the cluster. Large companies in the cluster should actively develop the ecological environment and study the application scenarios of the industrial Internet. Small and medium-sized companies should strive to improve the level of digitalization and actively integrate into the industry's Internet platform. However, the transformation of the Industrial Internet requires a lot of funds and time, and results cannot be seen in a short period of time [2]. Wang Yichen believes that the Industrial Internet plays an important role in the digitization, networking, and intelligentization of industries. The development of the Industrial Internet is of great significance for promoting the transformation and modernization of industries, expanding new spaces for the digital economy, and promoting the construction of buildings and power grids. In terms of promoting the transformation and modernization of industries in China's Industrial Internet, there is a gap between platform development and landing applications. There is a gap between the reality of business and platform requirements, there are problems between standard cases and replication and upgrades, and the integration of information technology and operation technology is not enough. There are four unresolved issues in the future, and we must start from these four aspects: perfect Industrial Internet policy system, maintaining the ecology of the industrial Internet platform, accelerating business model innovation and scenario implementation, strengthening the construction of complex talent teams, the development of industrial Internet and the acceleration of industrial transformation and modernization, but the transformation time requires a process, and the speed will be relatively slow [3].

Starting from the industrial IoT-based upgrade path and mechanism, small and medium-sized enterprises are an important contributor to the national economy. However, the ever-changing economic situation has brought many opportunities to small and medium-sized enterprises, but also brought many challenges. A large number of small and medium-sized enterprises have been eliminated by the market in the process of rapid economic development. This article takes small and medium-sized enterprises as the research object, from the perspective of social networks to study the role of social networks in acquiring the three major elements of the transformation and upgrading of small and medium-sized enterprises. Therefore, the research goal of this article is to use social network theory to analyze the role of social network in promoting the transformation and upgrading of SMEs. Specifically, it is through analyzing the influencing factors of the transformation and upgrading of SMEs, summarizing the essence of transformation and upgrading, analyzing and summarizing the mechanism of the social network's acquisition of the transformation and upgrading elements of SMEs, and constructing theoretical models to use empirical methods to effectively illustrate the SMEs' development which is inseparable from social networks, and social networks will actively promote the transformation and upgrading of SMEs [4, 5].

In the industrial IoT networks, relevant scholars have explained the transformation of enterprises, but they have not studied the specific path and mechanism of

transformation. In this regard, the article uses the Internet to explain the transformation of enterprises and the mechanism therein. Finally, it shows that SMEs in the social network must continuously strengthen their own absorptive capacity and actively exert the importance of social network functions, so as to provide theoretical guidance and suggestions for the successful transformation and upgrading of Chinese SMEs by intelligent sensing and communication. The research of this paper provides important guidance for the application of industrial IoT networks, especially for the intelligent sensing and communication.

2. Industrial IoT-Based Path and Mechanism of Transformation and Upgrading of SMEs

2.1. Industrial IoT-Based Transformation Background and Content Layout. From the perspective of the industrial IoT-based path and mechanism of small business upgrading, intelligence, precision, efficiency, and economy are the inevitable trends of future industrial manufacturing. How China's industrial small and medium-sized enterprises change from rough to refined development is a systematic and complex problem. In the context of "Internet+" and Industry 4.0, the world is becoming increasingly flat and everything is becoming more interconnected. "Connectivity" is the core content of the "Internet+" concept [6, 7]. This article explores the influence mechanism and process of the "Internet+" trend on industrial transformation and upgrading at the management level and the actual business process level of the enterprise, and analyzes how the industry uses Internet thinking to achieve strategic, organization, production, and market transformation and upgrading, and put forward policy recommendations on how to realize the transformation and upgrading of my country's industry under the background of "Internet +." The industrial Internet platform is shown in Figure 1.

Figure 1: Industrial internet platform (the picture comes from https://image.baidu.com/).

In the industrial Internet industry, how to make use of the technological upgrading and "Internet +" thinking brought by the new round of industrial revolution to make the connections between enterprises and resources, enterprises and consumers, and enterprises and enterprises more valuable, which is important for promoting the transformation and upgrading of industrial small and medium-sized enterprises. Significantly [8, 9], the specific research content of this paper is as follows:

(1) Distinguish and define confusing concepts such as "transformation," "upgrade," "enterprise transformation," and "industrial upgrading," and explain and differentiate the concept of transformation and upgrading of industrial SMEs under the background of "Internet +."

(2) Based on the analysis of the development process and status quo of my country's industry, the motivations for the transformation and upgrading of industrial SMEs are analyzed from both internal and external aspects.

(3) Put forward the goal of the transformation and upgrading of my country's industrial small and medium-sized enterprises-the concept of smart enterprise and build a network of actors based on the perspective of the value chain, and analyze the mechanism of the transformation and upgrading of industrial small and medium-sized enterprises.

(4) Based on the influence mechanism of the "Internet+" trend on industrial SMEs, study the transformation and upgrading path of industrial SMEs under the background of "Internet+" from four perspectives: production mode, business philosophy, organizational system, strategy, and management.

2.2. Research Methods

(1) Document retrieval method. This article selects foreign industries and domestic related industries as samples, sorts out the theory of enterprise transformation and upgrading, and combines the systematically sorted literature for fusion analysis, and summarizes this. Drawing on the existing research results of others, this research is not only inherited from the predecessors, but also innovative.

(2) Actor Network Theory (ANT, Actor Network Theory). The establishment of an action network diagram between industrial small and medium-sized enterprises and their stakeholders based on the network of actors has strong logic and rationality and is used to define, analyze, and clarify the integration mechanism of "Internet +" and industrial small and medium-sized enterprises [10, 11]. This paper constructs a network of actors in the transformation and upgrading process of industrial SMEs, emphasizing the equivalence between smart products and human subjects in the "Internet +" era and studies the transformation and upgrading of industrial SMEs through the analysis of forced access points and translation analysis of actors.

(3) Value chain theory. The influence of the "Internet +" trend on industrial small and medium-sized enterprises is not only reflected in the value chain of the enterprise itself, but also in the supply of the entire value chain of the business ecosystem, which is composed of resources, enterprises, consumers, and other elements [12, 13]. This article analyzes the important activities in the value chain of industrial small and medium-sized enterprises and their

stakeholders and lays a theoretical foundation for analyzing the mechanism, path and strategy of their transformation and upgrading.

(4) Case study method. The article takes the industrial rise of the industrial power as a reference case, provides case support and reference for the analysis of the paper, and uses Haier Group as a specific case to analyze the transformation and upgrading path of my country's industrial small and medium-sized enterprises to prove the transformation of industrial small and medium-sized enterprises proposed in the article the mechanism and path of the upgrade are typical and maneuverable.

3. Relevance Experiment of Industrial Internet Technology

3.1. Partially Observable Markov Decision Process. In the industrial Internet industry, the essence of MDP is a collection of a series of execution actions to achieve a certain purpose, that is, to maximize the long-term benefits. Therefore, the solution of the MDP problem is also called a strategy [14, 15]. Different strategies are selected for the same problem with different requirements. The specific process is shown in Figure 2.

In the industrial Internet industry, if R_t is used to represent the direct income at time t, then the maximum long-term income expectation from time 0 to k can be expressed as follows:

$$\max E\left[\gamma^n \sum_{t=0}^{k-1} R_t\right] = 0. \tag{1}$$

In the industrial Internet industry, in order to obtain the optimal strategy, so that the long-term return function is expected to reach the maximum value, it is necessary to establish a mapping from state to action, and this mapping relationship is the value function [16, 17]. Then, by calculating the value function, the optimal action to be taken in each state can be determined.

For infinite-order MDP, the validity of the strategy can be verified by defining the value function V [18, 19]. When the system is in state s and the strategy is adopted, the expected system benefits that can be obtained are as follows:

$$V^{\pi}(S) = E\left[\gamma_i^n R\left(s^t, \pi\left(s^t\right)\right)\right], \tag{2}$$

where s represents the system state at time t, Furthermore, formula (2) can be rewritten into a recursive form:

$$V^{\pi}(s) = R(s, \pi(s)) + \gamma \sum_{s \in S} T^{\pi(s)}\left(s, s^t\right). \tag{3}$$

The decision-making action k is made according to the system state at time k and k_1, and the total revenue of the system after all actions are executed can be expressed as follows:

$$V_k^{\pi} = \sum_{ij}^{\pi}\left[r_{ij}^{\pi} + \gamma \times V_{k-1}^{\pi}(s)\right]. \tag{4}$$

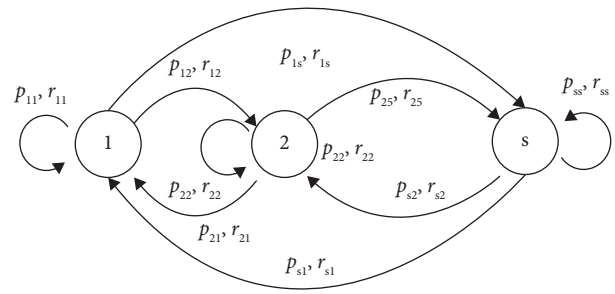

Figure 2: Markov decision process (the picture comes from https://image.baidu.com/).

From the above description of the value function of infinite and finite order MDP, it can be seen that its essence is the only common solution of a series of linear equations, so the value function can also be called an evaluation function (Evaluation Function) [20, 21]. In summary, the essence of solving the MDP problem is to find the optimal action strategy set that maximizes the long-term total profit. Compared with MDP, POMDP can determine the system information in practical problems in time, and the past enterprise income information can be determined in time by determining the status, which is also the advantage of the POMDP method.

3.2. Pomdp Basic Model. In MDP, the choice of strategy is carried out when the state information is completely observable. However, the system status information of many practical problems is sometimes not known, or the accurate status of the system cannot be directly obtained [22, 23]. In such problems, it is necessary to make decisions based on the incompletely known system state, which is the POMDP model. The POMDP dynamic model is shown in Figure 3.

The POMDP model is mainly based on the system state information to act, the system will observe it and update the state information at any time, through such a cycle to obtain the best benefit model. The goal of POMDP is the same as that of MDP, that is, to find an action strategy that maximizes long-term benefits [24, 25]. Similarly, the long-term expected return of the system can be expressed as follows:

$$R_{\exp} = E\left[\sum_{t=0}^{n} \gamma^t r_t\right]. \tag{5}$$

After introducing the belief state, the POMDP is transformed into a Markov chain based on the belief state for solution. According to the Bayesian equation, let b denote the probability distribution of the system in the states after the action occurs in the belief state s and the observation state o, namely:

$$\begin{aligned} b'\left(s'\right) &= \lambda O\left(o \mid s', a\right) \sum_{s \in S} R\left(t^n \mid t\right), \\ Pe(o \mid a, b) &= \sum_{s=i}\left[O\left(o \mid s', a\right)\right], \end{aligned} \tag{6}$$

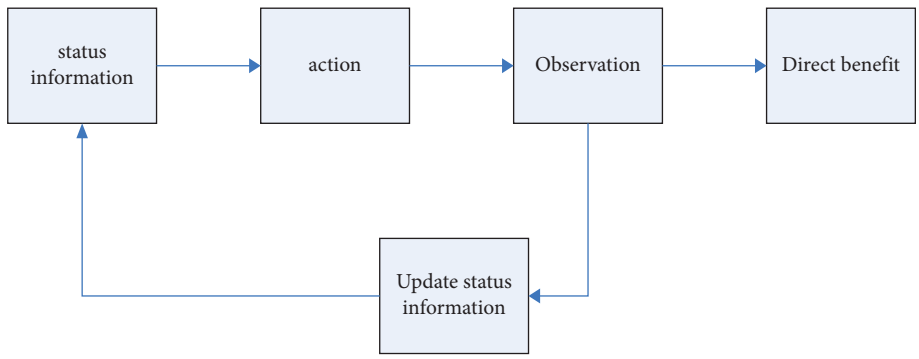

Figure 3: POMDP dynamic model.

where B represents the set of belief state information obtained from the observation state, A represents the set of actions, t represents the transfer function of the belief state, and r represents the revenue function based on the belief state [26, 27]. Among them, the transition function of the belief state can be expressed as follows:

$$t\left(a, b, a^{'}\right) = \Pr\left(a^{'} \mid a, b, o\right) \Pr\left(o \mid a, b\right), \tag{7}$$

and the income function r can be expressed as follows:

$$r(a, b) = \sum_{s=i} b(s) R(s, a). \tag{8}$$

3.3. Pomdp Strategy and Value Function. From the POMDP model, in short, the strategy of POMDP can be understood as a mapping relationship a, b from belief b to action a. According to Bellman's principle, assuming that the initial belief state is b, the expected value of the system's return by adopting the strategy can be expressed as follows:

$$V^2(b_0) = \sum_{t=0}^{n} \gamma_t r(a, b) = \sum_{t=0}^{n} \gamma E\left[R(s_t, a) \middle| b\right]. \tag{9}$$

Among them, v is the discount factor and $v < 1$. Similar to MDP, the goal of POMDP is to find the optimal action strategy that maximizes the expected total return [28, 29], namely:

$$\pi^* = \operatorname{argmax} V^n(b_i). \tag{10}$$

According to equations (10) and (11), the value function of belief b is the maximum system revenue expectation V that can be obtained when the action strategy is adopted, namely:

$$V^*(b) = \max\left[r(b, a) + \gamma \sum_{\alpha=0} O(o \mid a, b)\right]. \tag{11}$$

For the finite-stage POMDP, the optimal value function is a piecewise linear convex function, so V can be approximated by a group of finite vectors forming a convex shape [30].

4. Industrial Internet Industry-Based Transformation and Upgrading of Small and Medium-Sized Enterprises

4.1. Investigation and Analysis of Enterprise Transformation and Upgrading Based on Industrial Internet Industry. Based on the industrial Internet industry, in order to ensure that the samples of this study have a certain degree of representativeness, this study conducted a certain analysis and selection on the survey objects. In order to ensure the reliability and validity of the measurement data, the data collection of this study was conducted through questionnaire surveys (including electronic questionnaire surveys). For the questionnaire design, this article uses the Li Ke Characteristic Scale. This table can clearly and intuitively understand the information of various dependent variables, independent variables and intermediate variables, and control variables, and deliberately determine the relevant indicators through the characteristics of the relevant variables.

The research variables in this study are divided into four categories, namely dependent variables, independent variables, intermediate variables, and control variables. The dependent variable is the transformation and upgrading of the enterprise, which is measured from two aspects: product upgrade and function upgrade. The independent variables are the two dimensions of social networks, namely the structural dimension and the relational dimension, which are specifically subdivided into network scale, network density, network centrality and relationship quality, relationship connection strength, and relationship stability. The intermediate variable is the absorptive capacity of the enterprise, which is mainly measured from four aspects: cognitive value, resource acquisition, internalization of understanding, and development and utilization. The control variables are mainly firm size and firm age. See Table 1 for details.

The textile manufacturing industry, metal product industry, handicraft manufacturing industry, and cultural and sports education product industry account for a higher proportion. The reason is that the textile industry, metal product industry, small commodity manufacturing industry,

Table 1: Variable definition table of empirical research based on industrial internet industry.

Variable type	Variable name	Metrics	Symbol
Dependent variable	Enterprise transformation and upgrading	Product upgrade, function upgrade	Trans
Independent variable	Structural dimension	Network size	Size
Intermediate variables	Absorbing power	Cognitive value	Abso
Control variable	Enterprise size	Number of employees	Scale

etc. are relatively developed, and this type of enterprise is the majority. They all belong to small and medium manufacturing enterprises, which are in line with the research of this article, as shown in Table 2.

The IoT-based descriptive statistical analysis of the sample is mainly used to statistically describe some basic statistics of the collected measurement indicators of each variable, such as basic information such as mean, standard deviation, skewness, and kurtosis. Figure 4 describes the statistical information of social networks, control variables, and corporate transformation and upgrading.

Starting from the industrial IoT-based upgrade path and mechanism, as shown in Figure 4, it is generally believed that when the absolute value of the skewness of the sample data obtained in the study is less than 3 and the absolute value of kurtosis is less than 10, it indicates that the sample basically obeys the normal distribution. For the study variables, their mean, skewness, and median were 3.68, 2.64, and 3.88, respectively. The absolute values of the skewness and kurtosis of the data are within and meet the sample standard. Therefore, this study believes that the data in this sample survey basically obeys a normal distribution, which can be used for further data analysis.

The industrial IoT-based reliability and validity of the scale directly affect the results of subsequent data analysis. A good scale should have sufficiently high reliability and validity. The reliability of the questionnaire mainly refers to the reliability, consistency, and stability of the measurement results, that is, whether the test results reflect the stable and consistent true characteristics of the testee.

It can be seen from the coefficient test results in Table 3 that the industrial IoT networks-based reliability values of the variables in this study are all greater than the overall reliability values of the scale to meet the general research standards, so the survey data of this study can be accepted and the next step of data analysis can be carried out. The reliability value is the product of the reliability coefficient and the quantity of the product. In the pair of variable factors, their reliability coefficients are all between 0 and 1, and all are greater than 0.5, indicating that the coefficient can be used to explain the results of the experiment, and there is certain stability.

As shown in Figure 5, this study assumes that industrial IoT networks will promote the transformation and upgrading of SMEs under the intermediate role of corporate absorptive capacity, the better the development of social networks, the more conducive to the transformation and upgrading of SMEs. Since this study divides social networks into two dimensions: structural dimension and relationship dimension, the impact of these two dimensions on the transformation and upgrading of SMEs may be heterogeneous. Therefore, these two dimensions cannot be integrated into a single social network using a simple average method. Instead, we should analyze each dimension to find out its different effects on the transformation and upgrading of SMEs. The following will conduct regression analysis on each dimension of social network one by one. This research puts forward the hypothesis in chapter four: network scale, network density, and network centrality have a positive effect on the transformation and upgrading of enterprises. The absorptive capacity of SMEs is defined as the dependent variable, network size, network density, and network centrality are, respectively, defined as independent variables, and two control variables of firm size and firm age are inserted for regression analysis.

4.2. Industrial IoT Networks-Aided Impact of Industrial Structure Size on the Absorptive Capacity of Small and Medium-Sized Enterprise. After adjusting the three sub-regression models of industrial IoT network scale, network density, and network centrality under the condition of controlling the two control variables of firm size and firm age, the F value is significant, indicating that the model has a good fit. Among them, the regression coefficient between the scale of social network and the absorptive capacity of enterprises has a significant positive correlation, as shown in Table 4.

The previous section has shown the regression analysis of the industrial IoT-network to absorptive capacity and absorptive capacity to transformation and upgrading. The regression results show that social network will enhance the absorptive capacity of enterprises, and absorptive capacity will promote the transformation and upgrading of enterprises. Next, this research will further conduct regression analysis of social network, absorptive capacity and the transformation and upgrading of SMEs to verify the intermediary role of absorptive capacity in the transformation and upgrading of SMEs. The results of regression analysis on the mediating effect of absorptive capacity on the transformation and upgrading of SMEs in the dimension of social network structure are shown in Figure 6.

From the regression analysis results in Figure 6, it can be seen that in the given industrial IoT networks, the three subvariables of the social network structure dimension have reached a significant value under the action of the intermediate variable's absorptive capacity, which has a certain impact on the transformation and upgrading of SMEs. The absorptive capacity is in the social network structure. Dimensions play an intermediary role in the impact of transformation and upgrading.

From the development of industrial IoT networks, we can find that China's advantages in the international intelligent manufacturing industry are mainly reflected in the

Table 2: Industrial IoT networks-based economic proportion.

Industry	Plastic	Crafts	Textile	Metal	Stylistic education	Commodity	Fur leather	Food	Total
Number of companies	17	26	43	28	18	25	12	14	183
Sample specific gravity	9.3	14.2	23.5	15.3	9.8	13.7	6.6	7.6	100

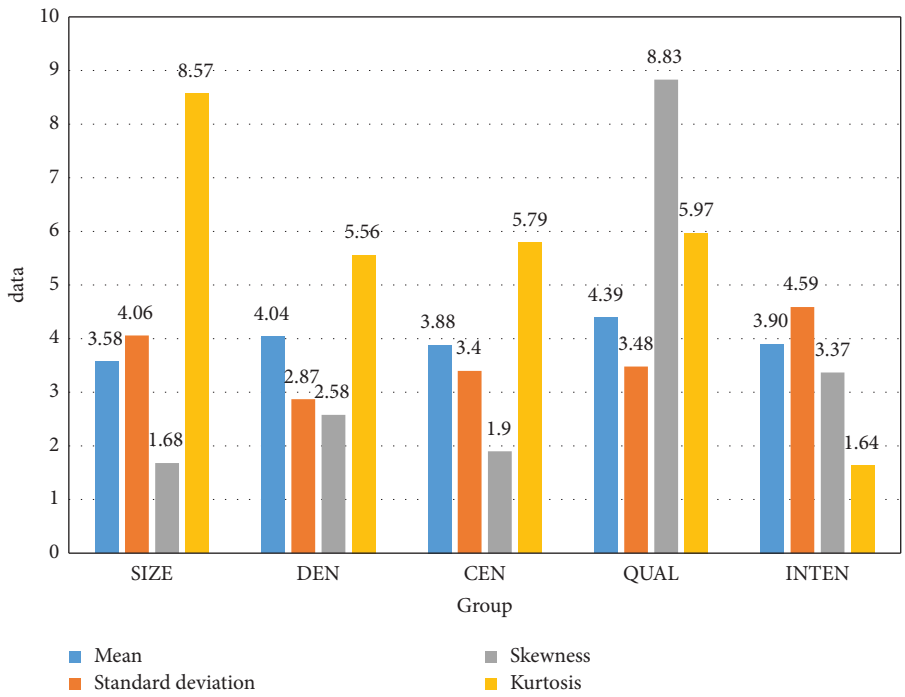

Figure 4: POMDP model-based descriptive statistical analysis of characteristic variables.

Table 3: POMDP model-based reliability measurement of survey scale.

Variable	Number of indicators	Coefficient	Processing method
Size	5	0.701	Accept
Den	4	0.547	Accept
Cen	4	0.589	Accept
Qual	4	0.552	Accept
Inten	4	0.644	Accept

huge market and complete supply chain. Based on the relevant content of the "Twelfth Five-Year Plan for the Development of Intelligent Manufacturing Equipment Industry," by 2015, based on relevant data forecasting and analysis, my country will receive nearly 1 trillion yuan from intelligent manufacturing equipment. Five years later, intelligent manufacturing will become my country's pillar industry and will enable Chinese manufacturing companies to have a certain competitive advantage in seeking overseas market development. Therefore, the formation of a complete set of intelligent system equipment will effectively drive 3 trillion yuan in revenue, of which the domestic market industry will account for more than 60% of the share, and the integration of intelligent equipment will be realized. It can be seen that in the next 10 years, an average annual growth rate of 25% will be achieved in this area. It can be seen that the huge potential of the smart manufacturing market can be seen. When the wave of smart manufacturing and "Internet +" strikes, Chinese smart manufacturing companies hope to rise rapidly in global competition. The growth of the Internet industry is shown in Figure 7.

Taking advantage of the "Internet+" wind, the technology required by the increasingly close connection between people, people and things, and things and things is undoubtedly more diversified. Enterprises must have relevant technical capabilities to open up existing and new markets. The popularization of mobile Internet enables smart hardware to access the network anytime and anywhere, which greatly expands and enriches the functions of smart hardware products. At the same time, China has formed a relatively complete ecosystem including makerspace, hardware foundry, cloud computing services, chip and parts production, overall solutions, channels, application development, and crowdfunding. Only by breaking the original organizational boundaries of enterprises, using the Internet as a basic and platform tool, and through collaborative innovation and collaborative manufacturing, can technology diversified upgrades be achieved. In addition to financial innovations, the legal provisions formulated by the state further clarify the scope of protection of intellectual property rights and improve the content of relevant provisions on infringements. These laws will better purify the

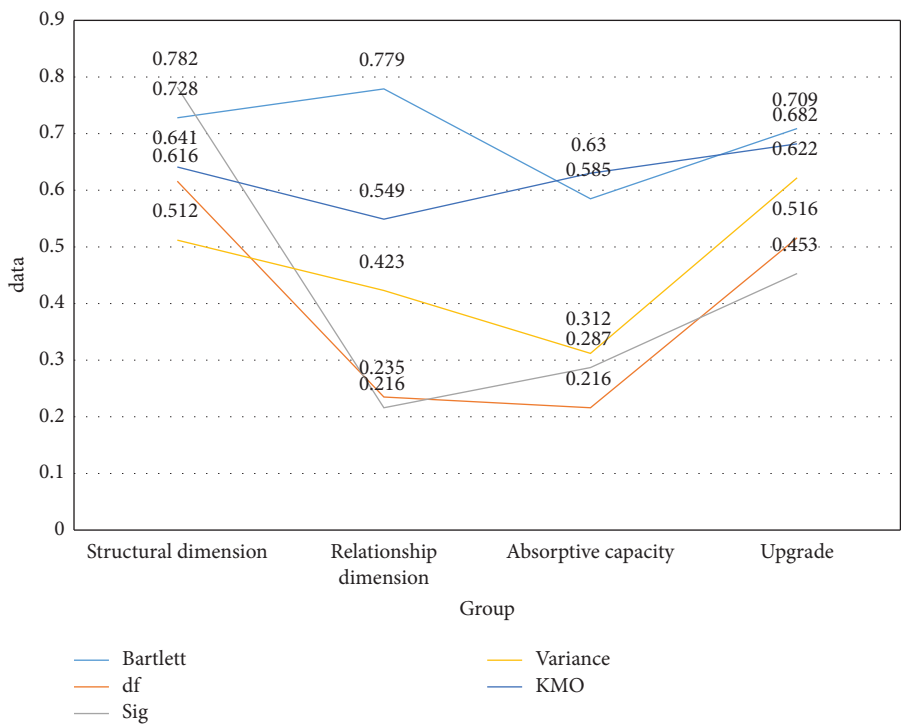

Figure 5: POMDP model-based result table of factor validity analysis.

Table 4: POMDP model-based regression coefficient of network size and absorptive capacity.

Model	R square	Adjusted R square	F	Sig
1	0.802	0.798	171.750	0
2	0.756	0.432	193.243	0
3	0.782	0.647	221.074	0

market, which can encourage more companies to invest more manpower and financial resources to increase business innovation and make corporate transformation successful. From 2010 to 2012, the average annual increase of smart devices in China was about 27. From 2015 to 2020, the number of smart devices increased every year, reaching 200 in 2020, with a total value of 30 billion yuan.

The industrial IoT networks-based organizational structure of industrial organizations has experienced significant modifications as a result of "Internet +." The conventional bureaucratic connection model increasingly disintegrates and is replaced with a network-like connection cycle model. Manufacturing companies will evolve to become "networking, modular, and informationized" in the future. However, the network organization system is differentiated and integrated in accordance with functional modules to form a functional network structure. Examples of these functional modules include the market organization system, the production organization system, the research and development organization system, and the organization system for decision-making. A key decision-making function for enterprise development, such as development goals, development plans, and development policies, is provided by the decision-making organization system. The R&D organizational framework offers R&D support for technical advancement, including standard technologies and significant technological advancements. The production organization system opens up the product, opening the way for technology deconstruction and integration as well as intelligent manufacturing. By establishing market platforms and dredging information routes, the market organization system offers cracking functions for the supply and demand paradox. Each organization system is interconnected, forming an open loop, as shown in Figure 8.

From the development of industrial IoT networks, we can find that the consumer needs will diversify as a result of the quicker integration of local, regional, domestic, and worldwide development brought about by the rapid expansion of the mobile Internet and e-commerce. Consumer demand is an organic blend of high-standard items that are production-oriented and high-quality services that can continuously broaden the business scope for manufacturing enterprises. In this sense, collaborative production will change the organizational design of manufacturing firms and become a development trend. Each enterprise's decision-making organization system, R&D organization system, production organization system, and market organization system can be linked to the corresponding organizational function systems of other enterprises and utilize Internet's borderless capabilities to realize resource sharing and information exchange. This is congruent with the meaning of the earlier-mentioned term "intelligent alliance." By relying on the Internet, every connection in the manufacturing business and every person in every link have become into information communicators. Modern communication software will considerably increase

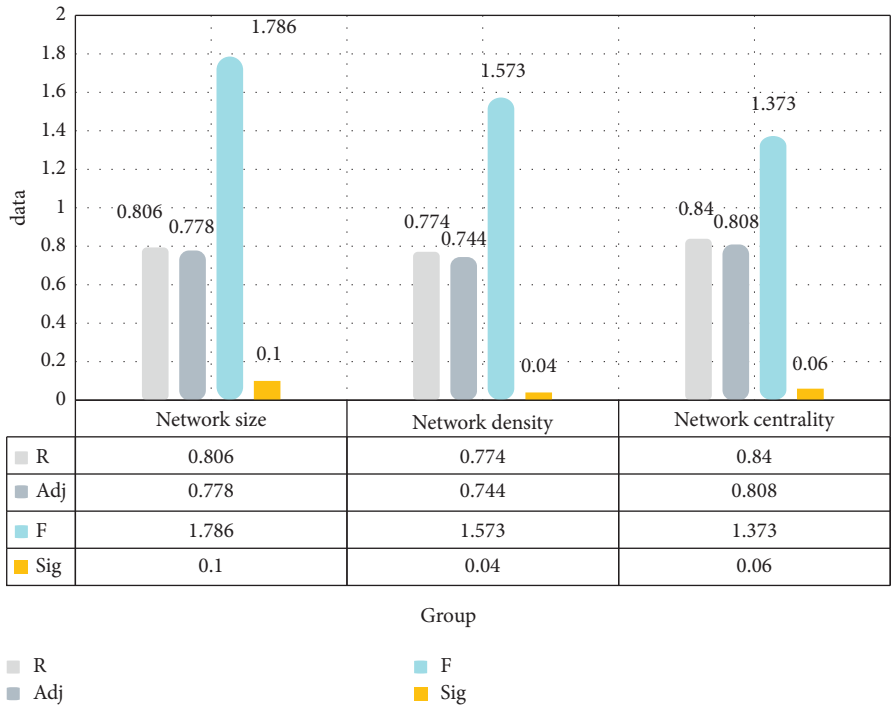

Figure 6: POMDP model and industrial IoT networks-based regression analysis results of enterprise transformation and upgrading.

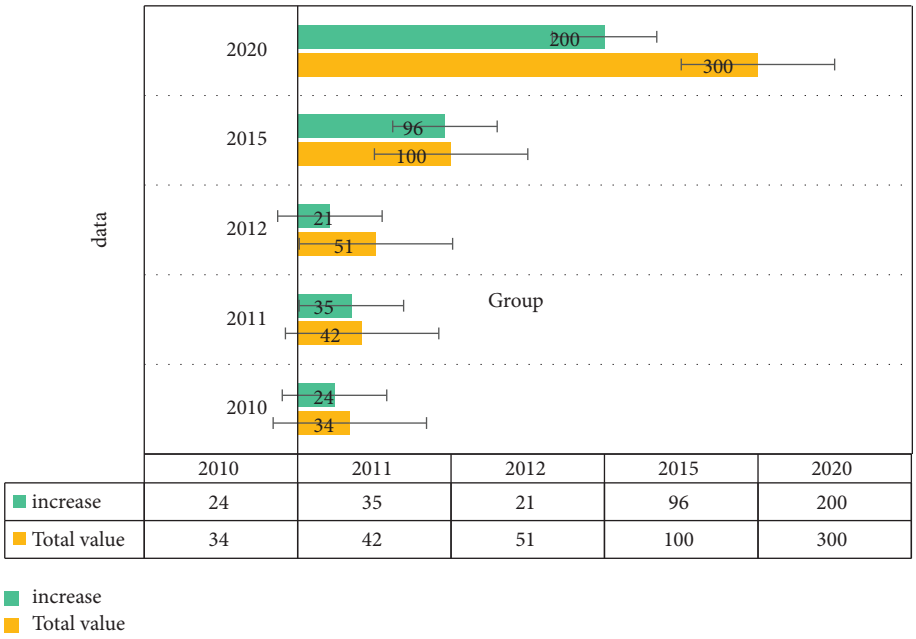

Figure 7: POMDP model-based 2010–2020 growth trend of output value of China's intelligent equipment manufacturing industry.

communication efficiency, which will lay the groundwork for increasing work efficiency. In the industrial sector, the design of a plan essentially aims to increase overall competitiveness. It will use a range of collaborative production techniques in order to increase its own competitiveness. This means that now or in the future, a company has an operating headquarters, but business production is outsourced to other companies. Such virtual enterprises will emerge as the times require. For example, Xiaomi has its own R&D institutions and R&D personnel. The production and warehousing of Xiaomi mobile phones involved are directly outsourced to other companies for operation. It can be said that such an integrated and innovative approach can provide more companies with the space for survival and development, and business management is gradually moving towards a flattened direction. For companies, consumers have become

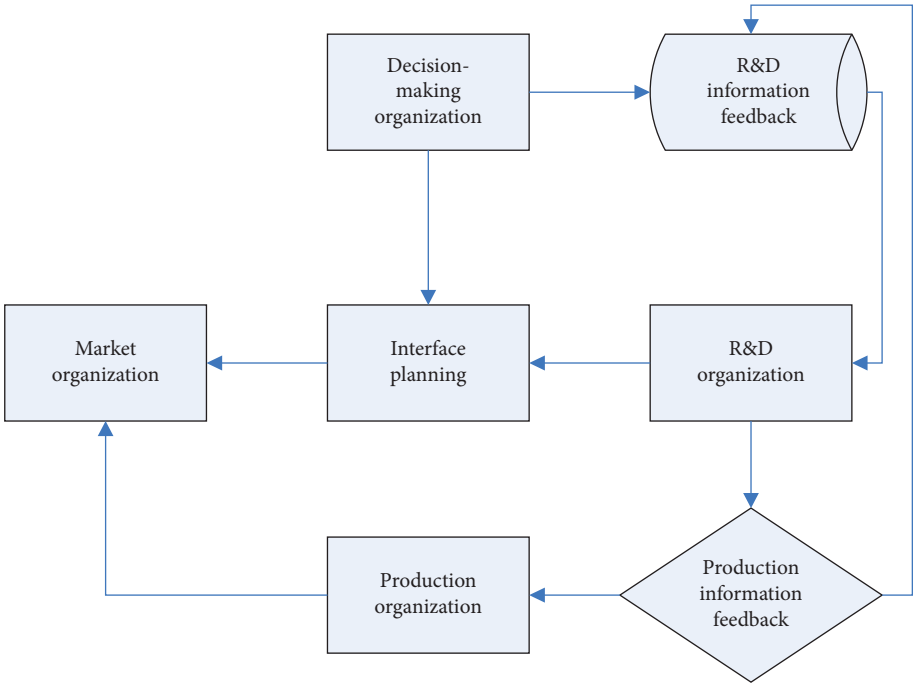

Figure 8: POMDP model-based analysis of the organizational structure upgrade model of manufacturing enterprises.

a key element of corporate strategic decision-making, and this has also become the core force of corporate development. According to the relevant information, the transformation of small and medium-sized enterprises under the Internet is mostly very successful. After the transformation, the enterprise also uses the Internet to improve the profit of the enterprise. Because in the new era, this is also in line with the way most people consume.

In the industrial IoT networks, the dual requirements of not only meeting the efficiency of mass production but also ensuring the accuracy of individual customization determine that the organizational structure of manufacturing enterprises needs to be changed accordingly, and it has the duality of flexibility and efficiency. One is the pyramid structure model. This model is mainly divided into two parts: the front end and the back end. The front end is composed of multiple teams, and the back end is formed by a unified organizational structure. Haier Group uses such a structural model to operate. According to the customer orders obtained by the front end, the production is made by relevant personnel at the back end. Through the acceptance and evaluation of orders by customers in the later stage and the profits enjoyed by relevant personnel, Haier Group guarantees the development advantages of each small team and at the same time, takes into account the high-level operation of the entire large platform, so that it can proceed smoothly.

5. Conclusions

With the development of wireless communication and edge computing, industrial Internet of Things (IoT) networks have been widely applied in many application scenarios. As a typical application of industrial Internet of Things (IoT) networks, Industrial Internet industry has attracted much attention from researchers. Specifically, with the advent of the fourth industrial revolution, the global industrial system is in a critical period of adjusting its industrial structure and reshaping its development advantages. This article then proposes the path of transformation and upgrading of my country's manufacturing enterprises driven by "Internet +," and obtains the different path choices of manufacturing enterprises in the transformation process, which will show the linear and nonlinear characteristics of the transformation of manufacturing enterprises at different stages. From the perspective of the value chain, "Internet+" can penetrate from information transmission to manufacturing, operation, sales, and other value chain links, promote the open integration of the value chain, use the value of the Internet platform, and clarify on the basis of the modular integration of the value chain by the intelligent sensing and communication. For its core competitiveness, we need to choose the right Internet tools to achieve transformation and upgrading. This article introduces the concept of smart enterprise to understand and discuss the transformation and upgrading mechanism and path of my country's manufacturing enterprises driven by the "Internet +," by the intelligent sensing and communication. Although some new viewpoints and conclusions have been obtained through research, and the research results are the construction of smart enterprises, the development of smart manufacturing and Enterprise transformation and upgrading provide reference and reference, but there are still some shortcomings. The weak point in this paper is that the decision-making process is explained in detail, and in the POMDP strategy, only the key points are selected for explanation, and the advantages and disadvantages of the strategy and the impact

on the enterprise are not explained. The unique nature of manufacturing will not change. Because of this, it will become even better with the advent of the Internet. I sincerely hope that this research can make some contributions to the development of my country's manufacturing enterprises and hope that my country's manufacturing enterprises can stride forward to the goal of "a world-class manufacturing enterprise." The research of this paper provides important guidance for the application of industrial IoT networks, especially for the intelligent sensing and communication.

Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to sensitivity and data use agreement.

Conflicts of Interest

The authors declare no conflicts of interest.

Authors' Contributions

All authors have seen the manuscript and approved to submit to your journal.

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Research Article

Wireless Network-Aided Delay Information System Correlation with Airport Grid Distribution Based on Multideterminants Big Data

Yujie Yuan and Xiushan Jiang

School of Traffic and Transportation, Beijing Jiaotong University, Beijing 100044, China

Correspondence should be addressed to Xiushan Jiang; xshjiang@bjtu.edu.cn

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The intelligent sensing and communication technology in the airports' grid information system provides a multidimensional big data set for analyzing flight delays. These data from air traffic control, weather, and multiple determinants will cause initial flight delays. Due to the influence of adjacent flight time correlation, the initial delay causes the delay of subsequent flights, discovered by mining information sensing data, forming the phenomenon of flight delay diffusion. Different determinants will lead to the delay diffusion form of different regions, and more seriously, it will lead to "disaster area" delay in the whole regional grid information structure. To analyze the spatial impact of each factor on flight delay and explore the regional distribution of delay determinants, this paper combined the spatial regression model and determined the key explanatory variables by statistical and processing of the aviation system data. The case study showed the spatial airport delay characteristics in terms of aircraft movements in China. After processing intelligent sensing and communication data, the results show that there is a spatial effect between airports in terms of delay and determinants. The high-delay clusters of delay constraints principally occurred in the Beijing-Tianjin-Hebe and Yangtze River Delta urban agglomerations. Direct flights, weather, new flight routes, take-off, and landing capacity have a more critical impact on spatial airport delays. The use of Internet of Things technology to perceive, analyze, and integrate multiple information of airport delay and combine spatial analysis models can accurately mine delay characteristics and effectively achieve digital and intelligent flight delay management.

1. Introduction

Intelligent flight sensing and communication data can extract multidimensional data about aircraft flight trajectories, weather, airport operations, and air capacity. Based on these data, systematic analysis of the delay information in the airport grid is the key to reducing the direct loss of passengers and carriers and promoting the economic development of the civil aviation region. Delayed spatial grid analysis combines the idea of the Internet of Things (IoT) network technology with the current research trend. This is achieved by integrating passenger mobile data, aircraft operation information, meteorological distribution information, and airport status information. Based on the analysis of flight information, Chen et al. calculated the indirect economic impact of flight delays on the Chinese economy and concluded that the total indirect influence in 2013 was 355.71 billion RMB, which also stressed the importance of controlling flight delays [1]. Except for China, the Federal Aviation Administration (FAA) has proposed that the increase in flight delays endowed tremendous pressure on the US air travel system with billions of dollars loss of airlines, passengers, and society annually. In 2007, the economic losses caused by airlines amounted to 8.3 billion dollars, and the losses included increased staff, fuel, and maintenance costs [2, 3]. Also, Air Traffic Flow Management (ATFM) estimated the total cost of delays in Europe (including all causes and reaction costs) to be 1.15 billion euros in 2011. The average delay cost for delayed flights has already reached 1,660 euros [4]. Flight delays have brought a significant impact on the global economy, emphasizing the importance of controlling flight delays.

Except for the enormous economic cost loss, the direct consequence of flight delays has reduced the on-time performance, which is also a widespread concern in the civil aviation industry. In 2017, 2.895 million China's passenger airlines were on time (4.039 million flights in total), and the average flight rate was 71.67%. Several primary reasons for the flight delay include air carrier problems, extreme weather, and air traffic control [5, 6]. Beyond that, spatial correlation can also lead to the propagation effects of airport delays. By using machine learning to simulate the aircraft operation, delays in the flight of one aircraft can affect the subsequent flight, which ultimately leads to delays in the propagation of airport pairs [7, 8]. By integrating the sensor communication information among the airports, routes, and aircraft, the airport delays have formed an extensive delay grid information system. How to accurately analyze the spatial relationship between multiple airports in the delay grid and lucubrate their determinants has become significant and challenging issues for civil aviation delay.

At present, the combination of new technologies such as the Internet of Things, big data, artificial intelligence, and 5G communication with airport operation management has begun to receive attention [9–11]. Among them, the intelligent analysis of delay management and control is also one of the research contents using the new scientific and technological revolution and industrial reform. Analyzing and integrating various information and element resources of a flight delay can help finally realize digital and intelligent decision-making on delay prevention, control, and mitigation. It is the extensive application and deep integration of new-generation technologies such as the Internet of Things, big data, and artificial intelligence in delay analysis. In addition to intelligent data mining, an effective analysis model is also the key to studying the distribution characteristics of delay in the airport grid.

About correlation between delay information system and spatial airport grid distribution, Hansen and Hsiao used the econometric model to examine the daily mean of 32 airports' take-off delays in the United States from a time dimension. The trend effects, including aircraft queues, flight schedule, and meteorological conditions, are statistically analyzed [12]. They found that the increase in total flight and operation demand would aggravate airport delays in the airport grid distribution. The delay effect of the destination and route weather counted on the number of flights. Zou et al. conducted a comprehensive empirical analysis on the impact between flight delays and flight frequencies in the US air transport system [13]. The results showed that flight frequency had a positive impact on flight delays. Duran-Fernandez and Santos found four critical variables that can explain delays in European airports (market concentration, coordination, hub airports, and hub airlines) [14]. In Europe, although the flight delay at the hub airport was higher than that of the nonhub airport, the flight delay of the hub airline was lower than that of the nonhub airline, which explained why the spoke-type hub system in Europe was not comprehensive, and the degree of control about the take-off and landing of airports was incomplete. Lall first attempted to use the count regression model to investigate delays and delay determinants among the three airports in New York City [15]. The Poisson regression model and the least-squares regression model were used to analyze the influencing factors of New York airport delay, while severe weather had the most significant impact on expected delays.

Since the relevant studies are interdisciplinary, scholars have used various parameters or nonparametric methods in their research. However, the study on the airport delays from the spatial grid is scarce, fragmentary, and unmethodical. Therefore, the contributions of this paper include (1) exploring the spatial grid pattern of flight delay at the city level; (2) evaluating the comprehensive spatial autocorrelation of delays between airport grids; and (3) quantitatively identifying the geographical distribution characteristics of each delay determinant and calculating its impact degree by processing the flight sensing and communication data. This paper uses spatial regression models to analyze the correlation and determinants of delays among multiple airports, and the results can provide a reference for the focus of delay prevention and control in different regions in air traffic management.

The results and multivariables statistics methods are reported in Section 2, which also show the relevant explanatory variables in this analysis. Section 3 presents the method of modeling. Section 4 discusses the methodology, and Section 5 provides conclusions and policy recommendations.

2. Multivariables Determination by Big Data Mining

The Internet of Things and big data application needs to be implemented based on the various flight delay activities and operations. Figure 1 shows the elements of the airport grid operation and correlation. According to these elements, we propose an airport grid of delay element framework based on the Internet of Things technology, which divides into three categories (operation control, aviation meteorology, and collaborative interaction). In Figure 2, the three categories include flight plans, aircraft track, aircraft performance, operation rules, flow control data, meteorological data, airport collaboration, company collaboration, passenger collaboration, and other determinants.

The intelligent sensing and communication data of airport delay IoT structure processed were from the Civil Aviation Administration of China, the Statistics Bureau, and the Beijing Capital International Airport database with route conditions and corresponding weather information system data. However, the weather database is an hourly record, and the flight database is not always consistent with other items. Therefore, in data processing, the database is divided into route (including real time flight route monitoring, spatial positioning and tracking, passenger movement, and other data) and weather type. According to the 2017 Civil Aviation Development Statistics Bulletin issued by the Civil Aviation Administration of China, there are ten major airlines i.e., Guide Air, Air China, China Eastern Airlines, Hainan, Shenzhen, Sichuan, Xiamen, Shandong, Shanghai, and Tianjin Airlines. The executed

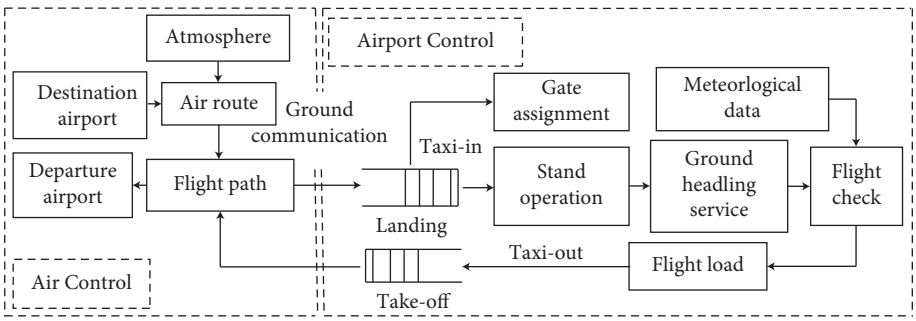

Figure 1: The elements of the airport grid operation and correlation.

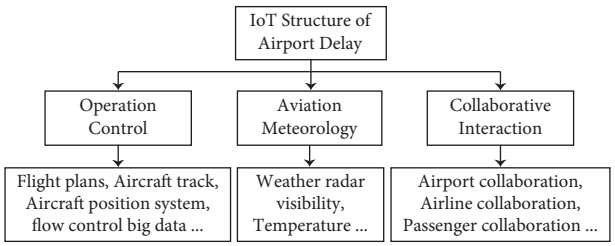

Figure 2: The IoT structure of airport delay.

flight volume accounted for 78% of the total flight volume, but its average flight on-time performance was 66.9%, which did not reach the average standard rate of all flights in China. The top 100 airports have almost covered the whole major airlines and routes under the comprehensive Chinese delay system. Therefore, the data are driven from top 100 traffic volume and processed airports from January 1, 2017, to December 31, 2017, including airport flight conditions, aircraft type, delay time, passenger load factor, and weather at the corresponding time. The data of the collection are as follows.

2.1. Dependent Variable from IoT Structure of Airport Delay. In the delay information system, the dependent variable is the average delay time for 15 minutes or more relative to the scheduled arrival/departure times. The Civil Aviation Administration of China has demonstrated the delays of airlines by the delaying of flights. In 2016, according to the draft "Statistical Measures for the Regular Flight of Civil Aviation (Consultation Draft)," the on-time flight referred to the flight [16] that arrived at least 15 minutes (inclusive 15 minutes) after the scheduled arrival time. The standard turn time was set based on the airport passenger throughput published by the Civil Aviation Authority in the previous years, stipulating the maximum time from the withdrawal of the airport to take-off. Table 1 contains the standard airport turn time. Therefore, during the sample period of the study, the calculation formula (1) and formula (2) for the delay time of each flight in each airport are as follows:

$$AD_{ij} = ATA_{ij} - ETA_{ij} - Taxiing_{ij}, \tag{1}$$

$$DD_{ij} = ATD_{ij} - ETD_{ij} - Taxiing_{ij}. \tag{2}$$

The total average time is as follows:

$$TD_i = \sum_{i=1,j=1}^{n} AD_{ij} + \sum_{i=1,j=1}^{m} \frac{DD_{ij}}{m+n}, \tag{3}$$

where AD_{ij}, $AD_{ij} > 0$ indicates the arrival delay time of flight j in airport i, ATA_{ij} means the actual arrival time, ETA_{ij} represents the estimated arrival time, DD_{ij}, $DD_{ij} > 0$ symbolizes the departure delay time of flight j in airport i, ATD_{ij} intimates the actual departure time, ETD_{ij} is the estimated departure time, and $Taxiing_{ij}$ indicates the standard turn time. TD_i implies the average delay time of airport i, n is the total number of flights arriving, and m signifies the total number of flights departing.

2.2. Independent Variable from IoT Structure of Airport Delay. The concept of the IoT is to connect any object with the network. Objects exchange and communicate information through information dissemination media to achieve intelligent identification, positioning, tracking, supervision, and other functions. Bringing the idea of the IoT into the analysis of flight delay can help research on mining information data related to delay from the systems perspective and as independent variables. Independent variables include average passenger throughput for each shift and average take-off and landing times for all aircraft at the airport each day, which are from the flight database of the Civil Aviation Administration, intelligent airport sensing, communication datasets, and summarized by shifts and hours.

Due to the inconsistent minimum spacing required between aircraft pairs, aircraft take-off and landing can affect airport capacity, resulting in flight delays, especially when instrument conditions are in effect [17–19] through

Table 1: Standard airport turn time.

Airport size	Standard ground turn time (min)
Domestic airport and overseas airport with annual passenger throughput ≥ 20 million passengers	30
Domestic airport with annual passenger throughput ≥ 10 million passengers	25
Domestic airport with annual passenger throughput ≥ 5 million passengers	20
Domestic airport with annual passenger throughput < 5 million passengers	15

aircraft positioning data. Aircraft types will also affect airport delays, especially in heavy-duty operations where mixed take-off (landing) has the most significant adverse impact.

Considering the capacity and airspace constraints in terms of airspace, the number of flights can reflect the congestion of the airspace. Duestablished delay causality grid (DCG) based on the Granger causality test and determined the airports associated with the delayed propagation links of the airports [20]. Figure 3 shows the directed grid which includes building DCGs and counting the number of flights between the two airports to reflect the number of airspace congestion routes at each airport.

In terms of airlines, through flight and passenger tracking data, considering the actual average capacity, the number of direct flights from each airport and the number of new direct flights to and from the port are independent variables. The increased demand (obtained through the movement trajectory of passengers' mobile information) has imposed the busy degree of airports and airlines, especially the hub airports. The average airport capacity will directly affect the air traffic congestion, thus affecting the take-off and landing time of aircraft, so it is necessary to consider the number of direct flights from each airport since direct flights are the decisive factor that can directly lead to the delay of the next flight. At the same time, the continued high increasing for new air routes has complicated the crowded airspace structure.

The weather system is an indispensable factor in the "IoT network" of airport delays. Lousy weather conditions can lead airport dysfunction and cause delays in almost all operation phases. Besides, due to adverse weather events, airport visibility will be reduced, resulting in large-scale airport delays. Previous studies analyzed the visibility in detail and collected various weather elements that affect airport visibility [20–22]. In the delay information system, regarding the daily weather conditions of each airport meteorological bureau (such as the visibility affecting aircraft take-off and landing), he sorted out the weather conditions of re-air flight and ground take-off and determined the factors that would affect the delay. All subweather variables would integrate into a total weather variable. The counting method is as shown in formula as follows:

$$\mathrm{WEA} = \left\{ \begin{array}{c} 1, \text{if delay occurs by weather,} \\ 0, \text{otherwise} \end{array} \right\}. \tag{4}$$

According to the meteorological radar big data from airport grid IoT structure, the conditions for weather selection are as follows [13, 25]:

(i) If there is a severe thunderstorm reported within 50 miles of the airport, the indicator variable will take a value of 1; otherwise, it is zero.

(ii) In the route, there are moderate and heavy road thunderstorms with a value of 1, otherwise zero.

(iii) The airport has heavy snow (24 hour snowfall between 5.0 and 10 mm) or blizzard (24 hour snowfall above 10 mm) with a value of 1, otherwise zero.

(iv) There is heavy rain at the airport (precipitation with a rainfall of more than 16 mm per hour, or a continuous rainfall of more than 30 mm for 12 hours, or precipitation with a rainfall of more than 50 mm for 24 hours). The value is 1; otherwise, it is zero.

(v) Strong winds will appear at the airport (is above level 4) with a value of 1, otherwise zero.

(vi) Haze weather at the airport (greater than 80%) has a value of 1, otherwise zero.

(vii) When the airport cloud level is lower than the lowest decision height (10 meters) of the instrument landing level, the value is 1; otherwise, it is zero.

(viii) The sandstorm storm at the airport (less than 1 km) takes the value 1, otherwise zero.

With the above research on the relationship between airport delays and related factors, the relevant variables of nine airport delays have been obtained based on intelligent sensing and communication data collation and statistics (as shown in Table 2).

3. Methodology

Spatial effects and autocorrelation tests must be carried out firstly on critical variable data before modeling in the delay information system. If a spatial effect exists, a spatial regression model will be further constructed to reach estimated measurement.

3.1. Spatial Correlation between Airport IoT and Other Independent Variables. Before studying the spatial correlation between airport IoT and other independent variables, it is necessary to determine the spatial correlation of delay between the airport grid. In order to detect the spatial relationship between delays, it is necessary to carry out a Moran I index test among multiple airport pairs for the average concentration of airport delays in spatial units and test the similarity, difference, or independence of airport delays across China.

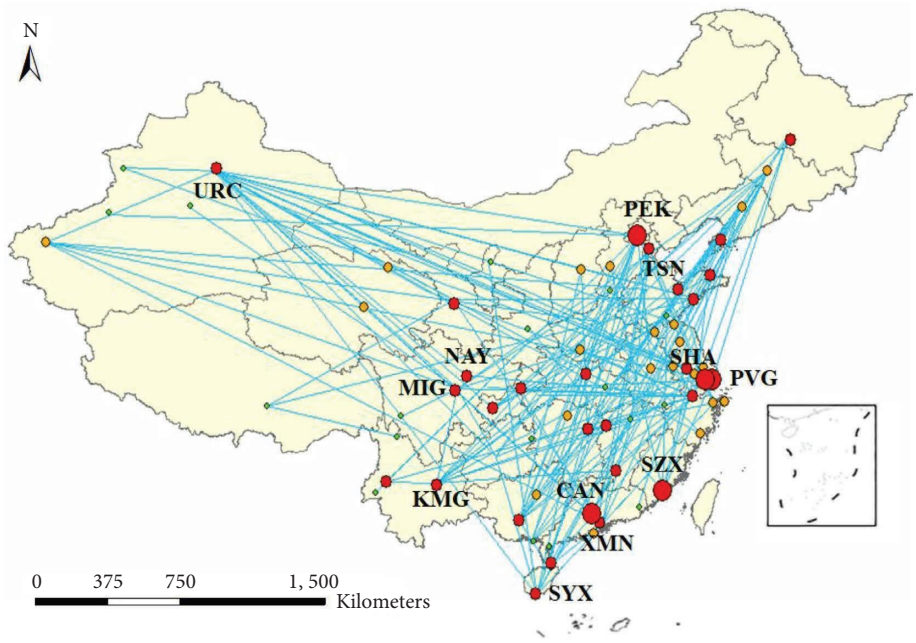

Figure 3: Delayed causal grid of the Granger causality test.

Table 2: A summary of key variable statistics of airport delay IoT structure.

Variable	Description	Min	Max	Mean	Std. dev.
TD	Airport average delay time (min)	18.31	49.22	32.57	7.01
AAC	Actual airport average capacity (seat/flight)	40.40	86.80	66.90	9.34
DFC	Number of direct flights from each airport (count)	16.86	1636.33	253.49	310.98
NDF	Number of new added flights to and from each airport (count)	114.00	1499.00	163.73	135.73
PTD	Average number of passengers arriving (departing) at each airport (person/flight)	4.00	247.00	57.19	50.38
ATL	The average number of landings of the total aircraft arriving (departing) at the airport every day (count)	0.00	32.00	10.78	7.88
NHA	Airport heavy aircraft ownership (count)	149.00	333.00	238.66	39.08
ACR	Airspace congestion route (count)	0.00	1619.00	144.80	248.62
WEA	Delay weather conditions (count)	1.00	29.00	5.89	6.15

Moran's I is ranging from −1 to 1, where if the value > 0, it indicates a positive correlation, as a high (or low) delay airport is adjacent to a high (or low) delay airport. Value < 0 indicates a spatial negative variable correlation, indicating that a high-delay airport is adjacent to a low-delay airport; when the index is equal to 0, there is no spatial relationship between airports. The higher the spatial correlation between airports, the greater the absolute value of the index will be. Equations (5)–(7) is as follows:

$$\mathrm{I} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \overline{x}\right)\left(x_j - \overline{x}\right)}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}, \tag{5}$$

$$S^2 = \frac{1}{n}\sum_{i=1}^{n}\left(y_i - \overline{y}\right), \tag{6}$$

$$\overline{y} = \frac{1}{n}\sum_{i=1}^{n} y_i, \tag{7}$$

where I represents Moran's I, n is the number of airports in a Geospatial space, x_i and x_j are the delay values of airport i and airport j, respectively, w_{ij} is an element of the space weight matrix, and $\overline{x}$ is the average of all observations for an attribute feature, x, in n study areas.

On the other hand, in the airport grid, the phenomenon of delay accumulation between local airports is measured by the Moran scatter plots and LISA aggregate plots, which can reflect the degree of association between an airport and its neighboring airports. The Moran scatter plot is calculated as follows:

$$\mathrm{I}_I = \frac{\left(x_i - \overline{x}\right)\sum_{j=1}^{n} w_{ij}\left(x_j - \overline{x}\right)}{S^2}. \tag{8}$$

The LISA aggregation graph enables visualization operations to be performed directly on the map by delaying aggregation. It has pronounced and intuitively showed the spatial distribution of delays situation in the located area.

3.2. Spatial Weight Matrix by Route Tracking Position Data. According to route track positioning data of aircraft, different from spatial neighboring weight matrices, airports cannot directly determine whether they are contiguous. The distance has a direct impact on the delays between the departure and arrival airports [23]. Therefore, the distance matrix can select as the spatial weight matrix. The formula is as follows:

$$w_{ij} = \sqrt{\sum_{i=1,j=1}^{n} \left(x_i - x_j\right)^2}. \tag{9}$$

After reciprocal distance processing, geographic distance matrix is established and standardized processing is completed as formula (10) and formula (11):

$$w_{ij} = \begin{Bmatrix} w_{11} & \cdots & w_{1n} \\ \vdots & \cdots & \vdots \\ w_{n1} & \cdots & w_{nn} \end{Bmatrix}, \tag{10}$$

$$w_{ij} = \frac{w_{ij} - \min w}{\max w - \min w}. \tag{11}$$

The space distance matrix of airport delay includes a set of airport pairs (that is, two-dimensional array). Therefore, given N airports in the Euclidean space, the distance matrix is a symmetric $N * N$ matrix with nonnegative real numbers as elements. In the spatial delay analysis, the greater [24] the distance is, the smaller the impact of airports on the delay will be.

3.3. Modeling. In order to analyze the correlation of the key factors in the airport delay Internet of Things, we established a spatial regression model for analysis. Spatial econometric regression models can be achieved in many forms [26], while spatial lag models and spatial error models are commonly used types. When airport delays have spatial grid effects, it is necessary to establish a feature delay model that includes spatial relationships. Then, the spatial lag model or the spatial error model can be applied based on spatial autocorrelation and spatial heterogeneity.

The flight delay impact function can be received based on the analysis on the determinants of airport delays. The following equation is the basic quantitative regression model:

$$\begin{aligned} TD_{it} = {} & \alpha + \beta_1 AAC_{it} + \beta_2 DFC_{it} + \beta_3 NDF_{it} + \beta_4 PTD_{it} + \beta_5 ATL_{it} \\ & + \beta_6 NHA_{it} + \beta_7 ACR_{it} + \beta_8 WEA_{it} + \mu_i + \lambda_t + \varepsilon_{it}. \end{aligned} \tag{12}$$

After determining the spatial correlation, in the analysis of the delay characteristics, except for the estimation of the OLS estimation, it is necessary to consider the spatial regression model of spatial effects. Therefore, with the base of the traditional regression model, extra spatial weight matrix can be adopted. The spatial Dubin model can be transformed to a spatial lag model (SLM) and a spatial error model (SEM) by setting constraints (when $\omega = 0$), so as to establish the only spatial Durbin model, and the model can obtained as the following equation:

$$\begin{aligned} TD_{it} = {} & \alpha + \delta WTD_{it} + \beta_1 AAC_{it} + \beta_2 DFC_{it} + \beta_3 NDF_{it} + \beta_4 PTD_{it} + \beta_5 ATL_{it} + \beta_6 NHA_{it} + \beta_7 ACR_{it} \\ & + \beta_8 WEA_{it} + \theta_1 WAAC_{it} + \theta_2 WDFC_{it} + \theta_3 WNDF_{it} + \theta_4 WPTD_{it} + \theta_5 WATL_{it} + \theta_6 WNHA_{it} \\ & + \theta_7 WACR_{it} + \theta_8 WWEA_{it} + \mu_i + \lambda_t + \varepsilon_{it}. \end{aligned} \tag{13}$$

The above model can also be displayed as the following equation:

$$\begin{aligned} TD_{it} = \alpha + \delta \sum_{j=1}^{100} w_{ij} TD_{it} + \beta_1 AAC_{it} + \beta_2 DFC_{it} + \beta_3 NDF_{it} + \beta_4 PTD_{it} + \beta_5 ATL_{it} + \beta_6 NHA_{it} \\ + \beta_7 ACR_{it} + \beta_8 WEA_{it} + \theta_1 \sum_{j=1}^{100} w_{ij} AAC_{it} + \theta_2 \sum_{j=1}^{100} w_{ij} DFC_{it} + \theta_3 \sum_{j=1}^{100} w_{ij} NDF_{it} \\ + \theta_4 \sum_{j=1}^{100} w_{ij} PTD_{it} + \theta_5 \sum_{j=1}^{100} w_{ij} ATL_{it} + \theta_6 \sum_{j=1}^{100} w_{ij} NHA_{it} + \theta_7 \sum_{j=1}^{100} w_{ij} ACR_{it} \\ + \theta_8 \sum_{j=1}^{100} w_{ij} EA_{it} + \mu_i + \lambda_t + \varepsilon_{it}, \end{aligned} \tag{14}$$

where TD_{it} is the explanatory variable, WTD_{it} is the spatial lag term of the explanatory variable, δ is the spatial autoregressive coefficient, AAC_{it}, DFC_{it}, PTD_{it}, ATL_{it}, NHA_{it}, ACR_{it}, and WEA_{it} are the explanatory variables, $WAAC_{it}$, $WDFC_{it}$, $WPTD_{it}$, $WATL_{it}$, $WNHA_{it}$, $WACR_{it}$, and $WWEA_{it}$ are the spatial lag term of the explanatory variables, W is the 100×100-order spatial distance matrix, θ_n is the explanatory variable space lag term coefficient, β_n is the regression coefficient, $n = 1, 2, 3, 4, 5, 6, 7, 8$, μ_i means a spatial effect, λ_t means time effect, ε_{it} is random error term, $\varepsilon_{it} = \omega \sum_{j=1}^{100} W_{ij} \varepsilon_{it} + \phi_{it}$ is spatial autocorrelation coefficient of error term, and ϕ_{it} is error term of independently and identically distribution.

4. Results

According to the data of delayed IoT mining and combined with the spatial model, the results in Table 3 show that the goodness of fit R2 for the basic model is 43.6%, and the adjusted R2 is 40%. F value is 8.8. The model passes the 1% level of the significance test, reaching obvious DFC and PTD on level 0.01, NHA, NHA, and WEA on level 0.05, while AAC, PTD, ATL, and ACR have passed a 10% level of the significance test.

As for the spatial correlation with different factors among the airports, four levels can describe the interspecific association, including high, higher, lower, and low. By applying regression analysis to all relevant determinants in the airport IoT network considering the average delay time, the spatial distribution of airport delay determinants can maintain the pattern of "high delay in the East and South area" and "low delay in the north and west area." Only a few airports have a different distribution.

About airport delay IoT grid distribution, Figure 4(a) shows that high-high agglomeration airports in North China have PEK, NAY, and TSN. The Yangtze River Delta region is an another high-high agglomeration area for flight delays, mainly including SHA, PVG, NKG, CZX, HGH, and NGB. The high-low clusters are mainly distributed between CTU, CAN, KMG, CKG, XMN, SYX and LJG, LZH, WXN, TCZ, while HTN, HLH, YIN, HET, and other airports are low-low clusters.

Figures 4(b)–4(i) show the delay factor distribution from AAC to WEA under the intelligent sensing and wireless communication data analysis. With the delay aggregation graph, the influence degree on each determinant of delay on the regional distribution is discrepant, except the hardest-hit areas located in Beijing, Shanghai, and Guangzhou. On the other hand, it is worth noting that critical delays have also occurred in Xizang. Combined with the correlation analysis of delay factors, the results present that the influencing factors do not play a decisive role in Xizang delay. Therefore, besides the influencing factors, the delay in Xizang may also be caused by airport operation failures.

For the determinants in the IoT structure of airport delay, the AAC aggregation map can express the distribution of airport flow and capacity delays. Traffic can delay distribution, concentrated in the Shanghai Pudong Airport and Shanghai Hongqiao Airport, as a high-high agglomeration area in the AAC variable. Beijing Capital International Airport, Guangzhou Baiyun Airport, and Shanghai's two airports have a high-high cluster (means the delays situation of airport and its nearby airports in the surrounding areas are both serious.) at the DFC, NDF, and PTD airports. Except for the metropolises and first-tier cities, airports worthy of attention include Yunnan Changshui airport, Inner Mongolia Baita airport, and Sanya Phoenix Airport. As a tourist city with high demand throughout the year, they have a high degree of agglomeration in NHA, ACR, WEA, and PTD.

Moran's I that calculated with the GeoDa software has displayed the 0.67 airport delay, indicating that the airport delay is not entirely random in spatial distribution with specific spatial correlation. Figure 5 is a scatter plot of Moran's I. This shows that the spatial big data mined from each flight path in the airport IoT has spatial correlation in the airport delay grid.

Table 4 shows the regression results for OLS, SLM, and SEM. Comparing the basic model and the spatial model, the Log L values of SLM and SEM are more significant, the AIC value and the SC value are smaller than OAS's AIC and SC, the spatial model is better than the basic model, and the fitting effect is also better than OLS. Therefore, the traditional regression model may have specific limitations in analyzing delay, which also implies the necessity of the spatial regression model. On the other hand, comparing SLM and SEM, it is found that the SLM has a more substantial Log L value, a more significant LR value, a smaller AIC value and an SC value, and a better SLM estimation effect. The result shows that the delay between China's airports has a strong proximity effect, while the spatial

Table 3: The results of OLS model with multivariable in airport delay IoT.

Variable	Ordinary least square (OLS)			
	Coef	Std. err	z	P
AAC	−0.0333	0.0374	−0.8898	0.3759
DFC	0.2881	0.0903	3.1908	0.0020
NDF	0.2252	0.0636	3.5436	0.0006
PTD	−0.0640	0.04461	−1.4333	0.1552
ATL	0.2706	0.1812	1.4932	0.1388
NHA	−0.0419	0.0163	−2.5669	0.0119
ACR	0.0145	0.0295	0.4921	0.6239
WEA	0.1077	0.0517	2.0816	0.0402
Constant	−0.3461	0.9085	−0.38092	0.7042
	$R2$	$R2$ (adj.)	F-statistic	Prob (F)
	0.4359	0.3963	8.7897	$7.82369e-009$
	LogL.	AIC	SC	
	19.8936	−21.7872	1.6594	

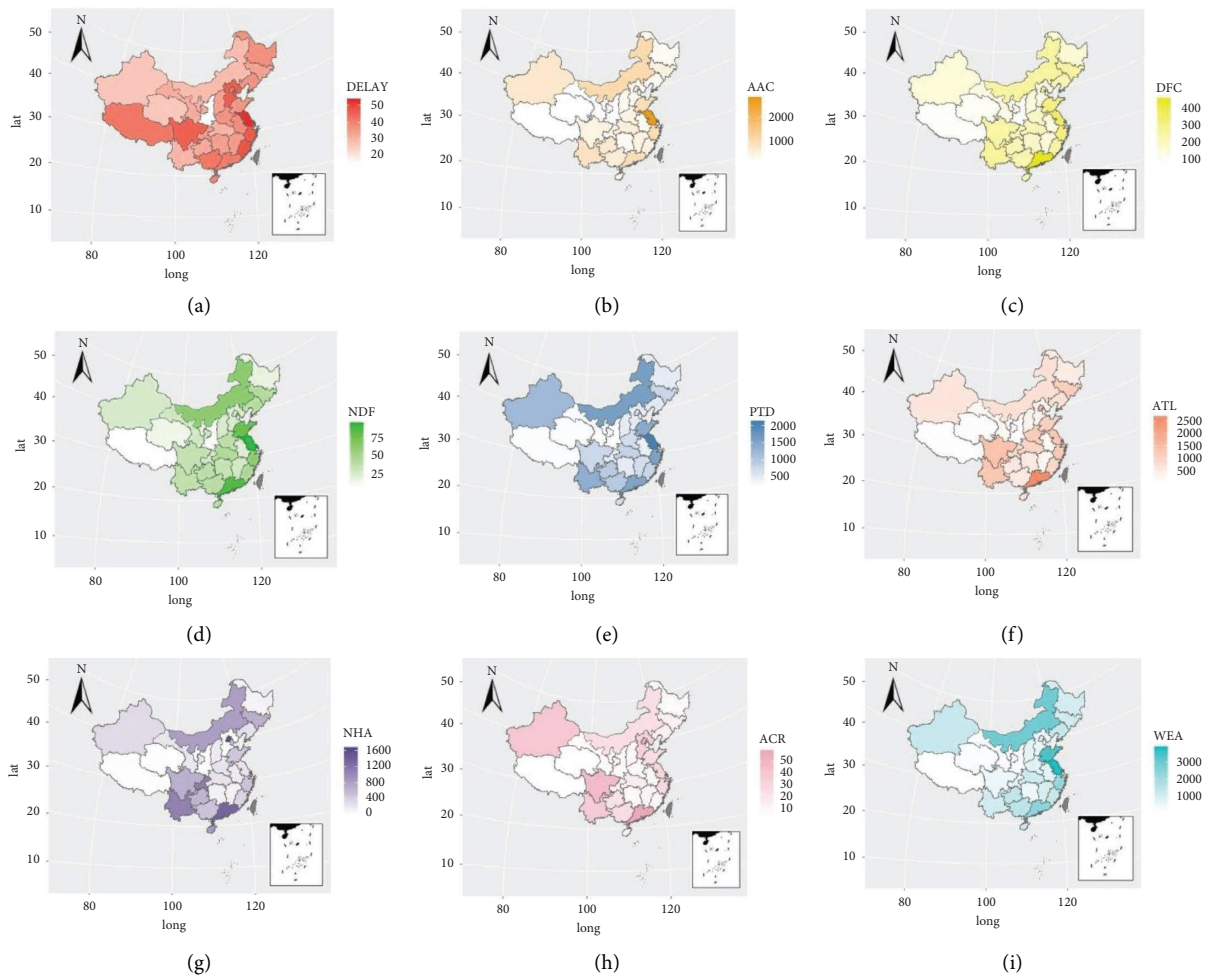

Figure 4: Aggregation map of an airport delay IoT system. (a) The distribution of delay grid. (b) The distribution of AAC. (c) The distribution of DFC. (d) The distribution of NDF. (e) The distribution of PTD. (f) The distribution of ATL. (g) The distribution of NHA. (h) The distribution of NHA. (i) The distribution of WEA).

heterogeneity of delays (errors) is relatively weak. In the SLM model, the airport delay has significant spatial effects with spatial correlation coefficient $\rho = 0.9863$, indicating that 100 airport delays have an extreme spatial dependence under the proximity effect in the airport grid.

As aforementioned, it is vital to provide some policy suggestions to reduce the aiport delay, as shown by conducting statitical analysis to the relevant intelligent flight sensing and communication data and combining the correlation degree of each determinant to airport delay in

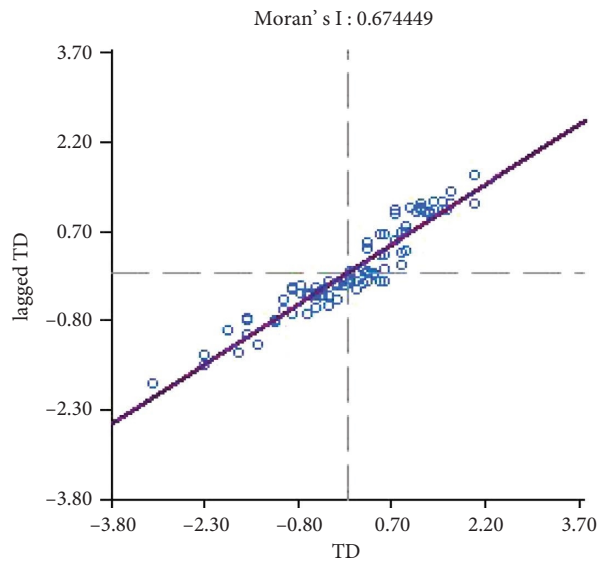

Figure 5: Moran's I scatter plot.

Table 4: Comparison of regression results between SLM and SEM.

Variable	SLM				SEM			
	Coef.	Std. err	z	P	Coef.	Std. err	z	P
AAC	−0.005	0.01367	−0.388	0.6978	0.0032	0.01586	0.2029	0.8392
DFC	0.0968	0.03364	2.8789	0.004	0.0849	0.03777	2.2485	0.0245
NDF	0.0616	0.0238	2.5882	0.0097	0.0247	0.02836	0.8706	0.384
PTD	−0.012	0.01716	−0.667	0.5045	−0.003	0.01913	−0.133	0.8944
ATL	0.0639	0.06781	0.9424	0.346	0.0403	0.07643	0.5273	0.598
NHA	−0.009	0.00609	−1.377	0.1687	−0.003	0.00682	−0.315	0.7524
ACR	−0.014	0.01079	−1.301	0.1934	−0.017	0.01209	−1.397	0.1623
WEA	0.02	0.01952	1.0252	0.3053	0.006	0.02285	0.2642	0.7917
WAAC	−0.031	0.07891	−0.393	0.6943	−0.019	0.08889	−0.215	0.8301
WDFC	−0.12	0.08469	−1.416	0.1569	−0.086	0.09464	−0.905	0.3655
WNDF	−0.049	0.12212	−0.395	0.6925	−0.022	0.13496	−0.165	0.8687
WPTD	0.0031	0.05811	0.0544	0.9566	−0.016	0.06491	−0.252	0.8012
WATL	0.0551	0.11145	0.4946	0.6209	0.004	0.12643	0.0318	0.9747
WNHA	0.0319	0.03677	0.8675	0.3857	0.0208	0.04078	0.51	0.61
WACR	0.0408	0.05215	0.7826	0.4338	0.0356	0.05909	0.602	0.5471
WWEA	0.0773	0.12081	0.6401	0.5221	0.0851	0.13443	0.6332	0.5266
Constant	−1.088	0.37027	−2.938	0.0033	2.3556	1.12365	2.0964	0.036
ρ	0.9863	0.00931	105.99	0	—	—	—	—
λ	—	—	—	—	0.9918	0.00564	175.99	0
R^2	0.920964				0.89792			
Log L	113.067				99.725176			
AIC	−190.134				−165.45			
SC	−143.241				−121.162			

the spatial dimension. Due to the different scales, systems, and natural conditions, the policy should consider the diversity of the environmental conditions among the airports especially in the rapid development stage of IoT technology. The number of direct flights and new flights has a more significant impact on airport delays. However, in recent years, the quantity demand and planning of new airports and flight routes would increase by verging to multifold levels. The overall optimization can fundamentally reduce airport flight delays and control the economic loss while meeting the transportation demand.

Take-off and landing conditions in the delay IoT system are also important factors that affect the flight delay. Airport congestion mainly comes from aircraft operation flow and flight capacity. Combined with the spatial distance, taking the delay impact of regional influencing factors into account as airport take-off and landing queue structure adjustment and evacuation may bring unexpected benefits to solve the delay issues. In the airport IoT network, flight delay also needs to consider a transmission delay. The congestion of airspace capacity would also affect the operational structure of the airport. On the other hand, although the passenger

throughput and the allocation of heavy aircraft will affect the delay of the airport, they are negatively related to the delay in the spatial. Therefore, when considering the allocation of passenger flow and aircraft types, airlines only need to consider its impact on the delay of a single airport.

Although the occurrence of flight delay is irresistible and the recovery of delay is uncontrollable when special weather conditions occur, the weather information system is a decisive factor with particular regional characteristics. According to the agglomeration distribution, in this case, Sanya, Haikou, and Shenzhen are cities which greatly affected by the weather. At the same time, due to the interaction of spatial distance between cities, marine climate characteristics, and the weather among airports, there is a strong correlation between the three airports in weather-induced delays. The weather conditions shall also be considered when the airport conducts a route schedule. However, from the overall point of view, compared with other determinants, there are few and concentrated areas strongly affected by weather factors. So, it is relatively easy to improve the delay in the high concentration area caused by weather factors.

5. Conclusion

The Internet of Things, big data, artificial intelligence, 5G, and other new technologies are still in continuous improvement. With these technologies, flight delay has formed a framework of delay mining technology systems in smart airport grids with advanced technology, open data fusion, security, and reliability. After the data set of airports, aircraft, flights, and passengers is collected through the IoT technology, this paper firstly utilized spatial autocorrelation to process multivariables-delay determinants (using intelligent flight location and communication data) and analyzed the spatial distribution characteristics of the airport delays grid in China. Basic regression models and geographically weighted regression models were then used to study the driving factors and regional differences in an airport delays information system. The results demonstrated the validity of the spatial econometric regression model. Secondly, the spatial aggregation characteristics of China's airport delays were high aggregation and low accumulation, while DFC, NDF, and WEA positively correlated with the delay time. At the same time, the results of the geographically weighted regression model revealed that different spatial differences between multiple factors would lead to diverse effects of civil aviation delays. The spatial regression model can more systematically and intuitively understand various determinants in the airport system in different regions. This method can also be applied to other relevant studies, for example, time-space analysis of delay factors, or apply the findings to delays in the study of systemic grid structure propagation and delay assessment.

The delay space analysis of the aircraft execution process is an effective measure to ensure the operation of flights. The results of delay distribution in the airport grid are directly related to the adjustment and control of flight operations. Based on the analysis of multiple determinants, big data and multiattribute data excavated by the Internet of Things application development techniques are used to conduct spatial assessment modeling. From the perspective of flight trajectory, weather, and passenger demand learning, it is significant to explore the spatial distribution level, delay diffusion level, and determinants of delay during flight execution. Furthermore, the results of spatial delay analysis can help the airport IoT technology to reallocate flight operation support equipment and facilities according to the distribution of abnormal areas involved in a flight delay.

Data Availability

The related data used to support the findings of this study were supplied by Xiushan Jiang under license and so cannot be made freely available. Requests for access to these data should be made to Xiushan Jiang, xshjiang@bjtu.edu.cn.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Display Design Model Based on the Internet of Things Prototype System

Pingshan Wang [1] **and Fei Yan** [2]

[1] *School of Digital Arts, Wuxi Vocational College of Science and Technology, Wuxi 214028, Jiangsu, China*
[2] *Principal's Office, Changshu Institute of Technology, Suzhou 215500, Jiangsu, China*

Correspondence should be addressed to Pingshan Wang; 5101033@wxsc.edu.cn and Fei Yan; yanfei@cslg.edu.cn

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The display design of the Internet of Things prototype system is the top priority of the design of the display space, and it is also a problem to be studied in the future development of the display space. However, the current research on the display design direction of IoT prototype system is not deep enough. This article mainly studies the display design model based on the Internet of Things prototype system. This article mainly uses the related technology of IoT heterogeneous protocol to analyze the structure of the IoT prototype system and proposes to use the heterogeneous network to speculate the future development trend of the IoT. In the aspect of display design, applications such as network information retrieval and data mining at the level of missions are accelerated in depth so that the arrangement of multiple factors is more reasonable. Finally, the data conversion function is used to design each port in the IoT accessor architecture. The protocol is adapted and converted, and the parsed protocol is uniformly encapsulated and uniformly transmitted on the platform. The model in this article integrates various heterogeneous detection networks, realizes the standardized operation of top-level applications, and completes the decoupling of top-level applications. It is encapsulated in a unified protocol and meets the standard operation requirements of web applications. The experimental data in this article show that the frequency of the audio signal designed by the system under normal working conditions is mostly concentrated at about 180 Hz, and the highest frequency value is less than 800 Hz; when the system has a partial discharge failure, the frequency of the audio signal is mostly concentrated between 1400 Hz and 1800 Hz. The experimental results of this article show that the prototype system of the Internet of Things can identify and judge the state of the display design model. Applying it in practice can effectively solve practical problems such as large-scale data storage of the Internet of Things.

1. Introduction

1.1. Background and Significance. In recent years, the Internet of Things, an important part of the new generation of information technology, has received widespread attention from the technology community. The basic characteristics can be summarized as overall perception, reliable transmission, and intelligent processing. In order to understand the spread and diffusion of information, the objects in the environment are connected. In the development of modern science and technology, the extension of the Internet is called "Internet of Things." The terminal can be extended to certain objects. In order to effectively process and distribute relevant information within the scope of the network, information can be exchanged with each other to achieve communication between different projects. The main responsibility of the system display design lies in the development and enrichment of multiple dialogues and communication possibilities between the IoT product configuration system and the audience group. In the communication activities, the design of the display should reflect the cultural characteristics of the display design system while conveying the information between the franchise store and the consumer group.

The Internet of Things itself is a complex network system. In addition, the application fields cover all walks of life, and there is inevitably a lot of overlap. The Internet of Things makes full use of various application programs, intelligent

terminals, and sensing equipment, through identification, development of data, data collection, processing, and communication and other technical equipment and links. Display design involves multiple fields. It covers multiple disciplines such as visual arts, marketing, materials science, design psychology, and ergonomics. It is a creative act that transforms design concepts, ideas, and intentions into visual images [1, 2]. Display design is also a new visual expression technique produced in it. It is a creative act that transforms the idea, thought, and intention of the product to be displayed by the informant into a visual image [3]. In the visual sense, the design of the display in the prototype system of the Internet of Things is crucial, which determines the standardization and order of the visual process of the consumer group [4, 5].

1.2. Related Works. In recent years, many scholars have conducted research on the application of the Internet of Things. Li et al. [6] believed that the Internet of Things (IoT) can change people's lives by connecting everyday objects together. For example, in a grocery store, all items can be connected to form an intelligent shopping system. In this IoT system, cheap radio frequency identification (RFID) tags can be attached to each product and placed in a smart shopping cart, which can be automatically read by a shopping cart equipped with an RFID reader [6]. However, the application range of the system he designed is not enough, and a large amount of data is needed to verify the feasibility in real life. Yang et al. [7] found that the rapid growth of mobile IP and the emerging IoT and cloud-based applications are driving a paradigm shift in wireless networks. By taking full advantage of the freedom of space, large-scale multiple-input multiple-output (MIMO) technology ensures a significant increase in data rate and link reliability. He proposed a 128-antenna massive MIMO prototype system based on a time division duplex (TDD), which was designed to operate on a 20 MHz bandwidth. He realized the uplink real-time video and downlink data transmission according to the system hardware design of the demonstration [7]. Guo et al. [8] proposed an IoT architecture based on transparent computing to build scalable and manageable IoT applications. The proposed architecture includes five layers, namely end user layer, edge network layer, core network layer, service and storage layer, and management layer. It can provide centralized management of various resources (such as operating systems, services, and data) for IoT applications and enable on-demand services to be executed on heterogeneous IoT devices [8]. Previous studies have explored the construction of IoT prototype systems through cloud computing, biometrics, blockchain, and other technologies, but the development process is extremely complex, posing severe challenges to technical capabilities. At the same time, due to the complexity of the development process, the investment in development has increased. These studies have discussed the technical scale of the Internet of Things in many aspects, but with the continuous acceleration of technology updates, these studies are difficult to guarantee in terms of system performance and reliability.

1.3. Innovation in This Article. The main innovations of this article include the following: (1) Analysis of the Internet of Things technology and functional analysis of thematic exhibition display, combined with the discussion of multiple disciplines. (2) Finding the combination of information interaction, exhibition display, and Internet of Things technology and proposing the design principles and strategies of thematic exhibition display centered on the Internet of Things technology. The research in this article can provide ideas for related research on the Internet of Things and can also provide new research directions for demonstrating the improvement of design models.

2. Related Methods of Constructing Prototype System of Internet of Things

2.1. Analysis of Related Technologies of IoT Heterogeneous Protocols. The IoT heterogeneous sensor network (the small-world network theory is applied to the field of wireless sensor networks, and a statistical method of small-world feature quantities in wireless sensor networks is established) is a network composed of many different sensor nodes; otherwise, the network composed of the same nodes is called the same kind of sensor network [9, 10]. For example, in agricultural applications, since a variety of objects are to be detected, changes in the environment will have different contents to collect information, so it is necessary to collect temperature, humidity, soil salinity, and sunlight information. The function and energy consumption of each sensor node are different, and the node performance is also different [11, 12]. Therefore, this type of sensor network is called a "heterogeneous network," and a wireless sensor network is one of the most representative networks.

In the Internet of Things, the main development trends of home systems for exchanging information are generally as follows: Information communication is mainly to provide information to ensure proper communication between family and the outside world [13, 14]. Network contracts include software and hardware interfaces. This is because many manufacturers have the premise of cooperation in this industry. If they dominate, there is no unified standard [15]. The goal of the standard composition is to change the current "self-government" situation and establish its own tailor-made system. The integrated module can modify the interface between the modules, thereby achieving a high degree of scalability. At the same time, electrical appliances are switched to sleep mode at night, to avoid the long-term operation of electrical appliances, to save a certain amount of electrical energy, and to ensure home safety at night. Safety and convenience include the safety and start-up of alarm systems and technical equipment in emergency situations [16, 17]. Energy management includes the efficient use of energy and the management of HVAC (heating, ventilation, and air conditioning). Comfortable controls include automatic switching of home appliances, home access control, and remote control. Communication services include PBX and ISDN. Multimedia services include movies and TV, media and other related systems, remote video transmission, interactive TV, interactive order-based, and other services

[18, 19]. The general development trend of the Internet of Things is shown in Figure 1.

2.2. RDF Sentence Structure Importance Calculation Based on Link Analysis. Link analysis comes from the multidimensional analysis of hyperlinks in the web structure. At present, link analysis is mainly applied to the deep acceleration of network information retrieval, data mining, and web structure modeling in verification points [20]. Link analysis, simply put, is a referendum. The higher the vote rate of the target keyword, the higher the ranking of the keyword in the search engine. As a necessary means of optimization, external links are irreplaceable in their important position. The relevance of search engines has that web pages mainly depend on two factors: one is the location of keywords and the density of web page links of keywords; and the other is the analysis, also known as the popularity of links. Required classification [21, 22]: the principle of link analysis is that the more backlinks a web page has, the more likely it is to become a high-quality or important web page. Closely related to link analysis are the hub value and authority value. These two values interact with each other. The authority value refers to the sum of the authority values of all links exported to the page. This value is the sum of the pivot values of all pages where the import link is located [23, 24].

This article introduces the link analysis technology for evaluating high-quality or high importance RS in the IoT ontology. The structural importance of each RS in the ontology can be determined by its pivot value in GBM or EBM, the authority value of each term in T or T′, and the value of each RS in the calculation path of S or S pivot value [25, 26]. The calculation method of the structural importance of s judgment in RDF is shown in the following formula:

$$\mathbf{I_s}(s)\mathrm{Hub}(s), \tag{1}$$

where Hub (s) is the hub value of the RDF sentence s in GBM (EBM), which is the sum of the authoritative value Au (t) of all the exported links of s in GBM (EBM) to the term 1. The calculation method of Hub (s) is shown in the following formula :

$$\begin{aligned}\mathrm{Hub}(s) = \sum w_s * \mathrm{Au}(t_1) \sum w_p * \mathrm{Au}(t_2) \sum w_o * \mathrm{Au}(t_3)\\ t_1 \in T, (s,t_1)L_s t_2 \in T, (s,t_2) \in L_p t_3 \in T, (s,t_3) \in L_0,\end{aligned} \tag{2}$$

where w_s, w_p, and w_o are the weights corresponding to the three connection types $\mathbf{L}_s$, $\mathbf{L}_p$, and $\mathbf{L_o}$ between s and t, respectively. Generally, the value of w_s is higher than the values of w_p and w_o, which means that if t is the subject of s, then the authoritative value of t has a higher contribution to the pivot value of s. Referring to the experimental research of Zhang et al., this article also sets the weights of the three to 0.6, 0.2, and 0.15, respectively. Au (t) is the authoritative value of the term t in GBM (EBM), where the authoritative value refers to the sum of the hub value (s) of s to which all imported links of t in GBM (EBM) belong. The higher the $\mathbf{L_o}$ significance, the greater the corresponding weight value. When the authority value of the web page increases, it will directly affect the ranking performance of the website on the search engine. The more authoritative and the higher the score, the easier it is to obtain a good ranking. The calculation method of Au (t) is shown in the following formula:

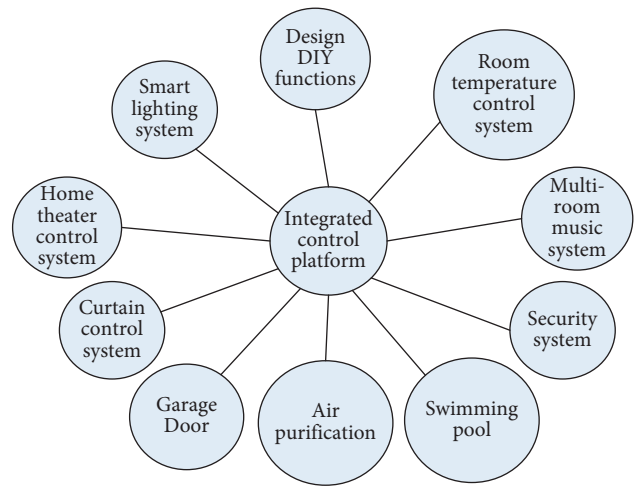

Figure 1: The direction of the Internet of Things.

$$\begin{aligned}\mathrm{Au}(t) = \sum w_s * \mathrm{Hub}(\mathbf{S}_1) + \sum w_p * \mathrm{Hub}(\mathbf{S}_2) + \sum w_o * \mathrm{Hub}(\mathbf{S}_3)\\ s_1 \in S, (\mathbf{S}_1,t) \in L_S \mathbf{S}_2 \in S, (\mathbf{S}_2,t) \in \mathbf{L}_p \mathbf{S}_3 \in S, (\mathbf{S}_3,t)\mathbf{L}_o.\end{aligned} \tag{3}$$

The structural importance degree RS (s) of RS can be calculated from formulas (1)–(3); the initial values of Hub (s) and Au (t) in the link analysis process are set to 0.5 after iteration These two values will be normalized in the calculation process. The sum of the square values of each Hub (s) is 1, and the sum of the square values of each Au (t) is also 1.

2.3. Data Conversion Function Design. In the IoT accessor architecture, the adaptive protocol module is responsible for analyzing and converting heterogeneous and nonuniform mappings of various protocols, completing the adjustment protocol, and ensuring unified packaging of transmission protocols for accessing heterogeneous and protocol analysis and a unified IoT gateway or service platform. Among them, the heterogeneous protocol interface in the protocol adaptation module is responsible for adapting to various heterogeneous protocols, and each type of protocol interface mainly supports a specific protocol. The heterogeneous protocol interface adopts a modular design, and specific function modules can be loaded or downloaded to achieve reasonable utilization of resources and reduce resource consumption of devices with limited resources. This project mainly analyzes the problem of equipment connection and unified transmission. In the sensor network communication protocol, the use of device and data routing mapping gate is completed, and different data objects (conceptual data, logical data, and physical data) are selected for unified encapsulation and routing installation. This module promotes the unified processing of protocols and data, converts

and protects the heterogeneity of sensitive-end protocols, and prepares for the intelligent cooperation of the next layer of gateways. The main functions of the heterogeneous protocol adaptation module are as follows:

2.3.1. Heterogeneous Protocol Communication Analysis. The analysis object of the device's communication protocol is the communication system, which is the key to the heterogeneous Internet of Things, especially for different network protocols, analysis type protocols, new protocol analysis, source address analysis, destination address analysis, etc. The unification of wireless communications such as Wi-Fi, 3G, ZigBee, etc., is analyzed to ensure the smooth access of heterogeneous protocols and prepare for the next protocol encapsulation.

2.3.2. Heterogeneous Protocol Packet Analysis. In addition to the analysis of the heterogeneous communication protocol, another key is to analyze the communication system between information objects and the accessor of the Internet of Things, mainly for a variety of different communication messages, how M3M develops COAP, etc., and to analyze the communication protocol and load response of the Internet of Things. The data can be analyzed in a unified encapsulation protocol.

2.3.3. Port Mapping Design. Port mapping requires the establishment of a port routing table, which contains the mapping between objects and routing ports. The mapping relationship can be one-to-one, more commonly one-to-many, that is an object corresponds to multiple ports according to different data types. When loading the collected data, it is necessary to modify or update the port routing table according to the change of the port information; when sending the control data, you need to refer to the port routing table. When canceling and adding objects, the port routing table must be modified. At the same time, the channel scheduling system also performs channel scheduling according to the port routing table.

2.3.4. Protocol Unified Encapsulation. Unified protocol encapsulation is the key to integrating various heterogeneous networks into IoT accessors. It mainly integrates various heterogeneous detection networks, protects the heterogeneity of the network, realizes the standard operation of top-level applications, and completes the decoupling of top-level applications. The model is encapsulated in a unified protocol to meet the standard operating requirements of web applications and provide a more effective functional operation mechanism.

2.3.5. Content Streaming. According to the identification and analysis results of the specific information received, based on the data conversion channel transmission, the size of the data packet and the format of the information need to be preprocessed to maintain the heterogeneous effectiveness of the information. For short action control command packets, the processor needs to use a single small packet structure to process the command and immediately make the data packet contain a close command to ensure the channel communication strategy. When accessing information such as video, audio, and monitoring sensors, content needs to be transmitted to convert the traditional soft-flow structure into an encapsulable unified description model package for unified encapsulation and analysis. The stream information structure is stored using a chain storage structure. The information structure of the command is stored and packed using the heap storage structure.

3. Simulation Test of the IoT Prototype System

3.1. Experimental Environment. The system is mainly composed of a controller based on the prototype system of the Internet of Things and a motor monitoring module. The motor monitoring module is mainly composed of two parts: a power parameter measurement module and a sensor parameter collection module. The power parameter measurement module completes the collection and measurement of motor voltage and current parameters, and the sensor parameter collection unit completes the motor temperature, vibration, abnormal noise, and other related indicators.

3.2. Experimental Procedure. The controller has a multichannel AD sampling I/O port, so this design can directly convert the high current and high voltage of the motor into a low-voltage signal and directly input it into the controller for collection and measurement. The principle of energy parameter measurement and the specific design process of the module are as follows.

The data collection of the controller should strictly follow the provisions of the sampling theorem. During the sampling process, when the sampling frequency fsmax is greater than 2 times the highest frequency fmax in the signal, the digital signal after sampling completely retains the information in the original signal. In application, it is to be ensured that the sampling frequency is $5 \sim 10$ times the highest frequency of the signal. According to circuit theory, the calculation principle of AC electrical energy parameters is as follows. The effective current value is

$$I = \sqrt{\frac{1}{T}\int_0^T i^2 \mathrm{d}t}. \tag{4}$$

The motor is powered by AC. From $i(t) = I_m \sin(\omega t + \varphi)$, the effective current value is

$$I\sqrt{\frac{1}{T}\int_0^T I_{m^2} \mathrm{Sin}^2(\omega t + \phi)\mathrm{d}t} = \frac{\sqrt{2}}{2} I_m. \tag{5}$$

Similarly, the effective value of the available voltage is

$$U = \sqrt{\frac{1}{T}\int_0^T U_{m^2}\sin^2(\omega t + \phi)\mathrm{d}t} = \frac{\sqrt{2}}{2}U_m. \quad (6)$$

In the actual application process, discrete sampling sequences are usually used to replace the continuous time-domain changing values to calculate the corresponding electrical energy parameters.

$$I = \sqrt{\frac{1}{T}\sum_{N=0}^{N-1} I_{m^2}\Delta T}, \quad (7)$$

where ΔT is the AC sampling time interval, N is the number of sampling points in a cycle, and I_m is the value of the sampled current sample.

3.3. Data Collection. In this design, when measuring the voltage and current of the motor of the prototype system of the Internet of Things, it is necessary to convert the collected data to a valid value after conversion. When the SCM sets the sampling frequency, the frequency is too high, the sampling interval is short, the amount of data required to be stored is large, and the calculation time is long; if the frequency is set too low, the measurement error will become larger, and comprehensive consideration is taken to determine the sampling setting for each cycle for 130 times.

4. Functional Analysis of the IoT Prototype System

4.1. Analysis of the Real-Time Distribution Function of the Internet of Things Prototype System. In the manufacturing of the Internet of Things environment, the distribution function solves the communication problem between the circulation resources and the information system and reduces the deviation between the circulation plan and the circulation solution. Dynamic manufacturing resources can realize ubiquitous recognition, which is the basis of the optimization of the workshop material allocation. The material allocation process mainly includes three parts: raw material resources, logistics resources (forklifts, BMX, etc.), and circulation tasks. The so-called material resources refer to the necessary parts, supporting parts, purchased products, raw materials, etc., in the production of the seminar. This is to ensure that production is completed normally. Allocating resources is the core of the material resource allocation of the work meeting, and is the executor who completes the task. The demand for material resources generated during the manufacturing process is met by circulating resources. In this unit, the modeling problem of dynamic manufacturing resources, assignment of tasks, in order to optimize the context, reflect resource information, and release resources and materials, and distribution tasks provide detailed instructions. Table 1 shows the description information of the allocated resources.

From the allocation resource description model in Table 1, we can know the task attributes and specific task content and service status of the IoT prototype system when it realizes the resource allocation function.

Material index description: the display design model information is shown in Table 2, and the specific image is compared using six sets of data as shown in Figure 2.

It can be seen from Table 2 that the materials used in the display design model in this article include copper coils and gaskets. According to different design requirements, the specifications of the two materials are also different.

The execution process of the distribution task is as follows: the distribution task matches the corresponding distribution resource service, and the distribution resource obtains the material resource requirements from the distribution task to complete the task from the material storage, and then according to the task requirements, the materials and resources obtained are be allocated, and after the materials are carried to the designated location of the task, the task is completed.

4.2. Determination of the Alarm Threshold of the Monitoring Index of the Internet of Things System. In order to the Internet of Things monitoring system to correctly identify the abnormal state of the display box-type substation, it is necessary to correctly set the threshold of the system monitoring index. Alerts are triggered when monitoring reaches a certain threshold. The threshold setting of the electrical energy parameter index is mainly based on the national restrictions on electrical energy parameters, actual user needs, and related requirements for relay protection. The system mainly measures and collects the electrical energy parameters of the low-voltage side loop. The national standard stipulates that the deviation of the 220 V single-phase power supply voltage is +8%, and the nominal voltage is −15%. The frequency deviation is set according to the actual system capacity, and the threshold is ±0.2 Hz ~ ±0.5 Hz. The threshold setting of the force rate needs to be set in the range of 0.7 ~ 0.9 according to the actual situation of the user. The current threshold needs to be flexibly set according to the actual project relay protection requirements. The setting of the nonelectric energy monitoring index threshold is mainly based on relevant domestic specifications and product specifications of box-type substation equipment. According to national standards and product specifications, the ambient temperature threshold is −15°C, which is set to 40°C, the humidity threshold is set to 90% RH, and the temperature threshold is set to 85°C. Relevant threshold points are connected, and the temperature is set at 75°C. Since the fire detection is output as a switch, the threshold is 1. The smoke threshold is set according to the actual test results, and the threshold is set to 1.2 V. In the National standard audio monitoring indicator, only the working sound of the device is less than 60 dB. If the fault is affected by the use of the box-type substation, there is no corresponding limit on the voice threshold, and further investigation is needed. In cooperation with relevant departments of Dongying Electric Power Company, the voice signals of the normal operation of the box-type substation were collected on the spot and the corresponding waveforms were obtained through software analysis, as shown in Figure 3. At the same time,

Table 1: Distribution resource description model.

Static attributes of resources	Resource context information
ID: forklift number, used to identify resources	Service status: three working states: idle, normal work, and fault state
Type: explain what function	Real-time location: location information obtained by reading location tags
Rated capacity: indicates that the distribution resources can carry material tasks	User ID: operator ID
Maximum capacity	Distribution task sequence: the distribution tasks undertaken
	Used capacity: the capacity of the task carried

Table 2: IoT construction material index information table.

Material index	Material number	Material name	Material location	Quantity of materials required	Unit material volume
5	4	Copper coil	(30, 40)	15	20
5	3	Gasket	(30, 40)	10	2

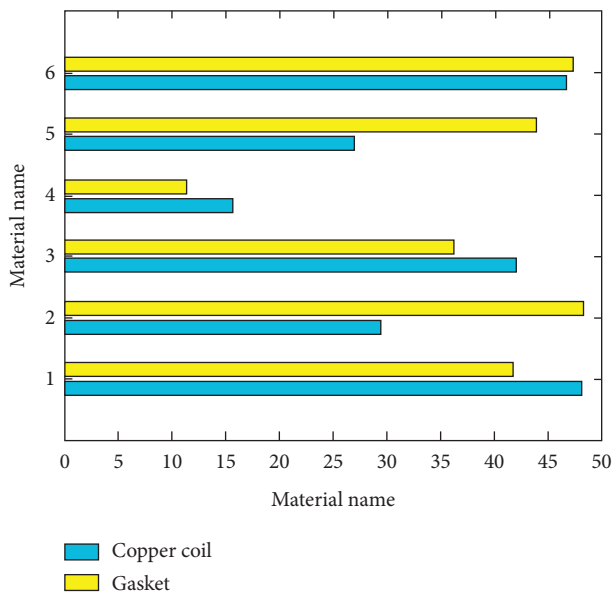

Figure 2: Comparison of six groups of IoT construction materials.

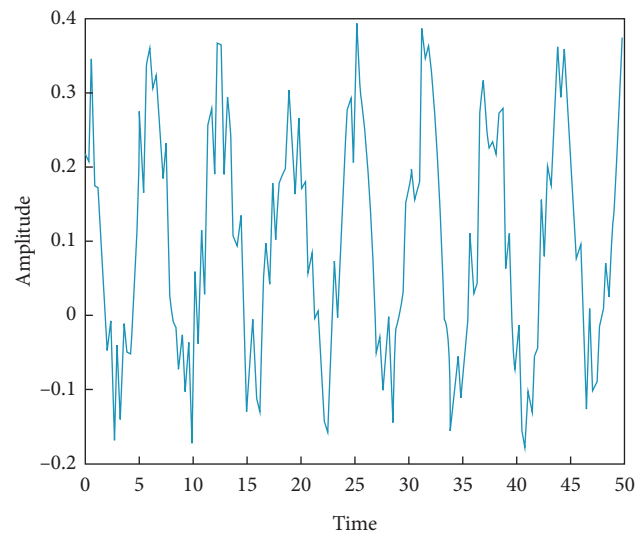

Figure 3: The audio waveform of the box becoming normal.

you can refer to the relevant reference materials to master the typical voice data of partial discharges and mechanical failures of box-type substations.

Two typical fault audio waveforms are mixed in the normal working audio signal of the box transformer, and the corresponding waveforms are obtained through software analysis as shown in Figures 4 and 5. Through comparison, it is found that the amplitude of the audio signal waveform of the normally operating box-type substation is much smaller than that of the two typical fault states. In normal operation, the amplitude of the audio signal waveform of the box-type substation is between ±0.4 V.

Because the audio signal is extremely susceptible to interference from external environmental factors (environmental factors, layout factors, and sound reflection factors), actual testing found that only the amplitude of the audio signal waveform is used to determine whether the system's operating sound index is normal, and there is a large error. To this end, consider converting the time-domain audio signal into a frequency-domain signal for analysis by fast Fourier transform. It includes information on the phase shift of each sinusoid in order to be able to recombine the frequency components to recover the original time signal. Through the analysis of the frequency-domain waveform diagram, it can be obtained that the frequency of the audio signal of the box transformer under normal working conditions is mostly concentrated around 180 Hz, and the highest frequency value is less than 800 Hz; when a partial discharge fault occurs, the frequency of the audio signal is partly concentrated between 1400 Hz and 1800 Hz; when a mechanical failure occurs, the frequency of the audio signal is distributed between 0 and 1800 Hz, and it shows obvious irregularities. After analysis, it can be concluded that the threshold of the audio signal in the frequency domain is set to 0 Hz and 800 Hz.

After the threshold is set, the audio signals in various operating states of the box-type substation are respectively applied to the time-domain criterion, the frequency-domain

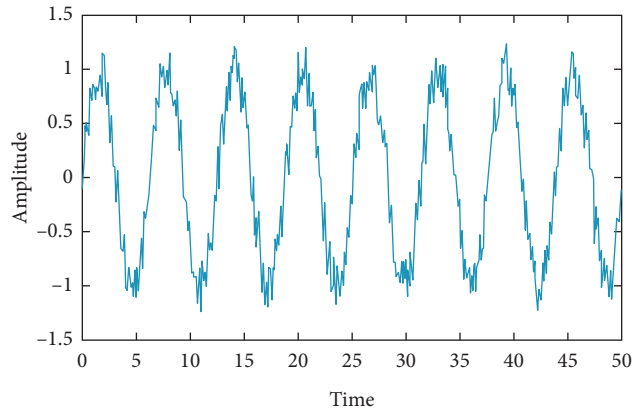

Figure 4: Mixed normal and partial discharge audio waveforms.

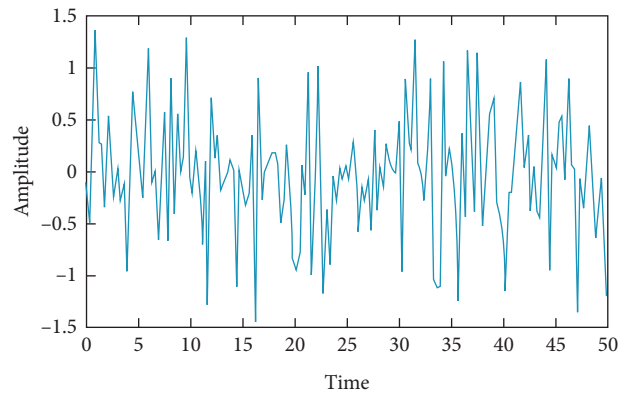

Figure 5: Normal and mechanical fault mixed audio waveform.

Table 3: Comparison of audio signal status recognition results.

Application criterion	Operating status	Number of samples	Correct number of samples	Accuracy (%)
Time domain	Normal status	15	12	80.00
	Fault state	20	16	80.00
Frequency domain	Normal status	15	13	86.00
	Fault state	20	17	85.00
Set of two	Normal status	15	14	93.00
	Fault state	20	18	90.00

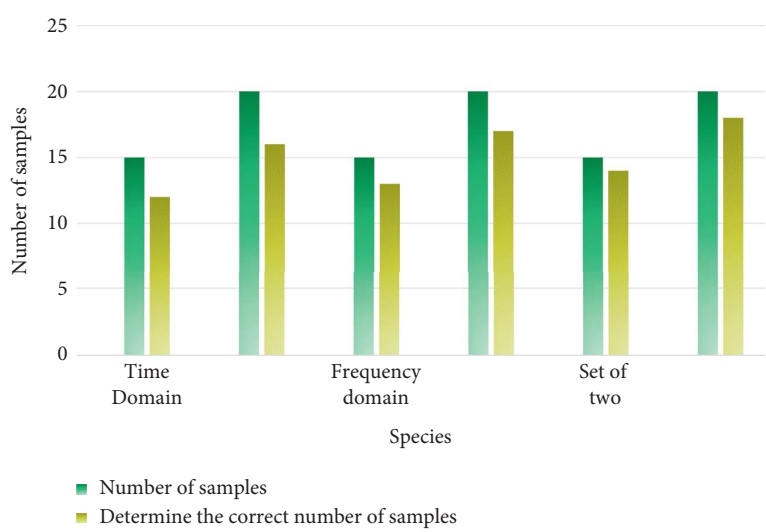

Figure 6: Comparison of audio signal status recognition results.

criterion, and the combination of the two criteria to identify and judge their status. The specific results are shown in Table 3. The highest recognition accuracy reaches 90%. The image is shown in Figure 6. The analysis can be concluded that with the combination of the time domain and the frequency domain of the IoT application criterion, the final state recognition accuracy rate is higher than the former two, and the average recognition accuracy rate can reach more than 88%. It meets the accuracy requirements of the Internet of Things prototype system to judge and identify faults based on audio signals. Under the condition that the number of samples in the fault state is 20, the maximum number of correct samples that can be determined by the IoT prototype system in this article is 16 and the accuracy is 90%. It greatly improves the recognition accuracy and the practical application value of the IoT prototype system.

5. Conclusions

This article designs and implements an IoT application prototyping system that improves data sharing to a certain extent and separates device developers from application developers, reducing the development limitations of IoT applications. This not only improves user convenience but also provides opportunities for the popularization of IoT applications. At the same time, it also describes the IoT manufacturing technology and environment, proposes service-oriented technologies and related definitions, and makes relevant theoretical preparations for the dynamic modeling of IoT manufacturing resource services in the IoT environment.

In this article, through reading and analyzing some typical engineering application cases at home and abroad, we have an in-depth understanding of the application characteristics of the discrete production system and the Internet of Things technology in the scheduling process and the key technologies involved in the display design model based on the Internet of Things technology; carried out research and analysis; and provided a theoretical basis and design basis for establishing an effective system architecture.

Various performance tests on the data storage model of the Internet of Things have verified the reliability, efficiency, and high scalability of the solution. Based on the storage model, a prototype of the Internet of Things data management system is constructed, which verifies the feasibility and practicability of the scheme in this article. It provides theoretical reference and application value for large-scale data storage solutions of the Internet of Things. The intervention of the Internet of Things technology has broken the limitation of time and space and become an important tool for connecting spaces and people. The Internet of Things technology will surely be the development trend of our future exhibitions. There are still some shortcomings in this article. The construction of the display design model needs continuous improvement. In the future research work, we will continue to use the existing technology to conduct in-depth research from different angles.

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

Evaluation of Urban Economic Benefit Value Calculation Method Based on Smart City

Weihang Zhu [1] and Manting Wang [2]

[1] *Faculty of Social Sciences, Hong Kong Baptist University, Kowloon Tong Hong Kong Special Admin, istrative Region, Hong Kong, China*
[2] *School of Software & Microelectronics, Peking University, Beijing 21447977, China*

Correspondence should be addressed to Weihang Zhu; 21447977@life.hkbu.edu.hk

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Economic growth has not only made life more comfortable for people but has also increased the demands and expectations of the living environment. Urban planning, layout, construction, transportation, environmental protection, etc. are increasingly attracting the attention of the government. Due to the increase in residents, there are many problems in cities, such as traffic congestion, smog, etc. The relevant departments hope to use intelligent means to effectively alleviate these problems, and many cities have achieved good results. As a part of urban economics research, analyzing the economic benefits of a city helps to study how to develop the city. Smart sensor and communication technology is an advanced technology for smart manufacturing and the Internet of Things. As an advanced sensor tool, it is of great significance for exploring the economic benefits of smart cities. This paper discusses the calculation method of urban economic benefit value based on smart cities and evaluates the calculation method. The purpose of this paper is to find out the calculation method applicable to the urban economic benefit and to propose an effective evaluation method for the urban economic benefit, so as to have a more complete and effective calculation and evaluation of the urban economic benefit. This paper introduces the smart city, combining intelligent sensing and communication technology, and designs the economic benefit calculation method and evaluation model. Finally, this paper designs an experiment of economic benefit calculation and evaluation. First, 18 cities in China are used as examples to explore the relationship between indicators and GDP. It is concluded that there is a long-term and stable relationship between GDP and household savings balance at the end of the year and that this does not exist with the average number of on-the-job workers. Then we took Wuhan Metro Line 5 as an example to evaluate its economic benefits. The experiment shows that the largest weight value is the investment return period, with a weight of 0.54, and the evaluation level of Wuhan Metro Line 5 is 4.

1. Introduction

In order to pursue a better living environment and living conditions, young people like to move to cities, which leads to the emergence of a series of social problems such as transportation, medical care, and the environment. The 21st century is an information society, so the construction of cities has also introduced information technology, which also includes intelligent sensing and communication technology, which has greatly improved the construction efficiency and operation of cities, and smart cities have emerged with the development of information. Cities are the birthplace of social progress and the main carriers of economic, social, political, cultural, and technological development. Economic benefits are the ratio of labor input to output. The purpose of economic activities is to improve economic benefits. The improvement of urban economic benefits is the focus of urban economic activities.

The economic benefit of a city is the sum of the various benefits of a comprehensive city. In order to correctly evaluate and measure the city's economic benefits, the indicators of the city's economic benefits must be scientifically designed and evaluated. The economic interests of the city are related to the city's input and output. From a macro

point of view, the input factors of a city are generally the number of employees, investment in fixed assets, energy consumption, etc., and the output factors are GDP, fiscal revenue, etc. The scientific evaluation of the urban economic effect is an important research topic, and the effect needs to be quantified in this process, so the calculation method of evaluating the urban economic benefit is very important. The creation of smart cities is important for the implementation of sustainable urban development.

The innovations of this paper are: (1) The calculation method and evaluation model of urban economic benefits based on smart cities are proposed, combining intelligent sensing and communication technology, and the calculation of urban economic benefits is designed with various analysis methods. (2) Based on the calculation method and evaluation model designed in this paper, experiments are carried out, and several cities are used as experimental objects to calculate and evaluate their urban economic benefits.

2. Related Work

With the continuous expansion of the urban population and the continuous progress of the industry, many problems have emerged in the city, such as traffic congestion, environmental pollution, etc., so smart cities have emerged. Paganelli et al. propose a framework that enables developers to model smart things as web resources and develop applications on top of them. Finally, Paganelli et al. conducted testing activities to test the effectiveness of the framework in smart cities [1]. Daniel et al. provide an obscure technique that uses various catalog parameters to dynamically match how vision sensors are stored [2]. Pasolini et al. represent two essential elements in Italian town practice. Cities need adequate planning to find out and must reduce transmission time to determine if the transmission has been lost [3]. Bates and Friday present a case study on creating a campus-scale "living lab" using existing IoT infrastructure to promote energy conservation and environmental sustainability [4]. In this article, Wu et al. intend to propose a smart city development framework with Chinese characteristics in big data, providing key steps for building smart city infrastructure and realizing opportunities for efficient urban governance [5]. Yeh surveyed Taiwanese cities that have participated in at least one smart city initiative at the Smart Community Forum. The study provides practical guidance for cities and technology providers to develop smart city plans, but the downside is that the design questionnaire is not comprehensive [6].

3. Calculation Method of Urban Economic Benefit Value Based on Smart City

3.1. Smart City

3.1.1. The Concept of Smart City. From the perspective of the fictitious source, "smart cities" develop their innovations on the basis of information technology, provide solutions for cities to realize walking, and provide basic ideas for optimizing and developing the city's operating system. "Smart city" is gradually being used to describe an urban development model based on information technology that promotes urban innovation [7, 8].

Smart cities take the pursuit of comprehensive and sustainable economic, social, and environmental development as the basic direction. Taking the artificial intelligence and human wisdom of information technology as an important means, through the comprehensive integration of various types of urban resources, can promote the innovative development of the city and, secondly, promote the optimal allocation of the city's core resources and the operation and development of the city, creating an all-round smart city.

3.1.2. Urban Development and Evolution. From the perspective of the development and evolution of cities, the emergence of smart cities is an important manifestation of the continuous evolution of urban forms driven by the advancement of human science and technology [4]. As shown in Figure 1, different human technology levels correspond to different social and urban forms.

It can be seen from Figure 1 that the first stage of the city was primitive tribes, and the earliest part of the city was caused by factors such as trade, religion, and politics; the second stage is the countryside or town; the third stage is the industrialized city, which is facilitated by the development of modern industries; the fourth stage is the digital city, which is facilitated by the development of the Internet; and the fifth stage is the smart city. A smart city is an important embodiment of social progress. The level of human productivity represents the ability of humans to transform the natural world. With every breakthrough improvement in human labor tools, human productivity has greatly improved, and it has also brought about ever-changing changes in the form of human society. Technological progress has driven the changes in social form and urban development model.

3.1.3. Elements of Smart City. The smart city system is composed of the interconnection and combination of human wisdom and several intelligent and intelligent city subsystems. The core components of a smart city can be summarized from five aspects: strategy, society, economy, support, and space [9]. The connection between human wisdom and the city's smart system is mainly reflected in the five aspects of the city's strategy: society, economy, support, and space. They are reflected in the smart city system as five major subsystems, as shown in Figure 2.

3.2. Calculation Method of Urban Economic Benefit Based on Intelligent Sensing and Communication Technology. There are many calculation methods for urban economic benefits, here are some of them to introduce.

3.2.1. Principal Component Analysis (PCA). The PCA method starts from the correlation between many features involved in the same problem, that is, the "overlapping" of the information of each feature and new features with nonoverlapping information to reflect most of the

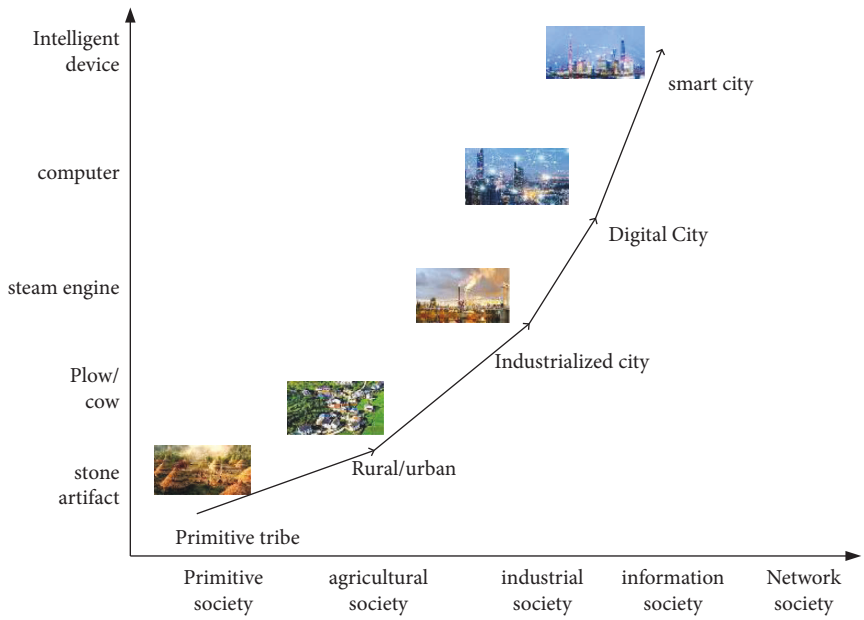

Figure 1: Urban development process.

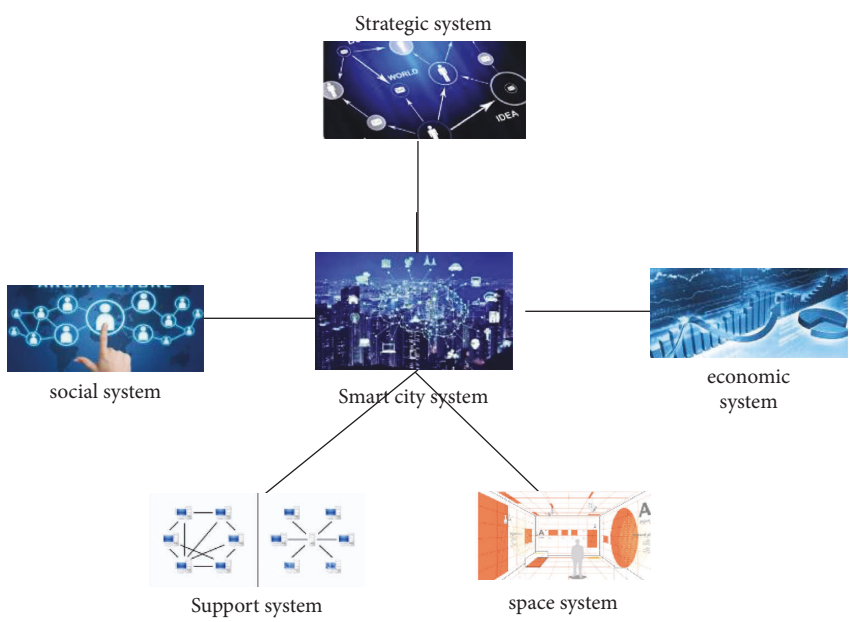

Figure 2: Elements of a smart city.

information provided by the original features, and then solves the problem by analyzing a small number of new features. The basic idea of PCA is to map multiple features onto several synthetic features, the purpose of which is to reduce elements [10]. PCA is to construct a series of linear combinations of the original variables in order to maximize the variance [11].

(1) Principal Component Export. Letting $X = (X_1, X_2,,, X_n)^T$ be an n-dimensional random vector, and $E(X) = r$, perform K-L transformation on X to reduce dimensionality.

$$\begin{cases} Y_1 = \mathrm{r}_{11}X_1 + \mathrm{r}_{21}X_2 + \ldots + \mathrm{r}_{n1}X_n = R_1^{\prime}X \\ Y_2 = \mathrm{r}_{12}X_1 + \mathrm{r}_2X_2 + \ldots + \mathrm{r}_{n2}X_n = R_2^{\prime}X \\ \ldots\ldots \\ Y_n = \mathrm{r}_{1n}X_1 + \mathrm{r}_{2n}X_2 + \ldots + \mathrm{r}_{nn}X_n = R_n^{\prime}X \end{cases} \tag{1}$$

$$R_1^{\prime} = (r_{1i}, r_{2i},,r_{ni})\,(i = 1, 2, n).$$

According to the principle of principal components, $Y_i = R_i^{\prime}X$ should be maximized as much as possible, and each Y_i should be independent of each other. Among them, Y_1 has

the largest variance, and it gets smaller and smaller in sequence. Indicator Y_1 is the first principal component of the original variable, Y_2 is the second principal component, and so on, and the variances of these components decrease in turn. The K-L transform is discussed below.

(2) Contribution Rate and Cumulative Contribution Rate of Principal Components. Letting $Y = (Y_1, Y_2,,,Y_n)^T$ be a random vector composed of n principal components, then:

$$p_k = \lambda_k / \sum_{i=1}^{n} \lambda_i = var(Y_k) / \sum_{i=1}^{p} var(X_i). \tag{2}$$

This process describes distributing all of the $X_1, X_2,,, X_n$ data obtained from the main unit's kth, and p_k is the total contribution amount of the large unit $Y_k k$th. The sum of the contribution rates of the first j principal components is the information ability of the first j principal components, usually $j < k$, if the cumulative share rate of the first component of j is equal to or equal to 85%, the initial variable may be replaced by the first primary component of j [12, 13].

3.2.2. Cluster Analysis

(1) Similarity Measure. When judging whether things are similar, a scale is needed, and this scale is called a similarity measure. Distance is a measure of similarity. It is judged whether two samples belong to the same class according to the difference in distance between samples. The smaller the distance, the more similar.

Letting the eigenvectors of the two samples X and Y be:

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \cdots \\ x_n \end{bmatrix} = (x_1\, x_2 \ldots x_n)^{\mathrm{T}}, \tag{3}$$

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ \cdots \\ y_n \end{bmatrix} = (y_1\, y_2 \ldots y_n)^{\mathrm{T}}. \tag{4}$$

There are various methods for measuring the distance between X and Y, such as Euclidean distance, included angle cosine distance, etc. The most common method is Euclidean distance. Euclidean distance, that is, the actual distance between two points in m-dimensional space and the distance in two-dimensional space. Its calculation formula is as follows:

$$d_{ij}^2 = (X - Y)^T (X - Y) = \sum_{k=1}^{n} (x_k - y_k)^2 \tag{5}$$

(2) Clustering Algorithm. There are many types of clustering algorithms, the following focuses on the dynamic clustering algorithm [14, 15]. The dynamic clustering algorithm first selects multiple samples as cluster centers and then classifies them according to the clustering criteria. During the clustering process, the cluster center will continue to change until it becomes appropriate. The basic process is shown in Figure 3.

Other methods can also be used to select initial cluster centers and to select initial classification methods. After classification, judge the rationality of the classification and decide whether to modify it [14]. Therefore, many clustering algorithms have emerged to judge whether the classification is reasonable. For example, the criterion function of the K-means algorithm is as follows:

$$\mathrm{J} \sum_{\mathrm{j}=1}^{\mathrm{k}} \sum_{\mathrm{i}=1}^{\mathrm{n_j}} \left\| \mathrm{X_i} - \mathrm{Z_j} \right\|^2 \mathrm{X_i} \in \mathrm{S_j}. \tag{6}$$

3.2.3. Cointegration Test

(1) Unit Root Process. First, the stationary stochastic process is expressed as follows:

$$Y_m = \mu + \varepsilon_m + \psi \varepsilon_{m-1} + = \mu + \psi(L) \varepsilon_m. \tag{7}$$

The root of $\psi(L) = 0$ is outside the unit circle, and ε_m is a white noise process with mean 0 and variance 3. Differentiating the stationary process once:

$$\begin{aligned} (1 - L) Y_m &= (1 - L)\mu + (1 - L) B(L) \varepsilon_m, \\ \psi(L) &= (1 - L) B(L). \end{aligned} \tag{8}$$

At this time, $\psi(1) = 0$, so when $\psi(1) \neq 0$, keep the horizontal variable nonstationary.

(2) Cointegration Test Process. If a linear combination is found, the variable after the linear combination of the nonstationary random process is in a stable state, then there is a cointegration relationship between the nonstationary processes, otherwise, it does not exist. The residual-based test method is to find a linear combination and judge whether the random process after the combination is stable [15, 16]. The basic idea of the covariance relationship is that a linear combination of two or more variables can exhibit stability even if they are not equal. Before performing the cointegration test, use the ADF unit root test to test the stationarity of the two-time series. The common test method is the unit root test method. The unit root test is a test for the existence of a unit root in a sequence, which can indicate that the unit root process in the sequence is unstable, leading to spurious regression in regression analysis.

3.3. Evaluation Method of Urban Economic Benefit Based on Intelligent Sensing and Communication Technology. The purpose of the analysis and calculation of a project is to give a corresponding qualitative or quantitative evaluation based on the results of the discussion, so as to provide decision-makers with guiding suggestions and a decision-making basis. There are two key issues in the evaluation method, one

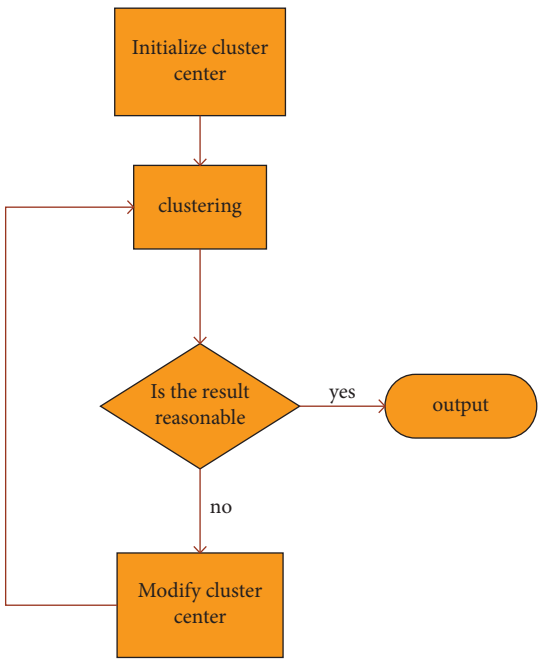

Figure 3: Dynamic clustering algorithm.

is the effective establishment of the index system, and the other is the proper selection of the evaluation method. Next, a comprehensive evaluation method for economic benefits is given.

3.3.1. Urban Economic Benefit Evaluation Index System. According to the characteristics of the city itself, combined with the classification results identified by the cost-benefit analysis, an evaluation index system of urban economic benefits is established. The evaluation of these index systems can effectively reflect the overall situation and development law of the economic benefits of urban rail transit projects, so as to analyze the existing problems and give reasonable suggestions [17]. Figure 4 shows the specific index system.

(1) Benefit to Cost Ratio. Benefit-cost ratio refers to the ratio of the discounted value of all internal benefits to the sum of all internal costs since the operation of the city project, as shown in the following formula:

$$\mathrm{BCR} = \frac{\sum_{i=0}^{n}\left[B_t/(1+i)^t\right]}{\sum_{i=0}^{n}\left[C_t/(1+i)^t\right]}. \tag{9}$$

In the formula, BCR represents the benefit-cost ratio, t represents the operation year after the project investment and construction are completed.

(2) Economic Internal Rate of Return. The economic internal rate of return is calculated as shown in equation (2).

$$\sum_{t=0}^{n}\frac{B_t}{(1+\mathrm{IRR})^t}\sum_{t=0}^{n}\frac{C_t}{(1+\mathrm{IRR})^t}. \tag{10}$$

IRR stands for economic internal rate of return.

(3) Net Discounted Present Value of Economic Benefits. It refers to the introduction of time value, that is, the sum of costs and benefits after all the internal costs and benefits involved in the calculation are converted to the calculation time point. Letting the social discount rate be i, then the formula for calculating the net present value of economic benefits NPV is:

$$\mathrm{NPV} = -C_0 + \sum_{t=0}^{n}\frac{B_t - C_t}{(1+i)^t}. \tag{11}$$

(4) Payback Period. The payback period is the period from the year before the net present value appears nonnegative to the start of the project. The smaller the value, the shorter the period for the project to recover the cost and the faster the net profit. According to different issues, returns are divided into social investment return period and commercial investment return period; according to the investment composition of return, they are divided into profit return period and income return period. When a dynamic payback period is used for the calculation, the social discount rate has a large influence on this value [18]. The higher the discount rate, the longer the project's payback period. The calculation method is as formula (4).

$$\sum_{t=1}^{p_t}\left(B_t - C_t\right) * (1+i)^{-t} \geq 0. \tag{12}$$

3.3.2. Establishment of Economic Benefit Evaluation Model

(1) Evaluation Method. The existing evaluation methods can generally be divided into three types: parametric evaluation method, nonparametric evaluation method, and comprehensive evaluation method. The essence of the parameter evaluation method is to analyze the operation efficiency of a project by constructing the relationship between the benefit function and the cost function. The comprehensive evaluation method refers to a comprehensive overall evaluation of the object system described by the multi-attribute structure. Figure 5 shows the classification of comprehensive evaluation methods.

The city is a huge and complex system, and the evaluation of its economic benefits needs to be comprehensively evaluated from all angles in order to obtain representative and referenced evaluation conclusions. The urban economic benefit index system has the characteristics of high dimension, multidimension, difficult to determine the weight and has imperfect industry standards. Based on the above characteristics, the projection pursuit method in the statistical analysis method is selected to comprehensively evaluate the economic benefits of the city. The principle is to use computer technology to project multi-dimensional data into low-dimensional subspaces and analyze the data structure to explore and analyze multi-dimensional data in low-dimensional space. Based on this method, this paper will establish an urban economic benefit evaluation model.

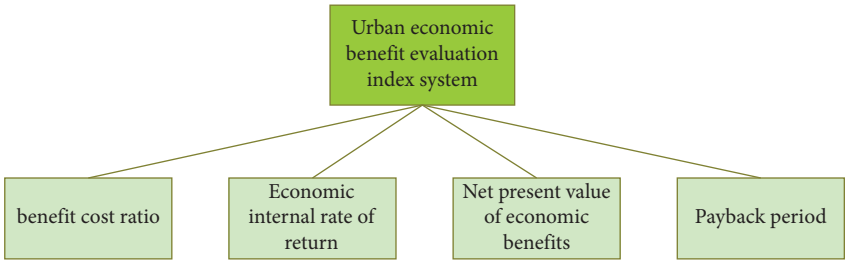

Figure 4: Evaluation index system of urban economic benefit based on intelligent sensing and communication technology.

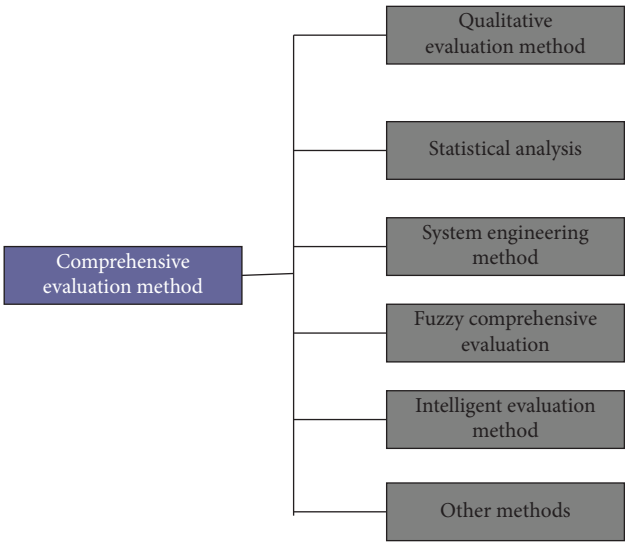

Figure 5: Classification of comprehensive evaluation methods.

(2) Model Establishment. According to the calculation result of the index, the index value of the grade is given according to the experience of experts, and the distance to the central threshold of each evaluation grade is calculated, statistically obtained index evaluation data are shown in Table 1.

For the index evaluation data set, let the kth level of the jth index be l_{jk} ($j = 1,2, \ldots, m$; $k = 1,2, \ldots, n$), m is the number of indexes 4, m 5 for the number of levels. The steps to establish an evaluation model for it are as follows:

Since the dimensions of each indicator are not the same or the numerical range is quite different, the data is normalized before modeling.

$$x'_{jk} = \frac{x_{jk}}{x_{k\max}}. \tag{13}$$

In the formula, $x_{k\max}$ represents the maximum value of the kth index sample.

Then do a linear projection. If $(r_1, r_2, , r_m)$ is an m-dimensional vector, set the projected eigenvalue of the index j in a one-dimensional linear space to Z_i, which is expressed as the formula:

$$Z_i = \sum_{k=1}^{m} r_k x'_{jk} \tag{14}$$

Table 1: Grade evaluation indicators.

	Very nice	Good	Commonly	Bad	Very bad
BCR	>2	[2, 1)	1	(1, 0.5]	<0.5
IRR	>j	[j, 0)	0	(0, −j]	<−j
NPV	>m	[m, 0)	0	(1, −m]	<−m
Pt	<0.1t	[0.1t, 0.5t)	0.5t	(0.5t, t]	>t

Then find the objective function, and locate the objective function $q(r)$ as the product of the inter-class distance $s(r)$ and the intra-class density $d(r)$, as given in the following equation:

$$q(r) = s(r) * d(r). \tag{15}$$

The formula for the distance between classes is as follows:

$$s(r) = \sqrt{\left[\frac{\sum_{j=1}^{n}\left(z_j - \overline{z_r}\right)^2}{\mathrm{n}}\right]} \tag{16}$$

$\overline{z_r}$ means the mean of $\{z(j)|j = 1,2, \ldots, n\}$. Letting the distance of projected eigenvalues be:

$$c_{jk} = \left|z_j - z_a\right| (j, k = 1, 2, n). \tag{17}$$

The formula for calculating the density within the class is:

$$d(r) = \sum_{j=1}^{\mathrm{n}} \sum_{a=1}^{n} \left(C - c_{ja}\right) f\left(C - c_{ja}\right). \tag{18}$$

Finally, the comprehensive index I of urban economic benefits is constructed, and $w = (r_1^2, r_2^2,, r_k^2)$ is used as the grade weight of each index, and the calculation formula (10) is obtained.

$$I = \pm \sum_{j=1}^{n} x_{jk} r_{\mathrm{k}}^2 . j = (1, 2 ,, m). \tag{19}$$

The positive polarity indicator is +, and the negative polarity indicator is −. The positive and negative polarity is defined as the larger the index data, the more positive contribution to the economic benefit is the positive polarity index, and vice versa is the negative polarity index. The larger the I value, the closer the evaluation level is to the level value corresponding to the maximum value.

4. Calculation and Evaluation of Urban Economic Benefits Based on Smart Cities

4.1. Calculation of Urban Economic Benefits Based on Smart Cities

4.1.1. Data Source and Indicator Selection. The data of this experiment comes from the China Urban Statistical Yearbook 2020. The subjects of the experiment are Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou, and the other 18 cities that have developed smart cities. The data of these 10 indicators (such as total number of people, gross product, investment in fixed assets, household savings balance at the end of the year, total industrial output value, total passenger volume, total freight volume, local fiscal revenue, number of on-the-job workers, and total wages of on-the-job workers) at the end of 2020 in these cities are counted and analyzed using MATLAB software. The reason for choosing these cities is that they are the most advanced cities in China and have developed smart cities, and some cities have also achieved some results in this regard.

4.1.2. PCA. In this step, the data is imported into a 10∗4 matrix, and then the covariance of the data after the standardization of the data range is obtained, and finally, the PCA is performed. The specific PCA method has been introduced above. The principal components are labeled from *A-J*, and the results are shown in Figure 6.

As can be seen from the figure, the cumulative contribution rate of the first four principal components reaches 96.76%, and this value is very close to 1, which proves that these four principal components contain almost all the information, so the first four principal components can be used to replace all the principal components.

Table 2 shows the principal component loading matrix.

4.1.3. Cointegration Analysis. This experiment selects the data from 2011 to 2020 for the most cointegration analysis of these time series.

(1) Cointegration Test of GDP and Household Savings Balance at the End of the Year. The sample length of the new work file is 10. The data is imported, and the variables are designed as x and y. Since the data dimensions are different, the logarithm of x and y is taken before the study. The x and y image is shown in Figure 7.

It can be seen from the figure that the x and y sequences are not stationary. Next, the unit root test is performed to see if they are stationary, and the first-order difference is performed on x and y to obtain lx, ly. The unit root test results for lx and ly are shown in Tables 3 and 4.

As can be seen from the table, the p value of the unit root test of lx is 0.0003, while that of ly is 0.0265, which means that both lx and ly have reached a stationary state, and x and y have a single integer of the same order.

(2) Cointegration Test of GDP and the Average Number of Employees. The time series from 2011 to 2020 is tested, and the average number of on-the-job employees, series X is shown on the left of Figure 8, and the GDP series Y is shown on the right of Figure 8.

It can be seen that both series are not stationary. Then, by checking the unit root of X and Y to see the specific numerical judgment, the results are shown in Table 5.

It can be seen that the two-time series are not single-integrated in the same session, so there is no long-term stable relationship between GDP and the average number of employees.

To sum up, this experiment adopts PCA and selects the first four principal components for the co-integration test. It is found that there is a long-term stable relationship between GDP and household savings balance at the end of the year.

4.2. Evaluation of Urban Economic Benefits Based on Smart Cities. In this experiment, taking the city of Wuhan as an example, according to the economic benefit evaluation model established above, combined with intelligent sensing and communication technology, to evaluate the economic benefits of Wuhan Metro Line 5. This experiment provides information on four dimensions: Benefit-Cost Ratio (BCR), Economic Internal Rate of Return (IRR), Net Discounted Present Value (NPV) of Economic Benefit, and Payback Period (1) of Wuhan Metro Line 5. 100 experts came to score the urban economic benefit index level. The evaluation results are counted and the data are normalized to obtain the results as shown in Figure 9.

Next, using MATLAB to realize the projection pursuit model, the calculation result is shown in Figure 10.

As can be seen from the figure, among the four economic benefit indicators, the largest weight is the investment return period, with a weight of 0.54, and the second is the benefit-cost ratio, with a weight of 0.48. Therefore, when evaluating economic benefits, these two items are the most important and should be placed first. And it can be seen from the second figure that the economic benefit status of Wuhan Metro Line 5 is 4. Metro Line 5 has brought great social and economic benefits to Wuhan, but it still needs financial subsidies to support operations. Therefore, it is necessary to deepen the reform, reduce costs, and increase the profitability of the project to improve the economic benefits of Wuhan Metro Line 5.

5. Discussion

Urban economic benefits refer to the comprehensive comparison of the input and output of all economic activities in the urban space within a certain period, and it is a national benefit that integrates production and various needs. The economic benefit index is an indicator of urban economic activities. It has the function of regulating and controlling urban economic activities and can induce the combination mode of urban production factors and the

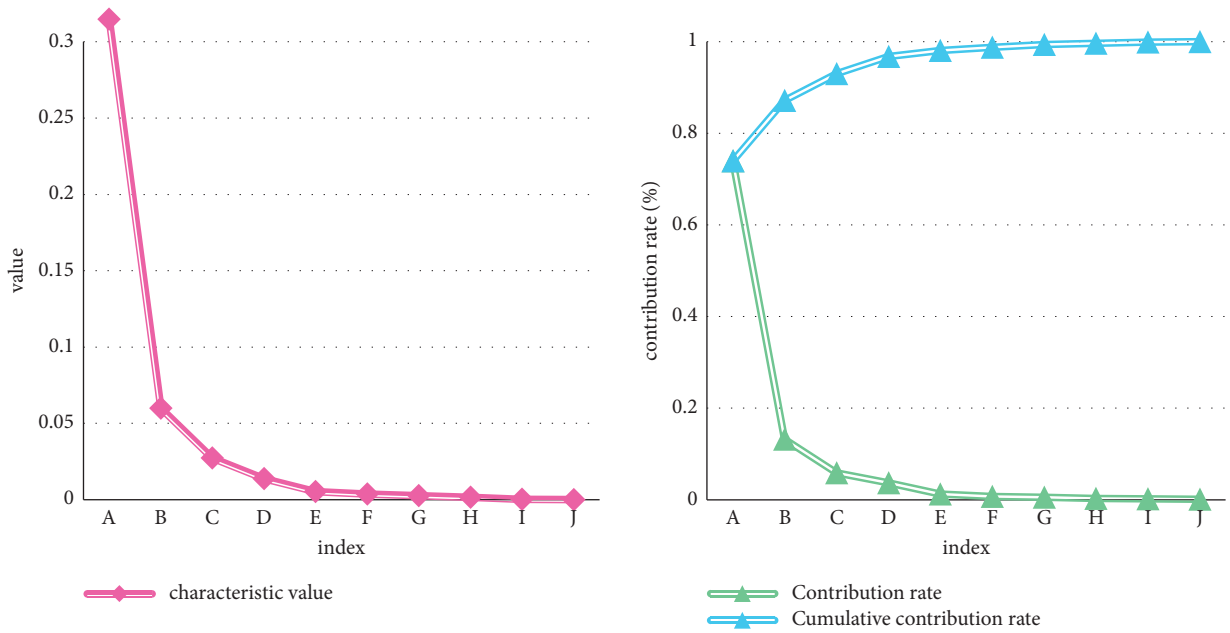

Figure 6: Pca results.

Table 2: Principal component loading matrix.

Index	A	B	C	D
Total number at the end of the year	−0.1967	−0.3756	−0.3209	−0.1423
Gross domestic product	0.4763	−0.1479	−0.1726	0.6281
The gross industrial output value	0.2344	−0.1162	−0.4493	0.2683
Total passenger volume	0.2879	−0.1605	−0.3092	−0.6217
Total freight volume	0.3318	−0.1821	−0.3105	−0.2492
Local fiscal revenue	0.6612	0.1362	0.4628	−0.1527
Investment in fixed assets	0.0635	0.2297	0.0921	−0.2216
Savings balance of residents at the end of the year	−0.1206	−0.1501	0.1744	0.0538
Number of on-the-job employees	0.0103	0.8193	−0.4382	0.0042
Total wages of on-the-job employees	0.1785	−0.0154	0.1612	−0.0291

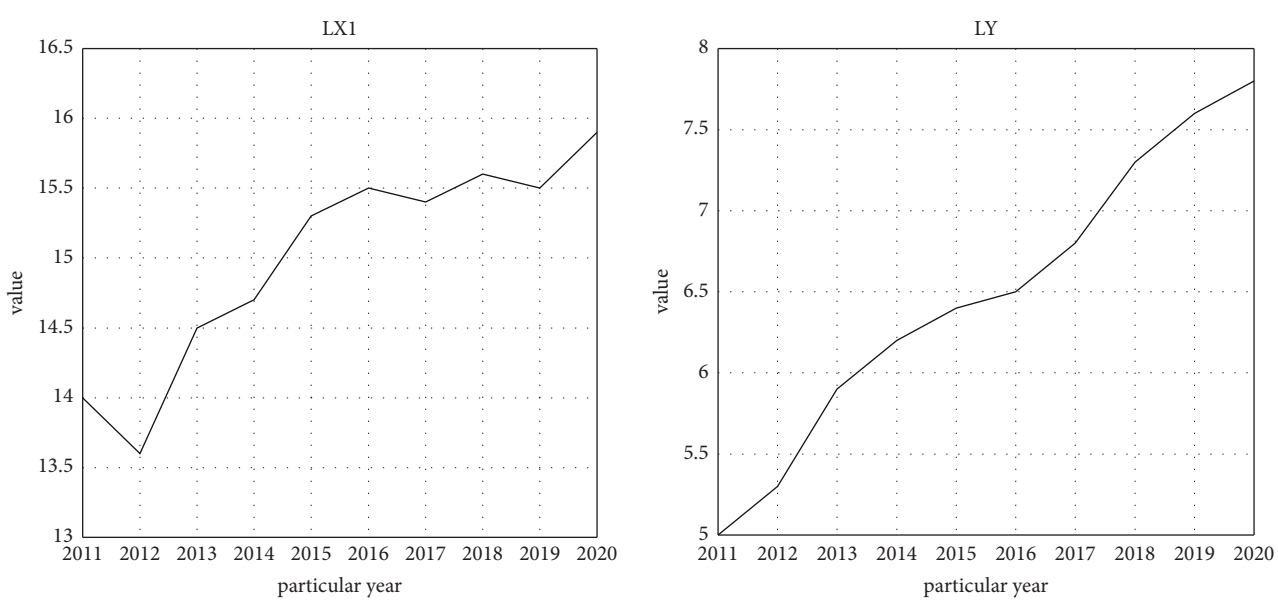

Figure 7: x, y trend graph.

Table 3: Unit root test results for lx.

		T-statistic	Prob.*
The augmented Dickey–Fuller test statistic		−5.7247	0.0003
Test critical values	1% level	−3.9281	
	5% level	−3.0372	
	10% level	−2.6913	

Table 4: The unit root test results of ly.

		T-statistic	Prob.*
Augmented dickey-fuller test statistic		−3.3532	0.0265
Test critical values	1% level	−3.9281	
	5% level	−3.0372	
	10% level	−2.6913	

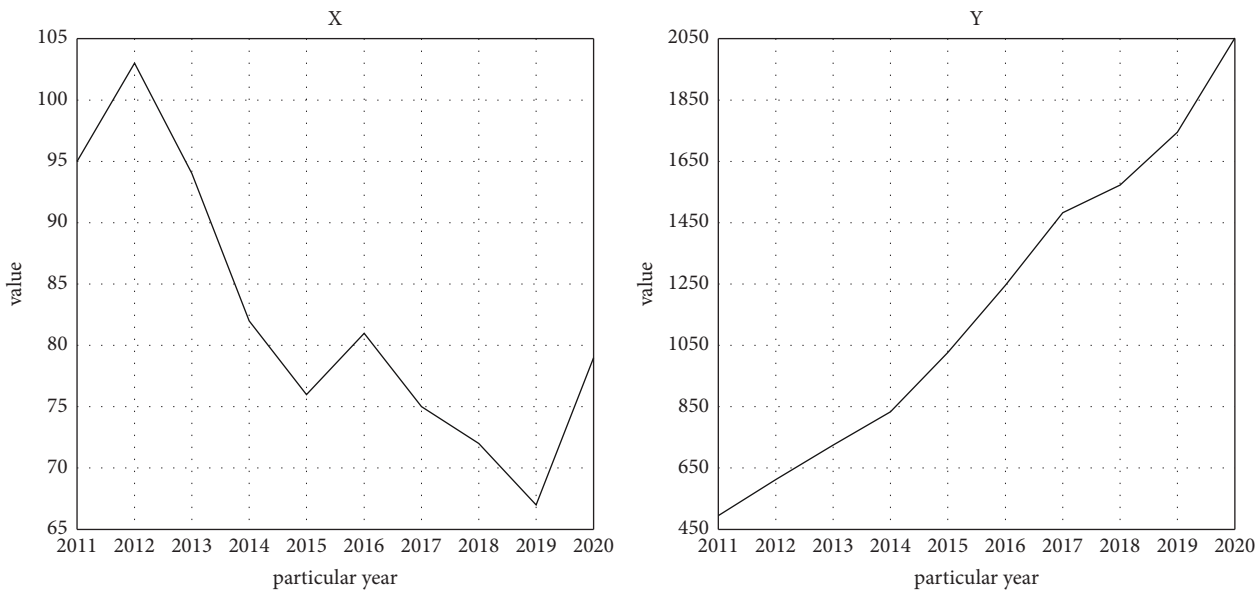

Figure 8: X, Y trend graph.

Table 5: X, Y unit root test results.

	P
X	0.5826
Y	0.9972
LX	0.0484
LY	0.1271

investment direction of resources. The new role of urban economic benefits is that it not only provides new theories and methods for urban management workers to comprehensively improve urban economic benefits and successfully realize urban modernization, but also breaks through the limitation of the concept of departmental economic benefits, and finds indirect factors, internal factors and external factors, individual factors and public factors that restrict urban economic benefits. This is to find a systematic way and a method to improve economic efficiency in an all-around way. Therefore, it is very important to explore the calculation and evaluation of urban economic benefits.

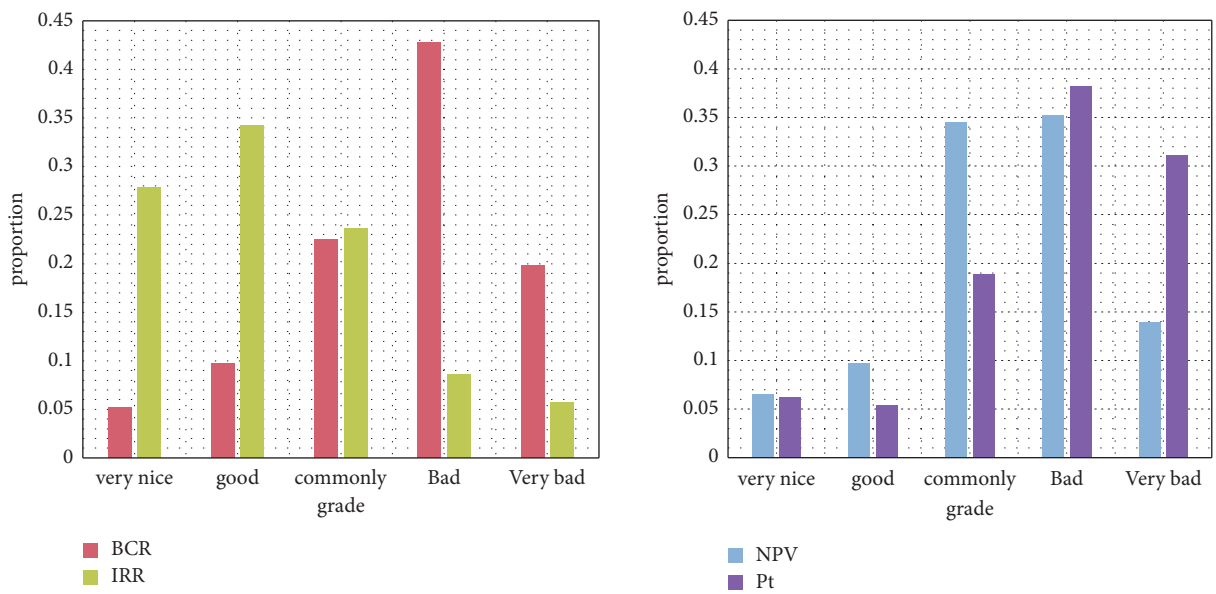

Figure 9: Expert scoring results normalized dataset.

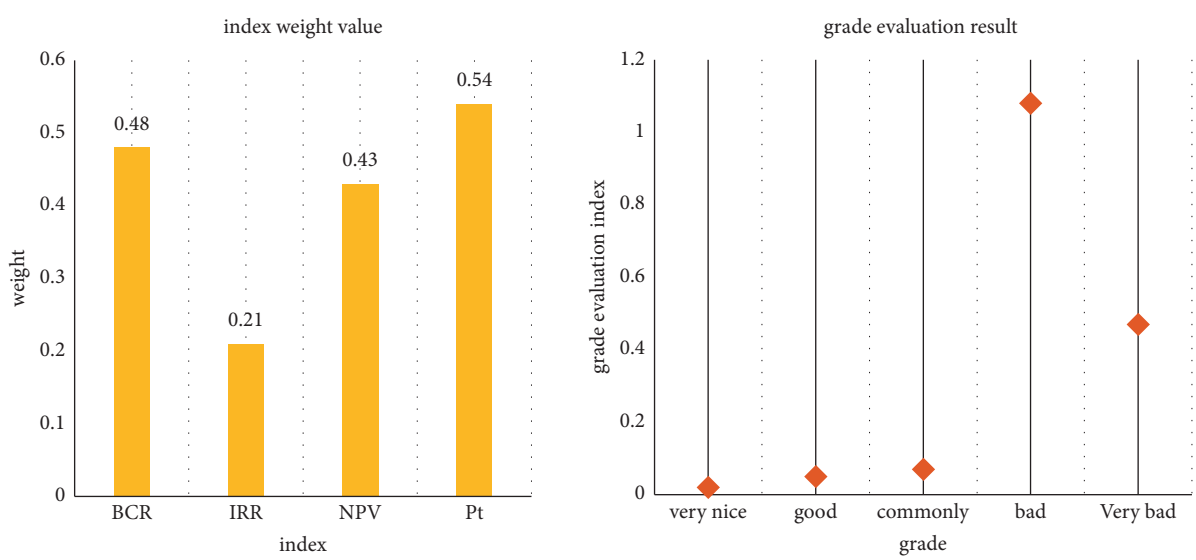

Figure 10: The weight value of the indicators and the comprehensive evaluation results of economic benefits.

6. Conclusion

A smart city is the goal of the current urban development process, which requires the promotion of sustainable urban development while developing the economy. The urban economic benefit is a comprehensive evaluation of a city. In simple terms, intelligent sensing technology is a system and a sensor with information processing functions. It has the ability to collect, process, and exchange information and is an indispensable part of the information age. This article discusses the economic benefits of a smart city. This paper firstly introduces the concept and elements of a smart city, combined with intelligent sensing and communication technology, and then designs the calculation method of urban economic benefit based on PCA, cluster analysis, and cointegration analysis; and then establishes the evaluation model of urban economic benefit; finally, this paper designs an experiment. First, 18 cities in China that have developed smart cities are used as experimental objects to explore the relationship between GDP and some indicators through several analytical methods. Then, using the evaluation model of this paper, taking Wuhan Metro Line 5 as an example, to evaluate its economic benefits, it is concluded that the economic benefit status of Wuhan Metro Line 5 is 4. Therefore, it is necessary to deepen the reform, reduce costs, and increase the profitability of the project to improve the economic benefits of Wuhan Metro Line 5. Although many scholars have paid attention to the field of smart cities, the

research is relatively macro and theoretical, and there is no article on the economic benefits of smart cities. From this point of view, the content of this paper is relatively innovative.

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 there are no conflicts of interest.

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Retraction

Retracted: Identification of Scientific Research Evaluation Indicators of College Teachers Based on Wireless Communication Network

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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Research Article

Identification of Scientific Research Evaluation Indicators of College Teachers Based on Wireless Communication Network

Zhi Li [1,2] and Zhanyong Qi [1]

[1] *Department of Education, Shaanxi Normal University, Xi'an 710058, Shaanxi, China*
[2] *School of Physical Education, Xi'an University, Xi'an 710065, Shaanxi, China*

Correspondence should be addressed to Zhi Li; ardonis@xawl.edu.cn

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The evaluation indicator of teachers' scientific research is a very important criterion in the evaluation of teachers' scientific research in colleges and universities. Generally, indicators are divided into three levels, and each indicator setting must be very precise. Many indicator systems for college teachers have been created at present. However, there are some problems in the identification of indicators in the evaluation process. There will be cross-repetition between indicators, and the quantification of indicators is not detailed enough, resulting in inaccurate results. To solve these problems and make the evaluation results more fair and accurate, this paper took a university as a case, a deeply discussed method based on wireless communication network, and conducts an experimental analysis on the identification of university teachers' scientific research evaluation indicators. Using the method of wireless communication network, the problem of index identification was analyzed, and the experimental research of index identification was carried out by using wireless communication network. The results showed that the index of engineering teachers' practical ability was relatively high, and the weight value was 0.38. The liberal arts was relatively low, and the weight value was only 0.26. However, on the cognitive index, the weight value of liberal arts was the highest, with the weight value of 0.33 while that of engineering was only 0.28. It can be seen that the method applied in this paper greatly improved the efficiency of the whole evaluation, and it made the index recognition more rapid and accurate. Therefore, further research on wireless communication networks and index identification can be considered.

1. Introduction

Colleges and universities gathered a lot of outstanding scholars, and they are rich in resources, which are favorable conditions for teachers to conduct scientific research. With the country's emphasis on this aspect of development, university scientific research has almost become the leading part of China's scientific research. And it made great contributions to China's scientific research achievements. However, due to the rapid development of society, the depth and breadth of scientific research are constantly expanding, the level of scientific research ability of teachers is also getting higher and higher, and this scientific research work is also becoming increasingly complicated. If colleges and universities want to keep up with the pace of the times and meet the ever-changing needs of the situation, they need to provide an effective evaluation index system for teachers' scientific research. However, the current evaluation indicators cannot accurately identify different types of teachers in different subjects. There are also many scholars who study the evaluation index system of this project, but few studies are based on wireless communication network technology. The wireless communication network combines two technologies of network technology and radio communication technology. It has strong work efficiency and high convenience. Therefore, this paper attempted to use this technology to study the identification of teachers' scientific research evaluation indicators, hoping to obtain the expected results.

Due to the steady development of scientific research in colleges and universities, increasingly scholars have

conducted research on the evaluation index system of teachers' scientific research. Among them, Hong proposed the principles and specific performance evaluation index system by constructing the basic course teaching team performance evaluation index system [1]. However, he ignored the evaluation index of scientific research achievements when constructing the performance evaluation system. Sadegh assessed the current applicability of articles in which college faculty show important advances in medicine [2]. However, he did not focus on the standards of scientific research evaluation indicators in the article. Yuan used a new evaluation algorithm to evaluate the scientific research ability of college teachers more comprehensively and effectively [3]. However, he did not show the flow of the algorithm in the text. Qi attempted to make the evaluation system of college teachers scientific, systematic, and standardized to promote the growth of teachers' research level [4]. However, none of the data he used in the paper was up-to-date. By studying the research reports of other scholars, Fan studied the internal control of colleges and universities based on two evaluation frameworks to conduct scientific and reasonable evaluations [5]. However, he did not take into account the variable that varies from school to school in his research. Chavda developed and implemented a structured evaluation model to develop research skills in medical schools [6]. However, the model he used in the paper was not very suitable for this topic. Azouaou assessed the impact of research indicators on the acquisition of basic knowledge for conducting research projects in three conceptual, operational, and editorial stages [7]. However, the theoretical knowledge he quoted in the article was too rich and lacked personal discussion.

Scientific research can be said to be a relatively innovative activity, which can well help the development of colleges and universities and promote the progress of the national scientific and technological level. The innovation of this paper is that it used a different method, wireless communication network, to conduct research on the identification of university teachers' scientific research indicators. In the research process, a large amount of relevant data were called and analyzed in a convenient way to provide support for the future teacher research evaluation system.

2. Method of Identifying the Evaluation Index of Scientific Research of Teachers in Colleges and Universities

2.1. Evaluation Indicators of Scientific Research of College Teachers. The work of college teachers is mainly in two aspects, one is to teach students and the other is to conduct scientific research [8]. The scientific research evaluation is a way to check the scientific research level of teachers. After the evaluation, the degree of the teacher's scientific research level can be quickly obtained. Then, according to the teacher's scientific research level, his future training, upgrades, and reward can be decided. An effective evaluation can effectively improve the scientific research level of teachers and improve the teaching level. It is also of great help to the growth of the country's scientific research strength.

Generally, the performance inference method is used to evaluate teachers' scientific research ability. Among them, the relationship between scientific research performance and scientific research ability is shown in Figure 1.

As can be seen from Figure 1, the relationship between scientific research ability and scientific research performance has a certain identity, and there is a certain interaction [9]. Performance can reflect the ability of teachers, and many evaluation methods are realized by studying teachers' performance. Because performance can well represent the state of the teacher's ability level, ability is the intrinsic factor of performance, and ability can determine performance. Generally speaking, teachers with excellent ability will perform well. However, competencies are sometimes influenced by external environments, such as teamwork or laboratory environments. Therefore, scientific research performance can represent scientific research ability, but it cannot represent the full ability of teachers.

Generally speaking, the evaluation indicators mainly have the following parts as shown in Table 1.

As shown in Table 1, there are generally four evaluation indicators. The first is the origin indicator [10]. It means what the teacher produces directly after conducting scientific research such as academic papers, monographs, and invention patents. The second is the additional index, which means that it is one level higher than the original index. A high-quality part is selected for addition based on the original index, such as scientific and technological rewards and citations of books. The third is the derived indicator, which is one level higher than the first two indicators. It is based on the first two indicators, and it represents a kind of social recognition for scientific and technological teams and individuals such as directors of societies and research societies, which represent the social recognition of scientific researchers. The fourth is the support indicator. It is the main support for scientific research, and it can guarantee the continuous output of science such as grant funding and human resources. However, after investigation, it can be found that when colleges and universities conduct the evaluation of teachers' scientific research ability, the evaluation index system will not be specially changed for different types of teachers. This is very unreasonable. Even in the same school, there are different disciplines, and the difference between liberal arts and science is still very big. The type and nature of scientific research activities undertaken by the faculty are largely different. Some teachers do basic activities, and some teachers do applied activities. Therefore, the evaluation indicators should be changed with different types of activities to preserve the characteristics of teachers' scientific research and ensure the objective nature and comprehensive nature of the entire evaluation system. Through this way, the enthusiasm of teachers to actively participate in the work is increased.

Then, the main factors that affect individual performance are studied as shown in Figure 2.

As shown in Figure 2, it can be seen that there are mainly four influencing factors. The first is skills. Skills can

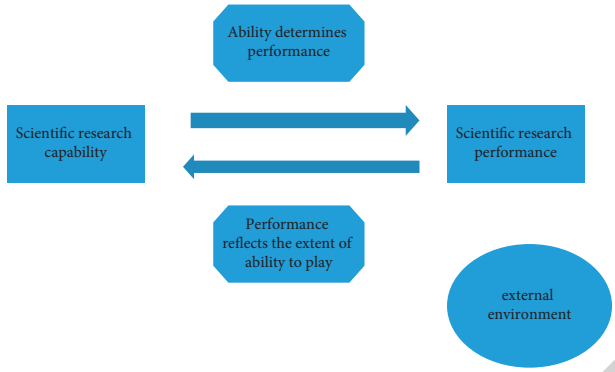


Figure 1: Concepts of research performance and research capacity.

Table 1: Evaluation metrics.

	The index type	The specific content
1	Source raw indicators	Academic papers, monographs, invention patents, identification, R&D achievements, and scientific and technological services
2	Additional indicators	Science and technology awards, citation, be called, be picked, be loaded and practical application, etc.
3	The derived indicators	Association, research association, professional journal editorial board, etc.
4	Support indicators	Funded funds, human resources, etc.

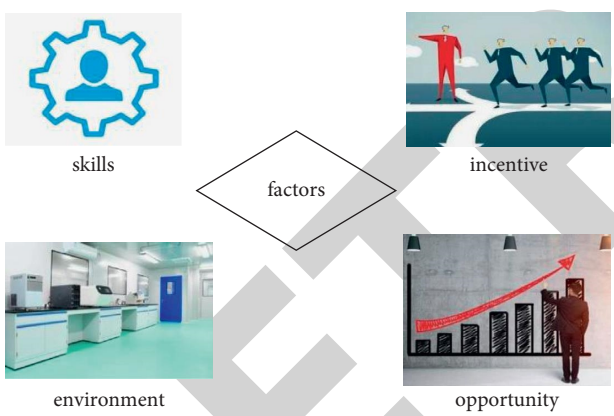


Figure 2: Main factors affecting individual performance.

be said to be the sum of personal abilities. In the process of scientific research, mastering the output of personal skills can effectively improve the level of personal performance [11]. If skills are lacked when working with people in a team, the contribution to scientific research will often not be great, so personal skills are the main factor affecting performance. The second is incentives. With the blessing of excellent skills, when perfect results are produced, although there is no corresponding reward, it will also affect the motivation of teachers in scientific research [12]. Just imagine, if the emphasis is put on the reward, teachers can make teachers work harder to carry out scientific research after receiving spiritual or material encouragement. The third is the environment, which has a great influence on teachers' scientific research. The most important thing in the scientific research process is the teamwork and the accumulation of previous scientific research. If the teamwork and cooperation are not good, the output of scientific research results will not be good, and the performance of teachers will decline. Therefore a good research environment is also essential to improve the ability of teachers. The fourth is opportunity. After entering the job, it is essential for teachers to seize the right opportunity. A suitable opportunity allows teachers to effectively improve themselves and display their abilities. It can also make a contribution to national scientific research.

Indicator is a way to quantify teachers' scientific research ability. The setting of indicators should be very precise and easy to be effectively identified [13]. The principles of evaluation index design are shown in Figure 3.

As shown in Figure 3, there are five design principles for scientific research evaluation indicators. The first is the principle of specificity. That is to say, the indicators must be very clear and specific and should not be too general. The indicators should be refined according to other factors such as the type of activities that teachers conduct, and the indicator settings should be flexible. The second is the measurable nature. The design of indicators should not be too written and should be set as quantifiable behaviors that can be obtained with data and information. The third is attainable, which means that the indicator is that which teachers can accomplish through their own efforts. However, this indicator cannot be set too low. If it is too low, the whole evaluation will be meaningless. The fourth is correlation, which is essential for evaluation indicators. Evaluation indicators must be related, and it must be related to the scientific research work of teachers. The sixth is time-limited, which means that the indicator must set a time unit, and the starting time for completing the indicator needs to be determined [14].

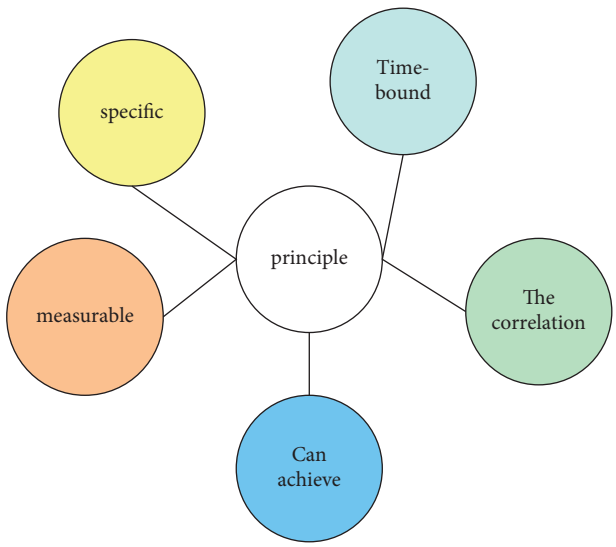


Figure 3: Design principles.

2.2. Wireless Communication Network. Wireless communication network refers to a wireless computer network, a technology that can generate information connections without cables [15]. Its development is actually very fast, and its application range is also very wide. About this technology, it is now a household name. However, due to the improvement of people's material living standards, the requirements for wireless communication network technology are also increasing. The coverage of wireless networks is very large [16] as shown in Figure 4.

As shown in Figure 4, it can be found that the wireless network covers a very large area in the entire city, almost everything is covered [17]. The development of computer technology and network technology is stable and rapid, and various industries have also applied this technology. It is not difficult to find that the most used network is the local area network at present. Although the existence of the wired network before this also has its advantages, the transmission speed is fast, and the popularity in the market is also very good. However, the generation of wireless networks has greatly reduced the cost of the product, and its potential in the market is unlimited. It has the advantages of reliable communication, low cost, and high flexibility that can make people's connections more convenient.

In regard to wireless communication networks in general, cellular networks come to mind. It is named cellular network because of the arrangement of base stations, which looks like a cellular frame [18]. A schematic diagram of a cell and a basic communication mode diagram are shown in Figure 5.

As shown in Figure 5, the cellular wireless communication network system is composed of mobile nodes, fixed base station, wired backbone networks, and switching control centers. The connection between mobile nodes and base stations is one-hop, also known as a single-hop wireless network [19]. Information is transmitted between base stations and wireless nodes through wireless signals. The switching center and the base station are connected by wired cables. In this way, the switching center can be connected to the public network, allowing users to communicate with the outside world. If the cellular network has a large coverage area, there will be a problem of blind spots. Blind spots are generally caused by obstacles blocking electromagnetic waves, such as subway stations, or the shadows of tall buildings. These places will have poor signal and poor communication conditions. There may also be problems with hotspot areas, mainly because the number of people using the network is too large, causing the network to be congested and the system to crash. It happens generally in areas such as commercial centers and traffic arteries. It has also been envisaged to ameliorate crowding by amplifying broadband. However, the effect is not very good, and it will affect the surrounding signal. Then came the microcell technology, which has small coverage, low power, and little interference with nearby signals. It is very good to deal with the situation of network congestion. However, since this kind of network has been superimposed many times, even if it can effectively solve the problem of blind spots and hot spots, it will cause trouble to the terminal.

After consulting the relevant information and summarizing, the advantages of the wireless communication network can be found as shown in Figure 6.

As shown in Figure 6, it can be found that its advantages can be summarized into five points. The first point is convenience. This technology combines wireless network and wireless communication technology. In terms of flexibility, it combines the advantages of the above two technologies and will be more flexible in information transmission. It is able to support roaming, and the mobility is also very good. The second point is affordability. Its carrying capacity is much better than that of a single communication technology, and it can withstand the transportation of big data. The third point is speed, which is much faster than wired transmission, and it is not limited to the location of the cable, as long as it is covered by wireless information that can be received. Even for very large data, the transmission speed can achieve a certain efficiency. The fourth point is aesthetics. The previous wired network was built with cables, which would lead to unsightly urban lines. The fifth point is work efficiency. Wireless networks are significantly more efficient than wired networks. The transfer rate is significantly enhanced.

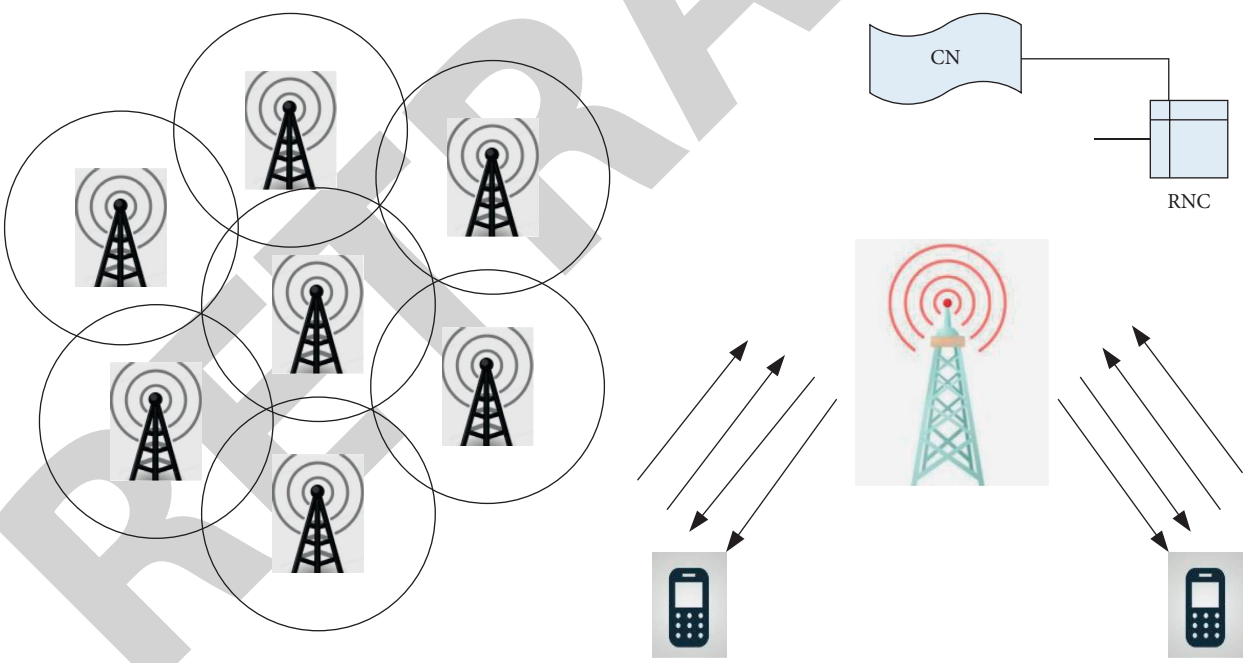
2.3. Related Algorithms. The traditional evaluation system relies on the evaluation of the system's simple network performance, but with the increasing complexity of evaluation indicators, more mature technologies are needed to help in the identification of evaluation indicators. This processing mode can rely on a series of models to achieve [20].

Assuming that there is M_{ND} system user, the power value received by the system is

$$O_Y = M_{TH} + B_{SG} \times M_{ND} Q_P. \quad (1)$$

If user K receives power Q_P to the system, then

Figure 4: Schematic diagram of wireless network coverage.



(a) (b)

Figure 5: Cellular network. (a) A cell. (b) Communication mode.

$$A_K = \frac{Q_P}{O_Y} = \frac{Q_P}{M_{YJ} + B_{SG} \times M_{ND} Q_P}. \quad (2)$$

Therefore, it is deduced that after M_{ND} users using the system, the total load is

$$A = \sum_{K=1}^{M_{ND}} N_{SG} \times A_K = \frac{B_{SG} \times M_{ND} O_P}{M_{YJ} + B_{SG} \times M_{ND} Q_P}. \quad (3)$$

If the system needs an energy of R_N to receive the signal of user K, the expression can be obtained as

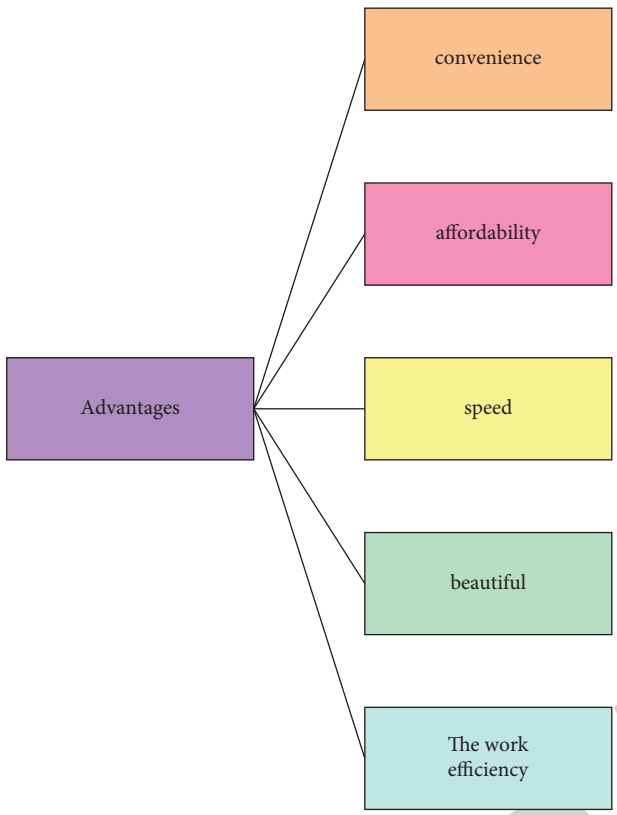


Figure 6: Advantages of wireless communication networks.

$$\left(\frac{R_N}{M_P}\right)_K = \frac{QH_K \times Q_P}{M_{YJ} + B_{SG} \times M_{ND} Q_P - B_{SG} Q_P}. \quad (4)$$

Among them, QH_K is spread spectrum, then get the formula Q_P as follows:

$$Q_P = \frac{[R_N/M_P]_K}{([R_N/M_P]_K/QH_K) + 1} \times O_Y. \quad (5)$$

The limit capacity of the network is 100% load, then it can get

$$100\% = \frac{M_{ND}}{1 + (OH/(R_N/M_P)B_{SG})}. \quad (6)$$

At this time, the limit capacity value M_{ND} can be expressed as follows:

$$M_{ND} = 1 + \frac{QH}{(R_N/M_P)B_{SG}}. \quad (7)$$

Among them, the relationship between R_N and M_P can be expressed as follows:

$$\frac{R_N}{M_P} = \frac{D}{M} \cdot \frac{E}{T}. \quad (8)$$

If $D \geq D_{MINS}$, then R_N and M_P will satisfy

$$\frac{R_N}{M_P} \geq D_{MINS} * \frac{E}{T}. \quad (9)$$

In the operation of the real system, the identification of indicators is relatively weak. Therefore, on the basis of the existing indicators, the interference problem of identification should be considered such as the interference of multiple users and the interference caused when there are many indicators. Among them, the interference formula can be expressed as follows:

$$O_{RC} = \sum_{L=1}^{M_{TD}} O_L. \quad (10)$$

The total influencing factors can be expressed as follows:

$$O_Y = O_{OM} + O_{RC} = O_{OM}\left(1 + \frac{O_{RC}}{O_{OM}}\right) = O_{OM}(1 + G). \quad (11)$$

If the moving coordinates of the system are functions of the variables, the energy required of N_K is

$$\left[\frac{R_N}{M_P}\right] = QH_K \frac{Q_{OK} A_{YK}}{M_{YJ} + O_Y}, \quad O_Y = \gamma O_{OM} + O_{RC}. \quad (12)$$

Under control, only part of the disturbance remains

$$\gamma O_{OM} = \gamma Q_{\mathrm{MAX}} A_{OK}, \quad O_{RC} = \sum_{Y=1}^{M_{ND}} Q_{\mathrm{MAX}} A_{YK}. \quad (13)$$

A digital model can be built based on it. Assuming that the minimum number of base stations required by the system needs to be met, it can be expressed as follows:

$$\mathrm{MING}_1 = |\delta|. \quad (14)$$

If the length of the set is expressed as δ, the power allocation of the system can be formulated as follows:

$$\sum_{K \in k} Q_{\mathrm{MAX}} \leq Q_{\mathrm{MAX}}. \quad (15)$$

User M_O of the system cannot exceed the maximum allowed total, then get

$$M_O \leq M_{\mathrm{MAX}} * \rho^L. \quad (16)$$

If the coverage area must be fully covered, then

$$\sum{}_{I=1}^{N} \left(\frac{D_O^L}{D^L}\right) = T^L. \quad (17)$$

Finally, the value range of the decision variable becomes

$$(C_O, U_O)\epsilon F. \tag{18}$$

3. Experiments on the Identification Scientific Research Evaluation Indicators for Teachers in Colleges

3.1. Survey of the Current Situation. First, the literature related to the scientific research evaluation of college teachers on CNKI [21] was searched. The result is shown in Figure 7.

As shown in Figure 7, the number of research papers has stabilized in recent years [22]. From 2017 to 2021, there is no significant growth, but the overall trend may have a slower growth in the later period. The year with the largest number of papers was 2018, with 23 papers. The minimum year is 2020, and the number is 9. It cannot be said that this year was anomalous, as it is estimated that the number of articles in 2020 will definitely exceed that in 2021. Then, 15 articles were published in 2017 and 2019. Compared with other years, these two years were relatively stable.

In addition to the references, the foreign evaluation index systems also were investigated as shown in Table 2.

From Table 2, it can be obtained that Australia pays more attention to the output of scientific research quality [23]. In fact, the main supporter of scientific research work in Australia is the government, and the entire evaluation body is also the government. The quality of the results will directly affect the funding for scientific research in the future. This is why there is a reputation indicator in the first-level indicator. Australia is mainly assessed on a subject basis. According to the data, it will fund more internationally competitive disciplines and institutions. From the table, this country focuses on the quality and quantity of scientific research output and can be clearly understood. It will pay attention to its application in real life and its international influence. And the country's evaluation method is peer evaluation.

The number of documents is counted, and foreign index systems are also listed. In the following, the problems existing in most university index systems will be analyzed.

First of all, most of the evaluation indicators of colleges and universities are very general. Even if different types of scientific research activities are divided, there is no subdivision on the secondary and tertiary indicators; thus, the results will be very vague and the specific quantitative indicators will not be clear. Secondly, the weights of secondary and tertiary indicators in most colleges and universities are clearly missing. The setting of indicators needs to show a hierarchy, that is, the gradient of the indicators. There must be a weight relationship between each indicator. If there is no quantification of weights, the final assessment result is only a formalism. The third point is that most of the indicators of colleges and universities have intersections. Although there should be links between indicators, they should not be repeated and intersected, which will make the entire assessment continue to repeat. It affected the objective and scientific nature of the assessment. The fourth point is that teachers' own development planning indicators are not perfect. Scientific and reasonable indicators are of great help

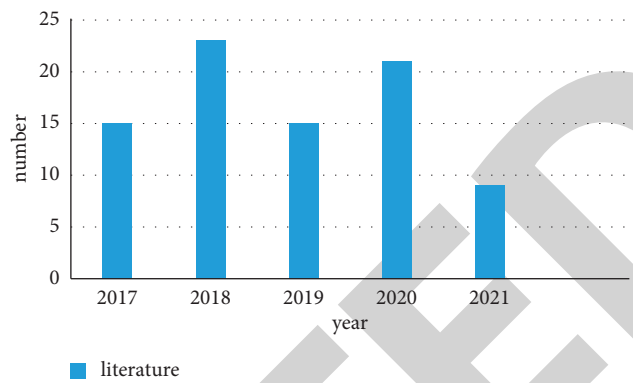


Figure 7: Literature statistics.

in motivating teachers to devote themselves to scientific research. In addition to actively paying attention to teachers' performance, they should also pay attention to teachers' own development plans. This will help to improve the level of teachers.

3.2. Identification Experiment of Scientific Research Evaluation Index Based on Wireless Communication Network. It can be concluded from the above that there are still many imperfections in the indicators of colleges and universities, so this paper proposed to use the method of wireless communication network to conduct experiments on the identification of these indicators and to verify the advantages of using this method in the identification of indicators.

Supposing that a school conducts teacher assessment and there are 12 assessment indicators. Based on the method of wireless network communication, the information entropy map of the assessment index and the correlation coefficient map of the index results can be obtained as shown in Figure 8.

It can be seen from Figure 8 that the information entropy of different indicators is quite different. The least information entropy is the editor because only a few people have the editor, and the amount of information provided when evaluating everyone is limited. Among the correlation coefficients between all indicators and assessment results, the three indicators of the number of papers in the journal A, national projects, and provincial projects are the highest. In addition, the correlation coefficient of the author is negative, that is, the negative correlation. The reason is that editing has almost no effect on scientific research assessment, and it happens that there are a few editors with poor assessment results among several samples, resulting in a negative correlation between editing and assessment results. In this case, the correlation coefficient needs to be artificially set to 0. This shows that based on wireless communication network technology, it can be very helpful to identify scientific research indicators. It greatly improved the evaluation efficiency [24].

The information entropy and relationship graph were listed above, which proved that the wireless communication network was very suitable for the identification of indicators. Next, multiply the two to get the result as shown in Figure 9.

Table 2: Australian research evaluation system.

	Level indicators	The secondary indicators
1	The quality of scientific research	Level of publications and conferences; reference analysis; peer review; international and domestic research revenue after peer review, etc.
2	Research quantity and research activities	Income and research output
3	Research and application	Scientific research commercial investment and other applied measurement indicators
4	Reputation	The number of editors of reputable publications; the number of participants in well-known academic groups and the number of winners of national scientific research prize

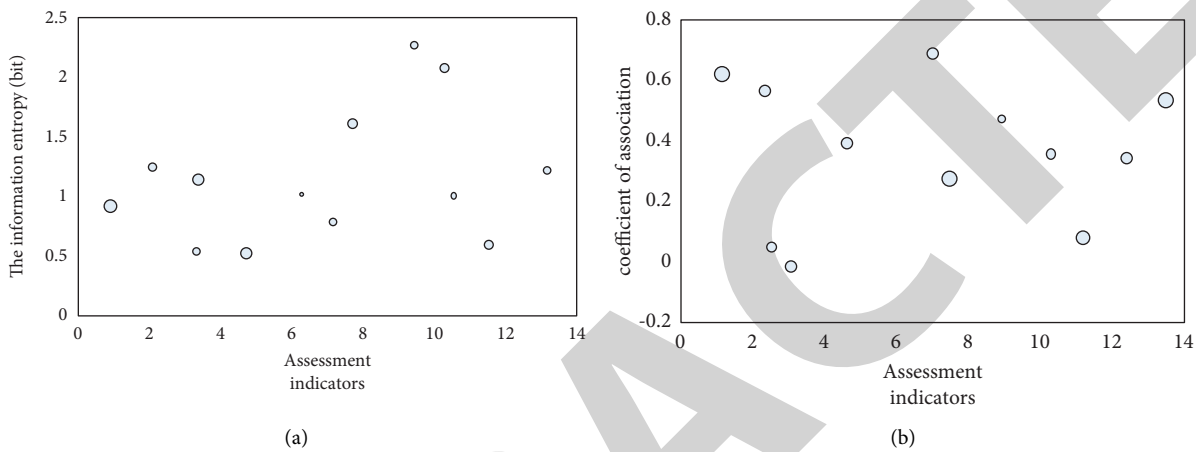


Figure 8: Evaluation index identification experiment result 1. (a) Information entropy of assessment indicators. (b) Correlation coefficient between assessment indicators and assessment results.

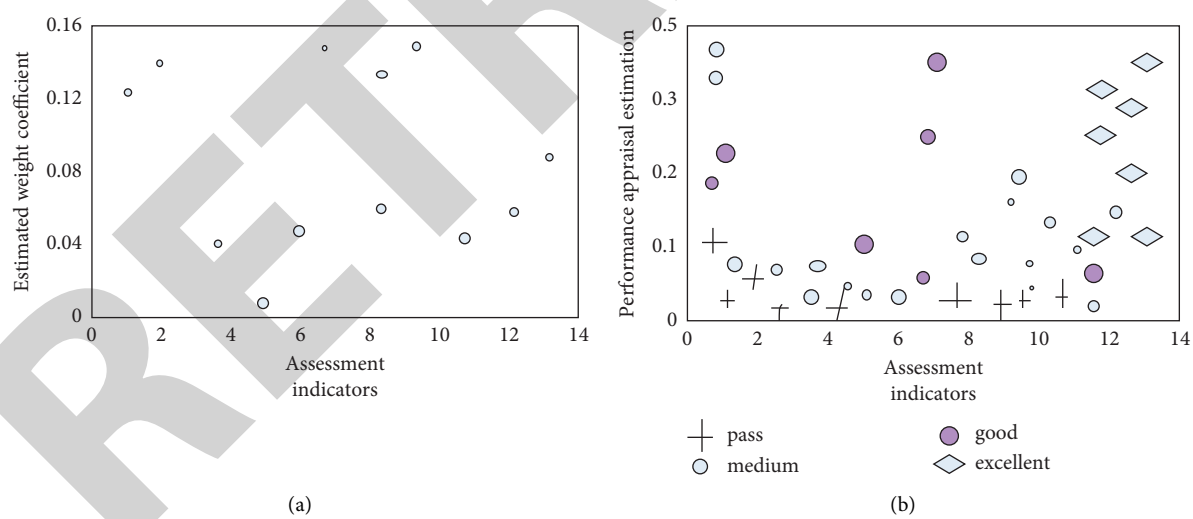


Figure 9: Evaluation index identification experiment result 2. (a) Weight estimates. (b) Sample distribution map after index weighting.

As shown in Figure 9, it can be found that the information entropy difference of different indicators is relatively small, mainly because the correlation coefficient difference is relatively large. Therefore, the graphs listed in this article are mainly dominated by correlation, and then, it is combined with information entropy to assign weights. Because if only the correlation is only considered, and the information entropy is not considered, it will lead to difficulty in identifying the indicators, and finally, the difference between the samples cannot be identified. If only information entropy is considered and correlation is not considered, it will not help the assessment results. It can be seen from Figure 9 that the weight coefficient is different from the component of the assessment index. During the assessment, it also finds that there are some indicators that only a few people have reached the value, and the amount of information is relatively small, so the weight is smaller than the core. This kind of indicator setting is actually not in line with the assessment

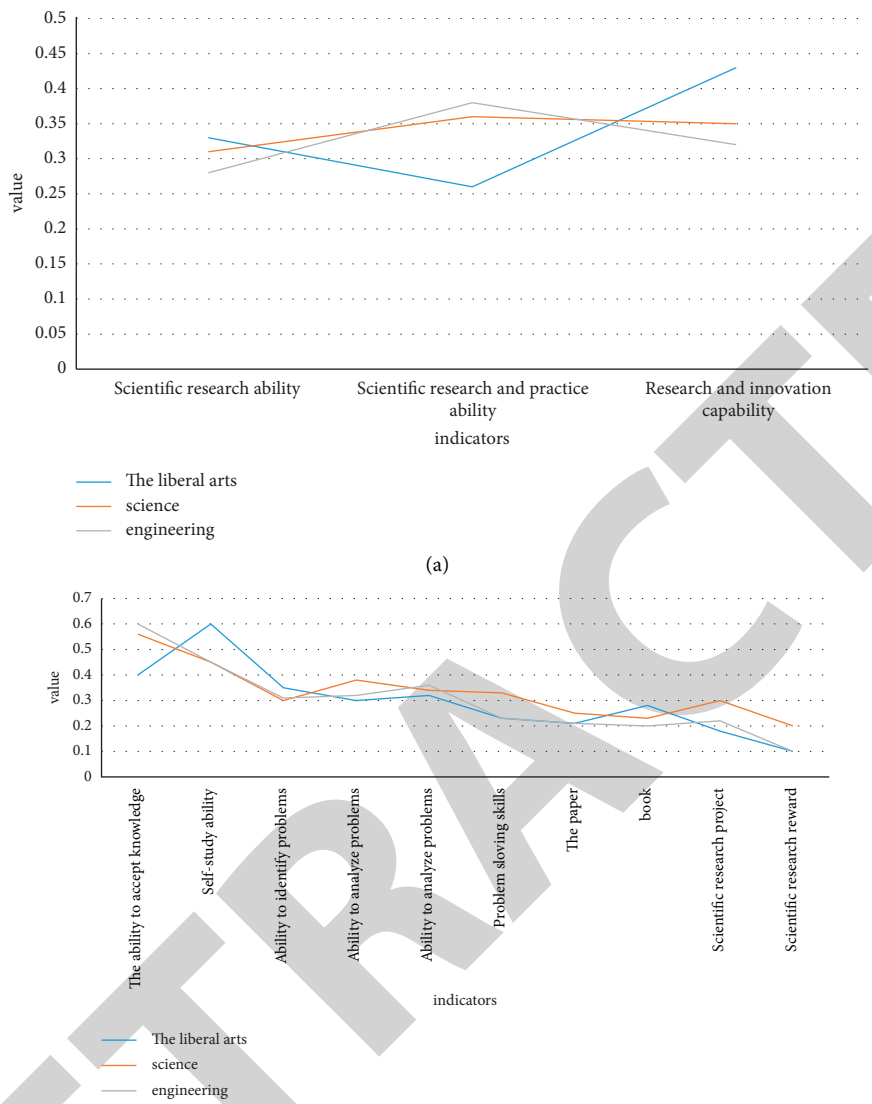


Figure 10: Analysis of indicator weight system. (a) Comparison of weight coefficients of primary indicators. (b) Comparison of weight coefficients of secondary indicators.

setting. In the identification of indicators, everyone should be able to have, and teachers should use the differences in indicators to participate in the evaluation, which is conducive to the final result. Later, to measure the pros and cons of the weight, the distribution of the sample is estimated by multiplying the indicator by the weight coefficient. It can be seen that there are different assessment levels displayed in the figure. And the sample distribution and the assessment results have a very good fit, indicating that this method is very reasonable. Because the correlation between the indicators is relatively small and the information is relatively small, the identification by the method of wireless network communication can well establish the evaluation model.

The three types of index weight system are analyzed by using the method of wireless communication network according to the scientific research evaluation index weight system of a certain school. The result is shown in Figure 10.

It can be seen from Figure 10 that in the evaluation process, the requirements for teachers' innovative ability are relatively high. In the figure of the first-level indicators, among the three subjects, it can be found that the weight value of the indicator of innovation ability is relatively high. Because the level of innovation ability of college teachers can determine the quality of scientific research output, the innovation capability has an essential position. And it can also find in the figure that the three subjects have different requirements in terms of practical ability. Engineering teachers' practical ability index is relatively high, with a weight value of 0.38, while liberal arts teachers are relatively low, with a weight value of only 0.26. However, on the cognitive index, the weight value of liberal arts is the highest, with 0.33, while that of engineering is only 0.28. Because most scientific research in engineering is produced in the laboratory, practical ability is essential for engineering.

Table 3: Research capabilities.

	Mean value	Standard deviation
Research cognitive ability	5.7600	0.83794
Scientific research and practice ability	4.600	1.12988
Research and innovation capability	72600	0.83794

Table 4: Research cognitive ability.

	Mean value	Standard deviation
The ability to accept knowledge	5.0000	0.71458
Self-study ability	7.5000	1.12988
Difference	2.5000	0.41530

Table 5: Research and practical ability.

	Mean value	Standard deviation
Ability to identify problems	6.7600	1.31279
Ability to analyze problems	5.7600	1.31279
Competence in solving problems	7.6000	1.12988

Liberal arts teachers, on the other hand, will be less concerned with practical ability. Among them, it can also be found from the figure that the weight values of the secondary indicators are basically similar in the three subjects. There are only minor differences. Liberal arts teachers have higher requirements for self-learning abilities than knowledge-accepting abilities while science and engineering require higher knowledge-accepting abilities than self-learning abilities; science requires a relatively high ability to analyze problems, which is also determined by the characteristics of science subjects. The teachers of the three subjects have basically the same views on the importance of scientific research awards, and their weights all are low. Scientific research awards belong to additional indicators such as papers, works, and patents. It should not be given high weight. Through the identification experiment of the index, it proved the superiority of the wireless communication network in identifying the index, which greatly increased the efficiency in the evaluation.

In the above, the weight value identification experiment was carried out on the first-level index and the second-level index. Next, the wireless communication network will be applied to analyze the reliability of the primary indicators. The reliability of the identification experiment is indicated. The results are shown in Table 3.

From Table 3, it can be concluded that the consistency of the indicators is very high, which fully meets the reliable requirements of the experimental reliability. And the deviation of the three indicators does not exceed 1.5. This showed that the results of the recognition experiments are very accurate.

The reliability analysis results of the second-level index of scientific research cognitive ability are shown in Table 4.

As can be seen from Table 4, although the value of the index is not very high, it meets the reliability requirements of reliability.

The following is an analysis of the reliability of the secondary indicators of scientific research practice ability, and the results are shown in Table 5.

It can be seen from Table 5 that the consistency of the three secondary indicators is relatively high and meets the reliability requirements. These three tables proved that the indicators used in this test meet the reliability requirements. It proved from the side that the wireless communication network can make the identification of indicators more efficient.

4. Conclusions

This paper studied and analyzed the identification of university teachers' scientific research evaluation indicators through wireless communication network. It drew a conclusion that the application of this method can be of great help in scientific research and evaluation of teachers. It can quickly and accurately identify and classify indicators. At present, there are still many deficiencies in the index setting of the current evaluation system, and the problem of cross-repetition often occurs in the identification index. However, the application of the method proposed in this paper can improve this situation. Therefore, it is recommended to consider this direction in the identification of indicators. Due to the limited space of the article, it cannot cover all aspects, and there are not many examples used in the research. This is also the limitation of this article. In the future, the author looks forward to using more real data to conduct deeper research and to dig more methods to help to identifying indicators. The author also firmly believes that there will be increasingly literature related to this topic in the future, and the establishment of a scientific research evaluation system will become increasingly in line with the needs.

Data Availability

The data underlying the results presented in the study are available within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Assistant Teaching of Hurdle Technology Based on Mobile Communication Multimedia Technology and MVP Theory

Tong Zhou,[1,2] Meng Zhang,[1] Xingxing Wu,[3] Wenzhi Hou,[4] and Lei Yu[5]

[1]*Public Basic Teaching Department, Xinjiang Institute of Technology, Aksu 843100, Xinjiang, China*
[2]*National University of Malaysia, UKM, Bangi, Selangor 43600, Malaysia*
[3]*Department of Mathematics, Xinjiang Institute of Technology, Aksu 843100, Xinjiang, China*
[4]*Foundation Department, ShanDong JiaoTong University, Jinan 264200, ShanDong, China*
[5]*Department of Physical Education, Guangdong Institute of Technology, Zhaoqing 526100, GuangDong, China*

Correspondence should be addressed to Xingxing Wu; 1531030131@xzyz.edu.cn

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In order to solve the problem that multimedia technology cannot give full play to its technical advantages, a method of assisted teaching in hurdle technology based on mobile communication multimedia and MVP theory is proposed. In this mode, the system adopts a layered structure design, which can reduce the coupling between modules, realize the reuse of platform business logic code, and improve the maintainability of the entire system. The average technical evaluation score of the experimental class was 89.28, and that of the control class was 80.64. Meanwhile, the standard deviation was lower than that of the control class. A lower standard deviation indicates that the sample data is less distributed and that the population value is closer to the mean. That is to say, the technical evaluation scores of the experimental class were generally in the middle, and there was a significant difference between the two classes ($P < 0.05$). The results of the pilot study showed that with the aid of mobile communication multimedia teaching technology, students' interest in preventing technology learning is increasing, verifying the validity of the experiment.

1. Introduction

Advances in scientific and technological research and the widespread use of information technology have had different impacts on all areas of life. In education, the advent of multimedia technology has somehow had a profound impact on traditional teaching. With the support of multimedia technology, traditional teaching can more comprehensively reflect the multidimensional and integrated characteristics of the technology. Using these features, teachers can clearly identify the key topics and difficult topics in teaching intuitively. With the advantage of mobile multimedia technology, the characteristics of traditional classroom teaching can be retained and the teaching effect can be further improved [1]. Physical education curriculum teaching, especially the technical physical education practice teaching itself, must rely on the practical education process, which requires physical education teachers to pay attention to technical explanation and skill teaching. However, compared with the traditional classroom disciplines, the physical education technology curriculum has a more open teaching environment and has more room to play in the innovation and practice of teaching methods [2]. The starting point of MVP theory is to provide more real and reliable experimental data for teaching innovation experiments by comprehensively explaining the relationship between students' curriculum learning motivation, learning willpower, and achievement. On the basis of fully absorbing the characteristics of multimedia teaching, it can better realize the integration with multimedia teaching methods, which can not only guide the curriculum design of multimedia teaching but can also ensure the integration effect of theory and practice in the process of curriculum experiment. This study takes hurdle physical education courses as the research object. In the process of studying the application of MVP theory in hurdle technology-assisted teaching, this study

designs a platform based on mobile communication multimedia technology to better improve the effect of MVP theory-assisted teaching, as shown in Figure 1.

2. Literature Review

Yu, H., and others said that although the amount of multimedia research related to teaching and learning is increasing, the research on multimedia learning is far from enough [3]. Sang and others said that some theories and models try to organically combine motivation, will, and learning, but they all have their own limitations [4]. Kairu and others said that Keller's mature ARCS Model on motivation, learning, and achievement integrates the concept, theory, and motivation design program of motivation but omits the theory of will and information processing [5]. Li, S., and others said that academic circles all over the world recognize that the measurement standard of a country's educational development level includes computer-assisted instruction. The author believes that the development degree of education is closely related to computer-assisted instruction, which is the standard to measure the educational level of teachers in a country [6]. Therefore, its research and application are very important. Even in daily life, multimedia has become an indispensable helper for every family in the United States. Li, W., and others said that the United States issued a policy on paying attention to the application of computers in teaching as early as 1989. The report on popularizing science–American 2061 plan pointed out that CAI teaching is popularizing science, and it is an important plan in national education [7]. Khozaei and others said that, for example, teachers in primary and secondary schools would leave part of the answers about searching for a question on the Internet to help primary and secondary school students obtain rich extracurricular knowledge [8]. Thurm and others said that American institutions of higher learning have more diversified applications of computer assistance. Teachers' teaching, students' thesis research, scientific research data query, information communication, and multimedia play a positive role [9]. Li, W., and others said that China's multimedia teaching started late and was introduced in the 1970s. In the 1980s, multimedia-assisted teaching began to be applied to college teaching [10]. Li and others said that the initial equipment was also very simple, using wall charts, slides, and models for teaching, but it was only applied in colleges and universities. At that time, the conditions of nine-year compulsory education were not mature. In view of the current situation of China's large population, if each school is equipped with the same multimedia teaching facilities, it is relatively difficult, and most of the teachers at that time graduated from normal schools and technical schools by graduation, they are not exposed to multimedia teaching, and their teaching level is limited, not to mention the use of electronic media for teaching [11]. However, after continuous development and the joint efforts of educators, some teaching equipment, such as slides and projection, video, and recording, began to be put into the classroom for teaching. At that time, this technology was called audio-visual teaching. Cheng et al. said that the current research situation in China and the theory of instructional design have received the attention of Chinese educational theory circles for a long time [12]. And many of them are about constructivist learning theory. For example, the research on the relevant master's thesis of a normal university scholar in recent years includes "Research on biology teaching design and application of junior middle school based on Constructivism," "Research on e-learning environment based on motivation design mode," "Research on mathematics teaching design of senior high school based on Constructivism," etc. There is also much content on the advantages and disadvantages of multimedia teaching, such as the exploration of middle school physics multimedia teaching and learning efficiency. There are also many multimedia teaching-related papers published. However, most of the research is not very systematic, and there is no complete theory to support multimedia teaching.

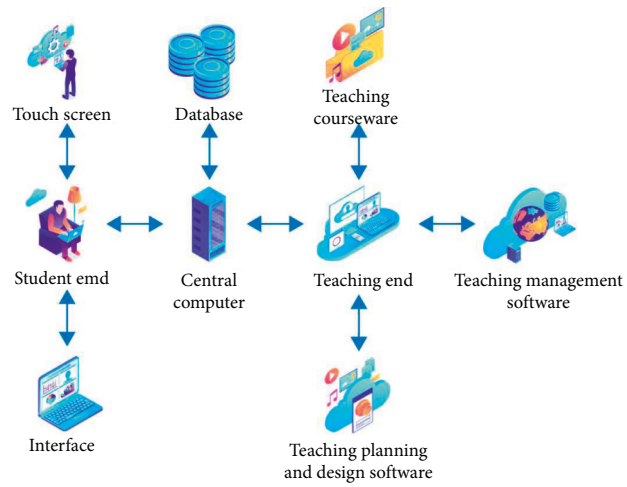

Figure 1: MVP theory-assisted instruction.

3. Method

The mobile teaching platform adopts the layered design mode of C/S and B/S. Learners log in and use the platform functions through the Android client. At the same time, in order to make it more convenient for teachers to use the platform, teachers edit and manage the resources uploaded by students and themselves through a web browser on the PC side. The administrator also manages the platform through web browsing on the PC side, manages student and teacher information, database information, and user permissions, and maintains the normal operation and use of the platform [13]. The system adopts a layered structure design, which can reduce the coupling between modules and realize the reuse of platform business logic code. Functional modules can be divided according to business logic, and the modules interact through interfaces, which is convenient for structure and dynamic update of client plug-ins. Thus, the maintainability of the whole system is improved.

The hierarchical architecture model of the mobile teaching platform involved in this study includes four layers:

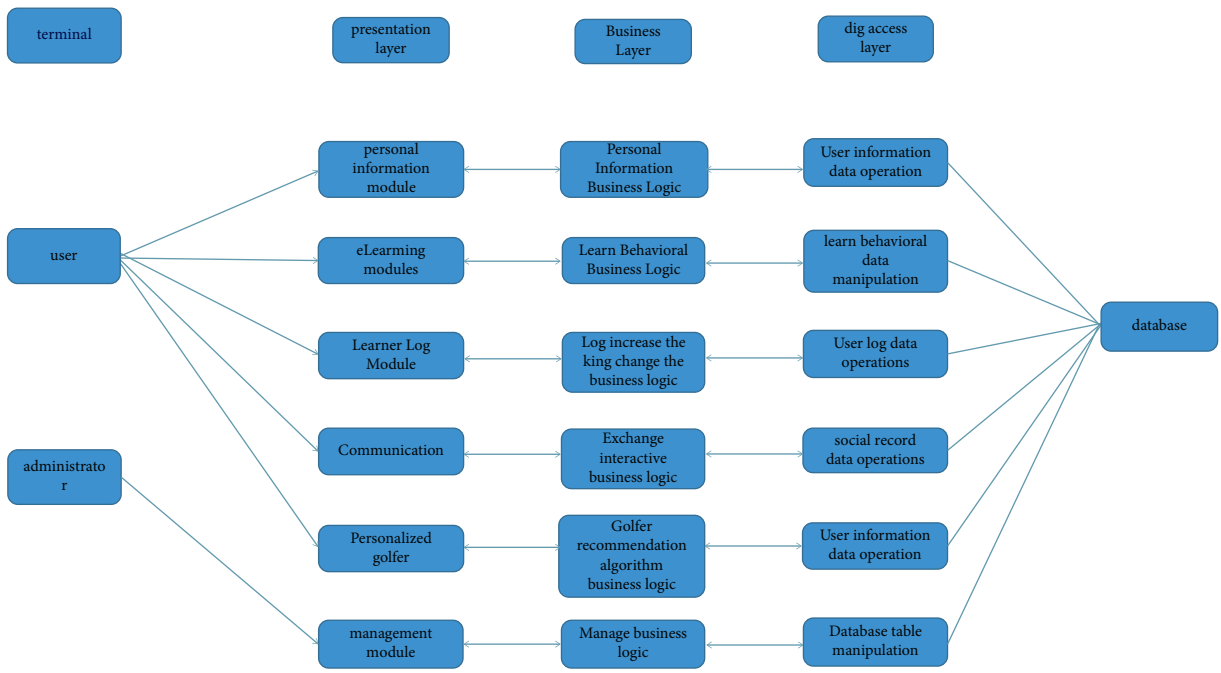

Figure 2: Platform four-tier architecture model.

presentation layer, business layer, data access layer, and database, as shown in Figure 2.

There are three main roles of mobile teaching platforms. Learner: learners can search and learn from learning resources, and can comment, score, collect, like, or share interesting learning resources. Learners can add friends to chat with friends online, exchange learning experiences, and share experiences with each other. The platform records learners' behavior logs. The platform recommends golfers for learners according to users' personal information, social behavior records, and learning behavior records. Teachers: in order to facilitate teachers to manage their teaching resources and students, the platform provides teachers with additional PC login interfaces [14]. Teacher users can upload teaching resources, manage teaching resources, and supervise students' learning on the PC. Administrators: the administrator user coordinates the overall situation, carries out platform management on the PC side, ensures the normal operation and maintenance of the server and database, and can maintain database security, modify database resources, modify user permissions, etc. The system use case is shown in Figure 3.

According to the design objectives and system use cases of this study, the functional modules of the platform are divided in detail, and the platform is roughly divided into the following six modules: resource display module, course learning module, communication and interaction module, personal center module, and personalized ball appointment module. The specific functional module division of the mobile learning platform is shown in Figure 4.

By analyzing the business needs of platform users and the feasibility of the system, the MySQL5.7.02 database is used to establish the platform database called hello Hamilton. At the same time, Navicatl0.1.7 is used to manage and operate the database for ease of operation and is also used to manage the primary foreign key relationships between tables in the database. The user model is an individual user feature extracted from the specific personality behaviors and objective attributes of learners. The user model can roughly reflect learners' behavior habits, knowledge of cognition, level, style, thinking habits, and other information. The user model based on the user information extracted by the mobile teaching platform is shown in Figure 5.

The trust score between learners cannot be obtained explicitly in the teaching platform. The intensity of information exchange and interaction between social network users can approximately reflect their trust relationship [15, 16]. Therefore, referring to the trusted sources of social networks, this study divides the trust relationship between platform learners into the following three aspects: learners trust people who have more contacts in the real world, such as relatives and friends; users have high trust in people with high prestige in the real world, such as celebrities; and users trust people who have similar social interest circles. For example, it is easier for two people in the same social interest circle to establish trust. In the real world, the trust relationship is directional and asymmetric, so this paper expands G (N, E, and W) into a directed weight graph. At this time, learners' nodes are connected through directed double lines, and their trust weights are not equal. Based on this, the directed social network map of the 020-badminton mobile teaching platform is obtained, and its schematic diagram is shown in Figure 6.

In Figure 6, the output vector of node A represents the trust weight distribution of learner a to other learners, and the input vector of A represents the trust weight of other learners to A. On this platform, the contact strength between users comes from two aspects: one is the online

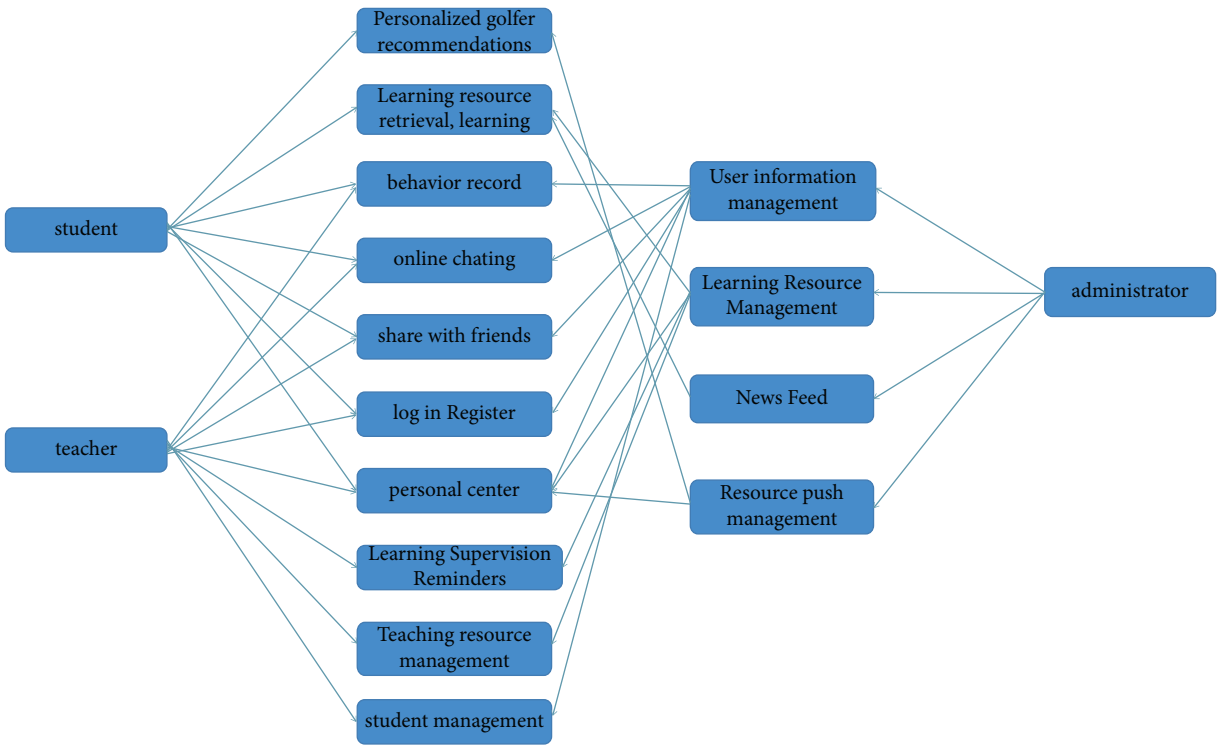

Figure 3: System use case diagram.

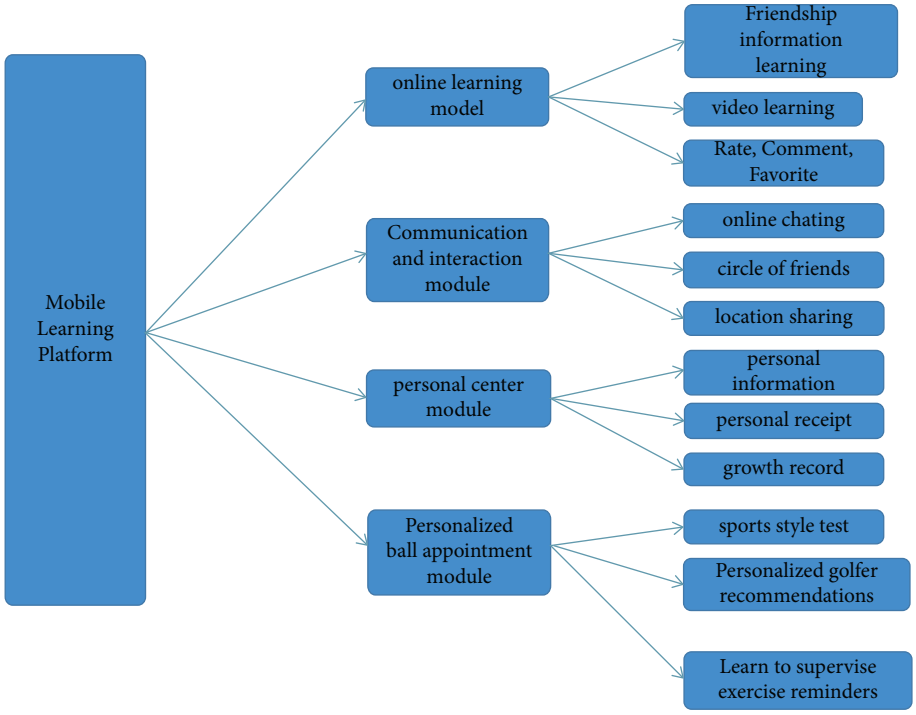

Figure 4: Platform function module design.

communication and chat records of users; and the second is the user's circle of friends interaction record.

On the teaching platform, it is not ruled out that there will be learners who have never had communication and interaction records with others. We keep these isolated nodes. Because their contact strength with any other node is 0, it will not affect the calculation results of trust, as shown in Figure 7 [17].

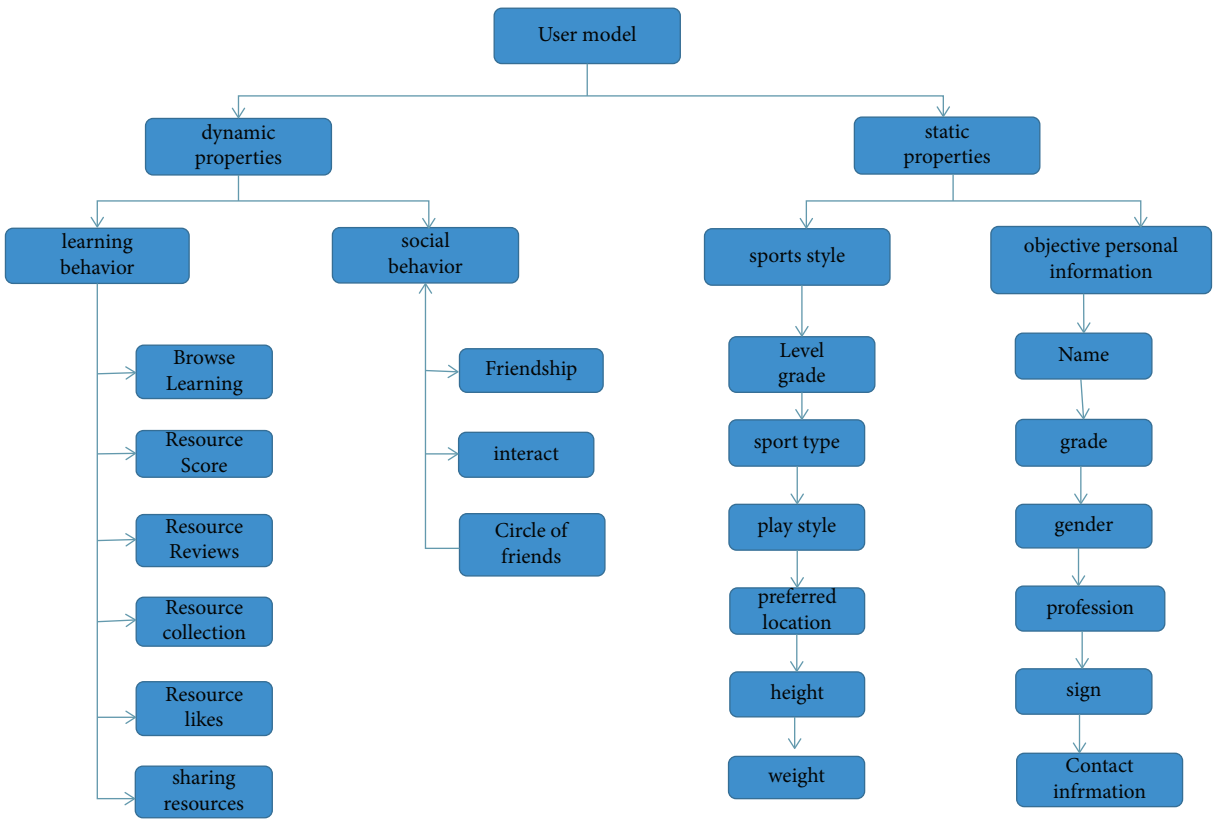

Figure 5: User model.

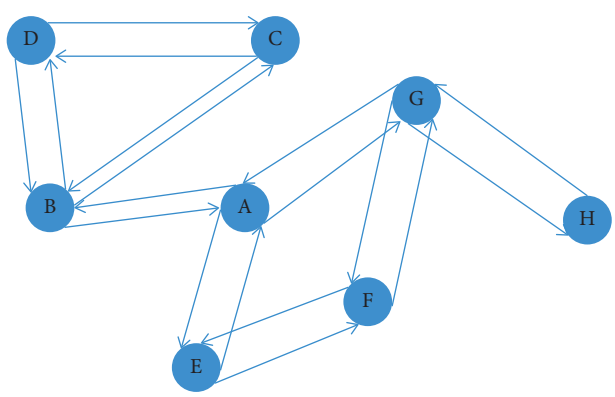

Figure 6: Learner social network map.

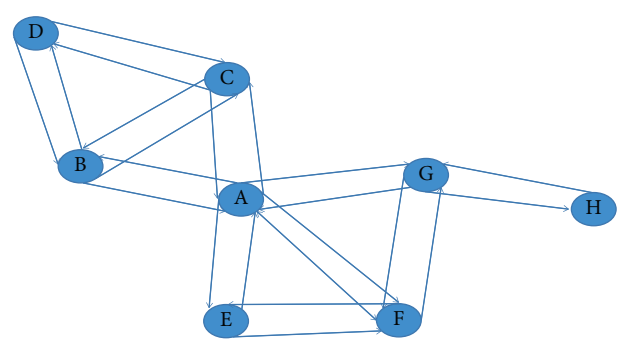

Figure 7: A-centered social network map.

In Figure 7, the following formula is used to measure the familiarity and trust between node A and its immediate neighbors, as shown in formula (1):

$$Ftr(A,n) = \frac{N(S_A, S_n)}{L_A}, \tag{1}$$

where n is one of A's friends, L_A is the sum of the social interaction information sent by a to all friends, and $N(S_A, S_n)$ is the interaction information sent by A to n. in this platform. Social behaviors include online communication, messages, pictures, voice, and location information sent by learners to their friends, and circle of friends interaction, comments on friends, as shown in formulas(2) and (3)

$$\frac{N(S_A, S_n)}{L_A}. \tag{2}$$

The calculation method is as follows:

$$\frac{N(S_A, S_n)}{L_A} = \alpha \frac{N(S_{A1}, S_{n1})}{L_{A1}} + (1-\alpha)\frac{N(S_{A2}, S_{n2})}{L_{A2}}. \tag{3}$$

In the aforementioned formula, the first item is the trust obtained by learners' online communication behavior, and the second item is the trust obtained by the interaction behavior of the circle of friends, and α is the regulatory

factor. By introducing the influence of the time factor on the calculation of familiarity trust, formula (1) can be modified to the following formula, as shown in formula (4)

$$Ftr(A,n) = \frac{N(S_A, S_n)}{L_A} * \frac{\sigma}{T_{A\leftrightarrow n}}, \tag{4}$$

where $T_{A\leftrightarrow n}$ represents the length of time in hours when A and his friend C become friends and σ is the adjustment factor. According to the aforementioned formula, mutual trust between any adjacent nodes in Figure 8 can be obtained, as displayed in Figure 8.

According to the trust propagation theory, the trust degree will be lost when passing through the intermediate node. The more intermediate nodes between the target node and a, the more serious the loss, which is also in line with our cognition in daily life. Accordingly, it is proposed that the trust degree of A to any other user in the trusted network is expressed as shown in formula (5)

$$Ftrust(A,n) = \omega_N \cdot \sum_{i=1}^{k}\left[\prod_{j=1}^{m} Ftr\left(P_{j-1}, P_j\right)\right]. \tag{5}$$

In the aforementioned formula, ω_N represents the hierarchical distance between root node A and target node n in a trusted network. Its value gradually increases with the increase in the number of layers. The calculation method of ω_N adopts the following formula:

$$\omega_N = \left(1 - \frac{layer_N}{layer_{SUM}}\right), \tag{6}$$

where $layer_{SUM}$ represents the maximum hierarchical distance of a trusted network. According to the aforementioned theoretical research, its value is 7, $layer_N$ is the hierarchical distance between the target node n and the root node, and when it is greater than 6, ω_N is 0. When sorting the trust degree of node A to other learners, if there are two learners with the same trust value, priority is given to the target node with the shortest path, the node with the least path, the weight of each side, and the largest target node. Finally, the trust ranking of node A to other nodes is: $G > F > B > H > C = E > D$, as shown in Table 1

When considering the reputation of students and the trust network, maintain the relationship of mutual trust, including the trust connection of all users, as shown in the figure 9.

The score of any node in Figure 9 depends on the scores of other nodes, and its score determines the score change of other nodes to prevent a few nodes from doing evil and modifying the score results. The calculation formula of social trust in this study is given as shown in the following formula:

$$Fsoc(i) = \frac{1}{\sum_{j\in N, j\neq A} Fsoc(j)} \sum_{j\in N, j\neq A} Fsoc(j) \times Fre(j,i). \tag{7}$$

According to our simulation experiment, the similarity of the circle of friends outside the three layers of the trusted network has basically no reference value, so this study sets

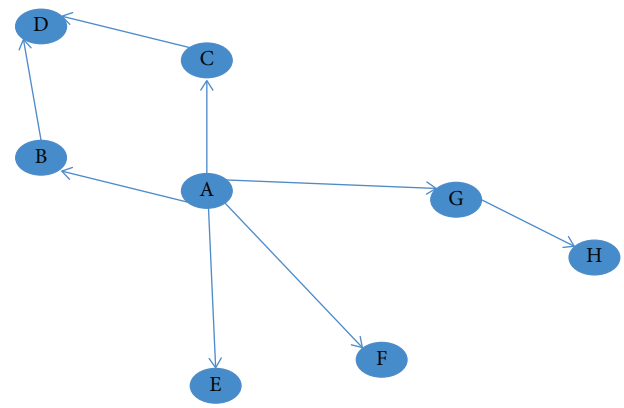

Figure 8: Trust network map centered on A.

Table 1: Ranking of trust nodes in A.

Target node	Familiarity trust value
G	0.309
F	0.240
B	0.171
H	0.103
C	0.069
E	0.069
D	0.056

the maximum number of calculation layers of group similarity as 3. This trust calculation, considering both direct and indirect circle of friends' similarity, adopts the idea of the Jaccard coefficient, as shown in formula(8):

$$STr_G(u,f) = \sum_{n=1}^{3} a_n \left|\frac{F_u^n \cap F_f^n}{F_u^n \cup F_f^n}\right|. \tag{8}$$

This study divides the trust between learners due to social behavior into three aspects: familiarity trust, social credibility, and a deep circle of friends similarity. The comprehensive trust between learners is the weighted sum of the three. The calculation method is shown in the following equation:

$$tr(A,n) = Ftrust(A,n) + Fsoc(n) + STr_G(A,n). \tag{9}$$

The overall calculation process of extracting the characteristics of learners' social attributes according to learners' social behavior to recommend potential players based on trust for learners is shown in Figure 10.

In the actual scoring process, different learners have different scoring standards for resources. For example, some learners' scores are generally high, while some learners' scores are generally low. In addition, some learning resources will get generally high or low scores due to their authority, particularity, and other factors. Therefore, adding user bias and resource bias to score prediction will make the prediction effect more accurate. The scoring prediction formula of the SVD model with bias is shown in the following equation:

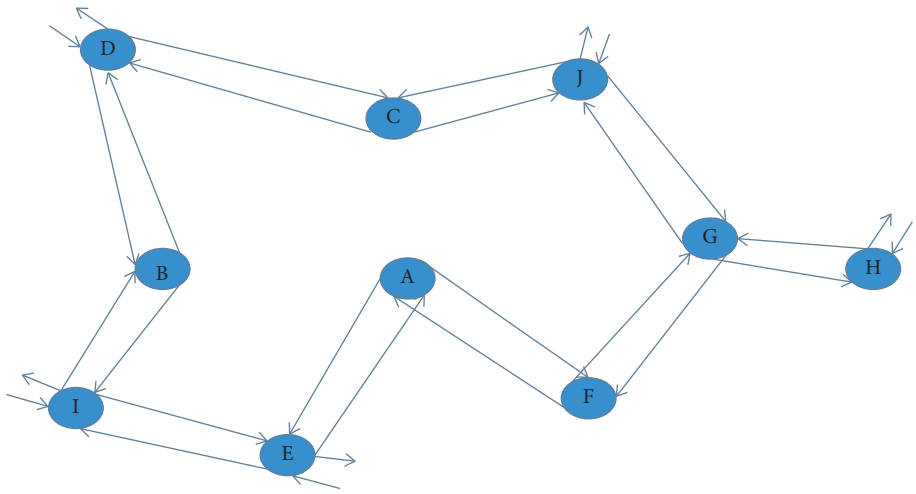

Figure 9: A schematic diagram of the trust network containing all trust contacts.

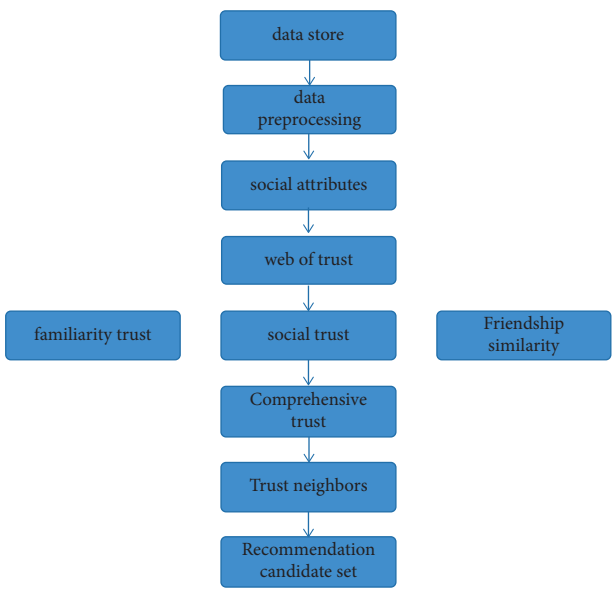

Figure 10: Learner trust calculation process.

$$f_{ui} = f\left(b_{ui} + q_i^T p_u\right), \tag{10}$$

where f_{ui} is the score prediction of learner u for resource i, and the definition of b_{ui} is shown in the following formula:

$$b_{ui} = \mu + b_u + b_i, \tag{11}$$

where μ is the global bias, that is, the average score of learners for all resources. Assuming that the known score in the user learning resource scoring matrix is r_{ui}, the error between the real value and the predicted value is shown in formula (12)

$$e_{ui} = r_{ui} - f_{ui}. \tag{12}$$

Then, the total square sum of errors can be calculated and expressed by the following formula:

$$SSE = \sum_{u,i} e_{ui}^2 = \left(r_{ui} - f_{ui}\right)^2. \tag{13}$$

The solution of the model is transformed into solving the least square problem as shown in equation (14)

$$\min_{p_*, q_*, b_*} \sum_{(u,i) \in K} \left(r_{ui} - f\left(b_{ui} + q_i^T p_u\right)\right)^2. \tag{14}$$

The SGD algorithm is the most commonly used and efficient gradient descent algorithm to solve the aforementioned problems in machine learning algorithms. The idea is to cycle in a set, select appropriate parameters for iteration, and choose a small step gradient descent each time to find the optimal solution. The formula group to be solved is shown in the following equation:

$$\begin{cases} b_u = b_u + \gamma \cdot \left(e_{ui} - \lambda_i b_u\right), \\ b_i = b_i + \gamma \cdot \left(e_{ui} - \lambda_2 b_i\right), \\ q_i = q_i + \gamma \cdot \left(e_{ui} p_u - \lambda_3 b_i\right), \\ p_u = p_u + \gamma \cdot \left(e_{ui} p_u - \lambda_4 p_u\right). \end{cases} \tag{15}$$

In the process of data training, a better training effect can be achieved by adjusting γ and λ.

4. Experiment and Analysis

Based on the MVP theory design mode, this study uses multimedia teaching means to integrate theory, purpose, and empirical research. This paper divides the teaching design into three modules: students' learning interest, learning will, and learning achievement. In each module, it is divided into several strategies. Learning interest is divided into the following categories: interest, curiosity, purpose, and value. In learning will, it is divided into factors affecting behavior planning and self-development. In academic achievement, it is divided into the presentation of academic achievement and feedback analysis [18]. Through comprehensive and systematic design, the integration of teaching

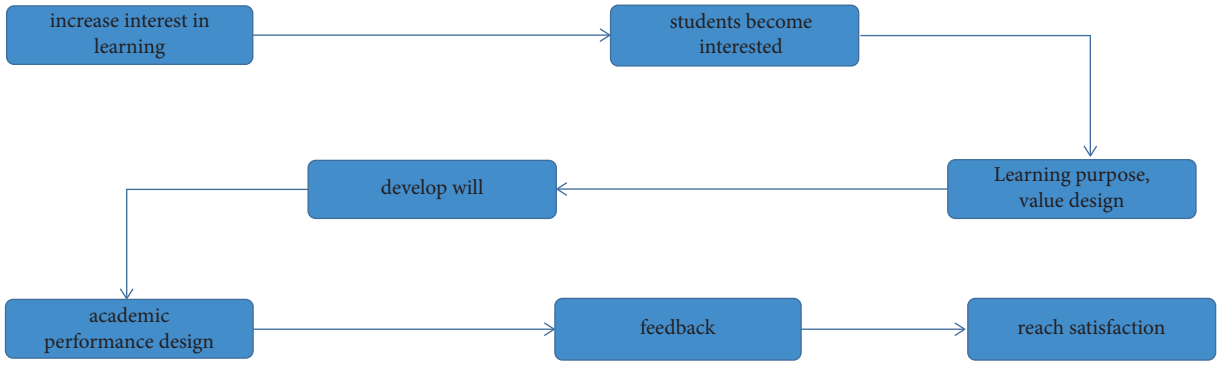

Figure 11: Process design flow.

ideas is clear, teaching experiments are optimized, students' learning efficiency is improved, and a positive and beneficial attempt is provided for the application of MVP in multimedia hurdle teaching [19].

The design of the experimental process determines whether the teaching goal can be realized. This study focuses on the role of teaching in hurdle teaching and integrates the MVP theory into design teaching. The specific implementation steps in the experimental group are shown in Figure 11.

The design of motivation in multimedia instructional design is based on the MVP theory. First, interest and curiosity learning interest can be divided into personal interest and situational interest. Situational interest refers to a short-term response to a certain situation [20]. Second, purposeful and valuable training can create a good psychological presupposition for completing the training task, which is the guarantee of learning. The purpose of training should be decentralized to each class, and the specific tasks, how many times to do them, and to what extent should be clearly specified. This can help avoid losing direction due to long-term training. Students are only interested in attractive or useful content. When they are exposed to new technologies, they often think what is the use of this? In this regard, in order to make students like the training course and believe that it is closely related to their future life, we should first connect students' needs and learning interests with learning objectives and learning content [21]. The design of a will in a multimedia learning environment has two factors that affect the cultivation of will, the first is implementation, and the second is self-management. Implementation refers to the factors that affect the implementation of the plan, mainly the impact of the external environment. Self-management factors are the factors that affect the support and development of self-management actions. It is the key to fully mobilizing students' time and initiative. Teaching should scientifically use management methods to carry out a series of activities such as students' self-control, introspection, self-knowledge, and self-study, so as to cultivate students' abilities of anti-interference, emotion regulation, cognition, and behavior control, and finally achieve the learning goal. Succeeding in a multimedia learning environment requires attention to the knowledge processes that take place in the course. Student recognition, achievement, and understanding of knowledge are also designed to improve student attitudes toward self-care and assessment, which have a significant impact on how knowledge is accomplished [22, 23]. The second, reactive alcohol, is about how to control emotions and measure outcomes. This is an important part of the feedback and also requires teachers to help students learn to think critically and generate interest, thereby developing a change in students' thinking style so that students know what it is and why it is during the training process [24].

We then divide them into an experimental group and a control group, and the two groups will make monthly test reports after finding a simple problem, which can meet the needs of the experiment. Prior to the experiment, the strengths of the two groups of students were tested and data was generated. During the experiment, the teacher is the same person, and the level of guidance is the same, which can effectively control the experiment, and there is no big difference. After the experiment, the basic qualities are tested and compared, and the academic achievements of the two groups are compared and analyzed, so as to improve the learning effect of students in all aspects as far as possible.

(A) Before the experiment, the two classes were tested for basic level (pretest). (B) The experimental class adopts the multimedia teaching method, while the control class still adopts the traditional teaching method. The teaching content is the teaching of the complete technology of track and field hurdles. (C) The questionnaire is distributed once a week. The data of the two classes are compared and analyzed with a t-test to understand the changes in students' learning motivation and training will. (D) After the hurdling technique training, make measurements and measurement models, and then test the analysis, evaluation, problem-solving ability, and thinking ability of the students in the two classes (after the test). Teachers with many years of teaching and school-running experience in our school's teaching and research center are responsible for testing to meet the measurement standards. The classroom teaching ability is evaluated by the researcher himself and scored according to the scoring rules of the latest "syllabus of Guangdong Institute of Technology."

According to the data analysis results in Table 2, there was no statistically significant difference between the students' learning satisfaction in the laboratory and the control room before the experiment ($P > 0.05$). After one week of

Table 2: Statistical results of students' learning interest comparison between the experimental group and the control group ($N = 100$).

Time slot	Experimental group ($x \pm s$)	Control group ($x \pm s$)	T	P
Before experiment	3.25 ± 0.20	3.26 ± 0.21	0.621	>0.05
Week 1	3.55 ± 0.23	3.45 ± 0.22	0.220	>0.05
Week 2	3.88 ± 0.23	3.60 ± 0.18	−0.325	<0.05
Week 3	3.96 ± 0.18	3.72 ± 0.17	−0.212	<0.05
Week 4	4.03 ± 0.19	3.78 ± 0.22	−0.656	<0.05
After the experiment	4.04 ± 0.15	3.77 ± 0.18.	−0.776	<0.05

asynchronous instruction in the laboratory and regular instruction in the control room, student satisfaction scores for both classes were calculated, and the time was assessed from the questionnaire. After the test, there was a significant difference between the two classes. In the second week of the asynchronous teaching method, the students' learning interests in the experimental class were higher than those in the control class ($P < 0.05$). The same difference was observed at 3, 4, and 1 week after the experiment ($P < 0.05$), as shown in Table 2.

It can be seen from the graph that the average learning interest of the students in the experimental group began to rise after the beginning of class, while the control group also improved to a certain extent, but the change was not great. By the third and fourth week, even after the end of the experiment, the follow-up survey found the same results. It fully shows that through multimedia teaching, students' interest in hurdles becomes stronger than that of traditional teaching methods, and the purpose becomes more clear. It shows that the control group is worse than the experimental group in improving and maintaining students' learning interests, as shown in Figure 12.

The following experimental data show that multimedia teaching uses the "video incentive" of authoritative people to arouse students' attention to training and encourage students to adhere to learning. It also help students to overcome their own inertia and other internal and external factors, and finally achieve the learning goal [25, 26]. Before the experiment, the will of the experimental group was 3.55 ± 0.22 and that of the control group was 3.53 ± 0.31. No significant difference was observed. In the second week, the mean of the test group was 3.86 ± 0.23 and the mean of the control group was 3.68 ± 0.18. The difference between the two groups was 0.318, $P < 0.05$. The academic performance of the two groups differed considerably. The academic satisfaction of the students in the control group increased only slightly, while the academic satisfaction of the experimental group increased, indicating that multimedia teaching has remarkable results. The data showed that the experimental group and the control group were 4.04 ± 0.15 and 3.62 ± 0.18, respectively, $P < 0.05$. This shows that the team is working hard to go beyond the board of willpower training, as shown in Table 3.

As can be seen from the figure below, the learning will of the experimental group gradually increased with the deepening of learning hurdle technology, while that of the control group reached its peak in the third week and then decreased. It shows that the cultivation of learning will in the experimental group is significantly better than that in the control group, and the learning will directly affect the

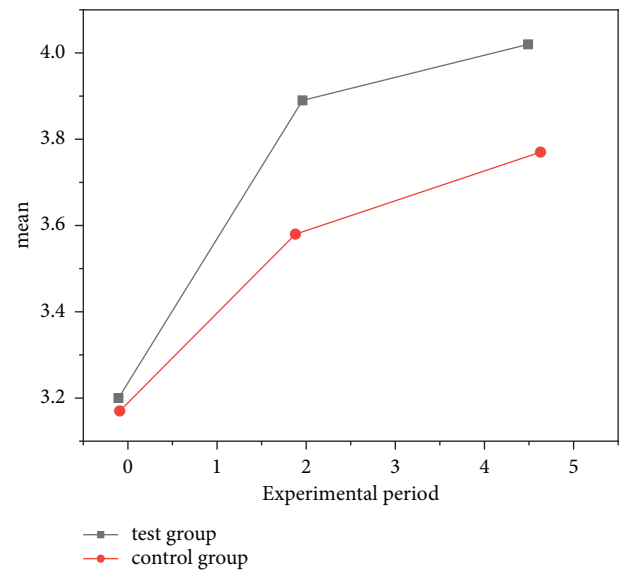

Figure 12: Comparison of the average change in students' learning interest between the experimental class and the control class.

training results. Therefore, it can be concluded that the cultivation of learning will is very important in hurdle teaching, as shown in Figure 13.

The teaching evaluation of the experiment is explained by comparing the hurdle performance of the two groups. This study selects two indicators: technical evaluation performance and time utilization [27]. The technical evaluation results are obtained by integrating the technical action quality, action performance, and speed. Time usage is also measured simultaneously by using electronic clocks and watches to ensure time accuracy and is used as a quantitative indicator of an obstacle course. The higher the timing level (the lower the score), the faster the obstacle and the higher the skill. Time utilization can make up for the lack of teachers' subjective evaluation and scoring and can make the hurdle performance objective and reliable [28, 29]. It can be seen that the test scores of the experimental group students in the laboratory are 89.28 ± 4.36, which is higher than that of the control group's 80.64 ± 6.22; the time-consuming value of 18.8 ± 0.06 is lower than the control class's 24.3 ± 0.10, indicating that the total skills of the laboratory students are high in the control class. After the experiment, there was a difference between the two groups ($P < 0.05$). The results are shown in Table 4.

The average score in the examination room was 89.28, and in the control room it was 80.64. At the same time, the differential structure was also lower than that of the control

Table 3: Statistical results of students' will comparison between the experimental group and the control group ($N = 100$).

Time slot	Experimental group ($x \pm s$)	Control group ($x \pm s$)	T	P
Before experiment	3.55 ± 0.20	3.53 ± 0.21	0.610	>0.05
Week 1	3.60 ± 0.21	3.61 ± 0.20	0.234	>0.05
Week 2	3.86 ± 0.23	3.68 ± 0.18	−0.308	<0.05
Week 3	3.93 ± 0.18	3.70 ± 0.17	−0.235	<0.05
Week 4	4.02 ± 0.19	3.65 ± 0.22	−0.766	<0.05
After the experiment	4.04 ± 0.15	3.62 ± 0.18	−0.858	<0.05

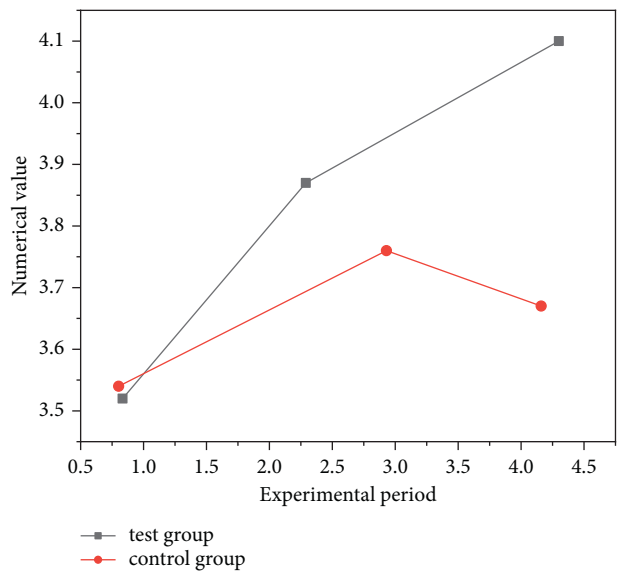

Figure 13: Comparison of the average change in students' learning will between the experimental class and the control class.

Table 4: Research on multimedia-assisted teaching of hurdle technology based on MVP theory.

Project	Experimental group ($x \pm s$)	Control group ($x \pm s$)	T	P
Technical evaluation score (points)	89.28 ± 4.36	80.64 ± 6.22	−1.625	<0.05
Utilization time (%)	18.8 ± 0.06	24.3 ± 0.10	−0.822	<0.05

room. The difference of the lower sample indicates that the distribution of the sample data is small and close to the overall average; that is, the assessment score of the class is the most important, and there are significant differences between different models. Two grades (P0.05).

5. Conclusion

The experimental results show that multimedia teaching created from the perspective of MVP can achieve the purpose of promoting students' physical and mental health in difficult courses. Not only do students enjoy learning, gain strong training, and excel academically, but they also learn to identify their strengths and weaknesses, identify causes, and offer solutions. Traditional problem-solving teaching can improve students' learning fun at the beginning of the class, but with the increase of difficulty, students' learning interest gradually declines in learning. The teachers do not pay attention to the encouragement and ideological training in the teaching process, and the students' training will also be shaken to a certain extent. They think that hurdles are too difficult and difficult to learn, or they have a fear and dare not cross hurdles, so they cannot stick to them, and this reduces their confidence in learning hurdles. It also further leads to unsatisfactory training results. After the course, teachers do not take the initiative to provide psychological counseling for students and guide reflection. Some students with unsatisfactory results will have negative emotions and are not satisfied with the results. Because we cannot concentrate in class and have a deep understanding of hurdle knowledge, we cannot analyze our own advantages and disadvantages and improvement methods. It can be judged that the overall effect of multimedia teaching is better than traditional teaching. The teaching design using the MVP theory is clear and easy to implement, as can be seen from the experimental results. Multimedia teaching helps to improve students' technical level, cultivate skills and abilities, stimulate strong will, give full play to the subjective initiative, and achieve the purpose of physical and mental health.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Retraction

Retracted: UAV Based on Communication Network to Obtain Oil Pipeline Data and 3D Modeling

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] M. Zheng and Q. Liu, "UAV Based on Communication Network to Obtain Oil Pipeline Data and 3D Modeling," *Mobile Information Systems*, vol. 2022, Article ID 6860631, 13 pages, 2022.

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Research Article

UAV Based on Communication Network to Obtain Oil Pipeline Data and 3D Modeling

Minggao Zheng and Qihua Liu

Sinopec Petroleum Engineering & Construction Jianghan Corporation, Wuhan 430070, Hubei, China

Correspondence should be addressed to Minggao Zheng; 2016120352@jou.edu.cn

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With the advancement of science and technology and the development of industry, the demand for oil is increasing, and the measurement of oil is becoming more and more reliable and accurate. The communication network refers to the physical connection of various isolated devices to realize the link of information exchange between people, people and computers, and computers and computers, so as to achieve the purpose of resource sharing and communication. Oil and natural gas pipelines are an important strategic resource and the economic lifeline of a country. China's long-distance oil and natural gas pipelines have developed rapidly in recent years, and the Beijing-Shijiazhuang Pipeline, the "West-East Gas Pipeline," and the western crude oil and refined oil pipeline projects have been completed. The UAV can produce geometric data with high precision and build its 3D model. Therefore, this study proposed a UAV based on the communication network to obtain oil pipeline data and 3D modeling. The study mainly talked about the energy consumption in the era of communication. The energy acquisition was analyzed, the pipeline transportation measures for petroleum energy under UAV technology were focused on, the three-dimensional modeling of its terrain capture was carried out, and then the experimental data were analyzed after the equipment was debugged in the experimental part. The final experimental results showed that, under different frequencies, the data collected by the host computer were compared with the field measurement data, and the errors of the water and oil phases were calculated. It can be clearly seen from the data that the error was less than 5%, which also proved that this method was feasible.

1. Introduction

Due to the signing of the Sino-Russian oil transportation agreement, the Sino-Russian crude oil pipeline in the Central Siberia-Pacific region is also stepping up. In the construction stage of China's rapid economic development, ensuring the safe operation of long-distance oil and natural gas pipelines plays an important role in the national economy and strategy. Due to the increase in oil production and stricter production requirements, the previous measurement methods could not meet the needs of the current industrial production. Many oil production sites still require workers to read real-time data at the production site. The methods of measurement are relatively advanced.

UAV flight can obtain high-precision image data, so as to achieve high-precision DEM, architectural geometric data, and high-precision digital orthoimage DOM. It is a solid ground model that represents ground elevation in the form of a set of ordered numerical arrays and is a branch of the Digital Terrain Model (DTM for short), from which various other terrain feature values can be derived. The drone can get the whole picture of the building, and the structure is simple. This method overcame the problem that only multiple images can be acquired in the case of dense buildings and trees occluded. Through the direct extraction of UAV flight data, the workload of field operations can be effectively reduced. Therefore, it is a very practical and feasible method to use the data collected by UAV for 3D modeling. The intelligent metering system can effectively reduce the demand for labor, and the measurement accuracy of the system is more accurate than that of the system. Through the cooperation between the upper computer and the metering

control equipment, the remote collection of data and intelligent control are completed to achieve more accurate measurement.

The study focused on the energy consumption and energy collection in the information age, the application of UAVs in oil pipelines, and how to use UAVs to collect 3D models. The innovation of this article was that the study used the most advanced equipment and has been tested and debugged many times before the test to ensure the accuracy of the experimental data. Judging from the domestic numerical simulation research on the pipeline UAV working flow field, most of the research studies were based on the two-dimensional model, and the three-dimensional modeling used in this study was also more accurate.

2. Related Work

Previous LCA studies of transportation fuels have not adequately considered the full variability of crude oil transportation phases, for example, the transportation of light crude oil through large diameter pipelines versus the transportation of heavy crude oil through small diameter pipelines. Choquette-Levy et al. have developed a fluid mechanics-based first-principles crude oil pipeline transportation emissions model (COPTEM), which calculates pipeline transportation-related greenhouse gas (GHG) emissions based on crude oil parameters, pipeline dimensions, and external factors [1]. Butchibabu et al. designed to protect crude oil pipelines buried at shallow depths from possible environmental hazards and theft. Surface and borehole geophysical techniques, such as resistivity tomography (ERT), ground penetrating radar (GPR), surface seismic refraction tomography (SRT), cross-hole seismic tomography (CST), and cross-hole seismic profiling (CSP), are used to map vulnerable areas [2]. Li et al. used 500 historical data from the monitoring and data acquisition (SCADA) system and established a neural network-based pipeline temperature and pressure prediction model according to the temperature and pressure changes in the pipeline. The remaining life of corroded oil and gas pipelines was predicted, which provided a reference for the optimization of maintenance decisions [3]. In view of the changes of pipeline corrosion conditions, Zhang et al. introduced the inverse Gaussian stochastic process theory into the corrosion assessment of oil pipelines and established a mathematical model of inverse Gaussian state pipeline corrosion deterioration and an optimal maintenance decision model [4]. They just analyzed their pipeline data and its significance, but did not model it in 3D.

There is no very effective and advanced technology in the geological research work of oilfield development. Reservoir geological research also mainly relied on manually compiled thickness maps, reservoir profiles, and connectivity maps. There is a great need for new technologies to be supplemented and improved. In the whole development stage of geological research work, the only thing that can be called new technology is 3D geological modeling. Therefore, 3D geological modeling can play a more prominent role in geological research in the development stage. In fact, 3D geological modeling should and can become the core technology for fine reservoir description and production measures deployment in the reservoir development stage. The CompuCell3D modeling environment provided a convenient platform for biofilm simulation using the (GGH) model, a cell-oriented framework designed to stimulate growth and pattern formation due to the behavior of biological cells. James et al. showed how to develop such simulations, based on the mixed (continuous discrete) model of Picioreanu, van Loosdrecht, and Heijnen (PLH), to simulate the growth of bacterial biofilms of a single species and to study cell-cell roles and cell field interactions to determine biological Membrane morphology [5]. Based on the premise that 2D modeling is assumed to be overstretched for practical purposes in various environments, Bybordiani and Arici aimed to critically evaluate the application of 2D modeling in predicting the seismic demands of these systems [6]. Terrestrial Laser Scanning (TLS) is a newly developed technology that can collect thousands of data points in minutes and has broad application prospects in tunnel deformation monitoring. The raw point cloud collected by TLS cannot show tunnel deformation. Therefore, Xie and Lu developed a new 3D modeling algorithm [7]. They all introduced the three-dimensional modeling technology of oil pipeline transportation machines, but they did not use the survey technology of unmanned aerial vehicles and wireless communication technology. Therefore, the experimental data and research results had a certain deviation from this study.

3. UAV Based on Communication Network to Obtain Oil Pipeline Data and 3D Modeling Algorithm

3.1. Energy Efficiency Based on Communication Network. Due to the rapid development of smart phones, the demand for high-speed data services is increasing day by day, and traditional mobile communication networks can no longer meet the increasing customer demands. Therefore, the development and commercialization of a new generation of mobile communication systems has become an important topic. 5G is expected to provide 1,000 times the network capacity of 4G, with features such as high bandwidth, high speed, and low latency. In order to meet the exponential growth of data traffic, the 5G network must be a multilayer heterogeneous network with multiple network architectures coexisting. With the continuous development of human society and economy, the exchange and transmission of information has become an indispensable part of people's life as well as clothing, food, housing, and transportation. In order to achieve this purpose, the communication technology has shown an unusually prosperous scene in the past 50 years, which has also brought about the coexistence of various types of communication networks, that is, heterogeneous networks. As shown in Figure 1, Macrocell undertakes the task of basic coverage, covering a wide range and serving many users. Microcell and Picocell are responsible for the coverage of hotspot areas. Compared with

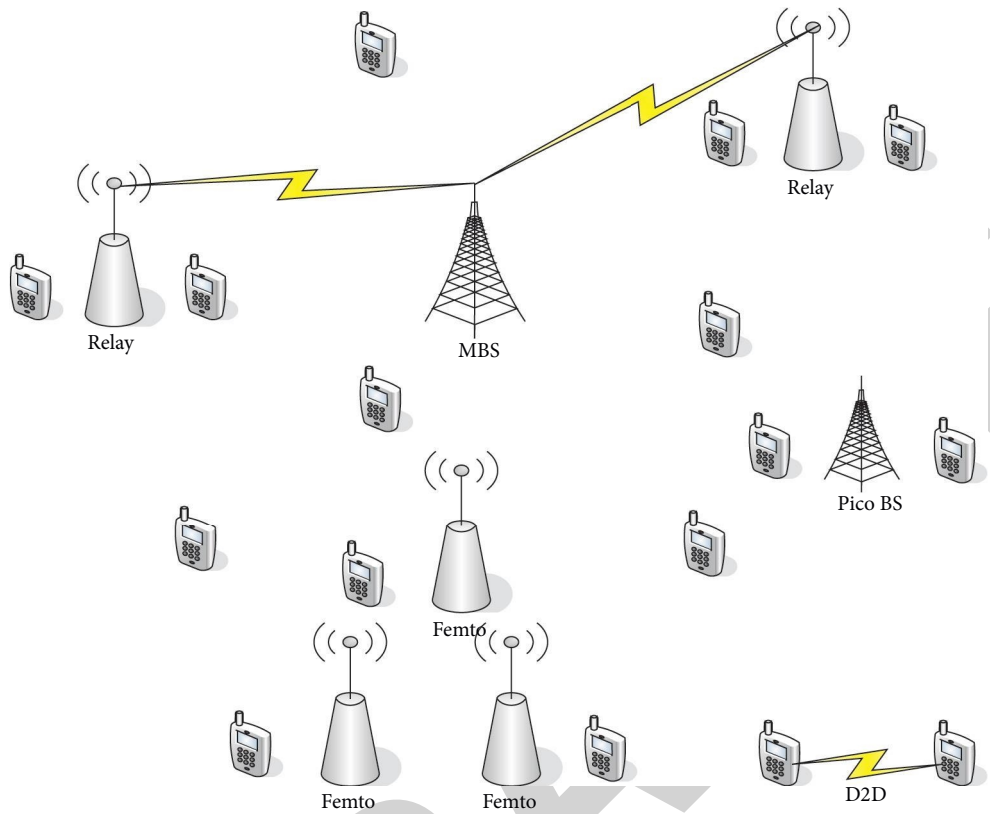

Figure 1: Multilayer heterogeneous grid architecture model.

macro cell base stations (MBS), their corresponding base stations have lower transmit power and smaller coverage. In addition, D2D is d2d three-dimensional map. It presents the industry information of local cities through the virtual representation of three-dimensional reality. The existence of D2D and cooperative relay can also improve the coverage of cellular network blind spots and improve the user experience at the cell edge [8, 9]. Obviously, 5G using this multilayered heterogeneous network will achieve better performance in terms of increasing network capacity, increasing coverage, and improving spectral efficiency. At the same time, the unprecedented rapid development of wireless communication technology has also resulted in huge energy consumption and increasingly serious environmental problems.

In the past ten years, the rapid development of information and communication technology (ICT) has further intensified energy consumption and the problem of environmental pollution has become increasingly serious. Currently, there are more than 4 million base stations around the world to provide communication services for cell users (CUs), and each base station consumes an average of 25 MWh of electricity per year. According to statistics, in 2007, the total carbon emissions from cellular communication networks were 86 million tons. It is estimated that, by 2020, the total carbon emissions from cellular communication networks will reach 235 million tons. With the continuous increase of carbon gas emissions, at the same time, due to the expansion of the network scale, the energy consumption of the cellular network further increases, which also leads to the OPEX becoming nonnegligible [10, 11]. In the total operating cost of MNO, energy cost can account for about 30%, and the energy consumption cost is higher than the revenue growth rate, which brings huge challenges to mobile network operators. Taking China as an example, it consumes about 20 billion kilowatts of electricity every year to maintain the normal operation of the communication network, costing more than one billion yuan, and with the rapid development of the communication industry, the energy cost will further increase.

It is foreseeable that if the existing wireless communication technology continues to be used, along with the further expansion of the network architecture, the resulting energy consumption, environment, and pollution problems will be more serious. Therefore, how to realize green communication with low pollution and low energy consumption under the premise of ensuring the quality of service (QoS) of mobile users and the benefits of operators has become an urgent problem to be solved in the new generation of mobile communication [12].

3.2. Terrain Reconstruction Technology of UAV Remote-Sensing Terrain. Due to its advantages of low cost, simple operation, flexible maneuverability, and the ability to obtain high-resolution images, its application on Earth has been rapidly developed. In the past, the remote-sensing image analysis of UAVs mainly analyzed the targets such as roads and vehicles in the two-dimensional image, mainly to extract

and identify the image of the target and then gradually convert it into a three-dimensional image in the two-dimensional image. This is a leap. Therefore, the study of terrain 3D reconstruction using UAV remote-sensing images has attracted the attention of many scholars. Unmanned reconnaissance aircraft are used to shoot three-dimensional images of targets and ground objects in the air and analyze their internal mutual constraints. The three-dimensional position, shape, and three-dimensional structure of objects are obtained [13, 14]. It includes the principle of image-based three-dimensional reconstruction, that is, recovering the relative movement of the camera and the three-dimensional structure of the spatial scene through different feature points at different positions. By 3D reconstruction of UAV remote-sensing images, 3D stereo reconstruction of UAV can be achieved [15].

3.2.1. Video Mode. The imaging model is a geometric perspective transformation, which reflects the mapping relationship between three-dimensional objects and two-dimensional objects. This imaging mode can be simply classified as perspective projection, also known as center projection or pinhole imaging mode, which is characterized by changes in the distance of the target from the camera. Its core is that the optical center, the object point, and the image point form a straight line, as shown in Figure 2.

Conversion between world coordinate system and camera coordinate system [16]:

$$\begin{bmatrix} a_o \\ b_o \\ l_o \\ 1 \end{bmatrix} = \begin{bmatrix} K & d \\ 0^D & 1 \end{bmatrix} \begin{bmatrix} a_s \\ b_s \\ l_s \\ 1 \end{bmatrix}, \tag{1}$$

where K is the rotation matrix of the space point from the world coordinate system to the camera coordinate system, which represents the cosine of the direction of the optical axis to the coordinate axis of the world coordinate system. In practice, it only contains three independent variables. d is the three-dimensional translation vector, which is usually called the external parameter of the camera and determines the position of the camera's optical axis in the world coordinate system.

Conversion between camera coordinate system and image physical coordinate system:

$$\begin{cases} A = \dfrac{g a_o}{l_o}, \\ B = \dfrac{g b_o}{l_o}, \end{cases} \tag{2}$$

where g is the main distance of the camera, and the conversion relationship between the two is expressed in homogeneous coordinates as

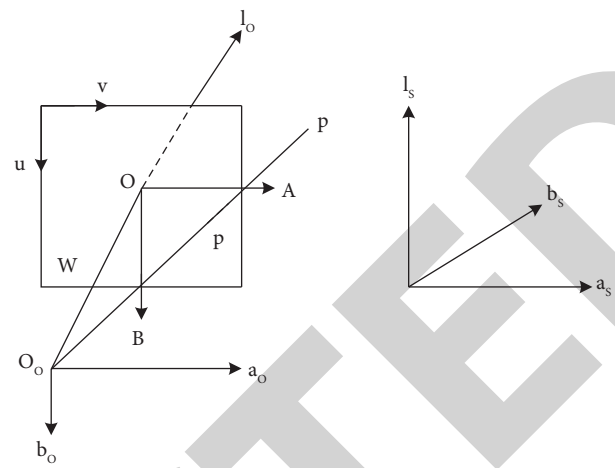

Figure 2: Coordinate system and imaging geometry.

$$l_o \begin{bmatrix} A \\ B \\ 1 \end{bmatrix} = \begin{bmatrix} g & 0 & 0 & 0 \\ 0 & g & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} a_o \\ b_o \\ l_o \\ 1 \end{bmatrix}. \tag{3}$$

Conversion between image physical coordinate system and image pixel coordinate system:

$$\begin{aligned} v - v_0 &= \frac{A}{t_a}, \\ u - u_0 &= \frac{B}{t_b}. \end{aligned} \tag{4}$$

Then, the coordinates are expressed as

$$\begin{bmatrix} v \\ u \\ 1 \end{bmatrix} = \begin{bmatrix} \dfrac{1}{t_a} & 0 & v_0 \\ 0 & \dfrac{1}{t_a} & u_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A \\ B \\ 1 \end{bmatrix}. \tag{5}$$

Combining the three coordinate processes, the imaging formula can be obtained:

$$\phi \begin{bmatrix} v \\ u \\ 1 \end{bmatrix} = \begin{bmatrix} g_v & 0 & v_0 & 0 \\ 0 & g_u & u_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} K & d \\ 0^D & 1 \end{bmatrix} \begin{bmatrix} a_s \\ b_s \\ l_s \\ 1 \end{bmatrix}. \tag{6}$$

It is shown in the following formula in matrix form, which is usually called the internal matrix:

$$R = \begin{bmatrix} g_v & 0 & v_0 \\ 0 & g_u & u_0 \\ 0 & 0 & 1 \end{bmatrix}. \tag{7}$$

At the same time, the rotation matrix K and translation matrix d representing the transformation relationship between the camera coordinate system and the world coordinate system are collectively called external parameters. It can be represented in matrix form, called extrinsic matrix [17]:

$$Z = [\,K \;\; d\,] = \begin{bmatrix} k_1 & k_2 & k_3 & d_a \\ k_4 & k_5 & k_6 & d_b \\ k_7 & k_8 & k_9 & d_l \end{bmatrix}. \tag{8}$$

The projection imaging relationship between the space point in the world coordinate system and the image pixel coordinate system can be expressed in the form of a projection matrix:

$$N = \begin{bmatrix} g_v & 0 & v_0 & 0 \\ 0 & g_u & u_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} K & d \\ 0^D & 1 \end{bmatrix} = R[\,K \;\; d\,]. \tag{9}$$

Then, the central projection imaging relationship is transformed into

$$\phi \begin{bmatrix} v \\ u \\ 1 \end{bmatrix} = N \begin{bmatrix} a_s \\ b_s \\ l_s \\ 1 \end{bmatrix}. \tag{10}$$

3.2.2. Stereoscopic Vision. In computer vision, recovering the three-dimensional information of an object from a two-dimensional image can actually be regarded as extracting the third-dimensional information implicit in the two-dimensional image, thereby constructing the three-dimensional structural information of the object. However, a single image cannot complete the three-dimensional description of an object, and it is necessary to use multiple images to observe the same object from different angles to complete the three-dimensional reconstruction of the target object [18–20].

Two or more images are often a constraint relationship, and this constraint relationship plays a very important role in the calibration of the camera and the three-dimensional reconstruction of the object. In research, epipolar geometry is often used to develop this confinement relationship. This method is not affected by the environment and exhibits the inherent photographic geometry between the two images, which depends only on the internal parameters of the camera and the relative position of the camera. This is the antipolar geometry of the two images, as shown in Figure 3.

When the position of the P-space point changes, the pair of polar faces rotates around the base line, thereby forming the beam of the opposite polar face, as shown in Figure 4:

The epipolar constraint geometric relationship can usually be represented by a rank 2 matrix G of order 3:

$$q_k^D G q_z = 0, \tag{11}$$

where G is called the fundamental matrix [21].

There are many ways to calculate the fundamental matrix G, generally including linear algorithm, iterative algorithm, and robust algorithm. In this study, the robust RANSAC algorithm is used to solve the problem. The main steps are

There is a pair of matching points q_z and q_k on the two images.

The coordinate values of all input matching points are normalized, the centroid of the matching points as the new coordinate origin is taken, and the average distance from these points to the new coordinate origin is D. Formula is normalized:

$$\hat{q}_z = Dq_z, \hat{q}_k = D' q_k. \tag{12}$$

The essential matrix satisfies $q_k \hat{G} q_z = 0$, that is,

$$[\,v' \;\; u' \;\; 1\,] \begin{bmatrix} G_{11} & G_{12} & G_{13} \\ G_{21} & G_{22} & G_{23} \\ G_{31} & G_{32} & G_{33} \end{bmatrix} \begin{bmatrix} v \\ u \\ 1 \end{bmatrix} = 0. \tag{13}$$

The formula contains 9 unknowns; therefore, at least 8 matching points are required to solve a fundamental matrix with scale coefficients.

3.3. Key Technologies of 3D Reconstruction Based on GPU

3.3.1. Parallel Computing. Parallel computing refers to that, on a parallel computer, multiple processors work together in parallel subtasks to complete the total task and ultimately improve the processing speed [22, 23]. Among them, task decomposition is the core of parallel computing, and the key is to find "exploitable parallelism." Generally, a directed data correlation graph is drawn to represent the interdependence between tasks. Through task decomposition, the parallelism between processing tasks can be divided into data parallelism, functional parallelism, and pipeline parallelism, as shown in Figure 5.

3.3.2. Normal Vector Calculation. When using the method based on local surface fitting to calculate the point cloud normal vector, it is assumed that the point cloud data are relatively smooth locally. Therefore, each data point can complete the plane fitting based on its local field points and indirectly obtain its normal vector. In practical applications, it is difficult to determine the number of neighborhood points due to the image of the point cloud density, the number of noise points, and the curvature. Delaunay-based methods first perform Delaunay triangulation on the point cloud and then solve for the normal vectors. The normal vector is solved by judging the position of the point p and the convex hull. If the point p is in the convex hull of the point cloud, then the connection between the point p and the Voronoi vertex farthest from p is the normal vector of the point p. If the point p is on the convex hull, then the point that is infinitely far outside the convex hull in the direction of the average normal vector of the convex hull plane adjacent to the point p is taken as the pole. The method based on Lupin statistics is based on the theory of robust statistics and

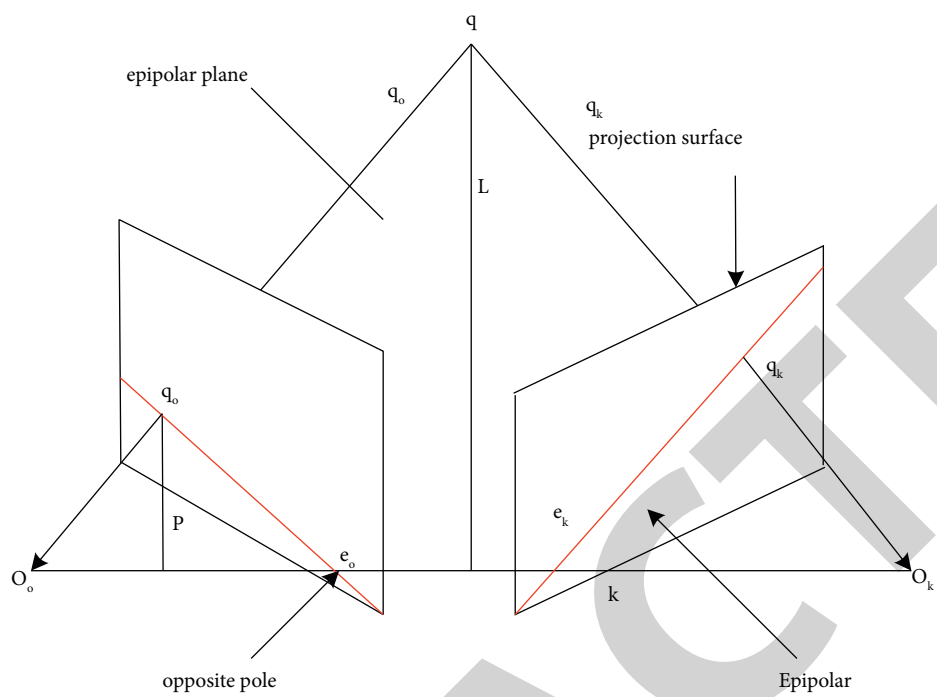

Figure 3: Schematic diagram of the epipolar geometry.

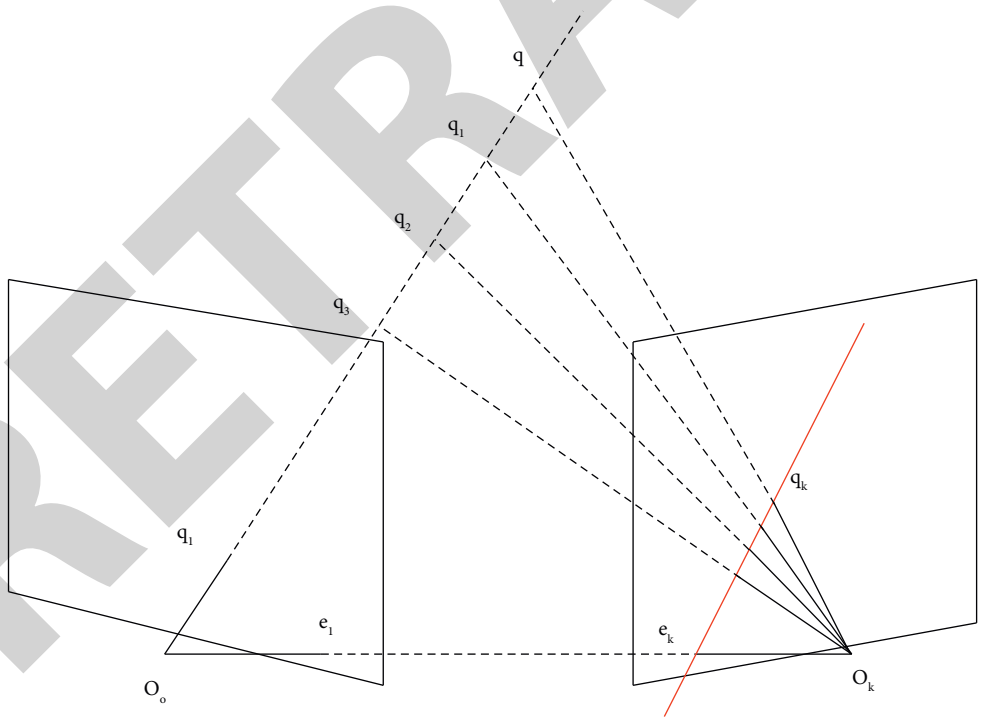

Figure 4: Properties of epipolar lines.

is mainly aimed at the point cloud model containing outliers and noise points, but the computational load is large. The solution of the normal vector in this study adopted the method based on local surface fitting, which is mainly used for the neighborhood point projection and sorting in the later work.

Assuming that a point is q, and its r neighbor set is $P = \{p_j\}$, and applying the least squares method to fit the tangent plane D of the point at this point, there is a normal vector m of the plane. That is the normal vector m of the point. The formula $\min(-u_j^D m)$ is the smallest, and $u_j = p_j - q$:

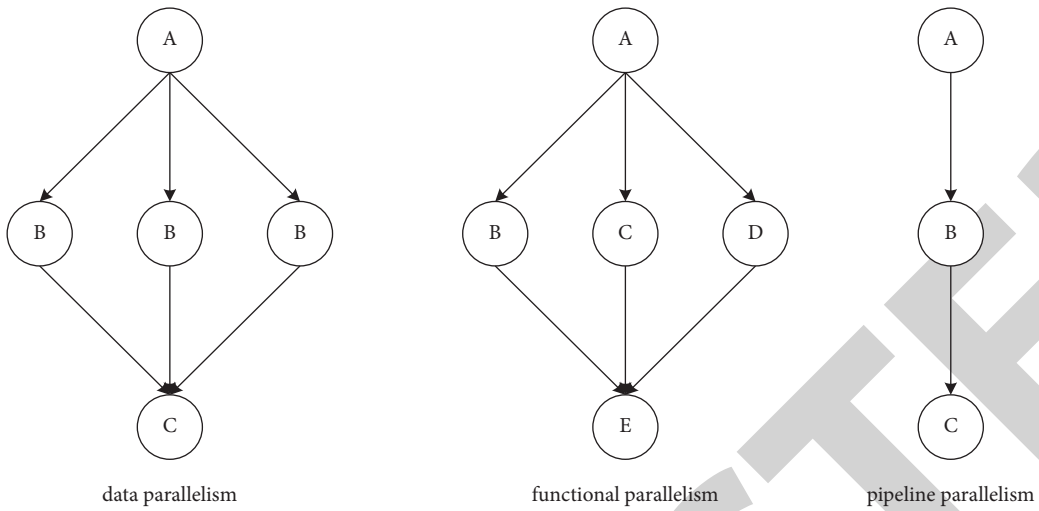

Figure 5: Data correlation plot.

$$\min \sum_{p_j \in P} \left(-u_j^D m\right)^2 = \min\left(\left(-u_j^D m\right)\left(-u_j^D m\right)\right). \tag{14}$$

O can be a 3×3 matrix:

$$O = \sum_{j=1}^{r} u_j^D u_j. \tag{15}$$

After completing the normal vector calculation for the point cloud, the next step is to project the point and its r neighbor points onto the tangent plane D passing through the point:

$$p_j' = q + \frac{\widehat{p}_j - q}{\left\|\widehat{p}_j - q\right\|}\left\|u_j\right\| \quad \widehat{p}_j = p_j - \left(mu_j\right)m. \tag{16}$$

Then, there are

$$\eta_j = \arccos\left(u_0^D u_i'\right). \tag{17}$$

In practice, in order to reduce the cost of calculation, the value of $\overline{\eta}_j$ is

$$\overline{\eta}_j = \left\{ u'^D_0 u_j' n^D u_j \geq 0, \ -2 - u'^D_0 u_j' n^D u_j < 0. \right. \tag{18}$$

Next, the q point is taken as the center, q_0 closest to the q point is taken as the starting point, and the size of the $\overline{\eta}_j$ value is sorted to form a continuous point ring around the point q.

4. Experiment on the Acquisition of Oil Pipeline Data and 3D Modeling by UAV Based on Communication Network

4.1. Debugging of Oil Pipeline Data System. Siemens S7–200CN series PLC has five different types of CPU, namely, CPU221, CPU222CN, CPU224CN, CPU224XPCN, and CPU226CN. Here, the PLC of the CPU224CN model is selected in this study, which can be connected to 7 expansion modules, and the interface is RS485 communication mode. The communication mode of S7-200PLC in this system is the free port mode, which communicates with other instruments through the MODBUS communication protocol. As a lower computer, PLC can not only accept commands from the upper computer but also output the programmed commands to the controlled equipment through PLC programming. EM235CN is an extension module of S7-200, which can accept 4 channels of input signals and send 2 channels of output signals. S7-200PLC and EM235 expansion module are used together, which can not only send instructions but also collect data from field devices to the host computer.

In this system, S7-200PLC needs 240 VAC power supply, while EM235 analog input/output expansion module uses 24VDC power supply, so the system is equipped with a 24 V power supply. The main variable settings in this system are shown in Tables 1 and 2.

ADAM module is an input and output device developed based on PC serial port. ADAM4520, ADAM4069, and ADAM4017+ are mainly used in this system. ADAM-4520 is a conversion device that realizes from RS-232 interface standard to RS-422/485 interface standard. It does not need to install any driver and only needs the correct connection of the device to complete the interface conversion. Because all ADAM modules support the RS485 serial port protocol, S7-200PLC and other ADAM modules communicate with the host computer through the ADAM4520 module. ADAM-4017+ is an analog signal acquisition module with 8 16 bit input ports. For example, 0–5 V voltage signal and 4–20 mA current signal can be collected by the 4017+ module. Each input channel of the 4017+ module has several different analog signal input ranges. This function increases the range of signal acquisition for this module in signal acquisition and data monitoring. The 4–20 mA analog signal output by the liquid level gauge is converted into a digital signal through the 4017+ module and then sent to the host computer. The

Table 1: System configuration main variables.

Water cumulative flow	I/O real	Water flow meter	41265	Read only
Instantaneous flow of water	I/O real	Water flow meter	41287	Read only
Cumulative oil flow	I/O real	Mass flowmeter	40135	Read only
Instantaneous flow of oil	I/O real	Mass flowmeter	40146	Read only
Gas cumulative flow	I/O real	Barometer	41155	Read only
Instantaneous gas flow	I/O real	Barometer	41578	Read only

Table 2: Main variables of software design.

Variable name	Variable type	Connect the device	Register	Type of data	Read and write type
Liquid depth	I/O real	ADAM4017	40001	USHORT	Read only
DO0	I/O integer	ADAM4069	00018	Bit	Read and write
DO1	I/O integer	ADAM4069	00019	Bit	Read and write
DO2	I/O integer	ADAM4069	00020	Bit	Read and write

function of ADAM-4069 is simply to output eight high and low level signals, which can realize the design of remote switch by controlling the relay. The blue wire in ADAM4017+ module and ADAM4069 module is connected to DATA+, and the green wire is connected to DATA. Then, the blue and green wires are connected to the DATA+ and DATAports of the ADAM4520. Thus, the parallel connection mode of ADAM modules in the system is realized.

Expansion tank consists of four parts: tank body, air bag, water connection port, and exhaust port. Used in a closed water circulation system, it plays the role of balancing water volume and pressure, avoiding frequent opening of safety valve and frequent replenishment of automatic water supply valve. The external structure of the surge tank is shown in Figure 6. Since the surge tank is a large pressure vessel, for safety reasons, a safety valve should be set at the top of its sealing end to avoid safety accidents caused by excessive pressure. In order to ensure the stable pressure of the storage tank, a gas filling valve is designed. When the dirt is mixed into the sealed tank, it can be discharged quickly, or when the pressure vessel is not used for a long time, it can be discharged to avoid its corrosion and rust.

The central control center is far away from the gas, oil, and water pumps. In order to solve the problem of starting and controlling each pump, the system adopts the upper computer operation to realize the remote control of the pump and can also realize the fault stop or emergency stop control of the pump on-site. The function is realized through the control of Adam ADAM4069 and electromagnetic relay. The host computer refers to a computer that can directly issue control commands. Generally, a PC screen that displays various signal changes (hydraulic pressure, water level, temperature, etc.). The electromagnetic relay uses a 250 VAC or 30 VDC power supply. The upper computer controls the I/O output of Adam ADAM4069 to control the contact closure and disconnection of the relay to realize the start and stop control of the pump and the emergency stop of the flow acquisition system when it fails. In the system, a total of three remote switches controlled by electromagnetic relays are used in this study, which are the "Drive" button and the "Stop" button of the inverter and the switch of the air compressor. In the central control room, there are host computer, PLC, and ADAM series modules. In this central control room, the staff can intuitively understand the instantaneous flow of oil, water, and gas in the system and the cumulative amount of time within a period of time through the host computer. The flow rate can also clearly know the liquid level in the mixed liquid separator. This is the most fundamental function to be realized by the data acquisition system.

There are always interfering signals in the laboratory where the data acquisition equipment is located, and sometimes these interfering signals may have a greater impact on the measurement results. Some of the interfering signals come from the surrounding environment and some come from the system itself. The main interference signal of this system is the strong EMI caused by the frequency shift. The electromagnetic interference of variable frequency speed control system mainly includes radio frequency radiation interference, harmonic interference, and radio frequency radiation interference. In order to avoid this situation, both hardware anti-jamming and software anti-jamming are used. Among these methods, hardware anti-jamming is the most basic and effective method. Therefore, the anti-interference of the system should be fully considered in the design. The system adopts the following anti-interference measures:

(1) Shielded twisted pair for data signal transmission is used to ensure that the shielding layer and the protective ground are connected.

(2) All equipment and instruments are reliably grounded.

(3) The signal line and the power line should be avoided as much as possible. Although the signal interference problem was considered in the system design, the interference signal generated by the frequency converter during the experiment still affects the stability of data acquisition.

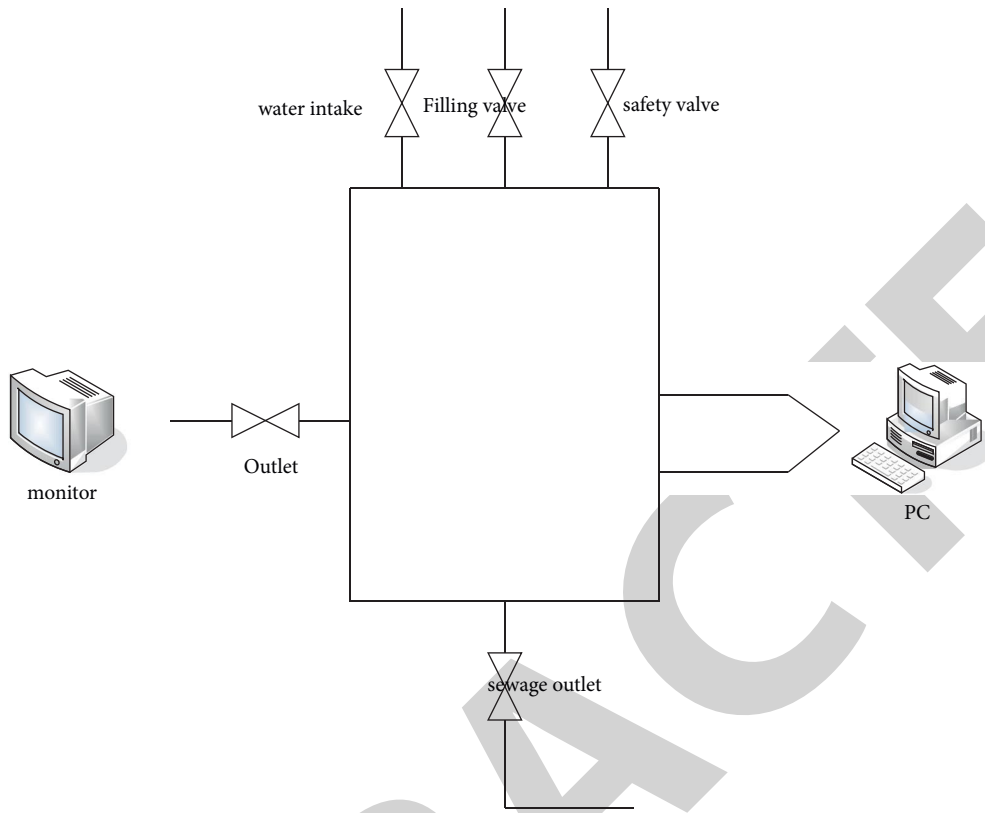

Figure 6: Schematic diagram of the structure of the surge tank.

Before using the signal isolator, when the system uses the inverter to control the frequency of the pump to control the flow of the oil phase or the water phase in the pipeline, the mass flowmeter will not be able to display the real-time collected data in the configuration system due to the signal interference of the inverter. After the signal isolator is added to the inverter control circuit, the electromagnetic interference phenomenon of the system has been effectively solved. When the system is running, the data of the mass flowmeter can be normally transmitted to the host computer for display.

4.2. Experimental Data. After the on-site and system configuration of the simulated oil production data acquisition system is completed and no signal interference is ensured, the system enters the operation experiment stage. In the system, the frequency converter is used to control the flow in the pipeline, so the frequency set in Kingview and the actual frequency of the frequency converter should be calibrated first. The frequency in the configuration software in the host computer is changed, and the frequency value actually displayed by the inverter at the same time is read, and the frequency comparison in Tables 3 and 4 is obtained. Among them, the frequency and the actual frequency value are the variables defined in the Kingview software before this study.

Kingview, namely, Kingview development monitoring system software, is a new type of industrial automatic control system. It replaces the traditional closed system with an integrated system composed of standard industrial computer software and hardware platforms. After calibrating the frequency, it can be seen that the error between the frequency set in Kingview and the actual frequency of the inverter is basically within ±0.1 Hz, and the error rate is less than 1%, which is within a reasonable error range, so the calibration result is ideal. After calibrating the frequency, this study starts to carry out the experiment of system data acquisition. During the experiment, this study

Table 3: Frequency calibration results (a).

Frequency value set in Kingview (Hz)	Frequency value displayed in the inverter (Hz)
1	1.00
2	1.95
3	2.87
4	4.09
5	5.04
6	5.98

Table 4: Frequency calibration results (b).

Frequency value set in Kingview (Hz)	Frequency value displayed in the inverter (Hz)
7	6.94
8	7.98
9	9.04
10	10.02
11	11.09
12	12.03

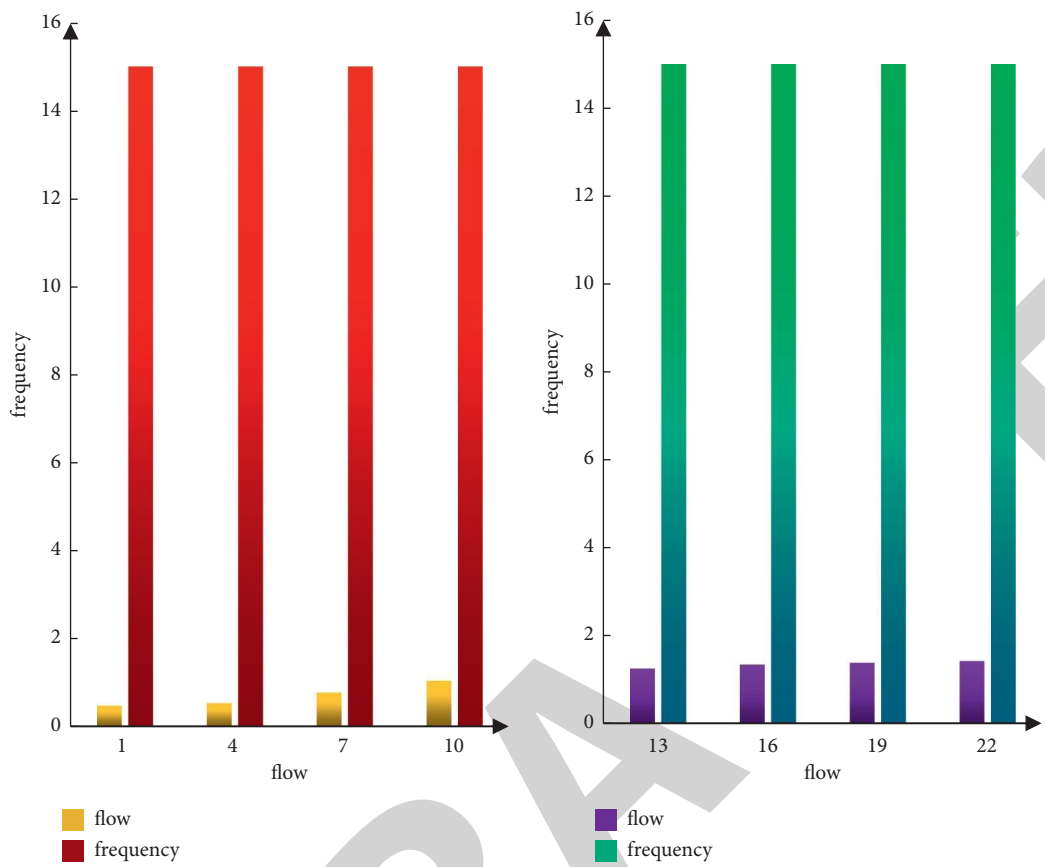

Figure 7: Water flow at a fixed frequency.

divides the flow collection into two parts, respectively, testing the stability and accuracy of the data collection system. For stability, the test method in this study is to adjust the frequency of the frequency converter to a certain fixed value, keep it unchanged, and observe the change of the flow in the pipeline. In this study, the frequency is fixed at 15 Hz and the stability test is carried out. The set acquisition time interval is 2000 ms. The flow data of the water and oil phases are shown in Figures 7 and 8.

From the data in Figures 7 and 8, it can be seen that the stabilization time for the flow in the water pipeline is about 20 s, while the time for the flow in the oil pipeline to stabilize is longer, about 25 s. After a period of time, the flow of the fluid in the oil pipeline and the water pipeline will gradually tend to a stable state, and the fluctuation of the flow is relatively small. Finally, the data obtained by the host computer and the field data of the flowmeter at different frequencies are observed, the two types of data obtained are analyzed and compared, and the accuracy of the data acquisition system is analyzed. The control program can also be adjusted and revised to improve the control system. Fluctuations will occur when the flow in the system changes. In the accuracy test of the flow, each time the frequency is changed, and the displayed data in the host computer and the on-site data of the flowmeter are observed and compared within a certain period of time to determine the accuracy of the data acquisition system. In the experiment, by comparing the data of the host computer and the data of the on-site flowmeter, the two-phase data of oil and water are shown in Figures 9 and 10.

By observing the two sets of data, it can be seen that there is still a certain error between the data collected in the host computer and the data collected on-site. This error is unavoidable due to pressure changes in the pipeline, accuracy of metering equipment, data collection intervals, etc. By comparing the data obtained in the host computer with the on-site data of the flowmeter at different frequencies, the errors of the two-phase data of water and oil are calculated. In Figures 9 and 10, it is clearly observed that the error does not reach 5%. Because the system requires that the error should be less than 5% to meet the requirements of the data acquisition system on the oil production site, although there are certain errors in the experimental results of the system, the method meets the design requirements of the system and also achieves good experimental results.

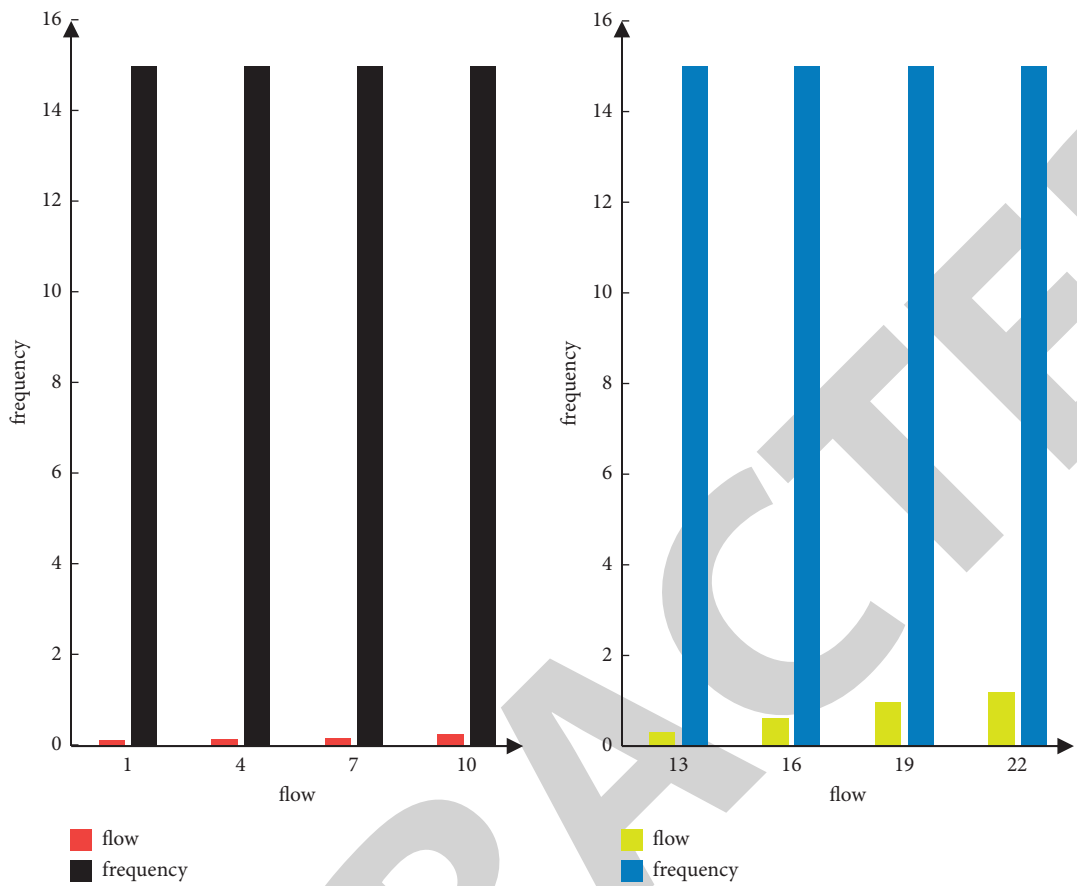

Figure 8: Oil flow at a fixed frequency.

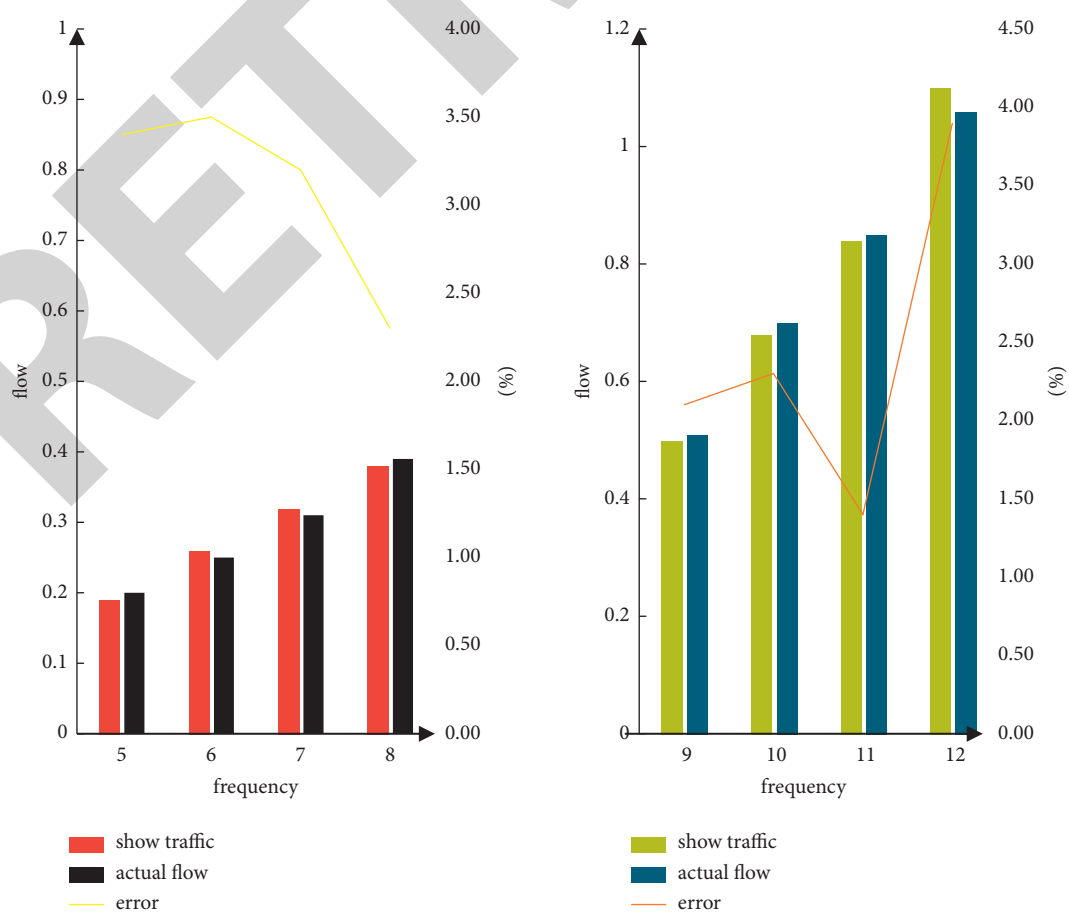

Figure 9: Water flow data relationship.

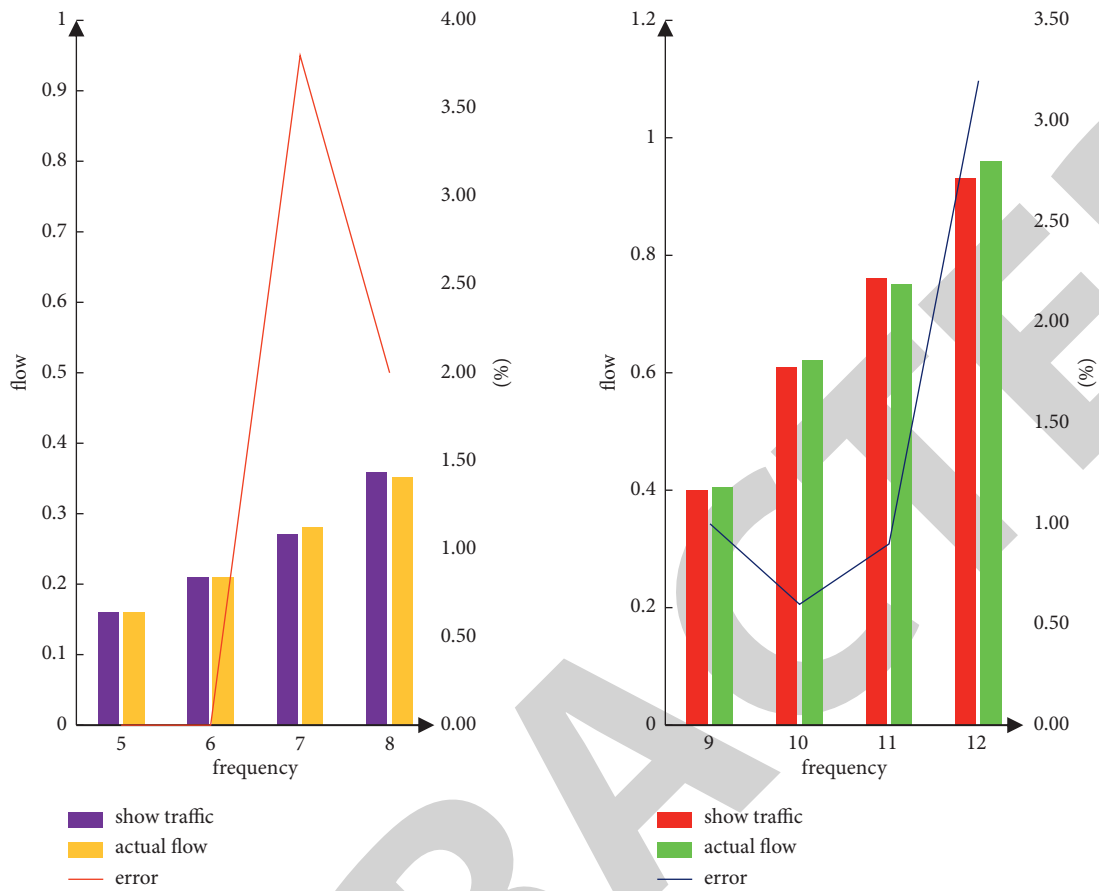

Figure 10: Oil flow data relationship.

5. Conclusion

According to the overall design idea of the system, hardware of the system was selected and configured, then the overall design of the system was improved, the design of each component was refined, and finally the configuration function of the system in Kingview was realized. The system has a high degree of automation and is easy to operate and has the following characteristics: the mass flowmeter and the turbine flowmeter are used as data acquisition equipment, and the two instruments have higher accuracy, better environmental adaptability, and wider measurement range. These fully meet the accuracy and reliability requirements of the data acquisition system on the production site. However, some parts of the system were still not perfect, and functions to make the system more intelligent can continue to be added on the basis of the existing system, and the degree of automation needs to be further improved. Although the system realized the functions of data acquisition and monitoring, there are still many tasks that need to be further studied and explored.

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 authors declare that there are no potential conflicts of interest in our paper.

Authors' Contributions

All authors have seen the manuscript and approved to submit to your journal.

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Retraction

Retracted: Tourist Attraction Recommendation Method and Data Management Based on Big Data Analysis

Mobile Information Systems

Received 13 September 2023; Accepted 13 September 2023; Published 14 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] F. Xu and F. Han, "Tourist Attraction Recommendation Method and Data Management Based on Big Data Analysis," *Mobile Information Systems*, vol. 2022, Article ID 7161522, 13 pages, 2022.

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Research Article

Tourist Attraction Recommendation Method and Data Management Based on Big Data Analysis

Fangyuan Xu and Feng Han

School of Management and Information, Chuzhou City Vocation College, Chuzhou 239000, Anhui, China

Correspondence should be addressed to Fangyuan Xu; xufangyuan@czcvc.edu.cn

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The proliferation of social networking data has opened up numerous avenues for providing additional perspectives to decision-makers. While big data analytics has the potential to aid in rational decision, so far there is little evidence to support this claim. More importantly, in the tourism industry specifically, a standardized approach to assessing social video big data for strategic planning has not yet been created. This project will use a research-based design science method to develop and estimate a "big data analytics" strategy for enhancing strategic decision-making in the control of tourist destinations. Using geotagged pictures provided by visitors to the picture social-media site Flickr as a matter of reality, with Melbourne, Australia as a case study, this method's applicability is demonstrated in helping destination management organizations analyze and predict tourist behavioral patterns at specific destinations. Extra source, recipient, and stakeholder groups were used to verify relevance. The produced artifact exemplifies a technique for assessing massive amounts of unstructured data to aid strategic decision-making in an actual problem area. The scope of the suggested method is examined, and it is possible that it could be applied to other types of extremely large data sets.

1. Introduction

As civilization has grown, many nations and areas have seen a rise in tourism as a major source of economic growth. Tourism is flourishing, and the government is increasingly appreciating its contribution to economic growth and job creation. Tourism consumption demand has risen much more. Internet of Things, cloud computing, and mobile intelligent agents have all contributed to the rise of intelligent tourism. Destination images are formed by people's thoughts, feelings, and opinions about a destination, as well as their views of social, political, economic, cultural, and other variables in that location [1].

The tourist industry is now thriving, and the government is increasingly appreciating its contribution to economic growth and job creation. Many challenges in the growth of tourism can be solved with the advancement of computer artificial intelligence technologies [2–7]. When planning a trip, people have a lot of choices to make, including where they want to go, how long they want to spend there, and what form of transportation they want to use. The most important choice is where they want to go on vacation. Operational research approaches, supermarket tourism routing architecture, and theme tourism route architecture are currently the primary methodologies used by several tourist organizations. Tourist route design should be taken into account while establishing market-oriented tourism routes [8]. Most analytics in the tourist industry have focused on travel recommender systems (TRS), despite the fact that early TRS hardly ever made use of social networking sites and did not intend for use by destination marketing organizations. Travel itineraries that may be customized based on interests and available time were identified and recommended by previous research using the sequence of sites in travelers' uploaded geotagged images. Using geotagged photographs from Flickr, other studies created personalized recommendations for individuals based on their preferences rather than simply on the most popular destinations.

Recommender systems may be a big assistance when organizing a vacation or looking for a provider among various places, attractions, and activities [3]. This kind of system is characterized as a way of identifying the most appropriate offerings (goods and services) for consumers, such as those that are comparable to other items they have purchased and appreciated or those that have previously been appreciated by other segment customer interests [9–11].

Benefiting from the free interchange of private details, uploaded content is feasible on a slew of social media websites. Given the large number of users' spontaneous posts and digital picture and video uploads, many sorts of data are constantly evolving inside social media networks (such as Facebook, Twitter, and Flickr).

Big data is a generic term for any really large or very complicated data set. In addition to these traditionally "structured" data sets, such as financial records and transactional details, big data also includes "unstructured" data sets such as text, documents, and multimedia files, as well as "semistructured" data sets like web server logs and streaming data from sensors. Big data is characterized by a number of factors, including its volume (which is significantly larger than standard data sets), variety (of formats in particular), velocity (the rate at which information is created and made available), diversity (through time and across resources), and fragility (the inconsistency of output levels) [12]. The process of specifying, collecting, storing, accessing, and analyzing massive datasets is referred to as "big data analytics" [13]. Data analytics is to get insights from data. There are several benefits to using big data analytics, such as improved decision-making and the prevention of fraudulent actions. This is done with the goal of making sense of the datasets' contents and maximizing its value when it comes to decision-making. Global transportation and tourism firms increasingly embrace big data analytics. Airline companies, for instance, utilize analytics to learn more about the demographics of their customers' purchases and travel habits. Everything we do today, across all industries, is powered by big data analytics. Data analytics on large amounts of data is rapidly becoming a pivotal factor in shaping developments across a wide range of economic sectors. The tourism and hotel industries are likewise adapting to this new reality. Information collected here includes requests for hotel stays, flight and hotel reservations, taxi service requests, hotel location choices, and other similar requests made by tourists. Researchers and people in charge of making business decisions are becoming increasingly interested in big data. To name a few, the tourism sector has shown a keen interest in topics like tourist destination (TD) tactical thinking, tourism management, relationship management, and even destination marketing [5–7, 14]. In despite the fact that digital networks have indeed been acknowledged as a helpful and dependable resource of information for travelers [8], it is still in its infancy in the analysis of large data created specifically via social media, especially in the domain of tourism management. Rational decision in this specific business is the subject of this research since big data analytics has not offered examples of how it may aid in this process. The big data analytics tools are as follows:

(i) Hadoop aids in data storage and analysis.

(ii) MongoDB is utilized for regularly changing datasets.

(iii) Talend is a data integration and management tool.

(iv) Cassandra is a distributed database used to manage data chunks.

(v) Spark is utilized for processing and analyzing enormous volumes of data in real time.

A geographic site that gives visitors with access to a variety of sights and activities, as well as all of the accommodation and in addition to what the visitor may need, is known as a tourist destination (TD). A tourist destination (TD) is, in its most basic form, a list of places where tourists spend their days and visit for the purposes of viewing (both man-made and natural attractions), participating in activities (such as skiing, swimming, and learning), and enjoying themselves (e.g., attending in events, bars, restaurants, and shops). In general, destination management organizations (DMOs) are in charge of administering and promoting the TD, as well as coordinating with the local tourist sector and directing growth initiatives. As a result, they must be aware of future marketplace demands and cooperation among the many stakeholders [15]. What activities visitors have really participated in; this information is critical for many TDs (usually with a big selection of diverse attractions). In addition, traditional methods of data collection for TD planning and oversight have mostly centered on the use of surveys and questionnaires. This strategy takes too much effort and yields too little fruit. The following crucial questions have not yet been satisfactorily answered for DMOs: What is it about a given place that makes people want to visit it? When touring a new area, where do tourists typically go? When seeing these landmarks, what were the tourists' individual impressions? How does future tourism demand break down into more granular categories (such as age group, country of origin, or market segment)? A DMO might gain full insights into travelers' actions, experiences, and personal reflections by utilizing big data.

It is essential to make use of big data technologies in order to conduct in-depth research on how tourists feel about the image of tourist destinations, the reasons people travel there, and the demand for tourism from the tourists' point of view. There are now three categories of big data in tourism: E-commerce data, user-generated content (UGC), and temporal-spatial behavior data.

E-Commerce Data. Nowadays, a tourist business transaction, such as reserving a hotel or purchasing an attraction ticket, may be conveniently completed through several tourism online portals or platforms. Tourism E-commerce alters conventional trading patterns in the tourist business while also producing more valuable data.

UGC (User Generated Content). Tourists like to discuss and upload their experiences on these platforms during and after their vacations, thanks to the increasing rise of online social media, travel professional websites, travel forums, and blogs.

Temporal-Spatial Behavior Data. Temporal-spatial behavior data from tourists is becoming an abundant source in the tourism big data. The approach of time geography is used to study the geographical and temporal behavior patterns of visitors.

In the specific application of data mining technology, there are three fundamental technologies involved: the technology for the using of data mining algorithms, the technology for the processing of original data, and the technology for the formation and representation of pattern libraries [16]. The real-time and accurate advice provided by the picture monitoring system at a well-known tourist destination are in direct opposition to one another. The image of a tourism location is shaped by a number of elements, including, but not limited to, the local economic and political climate, the global ecosystems, the accessible cultural tourist sources, the infrastructure, and the degree of tourism growth [17]. Though it is true that the tourism suggestion service has been the orientation of much investigation, it continues to offer tourists a tourism foundation that is both convenient and effective. On the other hand, time is not a factor in the investigation into travel suggestion services that we are currently conducting. The field of tourism recommendation has made significant strides forward, thanks to the application of mature data mining technologies, which has allowed for the provision of reliable and insightful tourism information suggestion services to site visitors [18]. There is a plethora of different tourist sites to select from in today's buyer's market for tourism. People would evaluate photographs of relevant tourist places before deciding on the one that best meets their tourist goals and psychological expectations [14].

The success of a tourist destination's tourism sector depends on the creation of a positive brand image. The use of this brand image may help tourist locations promote local tourism growth by displaying clients the local distinctive tourist resources and services in the most straightforward manner feasible. It is becoming increasingly difficult to address the informational demands of self-help visitors due to the fragmentation of local tourism information, the absence of data integration and exchange, the scarcity of correct services, and the dispersion of information access channels in place [19].

DSR approach will be used in this project to construct and test a new analytics tool for unstructured big data, but with information relevant to the tourist industry. To further understand our suggested design artifact, we describe its characteristics as a strategic and operational decision-support tool for tourism planning, which incorporates known and developing computational methodologies to allow multiple management-driven parameterizations.

When developing, analyzing, and presenting the solution utilizing a DSR method, Hevner et al.'s seven's design fundamental precepts are utilized throughout the process. What we are calling a technique is a design artifact that helps the DMO make reasonable decisions in the context of TD planning by analyzing social network big data (e.g., geotagged photographs) together with their accompanying private and metadata.

2. Big Data Source: Social Media

Using the term "big data" is a way of referring to massively big datasets that are becoming more accessible as the quantity of digital activity continues to expand. The growth of GPS, CCTV cameras, and sensor networks, as well as greater communication through electronic information, images uploaded to the internet, and blog postings, theoretically provides a vast quantity of data for analysis. Big data is generally defined as having not just volume, but also, there is a high degree of diversity (various formats) as well as pace, with data often being accessible in close time or in real time. This is in contrast to the traditional definition of big data, which focuses only on volume.

As a "generic term," the term "social media" is used for interpersonal relationships based on a variety of digital technology and media that let users to develop, share, and collaborate. Big data can be found in social media since it provides a wide range of data that can be used to make informed decisions. Social media data are generated as a result of the extensive use of sites and applications for social networking, such as Twitter, Facebook, Tumblr, LinkedIn, YouTube, Flickr, and TripAdvisor. Content created by the public includes everything from real-time activity blog updates to photographs, short films, personal, and/or professional data in form of brevity.

2.1. Tourism and Big Data Analytics. New paths for better decision support have been opened up by big data, that may be considered a "new generation" of the info-based precedent [3]. This research is still in its early phases (mostly for the design of information systems), but it has direct use in businesses that rely heavily on data, such as tourism, especially for DMOs when it comes to TD concept and execution. However, current support systems are unable to handle the large volume and rich diversity of data in this sector, as well as the information systems necessary as datasets and user-generated content proliferate. In most situations, many of the typical tools and procedures used in management information systems were not intended to interact with social media information. As a result, they are best suited to data that is well structured. New methods of analysis and procedures adapted to the features of large data sets are necessary since big data is almost entirely unstructured, at 95% [24]. Because of the complexity of big data analytics and the wide range of connected media and metadata, traditional predictive analytic methodologies will have to be augmented, supplemented, or replaced.

Diverse new analytic frameworks and methods have been proposed to address the challenges posed by the social media/big data revolution. For general social media and tourist social media analytics, we categorized the program. Social media data are being used by both companies; however, the former focuses on general business analytics and the latter focuses on tourist analytics. The next paragraphs go into great detail on each of these categories. Analytics solutions beyond the tourism region have been attempted several times. Musto et al. conducted a semantic

study of social media material (uploaded by a group of people) and social power indices using an opinion mining approach named SentiWordNet (such as sentiments of safety and trust). For each social indicator, an aggregated score of either positive or negative synthetic aggregate is assigned.

2.2. Brand Image Development for Tourist Destinations. The geographic topic model is used to examine the user's desire for the destination, and the tourist destination is recommended based on the tourism features. Choices of users for different destination attributes may be collected using this model, and their choices for other places can be forecasted using this model. In the same way, customers' preferences for locations can be expressed numerically. The satisfaction of each destination for each user P is computed using the following formula:

$$P = P(Y = 1) = F(\beta_i X_i). \tag{1}$$

A recommendation algorithm is at the heart of the recommendation system. The most fundamental kind of a recommender system, known as a demographic-based recommendation method, categorizes individuals into groups determined by factors such as their age and gender. The letter K represents the sensitivity of the unit, while the letter I denotes the output values of the hidden layer, also known as the multilayer perceptron before the nonlinear conversion. To update the weight of a hidden layer, the following rule is used:

$$U_{ij} = \frac{H_{ij}}{\sqrt{\sum_{t=1}^{k} H_{it}}} 1, \ldots n, j = 1, \ldots, k. \tag{2}$$

In addition to proving the correctness of each tourist scenery classification, we also demonstrated the efficiency of each tourist scenery gorgeous area in terms of its ability to be categorized. Table 1 presents information on how accurate the multistage transfer learning model is. The majority of the time, multistage transfer learning is the most efficient way to learn something. Table 1 lists the findings of the single-level transfer learning model.

Visitors' problems, attitudes toward self-help tours, obstacles faced, and solutions executed are among the objectives of this study. Prior to concluding the demand study, we created a survey using the surveying network. Information gleaned from a survey given to one hundred individuals who were randomly picked from the website was one of the sources used to conduct the demand analysis. Table 2 lists the information.

Sightseeing destinations and hotels are categorized according to visitors' interests and preferences, so the system may more accurately provide tourists with the details they want and meet their needs for personalized information acquisition. The experiment shows that lower bound checking is the most effective method of optimizing performance. Figure 1 shows that when the two optimization techniques are combined, the algorithm with the two optimization methods performs best in terms of time.

Table 1: Different levels of classification accuracy.

Levels	1	2	3
Classes	3	7	27
Rate of accuracy	97.22	94.77	98.29

2.2.1. Dissemination of Tourism Destination Brand Image. We utilize the frequent closed set mining approach in order to choose a tourist spot based on attribute criteria. First, we make a tally of the number of iterations and each location is referenced in data pertaining to tourism. Next, we mine the frequent closed set utilizing the FP-tree data structure. According to the heading, the conditional pattern tree mines every component and extracts frequent patterns from it using the FP-tree, or conditional database (Figure 2).

If it is in a beautiful location, we take note of the fact that tourists have already been there and then go back to the attractive location, in which the visitors are already present. Its complexity is as follows without an optimization strategy:

$$w_{ij}(k+1) = w_{ij}(k) + \eta \delta_i x_j. \tag{3}$$

After each layer's response graph and the convolution of the convolution kernel, each pixel of the first response graph of each layer is totaled, as shown in the following formula:

$$f(t) = \sum_{j=1}^{N} \sum_{k \in \mathbb{Z}} d_k^j \phi_{jk}(t) + \sum_{k \in \mathbb{Z}} e_k^N \phi_{Nk}(t). \tag{4}$$

Virtual worlds require real-time loading and display of three-dimensional models, which necessitates a balance between rendering efficiency and model fidelity. We have the ability to keep neurons from going into hibernation for extended durations. Hidden cell activation values are formally defined as follows:

$$Qi = C_q A_i \sqrt{\frac{2\Delta P_i}{\rho}}. \tag{5}$$

Using data connection pools, data control systems, and other administrative tools, this function may be better managed. Additional information is provided on each picturesque region's capacity to be classified as a tourist scene location. The efficiency of the multistage transfer learning approach is shown in Table 3. In most cases, multistage transfer learning is the most effective strategy. Table 3 lists the findings of the single-level transfer learning model.

Relevant models can be created based on the interests of consumers. In general, consumers can gain explicit information about themselves by sending questionnaires to them and basing their replies on their responses or other information, such as prior product assessments. The following outcomes are acquired using nonlinear conversion:

$$I(X;Y) = \sum_{y \in Y} \sum_{z \in Z} p(x,y) \log\left(\frac{p(x,y)}{p_i(x) p_z(y)}\right). \tag{6}$$

The accuracy data in Figure 3 show how different fine-tuning tactics lead to varying categorization accuracy.

Table 2: Distressing factors throughout the timetable.

Reason	Meal arrangement	Arrangements for lodging accommodations	Traffic safety	Open time
Number proportion	15	63	55	21
Proportion	15%	63%	55%	21%

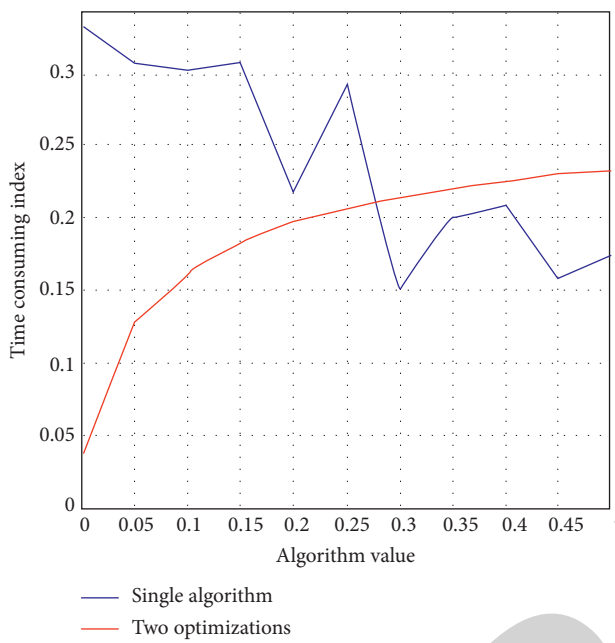

Figure 1: Comparison of algorithm performance time.

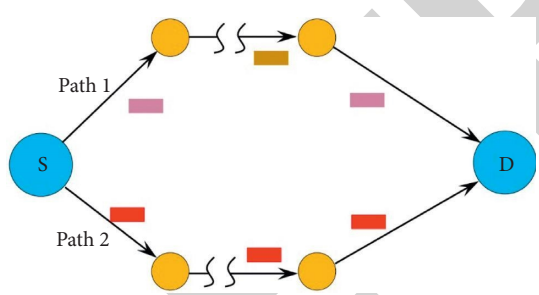

Figure 2: PP tree.

Table 3: Different levels of classification accuracy.

Levels	3	4	8
Classes	6	17	48
Rate of accuracy	93.13	95.88	97.92

3. Collection and Processing of Information

This research makes use of geotagged photo data obtained from Flickr. The pictures were taken on the move by the users with GPS-enabled photo capture devices that automatically collected geographic data. The application programming interface that Flickr provides may be used to get the images and any metadata that is associated with them. We are able to use a bounding box to specify the region, from which we wish to collect data for TD management. The coordinates of this box are referred to as lamin, lomin,

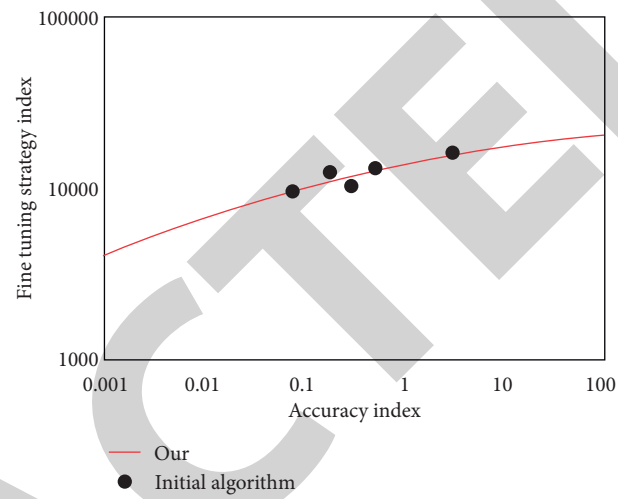

Figure 3: Accuracy index data.

lamax, and lomax, respectively, for a minimal level of geolocation, the greatest of geographical coordinates. This allows us to specify the region, from which we wish to collect data for TD management. The date and time of the picture's capture, in addition to its location, are automatically acquired and stored in the photo tag. By choosing the picture tag, we may get this information. The time range of an image may be specified using two factors: *t*min for the soonest and *t*max for the latest period. The search will only return images that were taken within the allowed time range and geographical area.

Temporal data, such as the date and time the photo was taken, are automatically captured and saved in the photo tag in addition to geographic data. Two parameters may be used to specify the photo capture period: *t*min denotes the earliest possible time and *t*max indicates the latest possible time. Only images taken within the specified amount of time and geographical area will be returned.

3.1. Textual Metadata Processing. Specific keywords are frequently found in the textual metadata of photographs, which may represent particular priorities or visitors' interests and motives when shooting photographs. The unstructured nature of such textual data makes it unsuitable for examination without some type of preprocessing. General architecture for text engineering (GATE) is a strong text processing tool that we use. GATE possesses a number of language databases, one of which is an English lexicon that contains a comprehensive selection of vocabulary words that may be used to describe interests.

Let us assume there is a collection of image data $P$where each image $p_i$is designated as $t^{(p_i)}$and includes tags metadata such as description and title. Each $t^{(p_i)}$metadata component

is fed through a text tokenistic method, which divides the text stream into phrases, symbols, words, and other significant parts. Stemming is a technique used to reduce stressed words to their simplest form, the stem. Items of interest are anticipated to be referred to using English noun type language (e.g., building, street, and tree). It is necessary to generate and name a list of stemming nouns that can be discovered in the data collection:

$$S = \{s_1, s_2, \ldots, s_m\}. \tag{7}$$

To determine the sort of word, such as noun, adjective, or verb, a collection of tags linked with each phrase in the English lexicon can be employed. If a discrete vector is

$$\mathbf{b}^{(u_i)} = \left\{b_1^{(u_i)}, b_2^{(u_i)}, \ldots.., b_m^{(u_i)}\right\}, \tag{8}$$

it is subsequently built per user, with $b_j^{(u_i)}$ taking the value 1 if s_j occurs in the written information at minimum once of user u_i image collection. U represents the whole users in the collection obtained, and $C(s_j)$ represents vector $\mathbf{b}$, which is $b_j = 1$. A support value is used to assess the each stemmed noun's level of interest $s_j \in S$, which reflects the level of tourist attraction:

$$\sup\left(s_j\right) = \frac{C\left(s_j\right)}{U}. \tag{9}$$

3.2. Clustering of Geographical Data. This stage seeks to find common locations based on the tourist interests that have been defined. Let us assume $\widehat{p}$ is a collection of images with textual information including a keyword reflecting a tourist's unique interest. It takes into account the quantity of images and the number of visitors, ensuring that the recognized areas have a large number of tourists who have come for a specific reason. Recent studies have demonstrated the benefit of P-DBSCAN in identifying popular tourism destinations. Longitude and latitude value pairs, $<\text{lop}_i, \text{lap}_i>$, are used to reference the geographical data of each picture p_i. $D(p_i, p_j)$is the difference between two photographs p_i and p_j. Let $\mathbf{r}$ be the radius of a neighborhood. The photo p_i's neighborhood photo $N_r(p_i)$ is therefore defined as follows:

$$N_r(p_i) = \left(p_j \in \widehat{p}, \mathrm{O}\left(p_j\right)\right) \neq \mathrm{O}\left(p_j\right) \Big| D\left(p_i, p_j\right). \tag{10}$$

In this equation, $O(p_j)$ is a function of ownership for determining who owns picture p_i. Let us consider $|N_r(p_i)|$ be the owner numbers of the neighboring photographs $N_r(p_i)$ and be a threshold for the number of owners. If $|N_r(p_i)| \geq \alpha$, the photo is termed a core photo. All photographs are designated as unprocessed at the start of the clustering process; if it is not, it is discarded. Until the queue is empty, neighboring images are analyzed and allocated to the cluster c. The process is repeated for the remaining images in $\widehat{p}$, yielding a group of clusters:

$$C = \{c_1, c_2, \ldots.\}. \tag{11}$$

3.3. Representative Photo Identification. Each visitor's interest is represented by a specific photograph, and tourism administrators want to select the finest one for each location. As a result of this, marketing materials and location iconography can be influenced by travelers' own experiences. Our artifact includes some representative images, which are defined as those that are chosen because their subject matter appears the most frequently in a group of photographs. In order to identify our sample images, we have to go through a two-step process: representation of information visually and kernel density estimation (KDE).

3.3.1. Representation of Information Visually. Local feature descriptors are effective signals in automated natural scene identification and are resistant to occlusions and spatial fluctuations. To describe photo material, we use an advanced feature descriptor called speeded-up robust features (SURF). For a huge number of local areas taken from a batch of random pictures, SURF descriptors are first extracted. To create a visual word vocabulary, K-means clustering is used. The amount of visual words accessible is determined by the value of k, which is defined as the center of clusters. The SURF attributes are retrieved and vector quantized into the image representation for the vocabulary for a new picture called pi, which has a number of different local locations. The photos are then displayed as a word cloud with titles:

$$\mathbf{w}^{(u_i)} = \left\{w_1^{(u_i)}, w_2^{(u_i)}, \ldots.., w_m^{(u_i)}\right\}, \tag{12}$$

With the MDS procedure, each k-dimensional bag of words $w(pi) = \{w_1(pi), w_2(pi), \ldots, w_k(pi)\}$ denotes converted into a d-dimensional low-dimensional vector $x(pi) = \{x_1(pi), x_2(pi), \ldots, x_d(pi)\}$. In order to provide a representative sample, we return the images with the greatest chance densities, based on the decreased dimensional vector x. It is possible to get a good sense of the collection as a whole for just about any topic of interest by looking at a small set of representative photos.

3.3.2. KDE. KDE is a quasi method for estimating the PDF of a stochastic number. The following formula is used to get the multivariate kernel density:

$$\widehat{f}_H(x) = \frac{1}{n}\sum_{i=1}^{n} K_H(x - x_i), \tag{13}$$

where H is a smoothing parameter, that is, $d \times d$ symmetric and positive definite matrix.

$$K_H(x - x_i) = \sqrt{|H|}K\left(\sqrt{|H|}\,(x - x_i)\right). \tag{14}$$

In reality, multivariate kernel density estimators are impacted by the curse of dimensionality when there are more than three dimensions involved. A higher-dimensional search space is only partially inhabited by data points; for every given value x, only a small number of data points are located nearby. As a consequence of this, the dimensionality of language attributes needs to be decreased while retaining

the same level of proximity or separation between each pair of points. The bag of words feature is thus subjected to the multidimensional scaling (MDS) approach.

3.3.3. The Modelling of Time Series. Given a set of geotagged photos, a time series may be generated by counting visitors visiting throughout each month. A parametric technique may be used to estimate the time series' trend since it creates smooth trend curves that depict the general tendency and allows for the computation of future trends for prediction purposes. The linear, exponential, and quadratic forms of fitting functions are all common, as described in reference [12]. In time series analysis, a common model performance indicator is the mean absolute error (MAE), which may be used to estimate the fitting function:

$$MAE = \frac{\sum_{t=1}^{n} \left| O_t - E_t \right|}{N}, \tag{15}$$

where O_t and E_t represent the original and estimated series, respectively. N stands for the whole set of data items that were taken. It is important to point out that the aim of MAE in this investigation is not to forecast the actual value of the time series; rather, it is to select the model that provides the most accurate assessment of the trend. A lesser MAE signifies a better acceptable model for our objectives. In addition to illuminating trends, the time series decomposition method can bring to light seasonal patterns. The seasonal component is produced. Seasonal average valuse are calculated by averaging the seasonal elements for the same month over the years, assuming that months represent seasons. It is easy to see the seasonal averages through the red line, which represents the mean of seasonal (Figure 4) parameters for each month. The trend was then modelled utilizing a quadratic equation (Figure 5).

The analytics artifact is made up of four methodologies, which are detailed in Section 3.3. As can be seen in Figure 6, the techniques consist of (1) processing textual metadata, (2) geographical data clustering, (3) selection of photos, and (4) modeling of time-series data. In a nutshell, textual metadata analysis seeks to uncover specific keywords that indicate tourism attractions (as they took photos). The data provided are used to create a list of candidates, which may be used to identify tourism subjects (such as destinations and attractions).

4. Case Presentation and Evaluation

There are five different approaches of evaluating design artifacts: descriptive, visual, analytical, empirical, and testing. Because we were using case data as a sample tourism destination that could be validated against generally recognized information and independent tourism statistics, we decided to use a descriptive method for our research. This allowed us to focus on the specifics of our findings. In addition, the experimental method was applied in some capacity, and internal analyses of comparable numeric settings and fitting models were utilized, as a means of better understanding the proposed artifact. During the course of the iterative development process, concerns of validity and utility were addressed by continuously consulting with stakeholders.

4.1. Data Description. Our solution product anticipates demand for several demographic groups as well as an aesthetic examination of visitor interests. Based on the UserID, Flickr was used to determine each user's geographic origin. Local tourists were Melbourne residents, and domestic tourists from other regions of Australia were classed as members of the Australia group. International tourists were separated into continent-specific groups. Because Europe, Asia, and North America accounted for the vast majority of overseas visitors, our study concentrated only on these regions. Many users did not enter their residence place because it is not required while registering a Flickr account. As indicated in Table 4, a total of 2550 visitors were recognized with their dwelling location.

For demand forecasting purposes, despite the fact that this number of tourists represents a lesser percentage of the standard dataset. In our research, we found that visitors from the area seemed to take considerably more pictures than tourists from other regions, with each visitor taking over 46 pictures. Other tourists in the group snapped an average of 16 photographs. This is likely due to the fact that tourists from other regions are constrained by their travel schedules, whereas local inhabitants have more time to explore, resulting in more images being taken.

MATLAB was used as the computer environment for early testing of the textual processing approach's performance, with support levels ranging from 0 to 0.1. Figure 7 shows the number of candidates of interest for various values. As the grows from 0 to 0.01, the number of applicants that are interested drops rapidly and then drops marginally. When = 0, the system retrieves all the nouns in the list. There were few nouns in the provided list when the value was 0.1. There were 52 possibilities in this stage of processing because the support level was set at 0.05, resulting in finding the most prevalent tourist interests. When descriptive terms were synonyms (such as "sunset" and "nightfall"), only the most popular term was used. Outline of tourist attraction candidates, arranged from largest to smallest support, with seventeen elements included (Figure 8). A tourist attraction may be made successful by providing great experiences to tourists and maintaining excellent marketing of the attraction.

5. Results

In this section, we construct time series models in order to anticipate future demand for tourism in Melbourne. The number of tourists who visited Asia, Australia, North America, and Europe on a monthly basis was tallied between the years 2011 and 2015. Models of metric fitting were employed on the time series data in order to achieve an appropriate estimate of the trend. Because the selection of an effective fitting model is reliant on the individual application, we analyze how well the three most prevalent kinds of

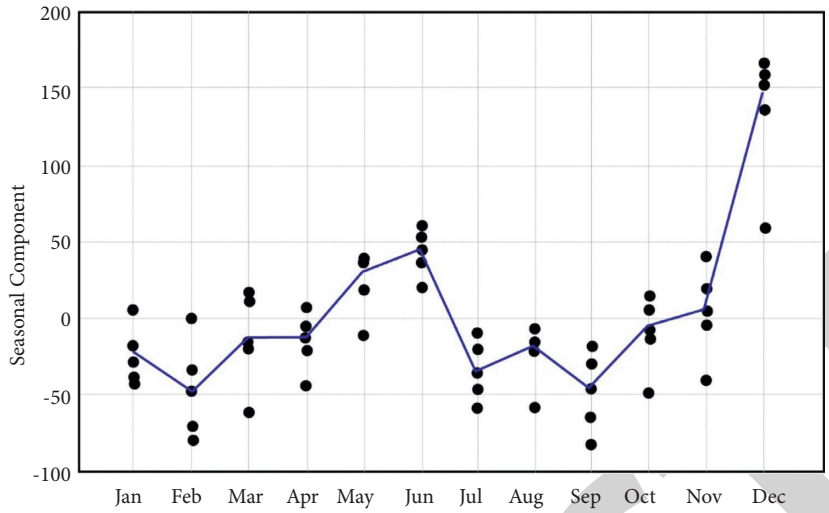

Figure 4: Average season.

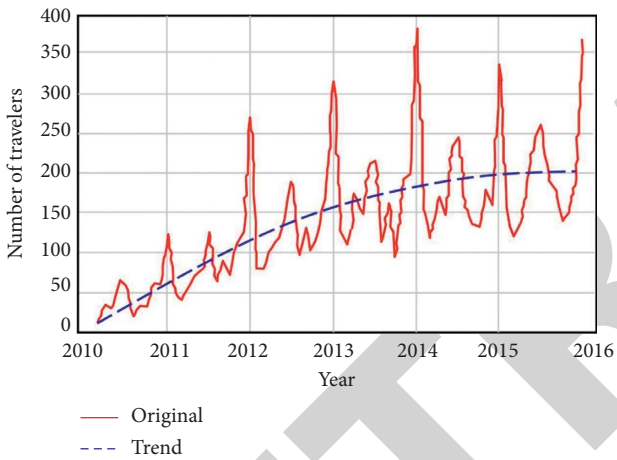

Figure 5: Trend.

models (linear and nonlinear) perform on the utilized data set. During the training phase, we used data from 2011 to 2014, whereas during the validation phase, we used data from 2015. The performance on the test data was evaluated using MAE, as listed in Table 5.

For Europe, we used the exponential model, and for North America, we used the linear model. All of these models were based on the aforementioned evaluation. The actual data and the projected trend are shown in Figures 6–10. From 2011 to 2014, the Australia group's trend decreased somewhat, then stayed constant in 2015, and may grow in 2016 (Figure 9). There was a growing tendency in the Asia group (Figure 10) until 2013, with more tourists to Melbourne, but then a fall from 2014.

In 2016, the number of tourists is expected to continue to decline slightly. The tourism demand in Europe and North America has decreased somewhat (Figures 11 and 12), and it is expected to continue to decline in 2016. The model was not built on exact visitor arrival records; hence, the projections can only provide an estimate of the future path demand from tourists instead of the real number of visitors that will be arriving. On the other hand, the method offers a fine-grained analysis to supplement and validate estimates that are based on data collected from surveys and official statistics. This can be done by providing a more detailed look at the data. In addition to being able to recognize trends, tourism administrators are required to have an understanding of the seasonal patterns of visitor arrivals in order to facilitate strategic planning and decision-making.

The fact that the mean values for the Australia group are so close to zero demonstrates that there was no clear seasonal trend in the data (Figure 13). The month of February sees an increase in the number of visitors coming from Asia, while the month of June sees a decrease (Figure 14). This trend has been verified independently for Chinese tourists to Australia, and it enables us to corroborate the relevance of our study. China is the second most popular tourist destination in Australia, behind New South Wales. Also, the Europe group (Figure 15) displayed a trend that was very similar; they are more likely to visit Melbourne between the months of December and March; however, they are less inclined to do so in the middle of the year. The trend seen in the North America group (Figure 16) is a little bit different: winter months (January to March and November) are particularly busy and spring months (April to September) are quite slow.

6. Discussion

To assist DMOs in the strategic decision-making, we have outlined a framework for analyzing social networking big data in this document. Tourist spots require DMOs to know their visitors' preferences, toured areas, and personal experiences in order to properly manage TDs. Social media data provides the DMO with moment, contextual, and scientific proof views into personal views and expressions, which helps it comprehend market views and behavior. As social networks grow exponentially, conventional design approaches and specialized procedures cannot keep up with the volume and variety of this information. While previous research has built analytics systems for accurately identifying

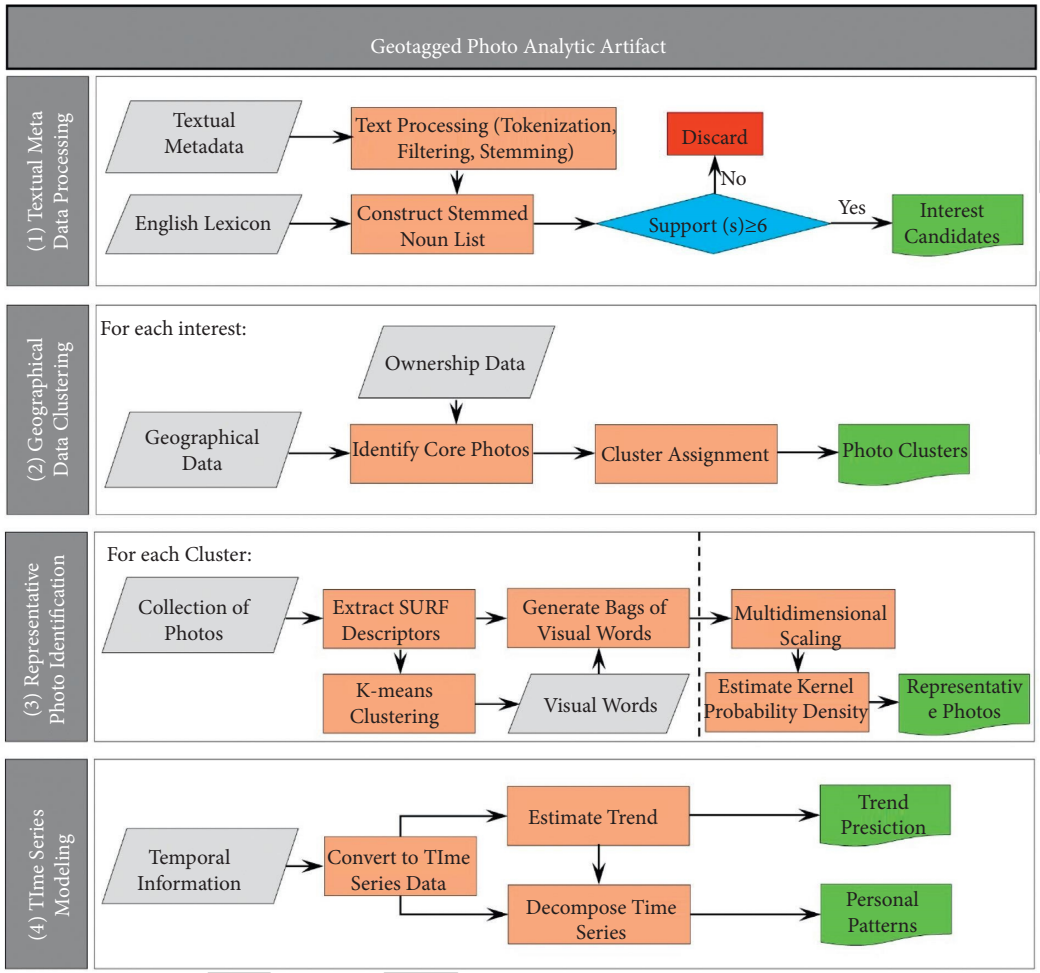

Figure 6: The proposed big data analytics conceptual framework.

Table 4: Travel groups' data collections.

Group	Number of tourists	Number of photos	Photos per tourist
Local	886	42,676	47.59
Australia	431	5,557	16.57
Asia	326	5,186	16.37
Europe	421	6,832	17.27
North America	423	7,991	17.87
Total	2487	68242	

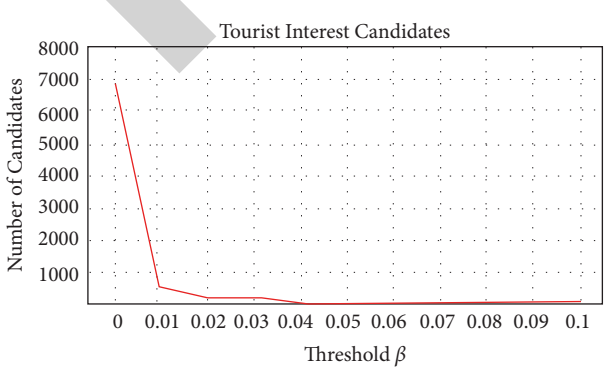

Figure 7: Candidate numbers with various β.

Figure 8: Candidates found with $\beta = 0.05$.

Table 5: Mean errors by fitting model for various travel groups.

Models	Group			North America
	Asia	Australia	Europe	
Linear	2.94	3.423	2.816	2.910
Exponential	2.55	3.411	2.815	2.927
Quadratic	2.88	3.481	3.942	2.950

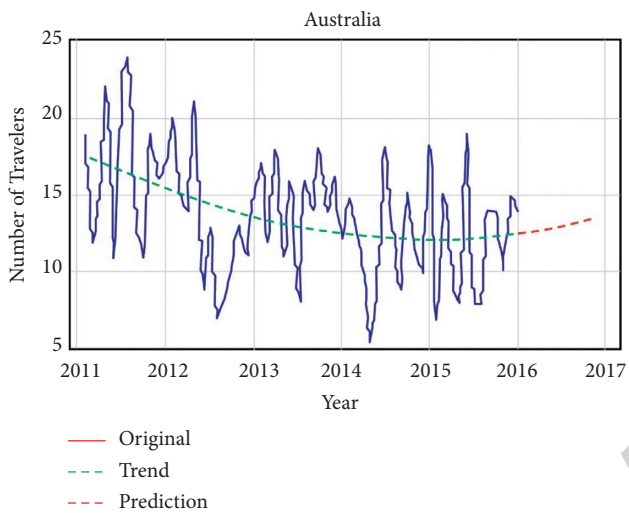

Figure 9: Trend estimation of Australia group's trend.

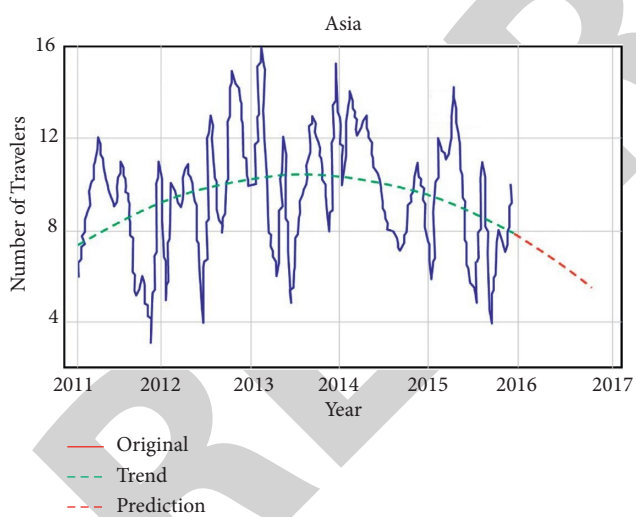

Figure 10: Trend estimation of Asia group's trend.

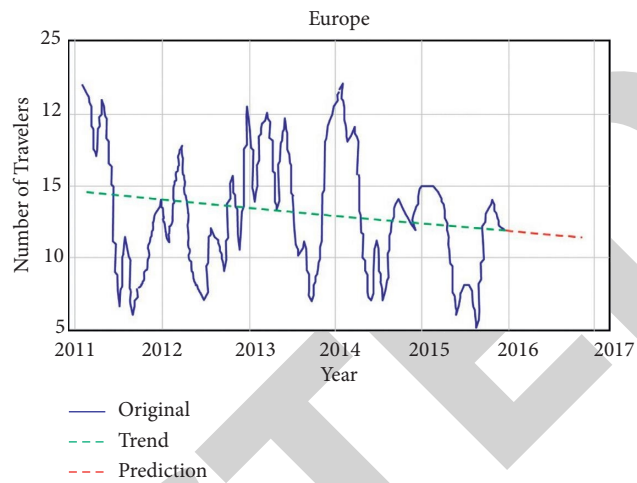

Figure 11: Trend estimation of Europe group's trend.

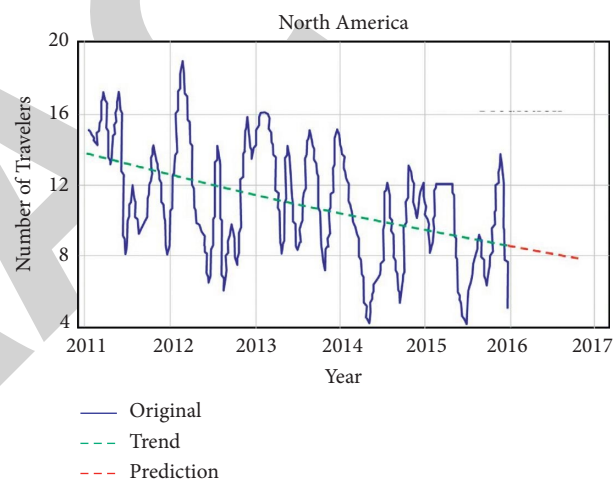

Figure 12: Trend estimation of North America group's trend.

visitors' behavior and city choices, they lack visual picture material and metadata computational resources to preserve visitors' impressions. Furthermore, they lack the ability to foresee perfectly alright tactical judgment requirements of a DMO. To estimate tourism industry, we use spatiotemporal data collected from publicly available data instead of conventional methods such as polls and surveys. While GIS design concepts for explaining and contextualizing data analysis and visualization are still immature, our study adds to these emerging ideas as well. DSR, one of the most renowned data management planning techniques, has helped us go further than operating big data analytics techniques in detecting various tourist attention in items, specific places, and groupings, as well as comprehensive perspectives on collaborative attitudinal and national origin characteristics. Our research has produced an IT artifact in the shape of a generic approach for producing useful data and predictions from location data photographs. For a tourism hub, our proposed technique (as an IT artifact) may identify critical relationships and correlations that are essential to corporate DMO judgment, as shown by the findings.

Using a variety of strategies, our solution artifact was able to provide findings that were both reliable and useable in both geographical and quantitative formats. It is possible for DMOs to generate customized marketing materials based on the results of visitor attractions and destinations. As an example, the Melbourne City DMO might promote the Southbank area's art, botanic garden, and building interests. To better cater to visitors' preferences and enhance their journey, city tours might be tailored to include St Kilda Beach as a sunset destination and the accompanying photos. Tourists' opinions and impressions may be gleaned from

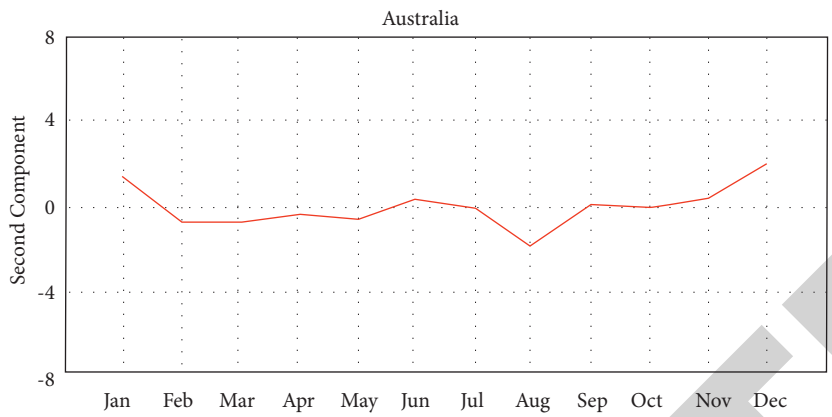

Figure 13: Seasonal pattern of Australia.

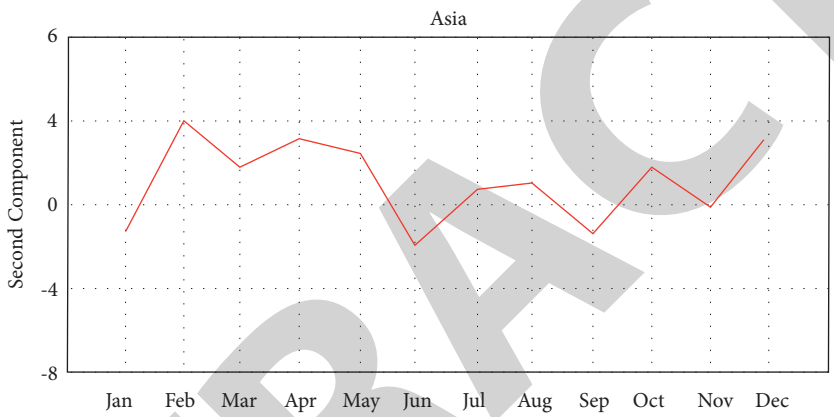

Figure 14: Seasonal pattern of Asia.

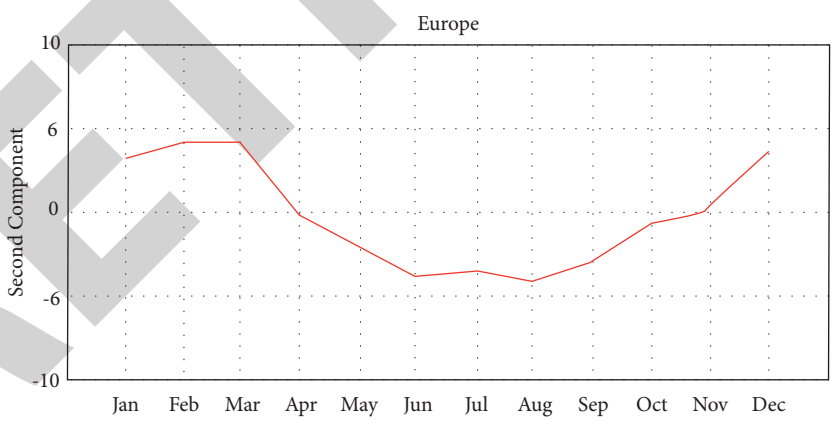

Figure 15: Seasonal pattern of Europe.

these photographs. When online before making or advertising material for the Webb Bridge and the Seafarers Bridge (which both have inherent structural attraction), DMOs might exhibit photographs of bridge structures, but for the more typical Princes Bridge, a river landscape could be featured instead. Increasing numbers of domestic visitors are flocking to Melbourne, and they are interested in a broad variety of things. DMOs might use the method's findings to create customized travel packages to meet the needs of both local and interstate customers. Prior to this, portions of the technique were explained to academic viewers (e.g., via educational seminars), and the entire artifact was also colloquially highlighted to research and business viewers, which helped optimize the effectiveness recursively and ensure the significance to the actual judgment processes of DMOs. A variety of tests were carried out to test the artifact; however, only the findings from Melbourne were provided in this study for the aim of proving an embodiment. If enough

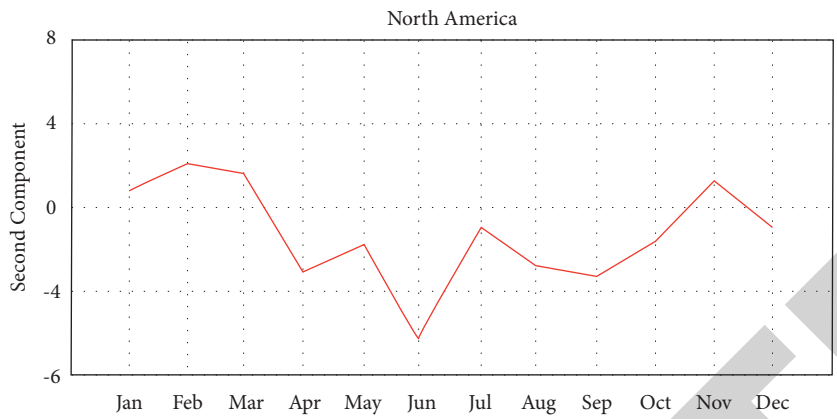

Figure 16: Seasonal pattern of North America.

geotagged photographs and documents are accessible, as in our illustrative scenario, the suggested approach should operate in any city (or tourist attraction equivalent to this one). To demonstrate the efficacy of the planned artifact for additional DMOs, comparable studies were conducted utilizing information for Sydney (we discovered 333,500 geolocation photographs from 9841 users on Flickr between 2011 and 2015). In the short term, the artifact may be used in other locations and their administration and marketing purposes, but there seems to be no explanation why the approach cannot be extended to handle many requests and domains in the longer run. This might include a travel route recommender system that uses geolocation to offer and display local sites that have been popular with previous visitors or a specific trip sequence for those with restricted time. Tourists' preferences and behavior may be analyzed for internal travel throughout multiple markets, as well as grouping smaller sites or unexplored regions of a region, which DMOs have a duty to promote. Additionally, geotagged public photographs (e.g., from security or dash cameras) might be used in traffic control to indicate patterns of movement or to identify congested routes among locations for public transportation design, outside of the realm of tourist uses.

7. Conclusion

We have proposed a method for extracting, ranking, locating, and identifying relevant tourist data from unstructured large data sets to aid DMO strategic decision-making. Our technology is adaptable to numerous places and provided valuable findings by analyzing geotagged photographs together with other pertinent facts, as demonstrated in the example of Melbourne, Australia. A methodology, one of the four kinds of design artifacts identified in DSR literature for data systems as a DSR design artifact, was used in the creation, development, and deployment of the generated artifact. MATLAB, a system for numerical computation, and Google Maps, an online desktop mapping service, served as the technology platform and atmosphere for developing and analyzing the solution method. In order to strengthen our suggested analytics method's technological capabilities, sophisticated applicable algorithms will be used. Support vector machines and neural networks will be used in our future research project to increase the accuracy of tourist demand predictions.

An end-to-end architecture that can gather massive amounts of data from social media sites, clean up noisy and incomplete data, extract key features, and finally execute analytics is required for a fully functional online marketing artifact in a certain issue domain. In the essay, we used this methodology in a case study. Future studies will involve collaboration with real-world decision-makers to further refine the solution artifact and formally evaluate its usability and applicability. Wine regions, areas with long-distance walking and cycling pathways, and areas inaccessible by any other means than automobile or boat will all be among the sites outside of cities that will be the focus of research. There is no reason to believe that the procedure will not work in these situations, but little tweaking may make it much more effective.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

A Corpus-Based Study on the Employment of Verb Keep between St3 and St4 in CLEC and Brown

Ning Zhang

Office of Basic Teaching Department, Weihai Campus of Shandong Jiaotong University, Weihai 264209, Shandong, China

Correspondence should be addressed to Ning Zhang; 201147@sdjtu.edu.cn

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The present paper focuses on the frequently used verb *keep* by Chinese non-English majors and native speakers based on three corpora, namely, Brown, St3, and St4 in CLEC. Brown stands for a corpus of native speakers, whereas St3 and St4 in CLEC stand for Chinese non-English majors who take CET-4 and CET-6 tests, respectively. This paper employs the contrastive analysis theory. The thesis investigates the commonly used *keep* senses by Chinese learners in CLEC compared with those senses in Brown by native speakers. This current research also employs a large amount of computer instruments like SPSS, AntConc, Microsoft Excel, and Wordsmith. Furthermore, the research aims to find out whether Chinese learners' performance on verb *keep* gets improvement with the promotion of their English proficiency. The results of the paper show that Chinese non-English majors do not have a good command of the frequently used senses of *keep* by native speakers. There exists overuse and underuse of some senses. Nevertheless, with the improvement of English proficiency, Chinese learners' employment of *keep* is becoming much closer to that of the native speakers. According to the research, some pedagogical reflections to improve English teaching and learning of verbs like *keep* are also discussed in the paper. Blended teaching can be applied before class, and microlectures can be provided online. Keep phrasal verbs, idioms, and collocations can be included in microlectures, while class teachers and students can collaboratively draw mind maps of verb keep. After class, more assignments can be provided online, such as multiple choice, blank filling, translation, and so on.

1. Introduction

In the acquisition of second language, vocabulary plays an unquestionably important part. The predicate is indispensable in making up a sentence. Meanwhile, the predicate of a sentence must be a verb. Jiang and Zhong [1] stated that different types of verbs constitute different sentence patterns. The most changeable and active of all parts of speech are exactly verbs in English. Different tenses depend mainly on different kinds of verbs. Therefore, verbs bring great difficulties to language learning, especially with regard to high-frequency verbs.

"*Keep*" is chosen as a representative of verb in this paper. "*Keep*" is considered to be one of the most usually used words in BNC English, as is shown in *Longman Dictionary of Contemporary English* [2].

1.1. Research Purpose. This thesis aims to research the features of *keep* used by Chinese learners in CLEC compared with those used in Brown. The different meaning distributions of *keep* between Chinese learners and native speakers are compared.

In general, the following four questions are the research questions in this paper: first, in the frequency of *keep* employed between Chinese non-English majors and native speakers, is there any resemblance and diversion? Second, what reasons can account for these similarities and differences? Third, does Chinese non-English majors' *keep* employment become much nearer to the mother-tongue speakers with the promotion of their English proficiency? Finally, are there any pedagogical implications on EFL teaching and learning according to the research?

1.2. Research Significance. The significance of this thesis exists in that it complements previous studies on verbs. This makes a new contribution to the study of verb *keep*. These two aspects are discussed in detail in section 1.3.

1.3. Theoretical Background. The contrastive analysis is a major theory used in linguistic analysis. The contrastive analysis stands for the comparison between the output of native speakers and the output of second-language learners so as to point out the similarities and difficulties between the two languages. Lado [3] puts forward the theoretical basis of the comparative analysis hypothesis (CAH). Lado pointed out that those components that are rather similar to their mother tongue are not quite difficult for second-language learners; however, the components that are distinct from their mother tongue are quite hard for them.

A corpus-based study of "Keep" by Wang Ying [4] is a previous study of *keep*. Wang Ying' research is based on corpora LOB and SLESSON. LOB corpus is a British English corpus modeled on the proportion of Brown corpus. SLESSON is a corpus based on a set of English textbooks used in high school in China by He Anping. As a result, Wang's study mainly focuses on the study of textbooks instead of the study of authentic use by Chinese learners. Only twelve senses and three patterns of sense 1 are investigated in Wang Ying's paper.

The author concentrates on the authentic Chinese learners' employment of *keep* instead of textbooks' employment. Some new pedagogical reflections, such as blending class, microlecture, and mind map, are provided in EFL learning. In addition, the fourteen senses are more specific than the twelve senses by Wang Ying.

2. Research Methodology

Three corpora are involved in the research. Moreover, this research is carried out with the help of computer instruments, such as AntConc, SPSS, Microsoft Excel, and Wordsmith.

2.1. Corpora. The corpora involved in this study are Brown and CLEC. The Chinese Learner English Corpus (CLEC) [5] is the first authoritative learner corpus in China with a total of 1.1 million words. CLEC's data are general genre English compositions of Chinese learners at different levels. It consists of five subcorpora, in which St3 represents the compositions of Chinese non-English majors in CET-4 and St4 represents the compositions of Chinese non-English majors in CET-6. St3 and St4 are test compositions written by CET-4 and CET-6 testees. Because they are authentic language users, St3 and St4 are appropriate for studying Chinese learners' second-language development patterns.

Brown corpus is a modern native speakers' universal corpus that is also computer readable and quite authoritative. The corpus is composed of 1 million words of texts in American English in 1961. Therefore, the size of Brown is compatible with CLEC.

2.2. Instruments. The data needed for this study are the sentences in which the verb *keep* appears. In order that the data needed in this paper can be available, the application of computer software is much more convenient and efficient. AntConc, SPSS, Microsoft Excel, and Wordsmith are used in this study [6]. AntConc is used to extract the required tested words. The chi-square value is tested by SPSS software package. Microsoft Excel is employed to calculate and graphically display results. This thesis employs Wordsmith to test the type-token ratio (TTR) of the three corpora [7].

3. Data Collection and Research Procedure

The fourteen *keep* meanings are evidently shown in *Oxford Advanced Learner's English-Chinese Dictionary* [8]. According to this dictionary, all *keep* in the three corpora are checked to determine what meaning they belong to, and each meaning's frequency and percentage are calculated. If necessary, the results are shown in tables and figures. The meaning distributions among the three corpora, between native speakers and Chinese learners, and between St3 and St4 learners are compared. The chi-square test is conducted in order to discover whether there is a significant difference in the use of *keep*. This paper analyzes the characteristics of Chinese learners' use of keep in detail.

The detailed processing of data collection, research findings, and explanations for the outcome are listed below. The author compared the employment of *keep* in Brown and in CLEC. In this thesis, quantitative and qualitative analyses together with the possible reasons of the results are provided in detail.

3.1. Keep Occurrences in the Three Corpora. Keep frequencies in Brown and in St3 and St4 in CLEC are computed to discuss the use of verb keep with regard to overuse and underuse. Table 1 [9] shows the results.

In Table 1, it is quite evident that *keep* frequency in St3 and St4 is 206 and 124, respectively, which are much lower than the *keep* frequency in Brown. Nevertheless, the employment percentage of *keep* in the three corpora shows that the percentage of the employment of *keep* in St3 is remarkably higher than the percentage in Brown. On the contrary, the percentage of the employment of *keep* in St4 is significantly lower than the percentage in St3 and at the same time narrowly higher than the percentage in Brown. The remarkable difference in overall *keep* frequency across the three corpora can be attributed to the difference in the size of the three corpora. As a consequence, we utilize the chi-square test to research whether there is a significant difference between Chinese learner's second-language corpora and mother-tongue corpus. In Table 2 [9], *keep* distributions across the three corpora are provided.

According to Zhou Shijie [6], the critical value of the chi-square test is 3.84. That means one degree of freedom at 5% level. In Table 2, we can see the chi-square value is up to 66.200 between Brown and St3. The chi-square value is remarkably larger than 3.84. As a consequence, it is safe to arrive at the conclusion that the difference in *keep* frequency

Table 1: *Keep* in the Brown, St3, and St4.

Corpora	Frequencies	Corpora words	Percent
Brown	518	1015537	0.051
St3	206	209043	0.0985
St4	124	212855	0.0583

Table 2: Outcome of *keep* distribution's chi-square test between St3 and Brown.

	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson Chi-Square	66.200[b]	1	0.000		
Continuity correction[a]	65.399	1	0.000		
Likelihood ratio	57.500	1	0.000		
Fisher's exact test				0.000	0.000
Linear-by-linear association	66.200	1	0.000		
N of valid cases	1225304				

a. Computed only for a 2 × 2 table, b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 123.64.

Table 3: Outcome of *keep* distribution's chi-square test between St4 and Brown.

	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson Chi-Square	1.768[b]	1	0.184		
Continuity correction[a]	1.632	1	0.201		
Likelihood ratio	1.718	1	0.190		
Fisher's exact test				0.191	0.101
Linear-by-linear association	1.768	1	0.184		
N of valid cases	1229034				

a. Computed only for a 2 × 2 table, b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 111.25.

in terms of Brown and St3 is significant. St3 English learners employed the verb *keep* much more frequently than English native speakers. The most evident reason for this result may be that the range of vocabulary grasped by St3 learners is quite limited. Consequently, St3 learners are liable to use *keep* much more frequently when they cannot figure out other appropriate substitutes for *keep*.

Similarly, in Table 3, the chi-square test between St4 and Brown is carried out using exactly the same procedure as Table 2.

In Table 3, it is quite apparent that with regard to St4 and Brown, the chi-square value is 1.768. The number is fewer than the critical value of the chi-square test 3.84. As a result, there is no significant difference in verb *keep* frequency between St4 and Brown. St4 in CLEC represents Chinese learners who have taken CET6, whereas St3 in CLEC represents Chinese learners who have taken CET4. Only those non-English majors who have passed CET4 can have the qualifications of applying for CET6 examinations. Consequently, it is quite obvious that the English proficiency of non-English majors in St4 is higher than non-English majors in St3. As a result, Chinese learners' employment of *keep* is a lot nearer to mother-tongue speakers with the promotion of their English level. Nevertheless, we cannot conclude hastily that there is absolutely no difference between St4 and Brown. St4 non-English majors are still inclined to marginally overuse the verb *keep* compared with English native speakers.

According to the same procedure as Tables 2 and 3, the chi-square test with regard to Chinese learners is conducted in the following Table 4.

In Table 4, it is apparent that the outcome of the chi-square test is 21.869. The number is much larger than the critical value of the chi-square test 3.84. Consequently, it is safe to conclude that the difference is significant among Chinese EFL learners between St3 and St4. It is distinct that compared with St4 learners, St3 learners are inclined to employ *keep* much more frequently.

As we can see from the above three tables, namely, Tables 2–4, Chinese EFL learners have a tendency to employ verb *keep* much more frequently compared with English native speakers, especially when it comes to the St3 corpus. Analysis of TTR (type-token ratio) or we can say lexical density can help to offer some reasonable explanations. With the application of Wordsmith software [7], TTRs of three corpora are given in the following Table 5.

From Table 5, we can safely conclude that among the three corpora, the largest vocabulary range exists in Brown. St3 non-English majors have the lowest TTR of 3.34, which signifies that the vocabulary *keep* used in St3 is rather limited compared with St4 non-English majors and Brown native speakers. Furthermore, the TTR of St4 non-English majors is also remarkably lower than the TTR of Brown, which shows that the range of vocabulary *keep* used in St4 is also quite limited compared with Brown native speakers. Meanwhile, the TTR of St4 is 0.23 higher than the TTR of St3, which

Table 4: Outcome of *keep* distribution's chi-square test between St3 and St4.

	Value	Df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson Chi-Square	21.869[b]	1	0.000		
Continuity correction[a]	21.357	1	0.000		
Likelihood ratio	22.082	1	0.000		
Fisher's exact test				0.000	0.000
Linear-by-linear association	21.869	1	0.000		
N of valid cases	422228				

a. Computed only for a 2 × 2 table, b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 163.54.

Table 5: TTR across the three corpora.

Corpora	St3	St4	Brown
Type	7757	8648	42579
Token	232541	241969	1015537
TTR	3.34	3.57	4.19

exhibits that the range of vocabulary *keep* used in St4 is a little less limited compared with St3 non-English majors. As a result, we can arrive at the conclusion that *keep* takes up a large ratio in overall Chinese learners' English output. Consequently, it results in the overuse of the high-frequency verbs like *keep* in Chinese learners' corpora.

To summarize the above analysis, Chinese learners are liable to employ verb *keep* too frequently compared with mother-tongue learners as a result of their limited range of vocabulary. Nevertheless, in the meantime, with the promotion of non-English majors' English proficiency, St4 learner's employment of *keep* is apt to be narrowly nearer to mother-tongue speakers than St3 learners.

3.2. Distribution of Different Keep Senses in the Three Corpora. This section aims to investigate whether there are differences in the use of different meanings of *keep* across the three corpora and on the employment of verb *keep* if higher-proficiency English learners that are represented by St4 non-English majors are apt to become more native-like than lower proficiency St3 non-English majors. Hornby [8] supplied fourteen senses of *keep* in his dictionary.

(1) continue to be in the specified condition or position; remain or stay; ~ (on) doing sth; continue to move in the specified direction.

E.g., She has the ability to *keep* calm in an emergency.

(2) cause sb/sth to remain in the specified condition or position.

E.g., These gloves will *keep* your hands warm.

(3) detain or delay (sb); ~ sb from sth/doing sth.

E.g., You're an hour late; what *kept* you?

(4) continue to have (sth); retain; look after sth for sb; retain sth; have (sth) in a particular place; store; retain (sth) for future use or reference.

E.g., Please *keep* me a place in the queue.

(5) own and manage (a shop, restaurant, etc.)

E.g., Her father *kept* a grocer's shop for a number of years.

(6) own and look after (animals) for one's use or enjoyment

E.g., She *keeps* dogs in her apartment.

(7) have (sth) regularly on sale or in stock.

E.g., "Do you sell Turkish cigarettes?" "I'm sorry, we do not *keep* them."

(8) not reveal (a secret)

E.g., Can you *keep* a secret?

(9) (of food) in good condition.

E.g., Do finish off the fish pie; it will not *keep*.

(10) be in the specified state of health.

E.g., "How are you *keeping*?" "I'm *keeping* well, thanks."

(11) make written entries in (sth); write down (sth) as a record.

E.g., She *kept* a diary for over twenty years.

(12) provide what is necessary for (sb); support (sb) financially.

E.g., He scarcely earns enough to *keep* himself and his family.

(13) guard or protect (sth); protect sb from (sth).

E.g., May the Lord bless you and *keep* you.

(14) be faithful to (sth); respect or observe.

E.g., I have an appointment to *keep* at 3 pm.

According to the 14 meanings listed above, all verb *keep* occurrences appearing in Brown, St3, and St4 are categorized and calculated, respectively. Then, the author calculates the percentage of each meaning in the three corpora, respectively. The percentages of these fourteen senses distributed in the three corpora are shown in Table 6. The order of the fourteen senses is listed in accordance with the sense frequencies from high to low appeared in Brown [9].

According to Table 6, both Chinese non-English major learners and English native speakers have a tendency to use the first four senses more frequently. It is quite apparent that when it comes to the rest ten senses, Chinese non-English major learners seldom use them. Figure 1 is provided according to Table 6 to offer a much more vivid presentation by means of Microsoft Excel.

As is quite evident in Figure 1 that Chinese non-English major learners and English native speakers are different

Table 6: Frequencies of *keep* senses in the three corpora.

Sense	Brown (Freq)	Brown (%)	St3 (Freq)	St3 (%)	St4 (Freq)	St4 (%)
2	256	49.42	39	19.90	30	25.42
1	106	20.46	116	59.18	54	45.76
4	69	13.32	29	14.80	27	22.88
3	34	6.56	11	5.61	5	4.24
11	16	3.09	0	0	0	0
14	16	3.09	0	0	1	0.85
6	7	1.35	0	0	0	0
8	5	0.97	1	0.51	0	0
9	3	0.58	0	0	0	0
12	2	0.39	0	0	1	0.85
13	2	0.39	0	0	0	0
7	1	0.19	0	0	0	0.
10	1	0.19	0	0	0	0
5	0	0	0	0	0	0

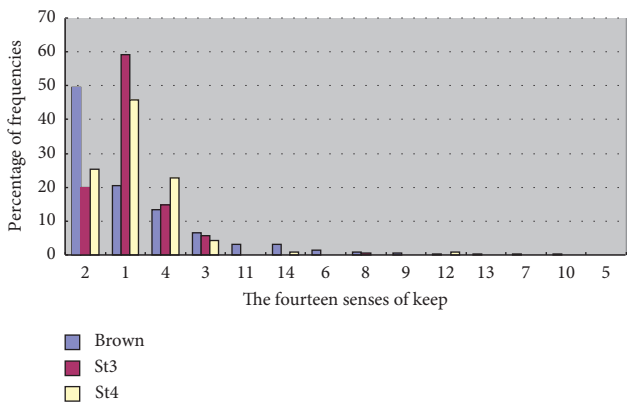

Figure 1: Comparison of *keep* senses across the corpora.

from one another with regard to the proportion of each verb *keep* sense. Compared with English native speakers, Chinese non-English major learners' use of *keep* is excessive with regard to sense 1 and sense 4. On the contrary, Chinese non-English major learners are inclined to underuse sense 2 and sense 3 significantly, especially when it comes to sense 2. According to Table 6 and Figure 1, the following two subsections offer a detailed analysis of the data and results.

3.2.1. Respective Analysis of the Data across the Three Corpora. At first glance, compared with the first four senses of *keep*, the other ten senses account for merely a small proportion of all the senses among the three corpora. Among the last ten senses, two outstanding senses that are sense 11 and sense 14 merely appear in Brown. In the last ten senses, Chinese learners only use three senses once, which are sense 8, sense 12, and sense 14. With respect to sense 5, nobody in the three corpora has ever used it.

St3 non-English major learners only use five senses of the verb *keep*, which are sense 2, sense1, sense4, sense 3, and sense 8 ranging according to the use frequency. Sense 8 of *keep* only appears once in St3. The percentage of sense 1 in St3 is remarkably higher than that of Brown, which is nearly triple of Brown. However, the percentage of sense 4 in St3 is slightly higher than that of Brown, which is about 1.5% more than Brown. The percentage of sense 2 in St3 is significantly lower than that of Brown, which is about 30% lower compared with Brown. The percentages of sense 3 in St3 and St4 are slightly lower than that of Brown.

The top four senses most commonly used by St3 learners are sense 1, sense 2, sense 4, and sense 3, which account for 99% of all *keep* occurrences in St3. From the data, St3 learners seem to use these four senses more frequently than the other ten senses, especially sense 1. Similarly, these four senses also rank the top four in St4 and Brown, but in quite different order. The order in Brown is sense 2, sense 1, sense 4, and sense 3 in terms of frequency. The most prominent sense in St3 is sense 1, the percentage of which is almost three times of Brown.

Although the overall verb *keep* percentage in St4, which is 0.0583, is not much different from that in Brown, which is 0.51, as is shown above in Table 1, and the frequency of each *keep* sense in St4 and Brown is quite distinct. St4 non-English major learners mainly use the first four senses, which are sense 1, sense2, sense 4, and sense 3 ranging according to frequency, whereas sense 12 and sense 14 only appear once in St4. In the first four senses, the percentage of sense 1 in St4 is more than twice of that in Brown. With regard to the percentage of sense 4, it is about 10% higher in St4 than in Brown. Nevertheless, the percentage of sense 2 in Brown almost doubles that in St4. Furthermore, sense 3 in Brown was 2.4% higher than the frequency in St4. All in all, the top four most commonly used senses in St4 are sense 1, sense 2, sense 4, and sense 3 according to frequency, which account for 98% of all *keep* occurrences in St4.

With regard to the two learner corpora St3 and St4, the first four senses in St3 and St4 and their order are consistent, which are sense 1, sense 2, sense 4, and sense 3. When it comes to the other ten senses, St3 and St4 non-English major learners seldom use them. However, compared with St3, the percentage of sense 1 and sense 2 in St4 was closer to that of Brown. This may signify that Chinese learners' English level gets improvement with the advancement of their English learning. Nevertheless, no matter how high their English

level is, Chinese learners are still likely to become closer to native speakers, whereas it is quite difficult for them to be exactly the same as English native speakers.

3.2.2. General Analysis of the Results. The above results show that although the verb *keep* has been learned in a comparatively early stage of English learning, Chinese non-English majors still do not comprehensively master the fourteen meanings of the verb *keep* as English native speakers do. Some senses like sense 1, sense 2, sense 4, and sense 3 are quite frequently used, while others are rarely used. The fact that Chinese teachers and learners have always emphasized the first four senses, especially with regard to the first meaning, probably may be exactly the reason. In St3 and St4, the first four meanings account for 99% and 98% of all *keep* occurrences, respectively. Furthermore, sense 1 accounts for almost half of all *keep* events in St3 and St4, while sense 2 has the highest frequency in Brown, accounting for almost half of all *keep* occurrences in Brown.

The following reasons may account for the higher frequency of the first four senses. First of all, these four meanings are basic meanings of the verb *keep*, especially sense 1. Chinese teachers tend to overemphasize these four senses. Second, Chinese learners are taught and have been familiar with these four senses since they began to learn English. Therefore, they are inclined to use *keep* with regard to the first four senses. Third, even after being admitted into college, students are likely to use words that they are quite familiar with and reluctant to memorize and employ unfamiliar and difficult vocabulary. As a result, they can save energy and reduce the burden of memorizing new words. Fourth, with regard to the last ten senses that Chinese learners seldom use, Chinese learners may be are lacking in adequate input. However, it does not necessarily mean that Chinese learners do not know these senses. The reason is likely to be that Chinese learners do not attach great importance to these ten senses. On the contrary, they prefer to use words or expressions other than *keep*. Finally, the overuse of sense 1 in St3 may be correlated with the corpus to some extent. Many St3 learners use "*so in order to keep fit*" repeatedly in one composition. The materials in St3 are all CET-4 compositions or compositions of similar levels, and one of them is "health." The title of the composition may contribute to limit learners' vocabulary output and expression. There are as much as 40 "*keep fit*" in St3 in all.

4. Conclusions and Pedagogical Reflections

To sum up, there is difference in the frequency of *keep* employed between Chinese non-English majors and native speakers. Chinese learners do not comprehensively master the fourteen meanings of the verb *keep*. Compared with native speakers in Brown, Chinese learners are inclined to mainly use the first four senses whereas ignore the other ten senses. However, in general, St4 Chinese learners' employment is a lot nearer to Brown compared with St3 learners.

The overemphasis on the first four senses, the unfamiliarity of the other ten senses, the limited range of vocabulary grasped by Chinese learners, the reluctance to memorize new vocabulary, and the limitations of the topics of compositions in St3 and St4 corpora can be attributed to the difference in the employment of *keep* senses across the three corpora.

Generally speaking, with the improvement of English proficiency, Chinese learners' use of *keep* is much closer to that of native speakers.

The present corpus-based study of verb *keep* can provide some implications for EFL teaching and learning in China, especially for the teaching and learning of English verbs. English verbs deserve more attention during vocabulary teaching and learning. Students should try to enlarge the depth and breadth of their understanding of vocabulary. Remembering as many words as possible can greatly help students to express themselves accurately and appropriately. At the same time, because the choice of words and sentences can demonstrate students' English level to a great extent, teachers are also supposed to direct the students to differentiate various similar terms, enrich their wording and phrasing, and offer profound example illustrations so as to expand students' words and phrases. Employing high-frequency words as much as possible is bound to get low grades and does not deserve excellence.

Blended teaching can be applied in verb teaching. Before class, microlectures on verb *keep* can be provided online. The sequence of the different senses of *keep* can be shown in accordance with the frequency of different senses in Brown from high to low. *Keep* phrasal verbs, idioms, and collocations can be included in microlectures. Students ought to learn these materials before class and know the different senses of *keep*, phrasal verbs, idioms, and collocations. In class, teachers and students can draw mind maps of verb keep collaboratively. After class, more assignments can be provided online, such as multiple choice, blank filling, translation, and so on.

Data Availability

The data that support the findings of this study can be obtained from the author upon reasonable request.

Conflicts of Interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Research Article

The Role of Bisection Class in Guiding Teenagers' Core Values from the Perspective of Deep Learning

Yajun Liu

School of Marxism, Guangdong Mechanical & Electrical Polytechnic, Guangzhou 510515, Guangdong, China

Correspondence should be addressed to Yajun Liu; 2020010037@gdmec.edu.cn

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Effective classrooms(EC) encourage students to participate in conversations, investigations, and experiments that help them learn and grow. Even in small groups, students are responsible for much of their learning. Split classrooms are ones where pupils from two or more grade levels are placed in the same classroom. Values taught in the classroom may aid students in distinguishing between right and wrong, influencing their attitudes and behaviours as adults. Some of the problems are students' lack of cooperation, empathy, and support for one another, insufficient financing for classroom resources and equipment, and students' unable to keep up with education because teachers are held more responsible than they should be to increase meaningful academic learning and facilitate social and emotional growth. Video editing programs provide a more satisfying sensory experience than just reading from printed information. Deep learning (DL) allows pupils to think critically and successfully collaborate with others in all academic areas. Deep learning is a strategy and attitude to learning using complex mental talents such as the ability to analyze, create, solve issues, and think the state of play to build long-term comprehension. Using this method, EC-DL decent employment is becoming more cognitively demanding, and advanced skills are essential for students to cope with this reality. Due to this programmer, students become interested, autonomous learners, and active citizens in a democratic society. Classrooms were successful because they incorporated exploratory learning through guided inquiry-based activities, which increased students' curiosity and encouraged them to develop higher-order thinking skills. In-class learning activities must be purposefully designed. According to one study, classes positively influenced student learning and success.

1. Introduction

Educators have a large issue in the general split classroom regarding keeping their students' attention, particularly when the class comprises students from different specialties [1]. The result shows that the challenges of using educational content are the nonavailability of materials, lack of motivation of the educators, lack of skill and strategies, financial constraints, lack of appropriate materials in the textbook, time constraints, lack of support from power, and lack of geographical learning materials. Student performance may be improved by using online learning and a split classroom, which can maximize university resources and people [2]. In the study, students who had greater starting levels of individual moral disengagement or who were in classes with higher initial levels of collective moral disengagement reported more offline and online in the split classroom [3]. The variety of skills and tactics instructors use to keep classrooms free of disruptive behaviour is called "classroom management." Nonexperimental research is the focus of this investigation. This research aimed to develop and test a tool to assess how well instructors and students in online education handle the split classroom. In classroom management, the traditional method is the most effective since it is directly related to students' acceptable conduct. They may assist students in big courses in personalizing their education. Teacher aids in the development of information, skills, dispositions, and values in their students [4]. A dynamic and diverse process, the classroom environment directly impacts student learning and well-being. Students were asked to reflect on their experiences of the classroom atmosphere throughout their four years of university study and to identify the variables that influenced their

opinions. Change, action, and progress define a dynamic learning environment. Every aspect of the curriculum has been carefully considered to ensure that it meets the requirements of all students while providing opportunities for them to develop new skills, interests, and understandings [5]. Even though classrooms may help students learn more efficiently, teachers still have difficulty implementing flipped courses. Implementing classrooms may be complicated by a lack of awareness by both instructors and students about its advantages and how to deal with implementation difficulties and problem-solving. Out-of-class preparation implies that students will do it at their own pace. To participate fully in the class, all students may not view the digital material or finish the out-of-class readings [6].

Among the Interaction Design and Children, community, teenagers are understudied. Museum curators and designers may utilize teenagers to help them better engage with their exhibits in a split classroom [7] and ensure that all students are held to the same standards and are given access to the same tools. Higher order thinking and academic discourse are not lost to low-income and racially diverse pupils due to this policy. Create a sense of belonging among students by providing opportunities to think about, discuss, and act on their individual through a split classroom. Educating students on how to behave in the classroom to study more effectively is important. All time spent in school is crucial. Everything will be chaotic if there are no regulations for the kids to follow [8]. The objective of educators is to help their students acquire the ability to think critically about moral concepts. Multiple case studies were conducted to investigate instructional methods for promoting value-laden critical thinking in the philosophical whole class [9]. School and classroom regulations are often found in handbooks and displayed in classrooms, and students are expected to abide by them in the split classroom. They should treat other pupils and teachers with respect. [10].

The detection method for deep learning and the observation material from instructors are utilised to increase teachers' split classroom teaching efficiency, and the objective detection technique for deep learning is improved [11]. Artificial intelligence (AI), Machine Learning (ML), and Deep Learning (DL) are all being utilised to gather enough application feasibility to minimize classroom workload. To compare the proposed system with the current one, we utilize the terms consistency, uncertainty, unverified, and out-of-place parameters [12]. Classroom teaching assessment relies heavily on student behaviour, and recognizing student behaviour in the classroom is a crucial aspect of this evaluation. The paper presents a technique for recognizing student classroom conduct based on deep learning that uses photos of student activities to extract and integrate crucial skeletal information [13]. Students' progress is assessed by instructors using a variety of arbitrary criteria. On-site crowds make it difficult for professors to monitor the progress of individual students.

On the other hand, the findings would be skewed by the subjective nature of the judgement. As artificial intelligence and machine learning progress, deep learning technologies are now feasible to scientifically evaluate the quality of classroom instruction [14]. According to these ideas, deep learning is based on a set of components that can be found in both—discovered that the relationships between task value and self-efficacy and classroom attention, group engagement, and deep learning were best moderated by achievement objectives in research [15]. Rather than relying simply on university lecturers and learning improvement units, this research shows the need to use various teaching methods in the classroom [16]. In regard to the categorization of face photos, deep learning may be a better option than other ML approaches. Furthermore, the approaches' excellent accuracy confirms their significance in optimizing teaching in a divided classrooms [17]. Educational institutions utilize various the approaches used to gather data from a representative sample of students who are actively participating in the learning experience and are aimed at improving the performance of both teachers and students. It is possible to classify and forecast students in a virtual classroom using the approach described here [18].

The paper's primary goals are as follows:

(i) Instructors collaborate to design and administer instruction for a class that includes kids with disabilities, often a general education teacher and a special education teacher in the split classroom.

(ii) Across all subject areas, students who are deeply involved in their education develop critical thinking, excellent communication skills, and the ability to collaborate with deep learning. Learning to be a lifelong learner begins with developing the ability to self-direct one's education.

(iii) One of the most important characteristics of deep learning is its ability to feature classrooms on its own. Algorithms scan the data for connected quality and then combine them to speed up learning without being explicitly directed to do so.

Section 2 is a literature review of the current approach, Section 3 proposes new methods for EC-DL, Section 4 is an experimental study, and Section 5 concludes the article.

2. Literature Work

Hirshberg et al. [19] introduced that preparing future teachers for the classroom may include both traditional teacher education and a nine-week mindfulness-based intervention. For our main objective, we used the Classroom Assessment Scoring System (CLASS), a six-month follow-up of successful teaching methods observed during full-time student teaching. The intervention group's instructional and classroom organization improvement was substantially correlated with daily mindfulness practice. Negative feelings or well-being did not vary across the groups. Classroom strategies show that mindfulness training may be one strategy to lessen the transition to professional teaching stress by providing greater instructional competency.

Martinelli and Zaina [20] introduced Human-Computer Interaction Learning (HCI) experiments that have been carried out to study techniques that might excite and

support students in postsecondary learning in the education system. This method aims to teach HCI to undergraduate and graduate students in a split classroom setting. Even though our method is based on a mixed strategy that divides the process of education into two different periods, in-class and out-of-class activities, we nonetheless implement it. Despite all difficulties they encountered, the lessons were structured in such a way that the students could exercise their agency and collaborate with one another.

Zhang and Xu [21] explained the deep learning Single Shot MultiBox Detector (SSD) target detection algorithm is developed, and the optimized mobile net SSD is constructed using a technique that leverages instructor monitoring information and deep learning to maximize teacher efficiency in the split classroom. There is a significant increase in detection accuracy when using the new approach compared to previous detection methods. When algorithms are improved, they improve detection efficiency, which is critical for providing contemporary technology aid to teachers to understand students' learning states better and increase split classroom productivity.

Zhang et al. [22] detailed that a Long Short-Term Memory network (LSTM)is a deep learning model that may be used to forecast the amount of Volatile Organic Compounds. Mean Absolute Percentage Error (MAPE) is used to evaluate the LSTM model's performance (MAPE). For LSTM model prediction, we will begin by discussing how to choose a few key parameters. The LSTM approach uses real-world events to train a learning network rather than constructing complex physical or chemical models and monitoring various variables. Researchers have discovered that the LSTM model can properly predict pollutant transport in various interior scenarios.

Cho et al. [23] identified the motivations in language learning perception of teachers in fluttered educational institutions and investigated the effect on learners' cognitive and motivational results, education, and learning factors. Since hypothesized, four components based on the learners' expertise inside a Split Classroom Model, Teaching Strategy [SCM-TS], relations with peers, instructor assistance, and classroom involvement were dramatically explicated. SCM-TS recommended the structure of blended learning and the assistance of instructors for successfully examining care.

Wang et al. [24] explained gesture recognition using convolutional neural networks for "double instructor" split classroom training and learning scenarios. The nonverbal actions of teachers that draw students' attention and improve their learning results may be studied using the hand gestures of known instructors. Research shows that the suggested algorithm beats the existing recognition and classification error approaches. Hand gestures may be predicted with an accuracy rate from comparison trials, according to the data.

Flanigan and Babchuk [25] introduced that despite previous studies demonstrating the detrimental effects of digital distraction on student learning, little is known about the perspectives and responses of instructors to this problem. Students' digital distractions have a significant impact on instructors' pedagogical decision-making, relationships with students, and professional happiness, according to interviews with 11 college teachers. This group of teachers clearly understands how digital distraction affects classroom learning and routinely encounters students who are distracted by their devices in the classroom. Furthermore, many educators are frustrated by their students' increasing use of technology. Student digital distraction has impacted educational decision-making and teenagers' student–instructor relationships.

Jin et al. [26] detailed that experiments will accompany the most important chapters and contents to help students better grasp the theory they have just learned and to provide them with some basic experimental skills that will serve as a foundation for their future knowledge reserves, professional abilities, and high-quality educational preparation. Split class is a novel teaching style that instructors may use to rethink physiology education. This study is based on the experience of establishing split classes in experimental classrooms. It helps to guarantee that the split class is successfully implemented by summarizing the key experiences from the experiment to be of actual use to the students, benefit from their own experiences, and use what they know. In the long term, the quality and abilities of pupils will be substantially enhanced.

Zhou et al. [27] proposed that classroom teaching assessment and conducting student classroom behaviour recognition are critical to classroom teaching evaluation. Using a 10-layer convolutional neural network (CNN-10) and information extracted from student behaviour photos, the study presents a deep learning-based technique for recognizing students' split classroom conduct. Utilizing the student classroom behaviour, the study performs a comparative experiment using CNN-10 and the student classroom behaviour recognition technique to demonstrate the usefulness of this approach. Students' typical classroom behaviors may be identified using the human skeleton and a deep learning-based student split classroom behaviour detection technique. This might enhance intelligent classroom instruction by quickly and accurately reflecting students' learning levels.

3. Split Classroom in Deep Learning

Learning goals, video summaries, and interactive exams are all part of an interactive classroom's design since the emphasis is on hands-on experience in a classroom environment. Interactive classroom learning begins with learning goals, which help students understand the skills and processes necessary for course learning. Identifying individualized learning needs is essential for students at various levels to choose appropriate learning resources. Observation and reflection may be done by watching a video demonstration and listening to the teacher's explanations. And the video's iconography, questions, subtitles, are all interactive, as are the questions themselves.

Figure 1 demonstrates that the purpose of educational activities is both the beginning and the end. As a result, the learning objective must be detailed before teaching. The student's study activity must meet this requirement and

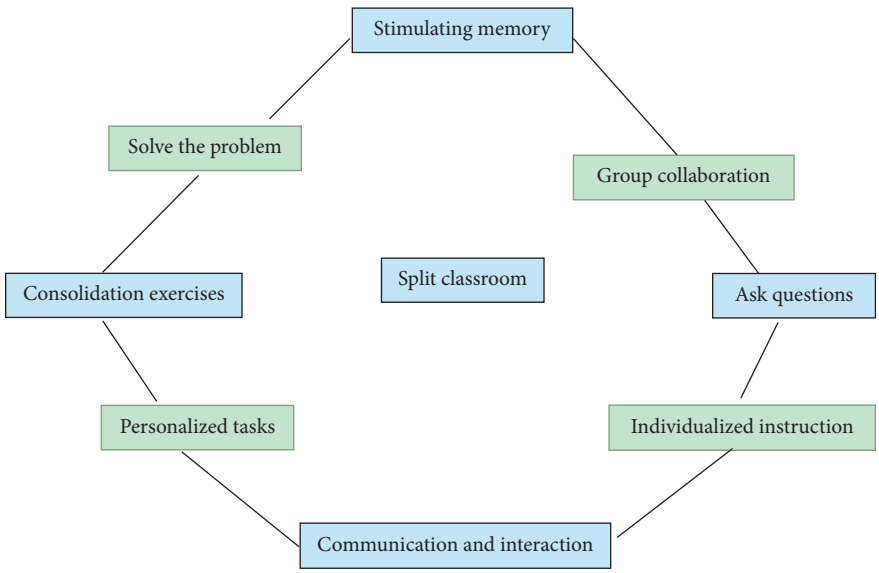

Figure 1: Learning activities in the split classroom.

predict the final study outcome. While teaching can be blinding at times, it can be avoided using instructional design principles that limit the scope of what can be taught. Virtual reality interactive classroom software is primarily responsible for meeting the instructional objectives of the split classroom. Teachers do not even go into too much detail about learning objectives, allowing students to grasp the information in this section, as well as the general framework in which the information is organized.

$$\mathbf{L} = \mathbf{c} - \mathbf{m} \times \boldsymbol{\sigma}\mathbf{s} - \left(\frac{(\mathbf{x_{st}} - \mathbf{r_{t2}})}{2\boldsymbol{\sigma}_{\mathbf{s}}^{2}} \right). \quad (1)$$

In σs, which s the performance of pupils in the split-classroom environment, and m is the model's latent state in the classroom teaching assessment model of learning effectiveness. L is the split classroom, x_{st} is the ideal running state, and s is the assessment methodology for interactive classroom teaching that is currently in the monitoring stage as described in equation (1).

$$\mathbf{x_n} = \mathbf{m}(\mathbf{t_o} + \Delta\mathbf{t}) \times \mathbf{L}, \quad (2)$$

where $\mathbf{x_n}$ is the statistical study on the efficacy of a divided classroom's teaching and learning t_o serves as a numerical and multidimensional measure of learning effectiveness in a dynamic classroom environment. In (2) of the regression analysis sequence of learning effectiveness evaluation and L is a representation of the performance ratio in Figure 2.

Figure 3 illustrates the training management coordinating and arranging the back-end instructor-led training and virtual instructor-led training operations in a classroom. Split classroom rules with students; students must adhere to the classroom rules. Teaching occurs in a classroom, where there is no interruption. In the classroom, students are expected to behave in a respectful and orderly manner. To improve student learning, classroom rules are implemented to teach students how to conduct themselves in the classroom. If a teacher can keep things flowing smoothly in the classroom, they are said to be smooth running. They maintain pupils' attention when moving from one topic to the next without causing much disturbance. Interaction between students is an essential component of every educational setting. Students naturally engage in this kind of engagement in the classroom by paying attention to one another's remarks, asking questions, and establishing a sense of community via repeated touch. There are concerns and impediments in management that cannot be resolved by a manager alone. Managers are often responsible for resolving problems and preventing new ones. The classroom's social, emotional, and educational components create a classroom environment. Motivated students put in more effort in class because studies show that a variety of factors in the classroom may influence student motivation.

3.1. Video Processing in the Split Classroom Effective. There are a variety of video files users can download on the Web. The video editing program has a limited capacity to identify and handle videos in several formats. First, it must transform media files into an MP4 type that X4 can detect and handle using the freeware "Format Studio."

Furthermore, Internet movies frequently contain commercial content or are made up of many scenes. The organization of the action sequences does not correspond to instructors' and learners' logical reasoning tendencies. The campaigns must be removed, and the images must be rearranged. The networking movie is "sectioned by scenarios" processed in the processor. It is separated into many individual scene movies, with unnecessary or marketing sequences removed while altering or combining images.

In the proposed EC-DL system, the video processing module system is depicted in Figure 4. It uses network video collection, recorded video, a video processing module, a video library, and a video feedback system to produce better results.

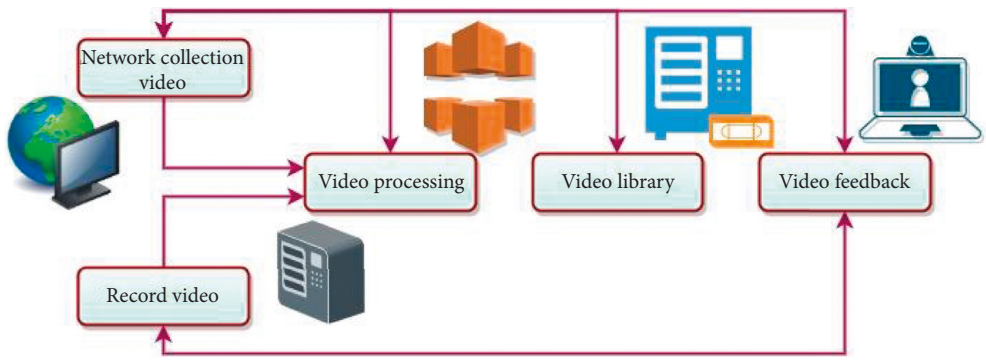

Figure 2: In the proposed EC-DL system, the video processing module.

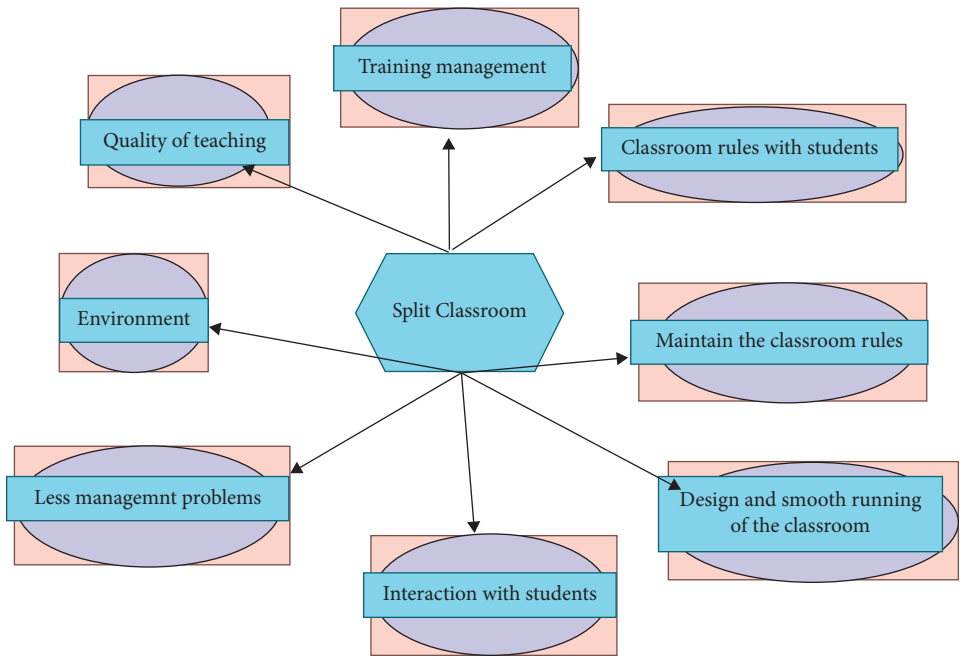

Figure 3: Split classroom.

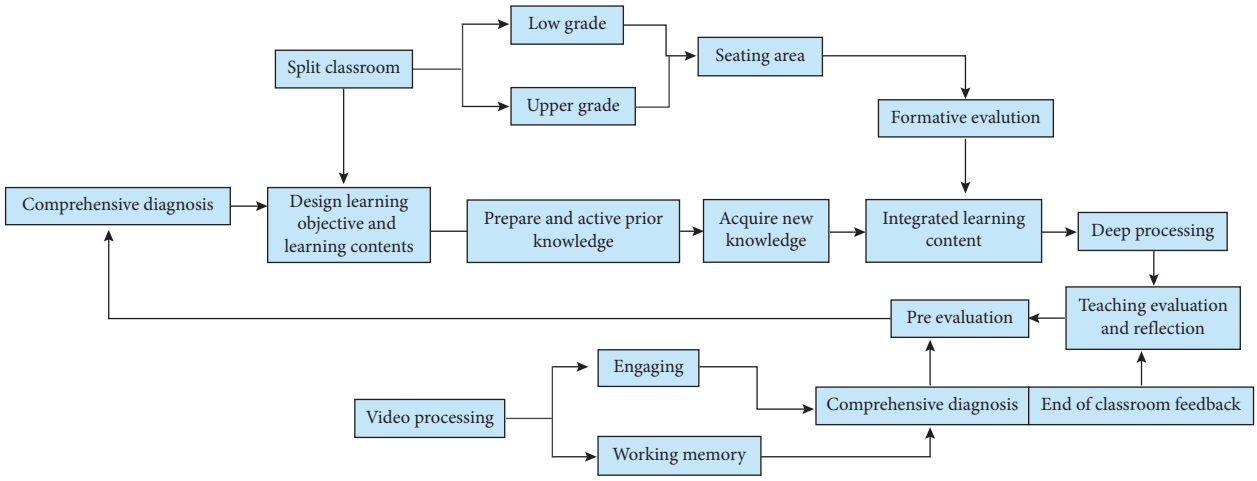

Figure 4: Action path in EC-AI proposed method through video processing.

When searching for an item that does not correspond to the collection, the likelihood of receiving 0 is higher if many hashes are employed; on the other hand, if the amount of hashes is limited, there are many more 0 in the bit arrays. The classroom rate $(1 - \exp(-ml/n))^l$, where $f = lq \ln(1 - \exp(-ml/n))$. It is used to calculate the best number of students l. When f has the lower number, g has most negligible value. The calculation rate is denoted in (3)

$$\mathbf{t} = \mathbf{exp}\left(-\frac{\mathbf{ml}}{\mathbf{n}}\right). \tag{3}$$

The number of samples is denoted n, the mean value is denoted m, and the error deviation n is denoted l. Convert g and represent it in the continuity equation at the exact moment, and it is expressed in (4)

$$\mathbf{f} = -\frac{\mathbf{n}}{\mathbf{m}}\mathbf{log}(\mathbf{t})\mathbf{log}\ (\mathbf{1} - \mathbf{t}). \tag{4}$$

The error rate is denoted t, the number of samples is denoted n, and the mean value is denoted m.

Equation (4) has a split classroom and process, and the outcome is indicated in (5):

$$\frac{\mathbf{df}}{\mathbf{dt}} = -\frac{\mathbf{n}}{\mathbf{m}}\left(\frac{\mathbf{log}(\mathbf{t})}{\mathbf{t}} - \frac{\mathbf{log}\ (\mathbf{1} - \mathbf{t})}{1 - \mathbf{t}}\right). \tag{5}$$

Furthermore, t is the likelihood that a bit in the bit matrix remains 0, i.e., $t = l/2$ correlates with half of 0 and l within bit arrays. The number of samples is denoted n, and the mean value is denoted m. The foundation is creating a multimodal movie library's quick feedback mechanism.

Figure 4 shows the road to deep learning in classroom evaluation. It combines many assessment styles to increase evaluation quality and promote instructional effects. To make classroom assessment realistic, it must be integrated into the classroom. As a result, there are few possibilities for in-depth research. Therefore, the first step in supporting deep learning is to portray it as the core axis of the whole action path and to increase learning in classroom assessment.

Regarding education, it is important to include and rely on evaluation at every step. As a result, the evaluation of enhancing deep learning should follow the route of deep learning. External driving circles, tightly encircling deep learning, should serve as the basis for the evaluation.

High function probability is derived from $h = f(C)$to get the maximum probability.

The probability ratio increases and decreases concerning two variables, and c are measured by using equations (6) and (7)

$$\boldsymbol{\gamma}_{\mathbf{q}(\mathbf{m+1})} = \boldsymbol{\gamma}_{\mathbf{q}(\mathbf{m})} + \partial\left(\mathbf{1} - \boldsymbol{\gamma}_{\mathbf{q}(\mathbf{m})}\right), \tag{6}$$

$$\boldsymbol{\gamma}_{\mathbf{r}(\mathbf{m+1})} = \boldsymbol{\gamma}_{\mathbf{r}(\mathbf{m})-}\partial\boldsymbol{\gamma}_{\mathbf{q}(\mathbf{m})}\forall\mathbf{r}. \tag{7}$$

In (7), $\gamma_{q(m+1)}$ increase probability and $(1 - \gamma_{q(m)})$ measure decreased probability to the component ∂ is calculated; when deep learning is received for all, the risk evaluation matrix is changed.$\forall r$value substitution to the probability of student performance in the classroom.

$$\boldsymbol{\gamma}_{\mathbf{r}(\mathbf{m+1})} = \frac{\mathbf{c}}{\mathbf{x} - 1} + (\mathbf{1} - \mathbf{c})\boldsymbol{\gamma}_{\mathbf{q}(\mathbf{m})}\forall\mathbf{r}. \tag{8}$$

As inferred from (8) is considered the second variable c for assessing student performance. $\gamma_{q(m+1)}$ defines the probability increase based on student engagement, $(1 - c)$ denotes decreased probability of substitution of student performance, $\gamma_{q(m)}$ represents the probability of the current session, $\gamma_{r(m+1)}$ denotes the probability of the entire subject, and $c/x - 1$ a total number of students. The learning process is completed after the best way possible has been found.

This proposed model is implemented with a practical, reconditioned education in the classroom and an iterative learning approach to evaluate the student's performance in education and classroom technologies to ensure the quality of service and privacy. Student feedback analysis measures the instructor's effectiveness in the classroom and factors to be improved.

The proposed system EC-DL is evaluated with reconditioned and intelligent learning approaches to enrich teaching quality by suitable means of intelligent learning approach with flipped classroom environments to maximize students' learning results. The classroom is incomplete by the nonappearance of an active response to control the initial stage of learners. Implementation was done with EC-DL and proven that it gives better efficiency in performance teaching, score, evaluation, analysis, implementation, and feedback evaluation.

4. Experimental Analysis of Effective Classroom

Students in productive classrooms participate in debates, investigations, and experiments that help them learn and grow. Students are responsible for much of their learning, even in small groups or independently. In higher education institutions, experimental teaching is essential to the teaching process. It is the primary method for students to develop their analytical and problem-solving skills and a spirit of originality and comprehensiveness. Classroom rules and procedures are an essential part of good classroom management. Students should not be subjected to rules and processes without their consent. There must be an explanation of the rules and processes for them to be correctly implemented.

4.1. Dataset Description. One hundred students are taken from various special effects. Analyze which course of the later stage corresponds to the goal here. Put another way, the grouping area is based on the optimization model of an effective classroom. At last, the dataset values are taken from.

At node$u$, $\forall j(t, u)$–optimal divisions have been chosen to maximize the divisive criterion, $j(u)$– when the uncleanness controls, $\forall J(t, u)$–indicates the criteria of division for a node was established with a decline in impurity.

Table 1 shows the teaching score efficiency of the proposed EC-DL system under the training and testing phase. The proposed EC-DL system is trained with the given dataset, and the simulation outcomes of the testing phases

Table 1: Teaching score efficiency of the proposed EC-DL system.

Method	Training score (%)	Testing score (%)
Explanation	46	38
Discussion	58	56
Drill	37	49
Competition	72	82
EC-DL	92	95

are validated. As a higher number of dataset are present, the proposed EC-DL system produces a higher teaching score. The classroom module achieves the higher simulation outcomes of the proposed EC-DL system and the video-based monitoring of the classroom's effective environment for the whole day.

$$\forall \mathbf{J}(\mathbf{t},\mathbf{u}) = \mathbf{q}(\mathbf{u})\forall \mathbf{j}(\mathbf{t},\mathbf{u}). \tag{9}$$

Figure 5 shows the performance ratio with analytical expressions of the estimated equation (2). It increases student engagement in understanding the concept of classroom teaching using an intelligent learning approach. In Figure 5, this paper concentrates on a formula for coordinates based on EC-DL that can be more conceptually traced than before, and the student performance analysis is improved.

$$j(u) = \sum_{j,k} D\left(\frac{j}{k}\right) q\left(\frac{j}{u}\right) q\left(\frac{k}{u}\right). \tag{10}$$

$q(u)$–the probability of a node event u, $q(j/u)$– the likelihood that a case in class j is nodding u.$D(j/k)$– the effect of class j category misclassification as category$k$.

The figure shows the proposed model EC-DL with an intelligent learning model. The greatness of the update process increased the probability of student involvement in the classroom and predicted the approximate outputs. Compared with other methods like CLASS HCI, SSD, LSTM, and SCM-TS, the level of evaluation can guarantee knowledge after applying EC-DL. Efficient quality control and analytical model for strength collection enhance student behaviour detection with reasonable standard errors. In Figure 6, when compared with the existing method, the proposed model can obtain. Evaluation equips establishing, assessing, and enhancing the effectiveness of the educational initiative. The follow-up on gaining knowledge sometimes is integrated tracking. It offers constructive feedback on the system's management and implementation.

Sharing of opportunities and skills in vendor relationship modelling is achieved by the linkage of students from both upstream and downstream enterprises $T^{(k)}$is defined as

$$T^{(k)} = \exp\left(\frac{\left(G^{(k)} + g\right)^2}{2l^2}\right). \tag{11}$$

As shown in equation (11), a scoring ideal $G^{(k)}$ can be created using the coefficients. Regarding practical classroom effects, g represents a visual interface design, l^2 indicates fast

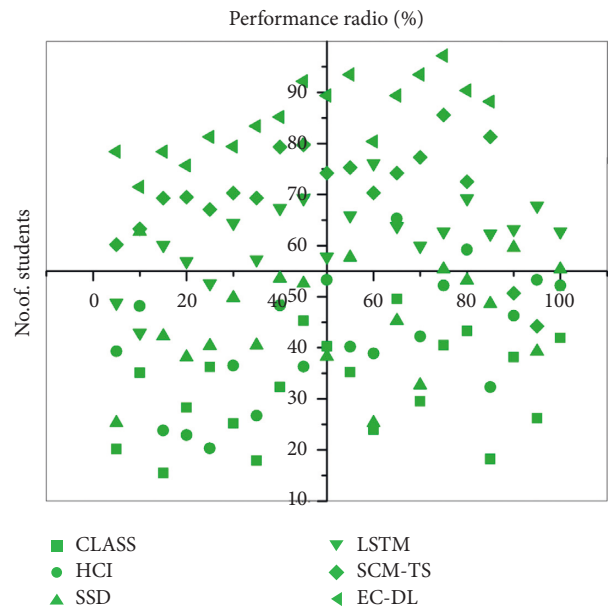

Figure 5: Performance ratio.

teaching effects, Figure 7 illustrates an educator's ability to improve their practice and inspire their students' academic and nonacademic progress through adopting, monitoring, and continuing to improve professional learning. Educating students on behaving in the classroom is essential to studying more effectively. Every second of time at school is crucial. Everything will be chaotic if there are no regulations for the kids to follow. Classroom rules and procedures assist instructors in maintaining class routines and student expectations for classwork and conduct. Students benefit from a clear understanding of the rules of classroom management and the consequences of breaching them are discussed in detail.

A variety of strategies D, such as students, are available throughout the classroom process. The emphasis on teachers$z$ operations is now on the real-time through interaction processes τ is stated as,

$$D(z \mid \tau + 1, \rho) = \rho z^k (1 + \tau - 1_k). \tag{12}$$

As shown in (12), in the case of the interaction of the effective classroom through the feedback evolution, the variables ρ and $\tau - 1_k$ represent demand and behavior, respectively. Each patch is computed usingz^k In correlation, the students consider the evolution process.

Table 2 shows the feedback evaluation of the proposed EC-DL system. The proposed EC-DL system is implemented under the simulation environment with 100 students, and their performance is evaluated under different simulation environments. The effectiveness of the proposed EC-DL system is analyzed by taking a survey of the students and teachers. Most students liked the proposed EC-DL system with the top ratings, whereas most teachers liked the proposed EC-DL system with the top two ratings.

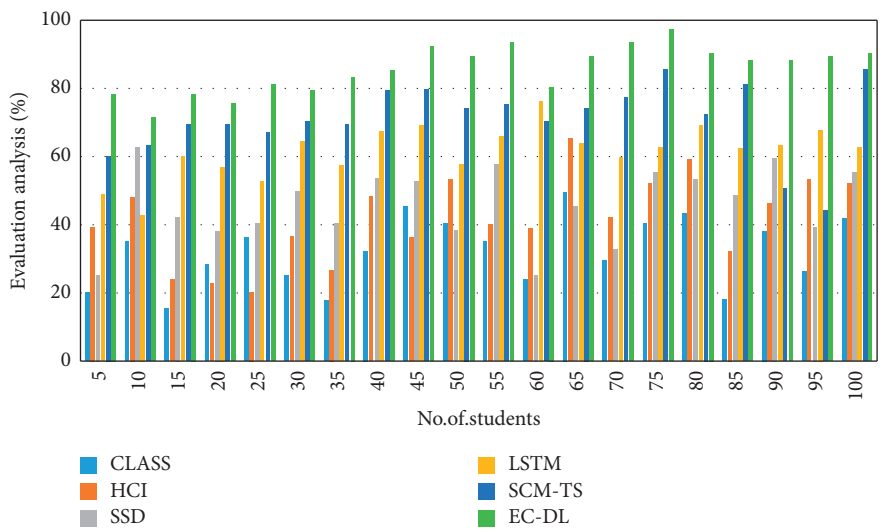

Figure 6: Evaluation analysis.

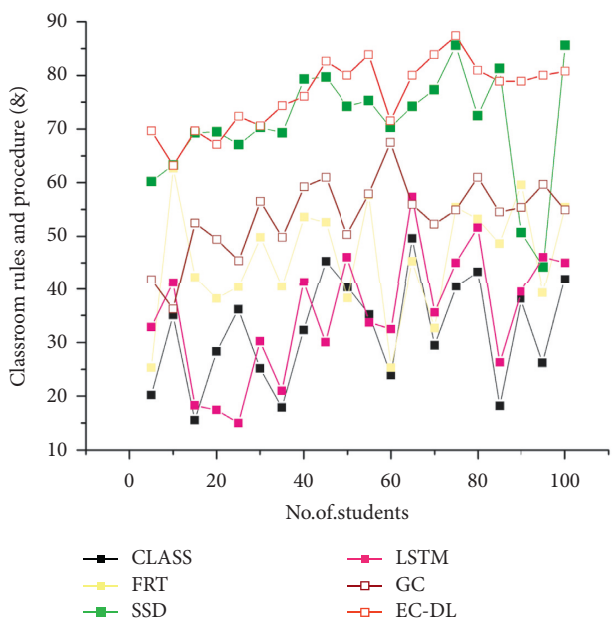

Figure 7: Implementation of split classroom rules and procedures.

Table 2: Feedback evaluation of the proposed EC-DL system.

Feedback	Student feedback (%)	Teacher feedback (%)
Very good	98	97
Good	87	94
Medium	62	87
Bad	9	2
Very bad	2	1

5. Conclusion

This paper proposes splitting classroom learning content and learning activities as a result of in-depth knowledge acquisition; the corresponding interactive classroom, built based on the correlation between the study impact and an increase in knowledge deficiency. As a result of the investigation mentioned above, the concept of engaging micro-courses is presented in a deep learning system based on summarizing earlier definitions of classroom effectiveness. This research separates the material of the split classroom into modules based on the features of reoperation. Learning objectives, videos, learning summaries, and interactive exams are all included. A split classroom is the goal of the corresponding model. Investigative findings show that individualized learning outside of the class may benefit from interactive students since they pique students' interest in learning and help them address challenges in the real world.

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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Research Article

Comparison of Phrasal Verbs and Idioms of Verb: A Corpus-Based Study between CLEC and Brown

Ning Zhang

Office of Basic Teaching Department, Weihai Campus of Shandong Jiaotong University, Weihai 264209, Shandong, China

Correspondence should be addressed to Ning Zhang; 201147@sdjtu.edu.cn

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This paper analyzes the use of verb, phrasal verbs, and idioms represented by the verb *keep* employed by Chinese non-English major students as well as by native speakers by way of corpora comparison and Contrastive Analysis. The corpora in this paper involve the English native speaker corpus (Brown) and the subcorpora St3 (non-English major Band 4) and St4 (non-English major Band 6) in the Chinese English Learner Corpus (CLEC). This thesis analyzes the use of phrasal verbs and idioms of verb *keep* which is commonly used by Chinese non-English major learners. The instruments employed in this thesis are Antconc, SPSS, Microsoft Excel, and so on. In addition, through corpora comparison and contrastive analysis, this paper contributes to explore whether Chinese learners' grasp of phrasal verbs and idioms of verb *keep* will get improvement as their English level develops. This research findings show that Chinese non-English majors' use of phrasal verbs and idioms of *keep* is far less plentiful than that of native speakers. The Chinese learners are liable to use only a small portion of keep phrasal verbs and idioms compared with the native speakers. Nevertheless, with the development of Chinese learners' English proficiency, their employment of keep phrasal verbs and idioms is getting much closer to that of the native speakers. Based on the above research, this paper also puts forward some teaching suggestions for verbs like *keep*. Some pedagogical implications are drawn on EFL teaching and learning. Microlecture videos can be employed for online and offline teaching, which is quite popular nowadays. The first five keep phrasal verbs should be attached great importance. As for keep idioms, the first six keep idioms should be emphasized. Some example sentences and related exercises can be involved. Students are also encouraged to use mind map during vocabulary learning.

1. Introduction

English has become an international language with the rapid development of globalization. Nowadays, English plays a critical part in international communication. A large number of people in China are learning English as a foreign language. That is, an essential part of language learning is word, which is unquestionable to all. Vocabulary also plays a crucial role in second language acquisition. Krashen and Terrell [1] noted that because it plays a prominent role in classroom success, vocabulary is of prime concern in foreign language settings. Wilkins [2] stated that little can be conveyed without grammar whereas nothing can be conveyed without vocabulary. As is shown in Jiang and Zhong [3], different sentence patterns are constructed by different types of verbs. English verbs are the most active among all the parts of speech. It is of great importance and significance for English learners to master these verbs and their corresponding phrasal verbs and idioms. Despite most high-frequency verbs are taught at a relatively early stage of English teaching and learning, Chinese learners still do not fully grasp them and they are not quite familiar with all of the keep phrasal verbs and idioms. Chinese learners cannot employ these expressions freely in their output.

As is shown in *Longman Dictionary of Contemporary English* by Summers [4], in both oral and written English in BNC, "keep" is listed as one of the most frequently used vocabulary. Since it is impractical to investigate all of the high-frequency verbs in this research, "*keep*" is sampled as their representative to be investigated in this present research.

1.1. Purpose and Significance. The purpose of this study is to investigate *keep* phrasal verbs and idioms used by Chinese non-English majors (St3 and St4 in CLEC) and native speakers (Brown). In general, the research questions of this study are as follows:

(1) What are the most frequently used *keep* phrasal verbs by Chinese learners as well as native speakers? What exists in the similarities and differences between Chinese learners and native speakers in *keep* phrasal verbs? What are the possible reasons for these similarities and differences?

(2) What are the most frequently used *keep* idioms by Chinese learners as well as native speakers? What exists in the similarities and differences between Chinese learners and native speakers in *keep* idioms? What are the possible reasons for these similarities and differences?

(3) With the improvement of English proficiency, whether Chinese learners' use of *keep* phrasal verbs and idioms is closer to that of native speakers?

(4) What are the implications on EFL teaching and learning in detail through the research?

1.2. Theoretical Background. Contrastive analysis is the main theory of language analysis. Contrastive analysis refers to the comparison between mother tongue and target language to figure out the similarities and differences between the two languages. Lado [5] said that "those elements similar to his mother tongue are very simple for him; however, those different elements are very difficult." Lado [5] first provided a comprehensive theoretical treatment and a systematic set of technical procedures for contrastive analysis. It includes describing the languages, comparing them, and foreseeing language learning difficulties.

A previous study is *a corpus-based study of* "*Keep*" by Wang [6]. The research of Wang Ying is based on corpora LOB and SLESSON. LOB corpus is a British English Corpus modeled on the proportion of Brown corpus. SLESSON was a corpora constructed on the basis of a comprehensive set of English textbooks used in high school in China by He Anping. Consequently, Wang's study is a study of English textbooks instead of a study of the authentic employment of Chinese learners in this present thesis. In Wang's paper, merely twelve senses and the three patterns of Sense 1 are investigated. Keep phrasal verbs and idioms are not included in the research.

This present research concentrates on the authentic employment of keep phrasal verbs and idioms by Chinese learners in comparison with native speakers. Furthermore, the author points out whether the differences between Chinese learners and native speakers are significant or not with the help of computer instruments. In addition, some pedagogical implications and learning tips are provided accordingly in the research.

2. Research Methodology

The corpora involved in this thesis are CLEC and Brown corpora. And as to the process of the corpora, computer instruments like Antconc, SPSS, and Microsoft Excel are employed to obtain the relative results related to the research according to Zhou [7].

2.1. Corpora. The databases involved in this study are Brown and CLEC. The Chinese Learner English Corpus (CLEC) is considered as the first authoritative learner corpus in China with a total of 1.1 million words according to Gui and Yang [8]. CLEC consists of five subcorpora, St2, St3, St4, St5, and St6. About 200,000 words are included in each subcorpus. St2 represents middle school students' writings. St3 represents non-English major students' CET-4 compositions. St4 represents CET-6 non-English major students' compositions. St5 represents freshmen and sophomore English majors' writings. And St6 represents English majors who have taken the test of TEM 8. Compositions in St2, St5, and St6 belong to free compositions that are written after class by respective students. On the contrary, compositions in St3 and St4 are test compositions that are written by CET-4 and CET-6 testees during CET-4 and CET-6 exams. Because St3 and St4 concentrate on compositions' test, they are suitable for the study of second language development model of Chinese learners.

Brown University Standard Corpus of Present-Day American English (Brown) is regarded as the first modern and computer readable general corpus. The corpus includes 1 million words of American English texts printed in 1961. Brown consists of 500 texts. And each text includes 2000 words. Brown takes samples from fifteen different text categories in order that the corpus can be a good reference. The fifteen categories represent the time's written American English. Consequently, the Brown size is compatible with the size of CLEC.

2.2. Instruments. The data needed are the sentences in which *keep* phrasal verb and idioms appear. Computer software has brought great convenience and efficiency in order that the data needed for research can be obtained. Antconc, SPSS, and Microsoft Excel were employed in this study [7]. Antconc is used to extract the required test words and expressions from the three copora. SPSS software package is used for Chi-square test. Microsoft Excel is used to calculate and display the results by way of graphs.

3. Data Collection and Research Procedure

The corpora in this study are Brown and CLEC. This thesis chooses two subcorpora such as St3 and St4 in CLEC as the sample corpora of learner language among the five subcorpora in CLEC.

This paper focuses on features of *keep* in context, that is, *keep* phrasal verbs and idioms used by Chinese learners in St3 and St4 in CLEC as well as English native speakers in Brown. In addition, the similarities and differences between Chinese learners and English native speakers on the use of them are also investigated in the thesis.

The author first sorts out "*keep*" phrasal verbs and idioms from the above three corpora by means of Antconc [9]. All sentences containing "*keep*" can be sorted out. After that

keep phrasal verbs and idioms are sorted out and studied. Since it is still a controversial issue as to how to distinguish phrasal verbs and idioms, this research selected a solid gauge. The gauge is *Oxford Advanced Learner's English-Chinese Dictionary* [10]. All of the *keep* phrasal verbs and idioms are selected from this dictionary. This study discusses keep phrasal verbs and idioms, respectively. The author calculated and compared the results among the three corpora. Chi-square test is also utilized by SPSS [7]. The paper puts forward the characteristics of Chinese learners' use of these three expressions.

3.1. Comparison of Keep Phrasal Verbs among the Three Corpora. Above all, it is necessary to clarify what "phrasal verb" stands for. As the term "phrase" is full of ambiguity, the term "phrasal verb" is used in this paper. A phrasal verb is a combination of a verb and a preposition, a verb and an adverb, or a verb with both an adverb and a preposition. Different from the original verb, a phrasal verb has its own distinct meaning. Phrasal verbs are taken as parts of the syntax of sentences. Furthermore, they are regarded as complete semantic units.

In this thesis, *Oxford Advanced Learner's English-Chinese Dictionary* [10] is seen as a gauge to determine *keep* phrasal verbs. There are thirteen phrasal verbs of *keep* in the dictionary at all. They are listed in Table 1 according to the alphabetical order.

The overall frequencies of *keep* phrasal verbs in Brown, St3, and St4 are listed in Table 2 to examine whether Chinese learners have a tendency to overuse or underuse *keep* phrasal verbs compared with English native speakers.

Table 2 shows that there exists difference on using *keep* phrasal verbs by Chinese learners and native speakers. St3 is listed as the highest by 27.67%, which is 6% to 7% higher than the other two corpora. St4 shows the lowest percentage among the three corpora by 20.16%. In Brown, the percentage of *keep* phrasal verbs' occurrences is narrowly higher than that in St4. Table 2 also exhibits that Chinese learners' employment of *keep* phrasal verbs is much closer to that of native speakers with their English competence's development. To determine whether the difference in the employment of keep phrasal verbs among the three corpora is significant or not, Chi-square tests among the three corpora are carried out in Table 3.

The critical value for all Chi-square tests is 3.84 for one degree of freedom at five percent level. Table 3 shows that there is no significant difference across the three corpora as to the use of *keep* phrasal verbs. In spite of this, it is rather possible that the employment of each phrasal verb across the corpora is different. Table 4 is offered to investigate the thirteen *keep* phrasal verbs employed by Chinese learners and English native speakers in detail. In Table 4, phrasal verbs are arranged in the sequence from high frequency to low frequency in Brown.

As exhibited in Table 4, it is evident that the top five *keep* phrasal verbs among the three corpora are compatible. They are "*keep from, keep on, keep up, keep out of,* and "*keep up with*." Nevertheless, "*keep at*" is not used in any corpora. The reason may be that the meaning of "*keep at*" overlaps the meaning of "*keep on*." However, the phrasal verb "*keep on*" is used so frequently by both native speakers and English learners that "*keep at*" is ignored. The rest seven phrasal verbs only account for about one fifth of the overall *keep* phrasal verbs in Brown. However, the percentage is even lower for St3 and St4 with about 4 to 5 percent for each corpus. Despite that the top five *keep* phrasal verbs in the three corpora are compatible, the sequences of the distribution of these five phrasal verbs in each corpus are rather different. Figure 1 aims to show the sequence of the frequencies of the top five phrasal verbs among the three corpora according to the order from high to low frequency in Brown.

As shown in Figure 1, it is quite apparent that compared with native speakers, Chinese learners have a tendency to overuse phrasal verbs "*keep on*" and "*keep up with*." In the meantime, St3 learners have the highest frequency of "*keep on*" among the three corpora, which is sufficiently twice of that in Brown. "*Keep up with*" by St4 learners is five times of that in Brown, and it is four times of that in Brown in St3. The reason for Chinese learners' overuse of "*keep on*" and "*keep up with*" maybe that the two phrasal verbs are taught at comparatively earlier stage than the other phrasal verbs during EFL learning. As a result, they leave deep impression in Chinese learners' mind. In addition, "*keep on*" and "*keep up with*" are listed as the top two phrasal verbs in both St3 and St4 learners despite their orders are quite the opposite. Nevertheless, Chinese learners tend to underuse the rest three phrasal verbs*: keep from, keep up, and keep out of.* The use of "*keep from*" in Brown almost doubles that in St3 and St4. The use of "*keep up*" in Brown almost doubles that in St3 and St4. Chi-square tests are carried out in Table 5 to examine whether there are significant differences among the top five *keep* phrasal verbs across the three corpora.

As shown in Table 5, there are significant differences in terms of the use of "*keep on*" and "*keep up with*" as for St3 and brown. There is no significant difference among "*keep from*," "*keep up*," and "*keep out of*" with regard to St3 and brown. There is a significant difference on the use of "*keep up with*" with regard to St4 and brown. In the meantime, there is no significant difference between the two corpora with regard to the first four phrasal verbs. There is no significant difference on the use of keep phrasal verbs in St3 and St4.

To conclude what I have discussed, Chinese learners tend to mainly use phrasal verbs "*keep from, keep on, keep up, keep out of, and keep up with*." In terms of the other phrasal verbs, Chinese learners seldom use them. Chinese learners are inclined to overuse "*keep up with*" remarkably compared with native speakers. In addition to "*keep up with*," St3 learners are likely to overuse "*keep on*." When it comes to the diversity of keep phrasal verbs, Chinese learners still need improving compared with native speakers.

3.2. Comparison of Keep Idioms among the Corpora. Above all, it is necessary to clarify what "idiom" stands for. An idiom is an expression which serves as a single unit.

Table 1: Thirteen *keep* phrasal verbs.

Phrasal verbs	Meanings of keep phrasal verbs
Keep at	(cause sb to) continue to work at sth
Keep away (from)	(cause sb/sth) not to go near sb/sth
Keep back	Prevent sth from moving; refuse to tell sb sth; remain at a distance from sb/sth
Keep down	Not show where one is; repress or oppress; not raise a part of the body
Keep from	Prevent sb/oneself from doing sth; not tell sb sth
Keep in	Detain (a child) after normal school hours as a punishment; not express an emotion; give or allow oneself/sb a regular supply of sth; continue to be friendly with sb, especially in order to gain some advantage
Keep off	(of rain, snow, etc) not begin; not approach, touch, etc sb/sth; not eat, drink, or smoke sth; cause sb/sth not to approach, touch, etc. sb/sth
Keep on	Continue one's journey; continue (doing sth); continue to employ sb; continue talking (to sb) in an irritating way (about sb/sth)
Keep out of	Not enter(a place); prevent sb/sth from entering a place; not expose oneself/sb to sth
Keep to	Not wander from or leave (a path, road, etc); avoid meeting people socially; not tell other people about sth
Keep under	oppress sb; control or suppress sth
Keep up	(of rain, snow, good weather, etc.) continue without stopping; prevent sb from going to bed; prevent sth from falling down; move or progress at the same rate (as sb/sth); rise at the same rate (as sth)
Keep up with	Continue to be in contact with sb; inform oneself or learn about (the news, current events, etc.)

Table 2: Distribution of *keep* phrasal verbs among the three corpora.

Corpus	Phrasal verbs	Total occurrences	Percentage (%)
Brown	110	518	21.24
St3	57	206	27.67
St4	25	124	20.16

Table 3: Chi-square tests on phrasal verbs among the three corpora.

St3 vs. brown		St4 vs. brown		St3 vs. St4	
X^2	P	X^2	P	X^2	P
2.103	0.147	0.046	0.831	1.429	0.232

Nevertheless, the meaning of the expression cannot be figured out from the separate words but as a whole.

"*Keep*" idioms are marked clearly as shown in *Oxford Advanced Learner's English-Chinese Dictionary* [10]. The overall frequencies of *keep* idioms in brown, St3, and St4 are shown in Table 6 to check whether Chinese learners are likely to overuse or underuse *keep* idioms compared with native speakers.

According to Table 6, Chinese learners are inclined to underuse *keep* idioms compared with native speakers. St4 learners' use of *keep* idioms is closer to that of native speakers compared with St3 learners.

Tables 7 and 8 are offered, respectively, according to the frequencies of keep idioms among the three corpora to examine the idioms employed by native speakers and Chinese learners.

According to Tables 7 and 8, it is quite apparent that the native speakers use *keep* idioms in a much wider range compared with native speakers. There are twenty-seven various *keep* idioms in Brown at all. Nevertheless, only six various *keep* idioms are used by Chinese learners. The top six *keep* idioms that are used in Brown are "*keep an eye on, keep*

Table 4: Distribution of each phrasal verb among the three corpora.

Phrasal verbs	Corpus					
	Brown		St3		St4	
	Freq.	%	Freq.	%	Freq.	%
(1) Keep from	34	30.91	10	17.54	4	16
(2) Keep on	18	16.36	19	33.33	7	28
(3) Keep up	16	14.55	4	7.02	2	8
(4) Keep out of	11	10	3	5.26	2	8
(5) Keep up with	8	7.27	18	31.58	9	36
(6) Keep down	5	4.55	0	0	0	0
(7) Keep off	5	4.55	0	0	0	0
(8) Keep to	5	4.55	0	0	0	0
(9) Keep away (from)	4	3.64	2	3.51	0	0
(10) Keep under	2	1.82	0	0	0	0
(11) Keep back	1	0.91	1	1.75	1	4
(12) Keep in	1	0.91	0	0	0	0
(13) Keep at	0	0	0	0	0	0

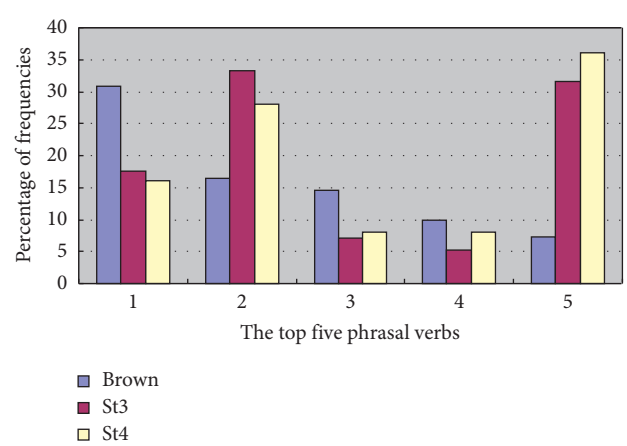

Figure 1: The top five phrasal verbs across the three corpora.

Table 5: Chi-square tests of the top five *keep* phrasal verbs among the three corpora.

Phrasal verbs	St3 vs. brown		St4 vs. brown		St3 vs. St4	
X^2&P	X^2	P	X^2	P	X^2	P
Keep from	2.090	0.148	1.357	0.244	0.021	0.885
Keep on	3.842	*0.050	1.185	0.276	0.120	0.729
Keep up	1.623	0.203	0.600	0.439	0.021	0.884
Keep out of	0.941	0.332	0.078	0.780	0.199	0.655
Keep up with	11.665	**0.001	10.303	**0.001	0.077	0.782

Table 6: Frequencies of *keep* idioms among the three corpora.

Corpus	Idioms	Total occurrences	Percentage (%)
Brown	74	518	14.29
St3	21	206	10.19
St4	14	124	11.29

Table 7: Twenty-seven different *keep* idioms in brown.

Idioms used in brown		
Idioms	Frequency	%
(1) Keep an eye on	15	20.27
(2) Keep one's eyes/ears open	6	8.11
(3) Keep quiet about sth	6	8.11
(4) Keep sth in mind	6	8.11
(5) Keep in touch (with)	4	5.41
(6) Keep one's word	4	5.41
(7) Keep abreast of	3	4.05
(8) Keep pace (with)	3	4.05
(9) Keep sb company	3	4.05
(10) Keep the peace	3	4.05
(11) Keep one's mouth shut	3	4.05
(12) Keep track of	2	2.70
(13) Keep house	2	2.70
(14) Keep a close eye on	1	1.35
(15) Keep an eye open/out	1	1.35
(16) Keep one's eyes peeled/skinned	1	1.35
(17) Keep one's own counsel	1	1.35
(18) Keep a straight face	1	1.35
(19) Keep count (of sth)	1	1.35
(20) Keep one's nose to the grindstone	1	1.35
(21) Keep one's fingers on the pulse	1	1.35
(22) Keep sb waiting	1	1.35
(23) Keep clear (of sb/sth)	1	1.35
(24) Keep up appearances	1	1.35
(25) Keep up with the joneses	1	1.35
(26) Keep faith with sb.	1	1.35
(27) Keep sth at bay	1	1.35

Table 8: *Keep* idioms by St3 and St4 learners in CLEC.

St3			St4		
Idioms	Frequency	%	Idioms	Frequency	%
(1) Keep in touch with	11	52.38	(1) Keep in touch (with)	6	42.86
(2) Keep an eye on	3	14.29	(2) Keep sth in mind	5	35.7
(3) Keep pace (with)	2	9.52	(3) Keep an eye on	1	7.14
(4) Keep track of	2	9.52	(4) Keep pace (with)	1	7.14
(5) Keep sth in mind	2	9.52	(5) Keep track of	1	7.14
(6) Keep sb in the dark	1	4.76			

one's eyes/ears open, keep quiet about sth, keep sth in mind, keep in touch with" and "*keep one's word*." In the six idioms, three of them are used by Chinese learners. They are "*keep an eye on, keep sth in mind,* and "*keep in touch with*." "*Keep pace with*" and "*keep track of*" are used by native speakers as well as Chinese learners. And the frequencies of them are three and two in Brown, respectively. The top five keep idioms utilized by St3 and St4 learners are exactly the same despite the proportion of them are different. "*Keep sb in the dark*" is unique in St3. Despite there is some difference in the use of *keep* idioms by native speakers and Chinese learners, in Chi-square test, there is no significant difference among the three corpora. Consequently, Chi-square test is not carried out.

The use of idioms stands for the purity of the grasp of English language to some degree. It is rather apparent that compared with the twenty-seven use of *keep* idioms by native speakers, Chinese learners' master of keep idioms is lacking in purity. Chinese learners need to enrich their idioms to make their English more native-like.

4. Summary

This thesis focuses on comparison of use of *keep* phrasal verbs and idioms by Chinese learners and native speakers. Therefore, we can figure out the characteristics of Chinese learners' use of *keep* phrasal verbs and idioms. And the limitations of Chinese learners' employment of *keep* phrasal verbs and idioms are discovered compared with native speakers. Consequently, vocabulary learning of Chinese learners can be improved. The following three parts conclude the three main aspects in this thesis:

(1) Comparison of *keep* phrasal verbs across the corpora: the top five *keep* phrasal verbs across the three corpora are the same, namely, "*keep from, keep on, keep up, keep out of,* and "*keep up with*." Chinese learners are inclined to overuse phrasal verbs "*keep on*" and "*keep up with*" and at the meantime apt to underuse phrasal verbs "*keep from, keep up,* and "*keep out of*" compared with native speakers. Chinese learners hardly use the rest eight phrasal verbs. The reason may be that during Chinese learners' English learning, the top five phrasal verbs are emphasized; however, the rest ones are not mentioned frequently. In addition, prepositions and adjectives are always difficult points in language learning. As a result, Chinese learners are inclined to use those expressions they are quite familiar with. Neither native speakers nor Chinese learners ever employ "*keep at*." Because of the familiarity of "*keep on*," "*keep at*" is rarely used by both native speakers and Chinese learners. To sum up, Chinese learners do not fully grasp *keep* phrasal verbs. They should attach great importance to learning of phrasal verbs and try to use them in context.

(2) Comparison of *keep* idioms across the corpora: with regard to the idioms used by native speakers and Chinese learners, Chinese learners are likely to underuse *keep* idioms compared with the native speakers. Furthermore, Chinese learners only employ six idioms compared with native speakers' twenty-seven various idioms. "K*eep sb in the dark*" is unique in St3 compared with St4. The reason maybe that idioms are closely correlated with national culture, background, and so on. Native speakers are more familiar with idioms in English. Many idioms are not learnt in class, but in daily life. As a consequence, Chinese learners only know a limited range of *keep* idioms. Chinese learners should learn in special cultural background and try to enrich their idioms.

(3) Generally speaking, with the improvement of English proficiency, Chinese learners' use of *keep* phrasal verbs and idioms is closer to that of native speakers.

(4) Some pedagogical implications can be drawn on EFL teaching and learning. There are twelve out of thirteen keep phrasal verbs and twenty-seven keep idioms employed by native speakers. Therefore, it is difficult for teachers to cover all of these expressions during school hours. As a result, microlecture videos can be employed. As hybrid online and offline teaching is quite popular nowadays, students can be provided microlecture videos on the use of keep phrasal verbs and idioms before class and after class. Teachers can search some appropriate microlecture videos online or make microvideos by themselves before class. In these videos, the first five keep phrasal verbs should be given great importance. At the same time, the rest eight phrasal verbs should also be covered. And that the use of "keep at" is similar to "keep on" is supposed to be pointed out. Furthermore, some example sentences and related exercises can be provided. Related exercises can be translation, multiple choice, and so on. As for keep idioms, the first six keep idioms should be emphasized. And the rest twenty-one idioms should also be included. The same with *keep* phrasal verbs, some example sentences, and related exercises can be involved. Students are also encouraged to use mind map during vocabulary learning, in which not only *keep* phrasal verbs and idioms but also different senses can be included.

To sum up, as to *keep* phrasal verbs and idioms, Chinese learners only use a smaller portion in comparison with native speakers. Chinese learners ought to improve their use of *keep* in context.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Intelligent Vehicle Engine Dynamic Test System Based on Internet of Things

Wenbin Wang[1] and Liyan Wu[2]

[1]*School of Automotive Engineering, Jilin Engineering Vocational College, Siping 136001, Jilin, China*
[2]*School of Engineering, Shenyang Agricultural University, Shenyang 110866, Liaoning, China*

Correspondence should be addressed to Liyan Wu; 2009500023@syau.edu.cn

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In the context of technological modernization in the field of automotive engine testing, the development of an intelligent automotive engine testing system based on IQ has become an important trend in the future. This paper mainly studies the development of engine test software platform, the technical control of test process conditions, and the intelligent conversion of important components such as temporary fuel flow meters. By comparing the traditional bench test system and the dynamic test system based on the Internet of Things, the efficiency of data information transmission, information security, perception ability, and response speed between them are compared, and the intelligent dynamic engine detection based on the Internet of Things is found. The system is more secure and more efficient in information transmission, with a 12% increase in perception performance and a 48% increase in system response time. This also fully shows that the intelligent dynamic engine detection system based on the Internet of Things will be more suitable for current equipment and can also be detected more accurately, which can realize effective supervision of the running status of the test prototype and remote online feedback of the analysis results, and solve the engine test process. It solves the problem of efficient, reliable, and safe transmission and transmission of data and information between all levels and layers, and improves the ability of rapid perception and response in the process of engine testing.

1. Introduction

Automotive engine testing technology is an important part of the automotive manufacturing process and one of the most complex parts testing technologies. There are many technologies for automobile testing, including voltage, current, resistance testing, internal environment testing, and connector testing. In recent years, integrated network technology has gradually entered people's field of vision with its fast information transmission speed and flexible management methods. Shared networks are an essential part of next-generation IT. IoT connects sensors, controllers, machines, people, and things in new ways through intelligent detection, identification, general information, and other communicating sensor technologies. It uses the local network or the Internet to create a network of people and things, things, and computing, and also creates remote control and intelligent control. With the growing maturity of network sensor technology, Google's development of an intelligent engine test system is based on an important trend and technological modernization background for future automotive engine testing.

The engine dynamic detection system needs to conduct experiments through the engine bench and evaluate the performance, economy, power effect, reliability, etc., of the engine through the experimental data. The engine bench experiment is also the most basic test platform and also needs to test oil, coolant, windshield washer dose, radiator, clutch, brake pump, etc. Because of the engine interior, the situation is changeable and complex, there are many experimental items, and there are many related parameters. The performance requirements for the engine bench will be relatively high, high accuracy and high-frequency acquisition are required, and the test bench needs to be adjusted in the control system.

In this paper, through the steps in the engine test, the development of the engine machine detection system is established, the technical state management in the test and the fuel consumption meter in the operation are the focus, and the research is carried out to establish a more efficient and convenient system. Various dynamic parameters inside the engine can be collected accurately and quickly, and various attribute information of the engine can be extracted from the database and analyzed, such as hydraulic pressure, cold temperature, ignition time, tire pressure, cylinder operating parameters, and fuel consumption to further improve the level of engine performance testing in China and lay a solid foundation for the development of engine products. In the comparison of the two systems, the performance perception of the system has been improved by 12%, and the response time has also been greatly improved.

2. Related Work

As human beings enter the era of intelligence, the use of artificial intelligence is gradually increasing smartphones, TVs, monitoring, etc., as well as the use of safety, and the increase in traffic accidents in daily life has caused people to be concerned about the safety of cars and lives. The development of intelligent driver assistance systems is becoming an important part of the structure of future intelligent transportation systems, with the goal of reducing the number of vehicles, traffic accidents, and their subsequent fatalities. The parameters derived from this intelligent system are the safety and comfort of the passengers. In this context, Moussaid and Toumanari propose intelligent braking system (IBS) by improving anti-lock braking system (ABS) technology. It can protect people's life safety and reduce the incidence of accidents. The simulation idea adopts the switching action of IBS and ABS mechanism to simulate the actual traffic situation [1]. Kishore et al. propose a compact wideband mmWave antenna for intelligent transportation (ITS) applications. The antenna uses coplanar waveguide feeding technology to achieve bandwidth. The proposed antenna operates at the resonant frequency of 79 GHz with a large bandwidth of 78.2 GHz. The measured gain of the antenna is 17.5 dBi. The proposed antenna is well suited for short-range radar (SRR) applications and technologies [2]. Andreev et al. proposed the application of intelligent engineering concepts to cyber-physical production systems (CPPS). Engineering to optimize the production process chain is becoming an important competitive factor. In this context, industrial companies are faced with the problem of producing customized and efficient products. Through the application of smart factory CPPS, the problem of improving economic efficiency can be ensured. Smart factories aim to plan CPPS to ensure that products are produced according to individual requirements at target costs [3]. However, this is rarely used in intelligent vehicles, especially in the engine dynamic test, and there is almost no introduction.

The development of the Internet of Things represents the development direction of the informatization of the entire society. As far as the communication industry is concerned, the long-term development goal is to achieve seamless connection and communication between people. The essence of the Internet of Things is industry informatization. The driving force for governments to vigorously promote the development of the Internet of Things is to find new economic growth points and create jobs. In this context, operators have become important promoters of the Internet of Things worldwide. Operators will gain huge benefits from the development of the Internet of Things and at the same time lead the entire communication industry to develop in a more in-depth direction. In the future, the in-depth development of the Internet of Things in more industries needs to be driven by innovative models. The current technology is developing rapidly, and the use of dynamic test systems has gradually increased. In order to accurately analyze the penetrating overload signal, Liu F proposed a dynamic test system with low power consumption and high load. The system can withstand an overload signal of 2×10 g. In order to achieve the characteristics of high sampling rate, low power consumption, and shock resistance, the system uses a silicon crystal oscillator as the main oscillator and a low-power CMOS chip. When the system starts working, the processor goes into deep sleep mode and starts powering the peripheral circuits when it enters transmit mode. When the missile launches a signal, the hysteresis trigger circuit will generate a trigger signal, thereby starting the acquisition system for data acquisition. Experiments show that this scheme can prolong the life cycle of the missile and accurately collect the overload signal of the air gun [4]. Inter-regional oscillations are most detrimental to the synchronization integrity of interconnected power systems. This damage comes from their broad spectrum and participant generators. Intrinsic damping associated with inter-regional oscillations, leaving potential for widespread outages, Fayez et al. explored the effect of a strategic dynamic braking intervention based on interval model fuzzy logic on a dual braking model to eliminate the danger of power oscillations between the negatively damped regions of the two Kundur regions, and they used in a test system MATLAB/Simulink environment. By analyzing the effects of the four perturbations on performance, the unstable nature of the system response is clearly detected. The system oscillatory behavior is stabilized in an appropriate manner. The performed nonlinear time simulation results highlight the great potential of the proposed scheme in mitigating inter-regional power oscillations [5]. In order to improve the dynamic accuracy of five-axis machine tools, Song et al. proposed an evaluation method based on the specimen and comprehensive evaluation (CE) system. Compare the frustum and S specimen in ISO 10791-7 to show their ability to reflect dynamic accuracy and build kinematics and dynamic simulation models to influence the effect of various dynamic factors on the S specimen. The relationship between dynamic factors and S specimens is applied to the construction of CE system. The data and dynamic accuracy of the system can reach the standard value through construction, and the accuracy can be affected by adjusting the offset of the machine tool. Finally, it is concluded that the dynamic accuracy of the five-axis machine tool can be improved by adjusting

[6]. The deep rock mass is a massive hierarchical structure, which plays an important role in the nonlinear dynamic behavior of rock. Jiang H developed a test system to study the dynamic properties of deep rock masses. The test system is mainly composed of a loading device and a measuring system. In the loading device, the vibration exciter is used as the power source, and various forms of dynamic and static loads such as horizontal static load, horizontal impact, and vertical impact are applied to the structural system composed of rock blocks. The test results show that the test system has reasonable design, convenient operation, and high measurement accuracy; it can be used to study the nonlinear rock mechanics phenomenon of massive rock mass [7]. The dynamic test system plays a huge role in various fields, and its application in intelligent vehicle engines is also in urgent need of development. There are many kinds of vehicle engine testing systems, such as emission testing and fuel consumption testing. The testing system is a system fully controlled by computer integration. Different data analysis is performed on different experimental projects in order to derive more detailed studies, finding out their differences, and control them by computer.

3. Development and Management of Test Systems

3.1. Requirements for Dynamic Test Conditions. The engine dynamic simulation test shall include dynamic process and vehicle simulation. A dynamic process or execution state is a function of time. In vehicle simulation, an engine test bench should be used to simulate the operation of the vehicle and wheels, not the engine mathematical model. In other words, apart from the real engine, the rest of the power transmission system is virtual. Compared with the vehicle axonometric conditions and the actual vehicle road test conditions, the vehicle simulation test conditions have unique characteristics and advantages. The vehicle simulation test has more real data and is suitable for the scene. The test environment has both the vehicle axonometric environment and the road environment. The traditional bench testing system mainly tests the instrument. The test is relatively simple, the function of the instrument is relatively single, and it is easy to have compatibility problems with other running equipment. The incompatibility between the instrument and the instrument will easily lead to low test performance of the engine bench and weak expansion, make major changes, or rebuild [8]. From the perspective of detection accuracy, the traditional test system is recorded by personnel, and the existing errors will be too large, resulting in inaccurate data and affecting experimental judgment. Naturally, the accuracy will not be too high, and the adaptability of its own system is too poor, not to a high degree. The current advanced intelligent equipment can meet the requirements of the experiment, but the equipment price is too high, resulting in less application in the detection system. At present, the engine performance test in the research and development is mainly to test the electric power. Products are usually tested with eddy current sensors in the factory inspection, but there are also a small number of manufacturers that use water eddy current tests. The dynamometer is the basic unit of the engine test bench, and its main technical parameters are shown in Table 1. There are still quite a lot of domestic tester manufacturers, but not many have high precision and meet the requirements. The market urgently needs high-intelligence and high-precision engine performance testing equipment. With the rapid development of the times, the requirements for engine electronic control technology are getting higher and higher, the sensors also need to keep up with the needs of the times and be updated or upgraded, the data storage, sorting, and accuracy of the electronic control technology are quite strict, and the sensors also need to be more precise. At present, most of China's sensing equipment comes from foreign companies. Because they do not have independent intellectual property rights, they cannot design high-demand sensors. Especially in terms of intelligence, the data obtained are basically a blank sheet of paper. With the progress of the current market, some companies that produce sensors have appeared in the market. The sensors produced are generally used in relatively poor environments, such as high temperature, high pressure, and other environments, and these sensors mainly detect engine speed, internal air pressure, temperature, instrument panel data, etc. The equipment still does not meet the requirements, the performance, accuracy, product quality, and reliability are relatively low, and the technology in these areas needs to be improved urgently.

As a complete emission testing system, the system measures computer engine parameters for simultaneous production and documentation. After the test is complete, the data can be edited and the test report published. The data module is a standard excel that can be used to download map analysis. The results of the package test and the results of continuous measurements (each exhaust speed, torque, power, exhaust temperature, vehicle speed, concentration, and flow) shall be provided. Continuous analysis of raw exhaust gas, continuous analysis of diluted exhaust gas, and general analysis can be performed. It can compensate for the time delay caused by the pipeline and control the catalytic conversion efficiency. The system software supports standard test cycles [9] (e.g., mock type I test cycle table and standard static test 13 as specified in the standard appendix) and defined user test cycles [10]. Software for simulating and evaluating relevant emission control standards includes equipment for validating test procedures, equipment for detecting emissions, and equipment for fully automatic monitoring and detection. Test reports can be created in predefined or user-defined formats. The control, data acquisition, and processing software used by the system must work on Windows 98. The testing process is fully automatic under computer control and can perform automatic testing (including automatic CO control and full flow particle sampling system), automatic calibration, automatic cleaning, automatic leakage control, automatic linearization control, automatic test status control, etc. [11].

Table 1: Comparison of main technical parameters of various dynamometers.

Dynamometer type	Hydraulic dynamometer	Eddy current dynamometer	AC power dynamometer	DC power dynamometer
Manufacturer	Hangzhou Keyi	South peak	Schenk	Schenk
Series model	WE	CW	DYNAS2	GS
Nominal power (kw)	110	100	120	120
Nominal torque (N.m)	380	320	270	390
Rated speed (rpm)	5500	6400	9600	8100
Torque measurement accuracy	±0.3FS	±0.3FS	±0.3FS	±0.2FS
Response characteristics	0–100% (0.4 s)	0–100% (0.3 s)	0–100% (0.5 s) 24000 rpm (s)	0–100% (0.4 s) 6440 rpm (s)
Moment of inertia ($n.m^2$)	0.38	0.25	0.32	1.02
Brake (drive bidirectional function)	Only brake function	Only brake function	Brake (drive bidirectional function backward drag control)	Brake (drive bidirectional function backward drag control)

3.2. Development of the Test System. Any product needs to undergo a number of tests before entering the market, and the engine is no exception. The engine needs to undergo durability testing, calibration testing, high-intensity temperature difference shock testing, engine emission testing, etc., to verify whether it meets the entry requirements and market demand [12]. In the process of engine research and development, it also needs to spend a sum of money. The direction of consumption is mainly in the testing equipment and verification services, and the cost accounts for nearly half of the total capital, so as to achieve high-precision, high-efficiency, and high-intelligence detection of engine performance indicators. It is very important to reduce product production time and reduce cost. The high-precision, high-efficiency, and high-intelligence detection engine can reduce the cost of enterprise expenses, reduce the running time of the instrument, improve the detection efficiency, and improve the system. According to the requirements of the test system, the test system is developed on the basis of dynamic theoretical data and actual operation data. The test system needs to have test process, console, data storage, parameter formulation, and other related data, so as to realize the control of these basic modules. The system can also create new modules by itself, edit the modules, and integrate them according to the same data, so as to realize the parameter cycle [13]. Doing so can ensure data stability within the module and increase system stability. All the designs of the system are designed in order from small to large. In the design, the versatility of various parameters is realized, which meets the dynamic testing requirements in the system design, and the shared program is implanted, so that the main application programs can be shared. The software platform is mainly composed of computer, card board, main control software, interface layer, and actual running software. Different software deals with different system problems. The main control software can manipulate the test and display the resulting data, as shown in Figure 1. The interface layer is mainly to form a connection between the main control software and the actual running software, and realize the intercommunication of data through the Dll interface [14].

3.3. Technical Status Management during Testing. At present, there are still many problems in engine testing, such as the validity of test data, the accuracy of data collection, and the problem of system management [15]. Traditional engine system testing has been unable to meet the current research and development needs of high-tech products, the traditional engine system test data error is large, the calculation is not accurate, and the data transmission is prone to problems. In this paper, the state of the engine during testing is managed and the entire system is planned according to a new model to ensure that the data of the engine during testing are as accurate as possible. According to the data parameters under management, the model can output information data stably, and this technology mainly combines the Internet, computer, and database to build models, so as to ensure high-precision sensing and implement remote control under multi-layer distribution [16]. In this way, it is possible to more accurately understand the data in the engine during the test, basic data such as fuel consumption, temperature, engine internal pressure, and coolant temperature. Transmit the data through the sensor, and transmit the data to the control system. Through the display function, the user can intuitively see the various data in the engine test. The environment, images, and other information can also be fed back through the remote server to achieve efficient transmission of information during the test. And the data are accurate and reliable, which solves the problem of low reliability in traditional detection systems and realizes fast perception and response [17]. The device data model is shown in Figure 2.

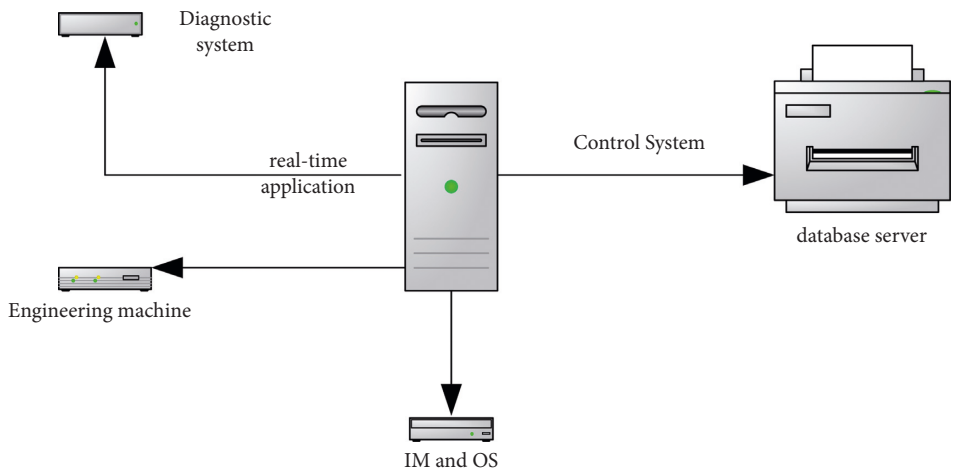

Figure 1: Development principle of test system platform.

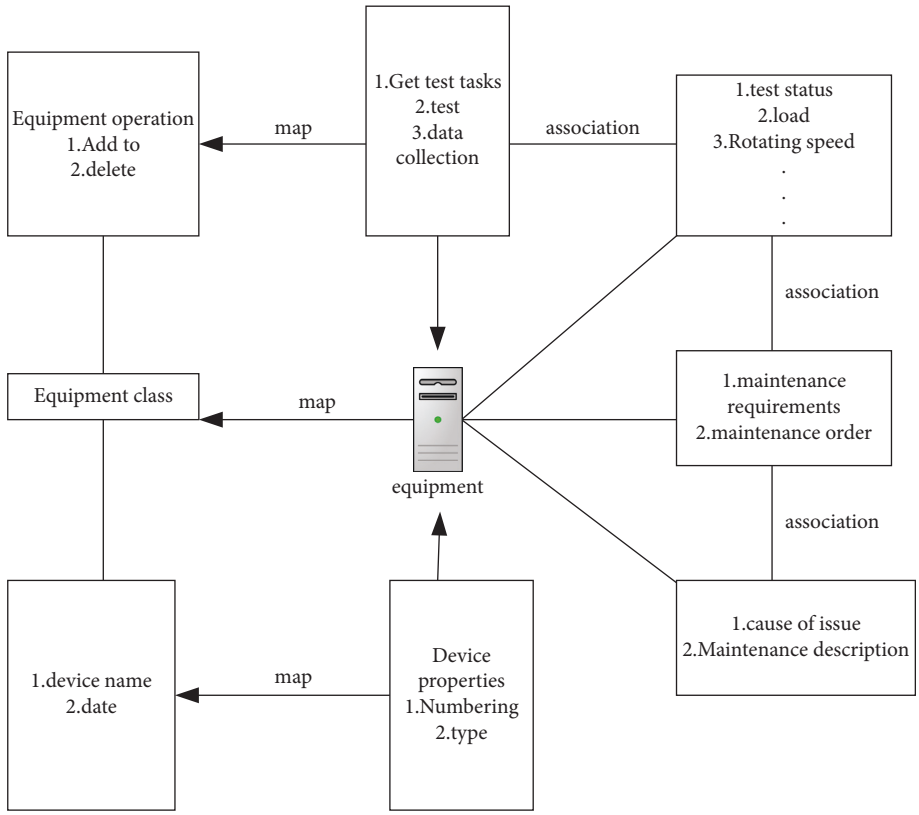

Figure 2: Device data model diagram.

Among them, the data acquisition system of the engine test bench is shown in Figure 3. The data acquisition system includes the instruments required for the test, the host computer, and the mobile terminal [18]. In the real-time test, the equipment to be tested is connected to the computer through the network, so that the computer can integrate various data. These instruments to be tested are: sensors, analyzers, fuel consumption meters, etc. [19]. Integrating these devices can avoid gaps in information collection and conflicts caused by manufacturers' mismatches in device information [20]. Sort out all the information of the equipment that has not collected data, and then analyze the collected information through the dynamic data software through the computer after the test, and extract the required file information from the analysis. After the information is processed, it is transmitted to the background through the database terminal for file organization and processing, and finally a web database is formed. In this way, users can also access the database through mobile phones or smart devices and can access or extract information only by request. Of course, IP is also required, and the access to the address, through the operation of the mobile phone, transmits the

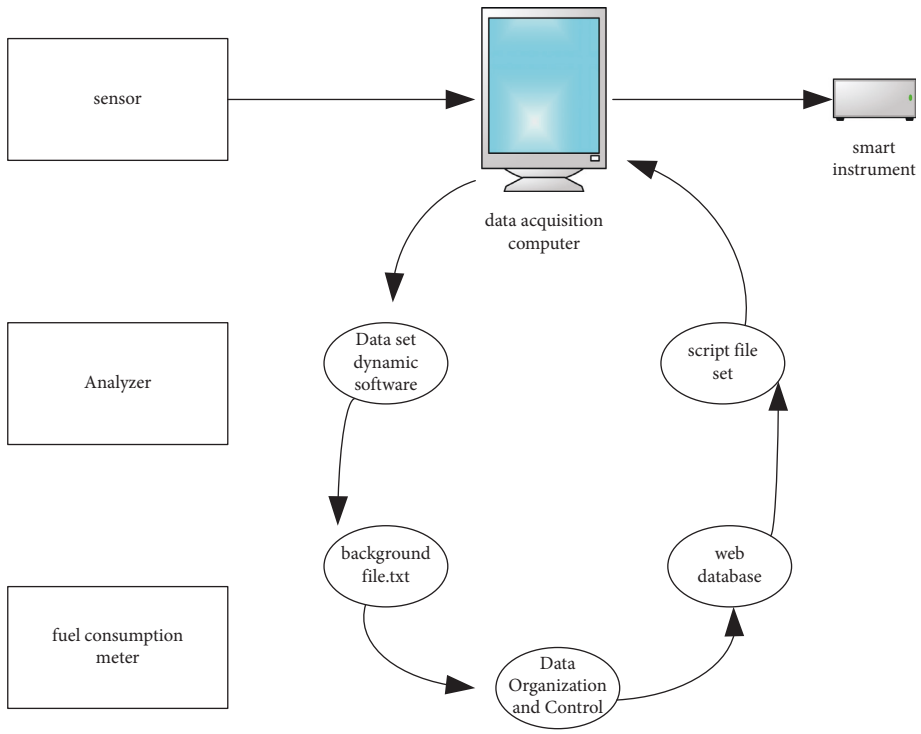

Figure 3: The data acquisition system of the engine test bench.

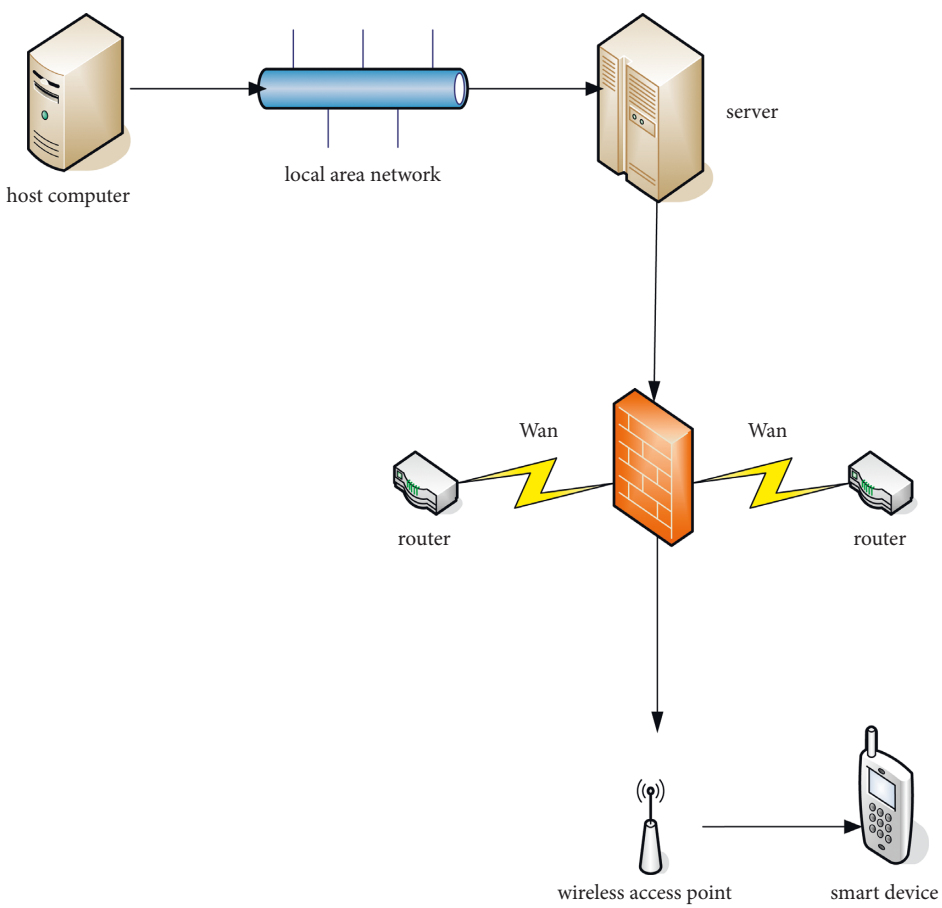

Figure 4: Transport network architecture.

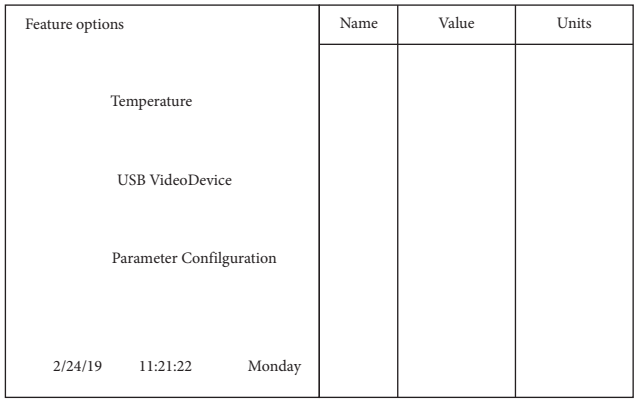

Figure 5: Mobile phone demo.

acquired information to the smart device, performs remote control and supervision, and makes timely suggestions for the information [21]. Figure 4 shows the framework of network transmission. Setting a firewall in the local area network can prevent infection by external viruses or network viruses. Figure 5 shows a demonstration diagram of the mobile terminal, which can be used for function selection or data selection.

3.4. Research and Development of Key Components of the Test System. The necessary condition for daily engine operation is fuel. As the test data of the engine, fuel consumption is also an important factor to consider in product development and design [22]. His role is mainly to measure the fuel consumption, the fuel consumption ratio of the vehicle running per unit time. The fuel consumption meter is also important reference data. The main disadvantage of the traditional fuel computer is that it cannot correctly calculate the fuel consumption, the response speed is relatively slow, there is no telephone function, and the level of intelligence is relatively low. This paper analyzes the theoretical basis of the network, tests the functional requirements based on the motor workbench, mainly studies the database storage technology and fuzzy theory algorithm based on artificial neural network, and develops the serial network technology. The two are combined at the same time to build a relatively good fuzzy neural network model. The artificial neural network has the characteristics of storage and learning. The test results are compared and analyzed through the model to meet the efficient and accurate measurement and transportation of fuel consumption [23]. The developed fuel consumption meter includes flow meter, variable frequency impeller pump, electromagnetic proportional valve, exchanger, automatic exhaust valve, temperature and pressure sensor, etc. Only with the help of artificial neural networks can we better utilize the expertise of experts to express the knowledge of the rules, but the number of hidden nodes affects the network noise. Since fuzzy conclusions cannot learn artificial neural units, fuzzy neural networks evaluate the accuracy of test data according to their merits. Figure 6 shows the neural network modeling process.

First initialize the neural network, formulate corresponding parameters according to the training environment, and then normalize it according to the weight function to obtain the normalized training data, which can be

$$\mathrm{y} = \left(\mathrm{y}_{\max} - \mathrm{y}_{\min}\right) \times \frac{\left(\mathrm{x} - \mathrm{x}_{\mathrm{map}}\right)}{\left(\mathrm{x}_{\max} - \mathrm{x}_{\min}\right)} + \mathrm{y}_{\min}. \tag{1}$$

Afterward, the obtained training data are evaluated for its accuracy. The evaluation is divided into five grades, 1–5 grades, respectively. The input parameters are determined by the learning algorithm. The parameters to be learned are the connection weight p_{ij}^{l}, which are

$$p_{ij}^{l}\,(j = 1, 2, 3 \ldots l = 1, 2, 3..i = 1, 2, 3, \ldots). \tag{2}$$

Calculate the error cost function E with the weight c_{ij} and the width μ_{ij} of the correlation function, and the calculation can be obtained:

$$E = \frac{1}{2}\sum_{i=1}^{r}\left(t_i - y_i\right)^2, \tag{3}$$

t_i represents the expected output, y_i represents the actual output, and the following formula is the learning algorithm of the parameter p_{ij}^{l}:

$$\frac{\partial E/\partial p_{ij}^{l} = \partial E/\partial y_1 \partial y_1/\partial y_{1j} \partial y_{1j}/\partial p_{ij}^{l} = -\left(t_l - y_l\right)\partial_j x_i}{p_{ij}^{l}(k+l) = p_{ij}^{l}(k) - \beta \partial E/\partial p_{ij}^{l} = p_{ij}^{l}(k) + \beta\left(t_l - y_l\right)a_j x_i}. \tag{4}$$

The fuzzy neural network structure is shown in Figure 7.

4. Analysis of Engine Dynamic Test System

In this paper, in order to better detect the dynamic system, in the case of meeting the needs of the engine and the integrated vehicle, the analysis is carried out to ensure that the constants are the same. In this paper, two vehicle companies are investigated, and one uses a traditional bench. The test system: the other one is an intelligent engine dynamic test system based on the Internet of Things, which records and processes the test data. The physical quantities that the dynamic test system needs to study include the in-cylinder pressure, the pressure of the intake and exhaust systems, the fuel flow rate, the standard voltage signal, and the elevation of the injector needle valve. 16BIT adopts special technology to input necessary parameters and needs to be connected online. All software is connected to the Internet, and dynamic data changes can be realized. The test system is equipped with a charge amplifier to ensure detection accuracy. When it exceeds 98pc Fs and when the error is controlled within 3% and the detection system requires multiple data sampling, the above data are saved and can be used at any time. There needs to be a pressure detector in the system to understand the pressure in the cylinder to prevent cylinder explosion. The system needs to indicate the effective pressure, the maximum pressure, and the position, record the mean value and deviation, measure it through the system function calculation formula, and calculate the output result. In this paper, the traditional bench test system and the

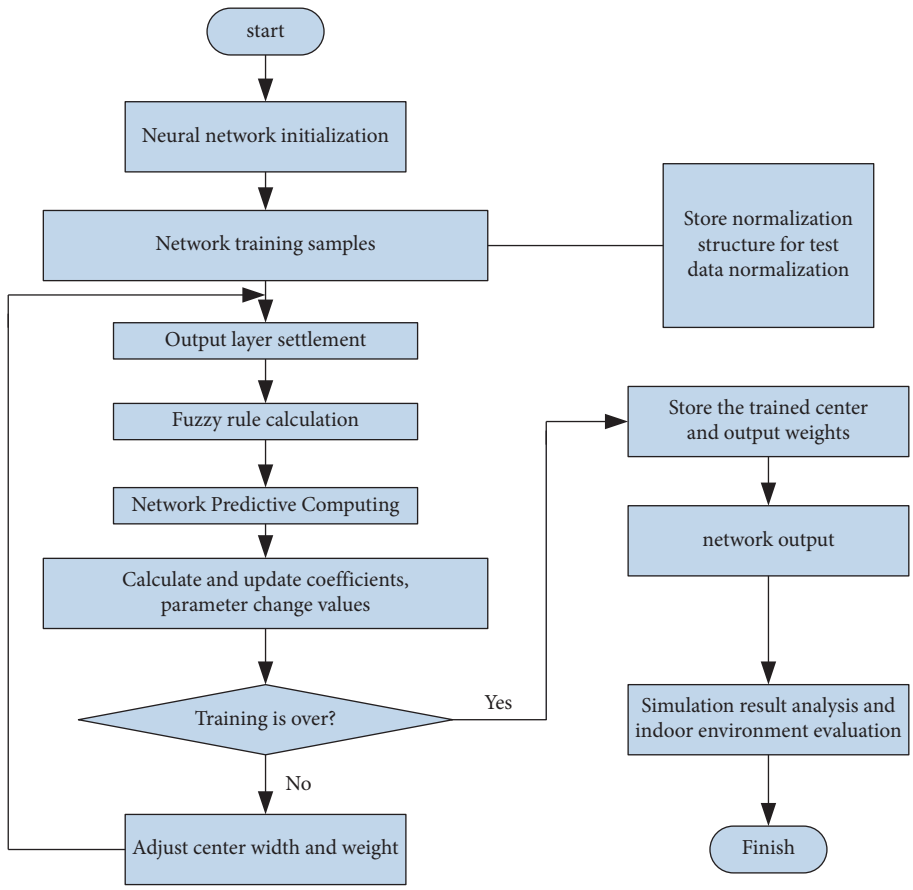

Figure 6: Neural network modeling steps.

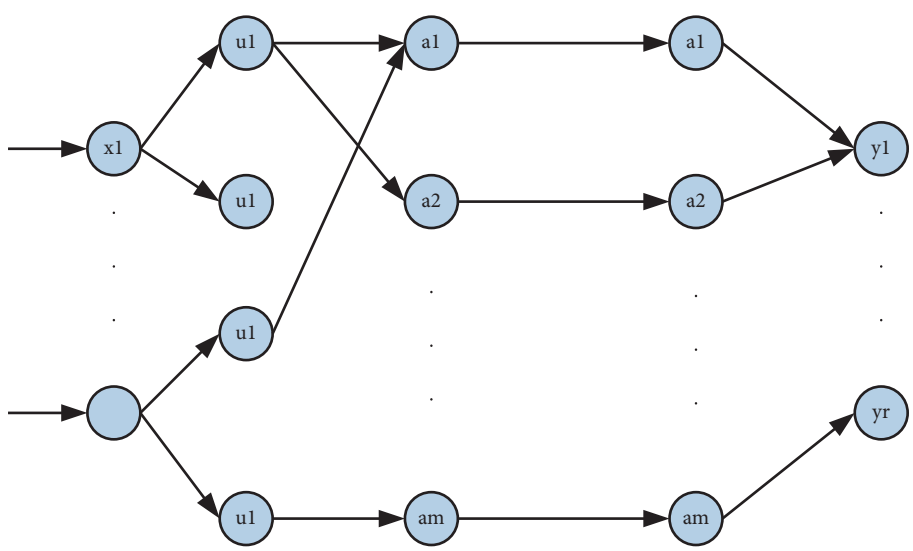

Figure 7: Fuzzy neural network structure.

dynamic test system based on the Internet of Things are compared, and the efficiency of data information transmission, information security, perception ability, and response speed between them are compared to illustrate the difference between the two differences. Figure 8 shows the comparison of data information transmission efficiency between the two companies.

Through the comparison chart, it is found that through the comparison of three sets of experimental data, the traditional test system can only reach about 75% in data information efficiency, while the data information efficiency of the intelligent dynamic test system can reach 95% or even higher. It shows that the intelligent dynamic test system is more efficient in information and data processing in engine testing.

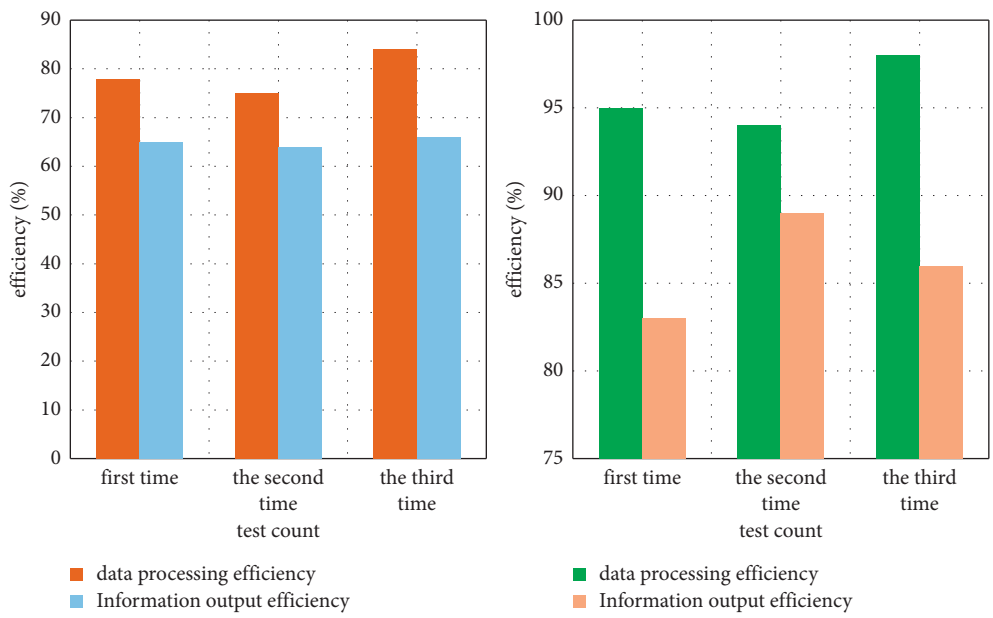

Figure 8: Comparison of data information transfer efficiency.

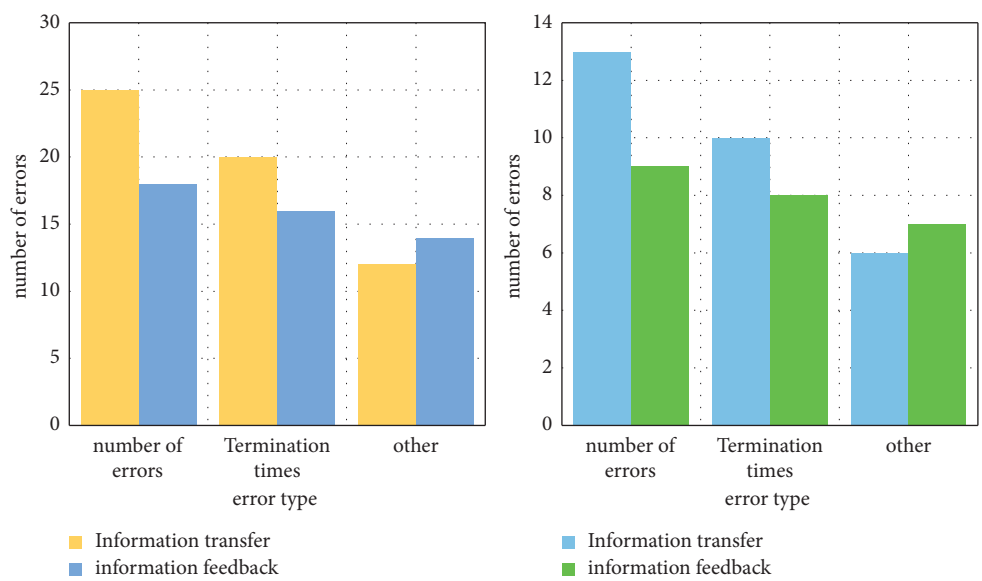

Figure 9: Comparison of system error times.

There are also differences in the information security between the two systems. The article analyzes and compares the system error data of the two companies within one month. The traditional test system is prone to system transmission errors in the process of information feedback and transmission, which leads to the inability of information to continue to be transmitted to the next step and reduces the security of information transmission. The security of the system is judged by the number of errors in the system. The more the errors, the lower the information security. Figure 9 shows the comparison between the two in information security.

From the number of errors of the two systems, it can be seen that the number of errors in the traditional test system is nearly twice that of the intelligent dynamic test system, and the security is greatly reduced, which also shows that the intelligent engine detection system based on the Internet of Things is more reliable in terms of security.

When the test system perceives the middle of the engine text, it judges the internal conditions of the engine through the perception of the system. The accuracy of the system perception also determines the pros and cons of the system. The comparison between the two systems in the text is shown in Figure 10.

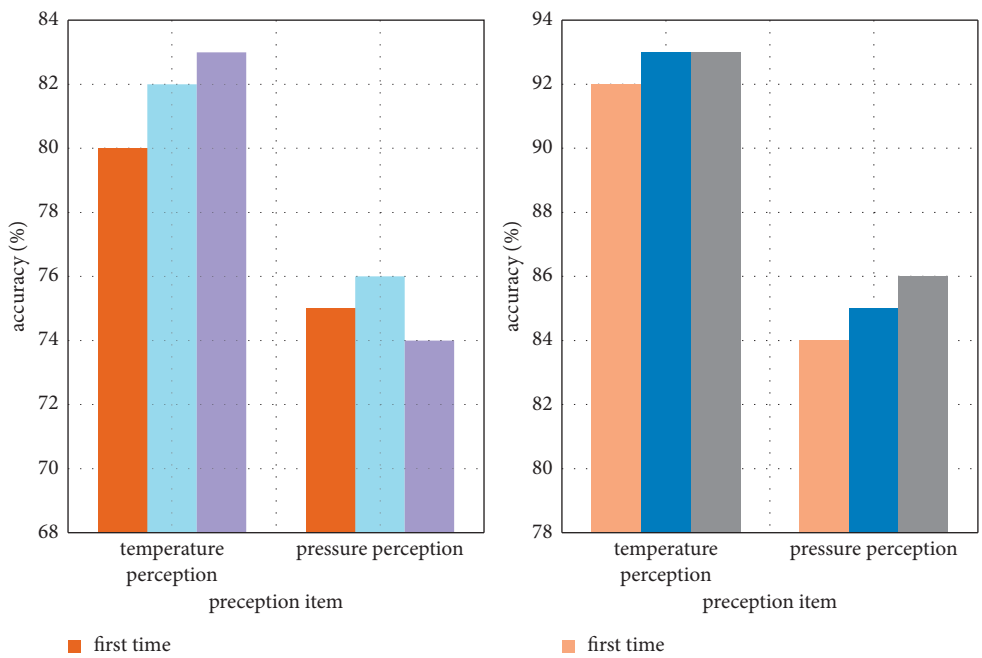

Figure 10: Perceived accuracy comparison.

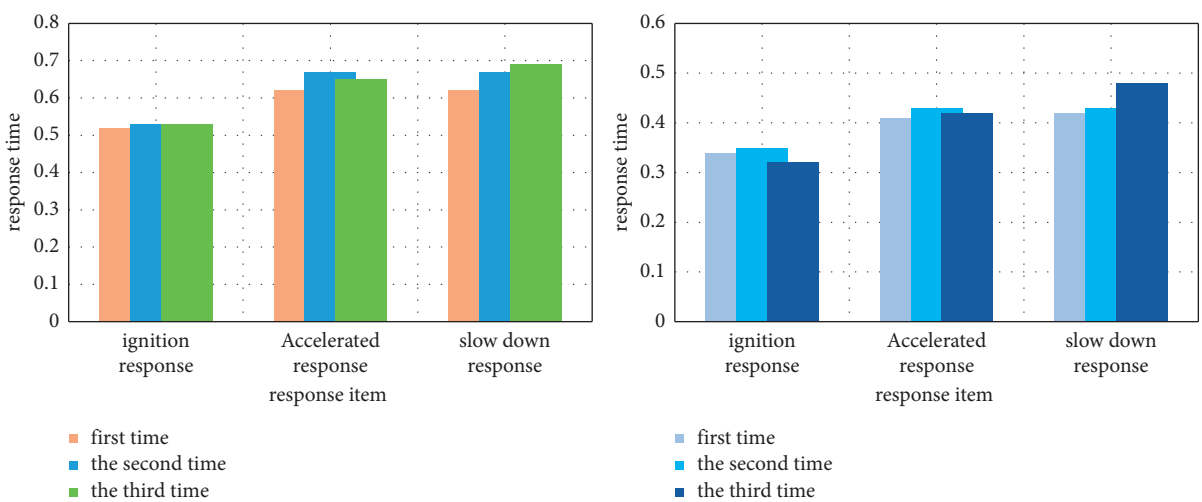

Figure 11: Response time comparison.

By comparing the sensing accuracy of the two systems, it can be found that the intelligent dynamic test system based on the Internet of Things has improved the sensing accuracy by about 12% compared with the traditional detection system. If there is a high situation, it needs to be dealt with in time. If there is an error in perception or inaccuracy, it will easily lead to danger, which also shows that perception is very important to the system. It also fully shows that the intelligent dynamic detection system based on the Internet of Things is more secure and more sensitive.

The response speed of the system also determines the pros and cons of the system. The faster the response speed, the faster the system can respond after the driver's command, such as acceleration, deceleration, and engine ignition. It will be more smooth to use and enjoy for the driver. As shown in Figure 11, the response time of the two systems is compared.

From the response time of the two systems, it can be seen that the response time of the traditional system is about 0.65 s, the response time of the intelligent dynamic test system is about 0.35, and the response time is increased by 48%, which greatly shows the superiority of the intelligent dynamic test system. It also shows that the model established by the Internet of Things is more suitable in the field of vehicle engine testing. It can also solve the problems in the test more effectively.

5. Conclusion

This paper mainly uses the Internet of Things thinking to analyze and compare the traditional engine testing system, explain the engine testing requirements, simulate the testing of the vehicle on the traditional bench, and obtain the experimental data. By judging the data, it is found that the performance of the traditional engine testing system is relatively low and not suitable for current equipment. The dynamic detection system based on the Internet of Things is introduced. Through the comparison between the two in the efficiency of information transmission, information security, system perception, and system response time, the intelligent dynamic engine detection system based on the Internet of Things is found. It is higher in terms of safety and information transmission efficiency. The perception performance is improved by 12%, and the system response time is improved by 48%. It also fully shows that the intelligent dynamic engine detection system based on the Internet of Things will be more satisfactory. The current equipment can also be tested more accurately. Through the research and development of the system, the cost of new products can be reduced. The principle of research and development is explained, and the state management in the system is explained, etc., and analyzes it by establishing a fuzzy neural network. The analysis of the internal situation of the engine is not enough in this paper, the number of variables in the two systems is not enough, and there may be errors in data processing. In the future, more companies will adopt intelligent dynamic engine test systems to save cost, enhance engine performance, and ensure driver safety.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no potential conflicts of interest in this study.

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Volume 2023, Article ID 9801432, 1 page
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Retraction

Retracted: Psychological Counseling and Adaptive Adjustment Methods for Employment Psychological Distress Based on Intelligent Internet of Things

Mobile Information Systems

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 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.

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] X. Kang, "Psychological Counseling and Adaptive Adjustment Methods for Employment Psychological Distress Based on Intelligent Internet of Things," *Mobile Information Systems*, vol. 2022, Article ID 6948351, 10 pages, 2022.

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Volume 2022, Article ID 6948351, 10 pages
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Research Article

Psychological Counseling and Adaptive Adjustment Methods for Employment Psychological Distress Based on Intelligent Internet of Things

Xiaomeng Kang

School of Clinical Medicine, Xi'an Medical University, Xi'an, Shaanxi 710021, China

Correspondence should be addressed to Xiaomeng Kang; kangxiaomeng67@mau.edu.mk

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Academic Editor: Yanyi Rao

With the rapid progress of the current era, the outside employment pressure has gradually become severe, and with more and more college students, the competition pressure is also gradually rising, which also leads to many college students in the face of psychological problems from campus to society. In this paper, based on the intelligent Internet of Things, the psychological problems that easily arise when college students are employed are explained, and from the problem, targeted employment guidance is proposed, and a comprehensive debugging method of related causes is proposed. Using the mathematical modeling method, the traditional psychological counseling and the intelligent IoT-based psychological counseling methods are compared. It was found that the counseling time was reduced by 30%, the consideration of problems was more comprehensive, the number of students' consultation problems was increased by 32%, and the number of debugging was increased by 23.

1. Introduction

With the opening of major universities to enrollment, the number of college students is increasing. According to the statistics of recent years, there are more than 6 million graduates from colleges and universities nationwide, and there are also graduates who have not been employed before, and all of them add up to more than ten million people who need to be employed. The current employment situation is severe because the employment industry will not change because of the change of graduates' education. Although the education of graduates increases year by year, the social positions still follow the social requirements and only choose graduates who meet the demand or need some technical students. There is also the fact that what is really learned in the current general institutions is only theoretical knowledge, without much practical operation, which cannot meet the current needs of society. This also leads to the difficulty of employment and the confusion of being unemployed upon graduation.

A large number of graduates have developed psychological problems, and there is an urgent need for psychological counseling to prevent graduates from developing bad emotions and psychology, such as jealousy, anxiety, low self-esteem, self-doubt, and falling into a deep quagmire from which they cannot extricate themselves. If left unimproved, it can have a significant impact on later life, relationships, and social relations, and in serious cases, it may cause social panic. Psychological counseling can help graduates to improve this pessimistic psychological mood, so that students can make the right choice of direction according to their own situation, and adjust graduates to the right state of mind, positive and sunny, not humble. Psychological counseling has great significance for graduates.

In this paper, based on the intelligent IoT, the psychological problems that tend to arise when college students are employed are explained. And from the problems, targeted employment guidance is proposed and a comprehensive way of debugging the related causes. It is also shown that the IoT-based counseling and debugging method is

more suitable for contemporary college students and can be more effective. This paper mainly deals with the current employment problems of college students through the Internet of Things and helps college students better adjust their employment mentality through the Internet of Things. Traditional employment counseling requires specialized psychological counseling. In the case of the Internet of Things, college students can also better and more effectively conduct psychological counseling and make corresponding debugging methods.

2. Related Work

With the rapid economic growth, people's standard of living is also gradually increasing, but the pressure they take on themselves is also increasing, with car loans and mortgage. In case of unemployment, people are anxious and irritable in their mind and people become psychologically disturbed in employment, and unemployment, poverty, and inequality are related phenomena. To address such issues, Harish N explores poverty and unemployment under Indian economy and proposes to alleviate poverty, create employment and income generating opportunities, and provide infrastructure and basic services to meet the aspirations of rural poor unemployed people in accordance with government policies and programs. To achieve these goals, self-employment and wage employment schemes continue to be practiced in a different way [1]. As consumer demand declined, firms with higher business float experienced significantly larger declines in firm employment. These results are not due to lower firm productivity, but rather to excessive expansion prior to the Great Recession. Typically more sensitive to fluctuations in aggregate employment or house prices, Giroud X's research suggests that firms' balance sheets played an important role in the propagation of consumer demand shocks during the Great Recession. In addition to traditional stimulus measures, employment policies that directly target firms may play a role [2]. Distress from employment can also have an impact on people's health, and although socioeconomic status (SES) has a recognized impact on health, SES resources such as employment may have different effects on health outcomes across populations. In this regard Assari S conducted a study where his focal predictor of interest was baseline employment, operationalized as a dichotomous variable, and the study found that because employment distress does create health problems for people, it also includes mental health [3]. Workforce restructuring is a key driver of acquisitions and associated synergistic gains on a global scale. In a difference-in-difference research design, Dessaint O showed that a significant increase in employment protection reduces acquisition activity by 14–27% and reduces the combined firm gains (synergies) by more than half. Increasing employment protection discourages layoffs, resulting in wage costs that match the magnitude of synergy losses. Offers are not fully adjusted, and the reform results in lower returns for both bidders and targets [4]. Employment problems bring distress that people have no way to regulate through self-regulation and need professional counseling to help them carry it out to improve their current situation.

There are many people who are currently troubled by employment problems and need professional counseling to guide them, and counseling is the medicine that needs to be healed for people. The need for care is even greater in patients who are physically and mentally unhealthy, and those with infertility often carry a high pressure psychological state. In some cases, this represents a risk of developing depression or anxiety. Questionnaires are a useful tool to assess such risk, and Volmer et al. conducted the SCREENIVF questionnaire on this, which realistically demonstrated that some coping strategies are associated with stress levels in infertile couples, identifying which strategies are associated with higher levels of depression or anxiety risk. It helps to provide targeted counseling to reduce the risk of depression or anxiety [5]. Ganieva analyzed the multicultural approach in counseling using the specific case of an adult daughter-father relationship as an example. The approach takes into account the ethnic and religious characteristics of the visitor and shows the positive dynamics of psychological work based on the values of the Ingush culture and Islam. It was concluded that the multicultural competence of psychologists can provide counselors with a high level of trust of the client, as well as based on the use of ethnoreligious resources [6]. Schools are in a unique position to influence the mental and behavioral health of children and adolescents. However, little is known about school district counseling, psychological, and social services staffing policies. Brener and Demissie analyzed the status of such policies in public school districts in the United States. Using online or mailed questionnaires, data related to counseling, psychological, and social services were collected from a nationally representative sample of school districts, and those who were knowledgeable about each questionnaire were sampled. Results showed a significant increase in the percentage of districts with district-level counseling, psychological, and social service coordinators [7]. Psychological problems caused by employment distress urgently need to be addressed and seriously affect all aspects of people's lives, studies, life, culture, etc.

3. IoT Employment Troubles and Problems

3.1. IoT Employment Status. Since the IoT major started to be established in universities in the decade, the IoT industry has started to grow wildly like grass in the summer [8]. And then, many universities started to establish the program in their academic halls to provide a new direction for students to study. As an emerging industry, it is composed mainly through information technology, combined with environmental protection and new industries, and is designated as a strategic emerging industry; the state has also set up special rules for this profession to facilitate students to study and read and some welfare policies to promote the rise of this industry. The IoT industry will also break through barriers, overcome difficulties, and open new paths forward. Society is moving forward, and the first industrial reform makes China enter a new era and see a new direction. Later on, after the baptism of time, it entered the electrical age and the information age one after another [9]. The industrial revolution brought great convenience to people and

their happiness index rose significantly. After people have entered the information age, from the old days of "carriages and horses are slow, letters are far away" to the present day when meeting each other is just a video, a phone call, or a text message, completely free from the traditional constraints, no longer for the geographical and time impact, the connection between people has become close, and transportation has become more convenient [10]. IoT majors have also become a new trend of choice for college students, and the employment prospect it brings is undoubtedly broad. However, the current social demand for IoT majors is also determined by the current number of IoT majors, and the number of talents and market demand are closely related. After China entered the information age, the use on intelligent instruments has become more extensive, and the role in the Internet of Things is no less important. From smart buses that are convenient for travel to smart homes and for daily life, all kinds of smart electronic devices are big enough to go deep into the field of science, and small enough to enter the homes of ordinary people, and more and more fields are involved. These fields also need IoT professionals and provide a friendly job environment for the students of this major, and the market will not have the problem of less demand because the industry is just emerging [11]. Currently, it seems that the employment prospects of the industry are very broad, but there are also considerable challenges for the students of IoT. This is because as a new industry, the roots of the profession remain in computing. The Internet of Things is a network that combines the Internet on the client side to spread and extend to any object between lines into information exchange and communication. In contrast to the computer profession, the computer requirements for professional skills will be higher and need systematic learning; there is a strong professionalism. It also leads to more corporate companies to favor computers when it comes to the demand for talents, which also shows that the IoT industry has certain problems in the present time [12]. There is a wide range of IoT applications today, such as cloud computing, intelligent sensing, etc. The mastery of this knowledge is not easy anymore, and it requires higher and deeper skills to be helpful to the companies. Not just in books, but also technically, teachers should not limit themselves to book knowledge, but should let university students understand the difference between practical and book knowledge, so that they can have an understanding of social needs in advance. It can also promote students to master better in school as a way to cope with different needs in the business [13].

3.2. Manifestations of Psychological Distress in the Employment of University Students. There are these five main aspects of psychological distress that exist in college students' employment [14]. As shown in Figure 1, the main manifestations of this are anxiety, frustration, jealousy, low self-esteem, and conceit; most college students show fear of society and anxiety about finding a job for a period of time near graduation in school. In fact, the main worry is about the future, thus causing anxiety and considering whether they can find a job. However, this is a very normal situation, and appropriate anxiety will also have a certain catalytic effect on itself. If the impending graduation does not yet show a little worry, it can only mean that it may have already chosen the path after graduation or does not care about their future. If it is the second, this will be the sadness of society.

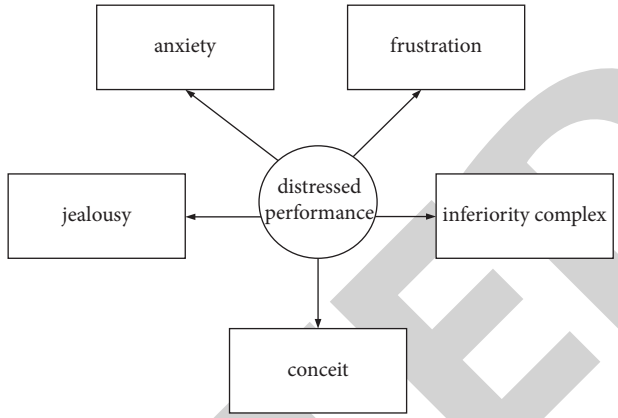

Figure 1: Main manifestations of psychological distress.

Frustration psychology is the attitude that students show when they handle things or engage in activities that are not properly handled or not completed. In fact, there are more or less setbacks in life, and it is also an essential experience in our life; this mentality can easily lead to a loss of confidence in oneself after a setback and then to indulgence in oneself and going with the flow, to the detriment of one's future development, and only after absorbing enough experience can we make the future road smoother and take fewer detours. On the other hand, college students are relatively fragile because they are carefree on campus and have not experienced the storms. If they have a distorted psychology after experiencing social beatings, then their worldview is likely to change and have a great impact on their own character, in terms of either arrogance or depression [15].

Jealousy is a hostile psychology that arises when you see the condition or situation of others combined with yourself. Among college students, because of this situation it is easy to lead to the gradual alienation of friends around them, reduce the scope of intercourse, and place themselves in a more isolated position, struggling internally, causing jealousy or unclear cognition of themselves [16]. College students should perceive their own shortcomings independently and learn more about society and get in touch with it. It is also beneficial to become strong inside.

Inferiority complex is an internal self-perception of being inferior to others. It has to do with experience, family, and one's own personality. When college students are employed, they are always worried about saying the wrong thing and behaving in a more formal manner, which leads to a lack of words and affects the interviewer's impression of you when you are employed. In fact, in employment, it is more important to show your confident side, so that the interviewer can see your shining point, rather than coyness, affecting their own play. In the time of school recruitment, the interviewer also knows the state of most students in the university, doing a good job on their own.

Conceit and inferiority complex are very different. Conceit is like being the moon and everyone else is the star

holding you. Conceit is the state of the stars holding the moon, too high evaluation of their own; people who are conceited and do not bother to communicate too much with others around them, or always show their superior side, tend to have few real friends; the requirements for employment is also relatively strict, thus causing conceit. This mentality generally exists among students who are good at their studies, or who excel in a certain area, and who have been chosen in employment, leading to being left behind in the end [17].

For these students with problems, they need psychological counseling, which has these main aspects; it develops a sense of independence, gives students a basic understanding of society, and establishes a good attitude towards employment, as shown in Figure 2. The first point is to develop their own awareness of employment. This step is like letting them run; they must first learn to walk; when they first come into contact with society, they need to let themselves have a basic understanding of employment. Because they face little practice in society, it is easy to do not know how to do when they are employed; they can first understand from their own profession, understand what aspects of the Internet of Things can be engaged in, and understand the difference between in school and in society. It is necessary to let students understand the basic information and rules of the Internet of Things industry, which will also help students find jobs. Teachers can also tell students something about society, work, and graduation in the classroom, which can also be useful for students to have basic understanding of society when they are employed [18]. The second point is for college students to have an understanding of knowing themselves. You need to know what you like, what your interests are, what you have to offer, and so on, which will also help you in your own employment. Because they have just come out of the society, they do not know what kind of work they should do, and they mostly choose to go according to the arrangement of their family, or the recommendation of their friends, and not what they expect. Or they do not have any special idea themselves; they just want to find a job. Then they try while looking, because different jobs corresponding to the environment, atmosphere, future, pressure are very different. From their own personality characteristics, to understand their own personality, different personalities are suitable for different duties. Secondly, you need to list your interests, characteristics, preferences, etc., which is also an essential part of consideration in employment, because in these areas you can get better expansion and have a broader space for development, but are also conducive to the realization of personal ideals and ambitions [19]. The third point needs to establish a good concept of employment. You can start in the workplace, learn more about society and the relationship between work and society, and build your view of employment in practice. Because of the limitations of the industry of their own learning, all enterprises in the society start to understand newcomers from a basic resume and examine their education and experience. But it is still difficult for some students from ordinary colleges and universities to find a position that is ideal for them. College students can get a job first, and then consider their expectations for the position, accumulate a certain amount of employment experience first, and then have the ability to choose the industry and job they like when their abilities in all aspects are improved. The post is not only a platform for you to exercise, but also a motivation for you to go over the mountain later [20].

3.3. Adjustment of Psychological Distress in Employment. Self-adaptation is also a necessary skill after contact with society. Self-encouragement can be used to help self-adjustment and to find the best way to achieve one's ambition in case of difficulties. With not only the problems in employment, but also more problems after entering the society, they also need to face the debugging by themselves [21]. In the paper, the way of psychological debugging is presented in six main points. They are to enable students to maintain self-confidence, face up the actual society, develop a sense of independence, view setbacks correctly, focus on learning professional skills, and build psychological intervention and prevention mechanisms, as Figure 3.

(1) Stay confident. In the society, you will meet all kinds of people and difficulties of different levels.

College students should know themselves well enough to combine their current difficulties with their own experiences, to mentally cheer themselves up, not to be defeated by the difficulties they currently encounter, and not to be afraid to rise to the occasion. Self-confidence is your sharpest weapon to break through in difficult situations and also help yourself grow. Lower your own expectations on the way to employment and be content with what you have [22].

(2) Facing up to the actual society.

This skill comes from the perception of society and the basic understanding of society by college students. It requires a clear perception of one's own contribution to society, a perception of one's own abilities, and an understanding of one's surroundings. And it requires calm acceptance, maintaining a healthy mindset, starting from oneself, doing well the next time one does not do well, and adapting positively.

(3) Cultivate a sense of independence. College students have just stepped out of the society, and their contact with the school has gradually decreased, which also means that you are already an adult, need to support yourself independently, and need to establish good self-control ability. You can read thoughtful publications, spiritual readings, and philosophical books on your own, all of which help to develop your awareness. After leaving society, you need to be responsible for your own life and work, and you need to have your own ideas in mind, not to follow the crowd, which will also help you in your subsequent career choice.

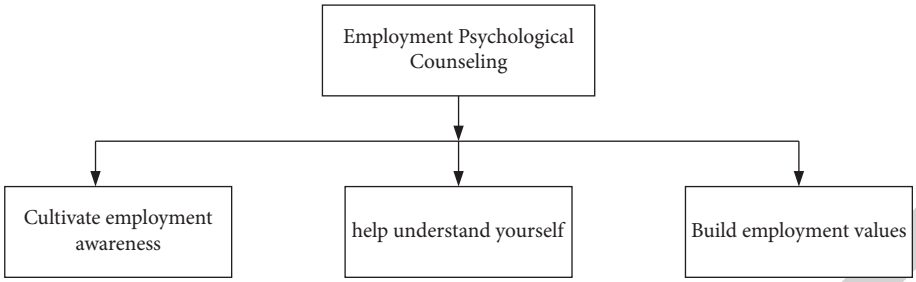

Figure 2: The main issues of psychological counseling.

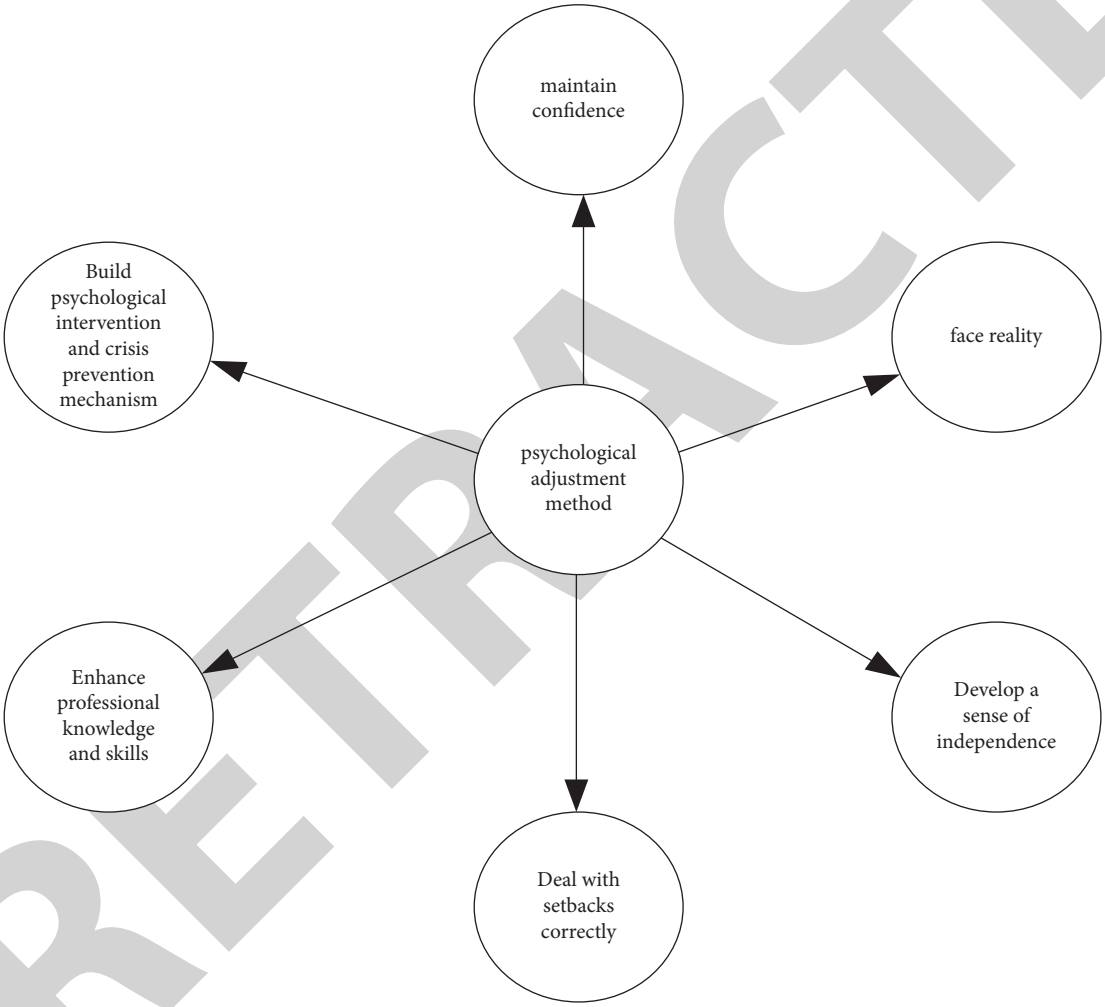

Figure 3: Psychological tuning mode.

(4) Properly view setbacks. In work and study, setbacks are essential but need to therefore recognize their own shortcomings, make adjustments, rise to the occasion, and be indomitable, which is the road to success, because there is no shortcut on the road to success.

(5) Focus your studies on professional knowledge skills. If college life does not focus on learning the basic knowledge, it is also difficult to find a job in the society. Some college students think that being in college is to enjoy the college time and have absenteeism, failing the course and other behaviors. In the psychological performance of loose, such students sit idle all day, frequently miss classes, waste educational opportunities, and in the end may face being expelled from the school. If you continue to follow your studies closely after entering university and study hard to solidify your basic knowledge, you will also have more options when it comes to employment, and you can also enrich your experience for the subsequent realization of your ambitions, because in the current society, competitive pressure

is always present [23]. As college students graduate one after another, the competitive pressure will only increase.

(6) Build psychological intervention and prevention mechanisms. Schools can establish links with counseling platforms for students in need of counseling. A professional counseling platform can be designed to address all aspects of students' psychological problems. Questionnaires can also be used to understand student information and provide targeted, private psychological answers to students. Help students develop a good psychology, avoid negative emotions, and face employment situations and social difficulties positively. In fact, many students will have the psychology of escape when they go out of society; also because they are not strong enough inside and think of escape when they encounter difficulties, they will easily form this psychology.

In short, it is necessary for college students to set up a good employment concept on the road of employment, to be confident in life and career, to be aggressive, to be tenacious, to not be afraid of difficulties, to go forward, and to keep smiling. Keep a strong and stable self-regulation ability to face social, life, and emotional problems in the best condition. It allows college students to understand the society as soon as possible and eliminate their inner doubts, so that their identity in school and society can be correctly transformed and smoothly employed [24].

3.4. Computing Based on IoT Counseling. In order to determine if employed students need counseling, students are required to take a quiz in which they describe the difficulties they are experiencing. After obtaining some information from this, after communicating with the student based on this information, it is determined whether counseling is needed or not [25], reducing unnecessary hassle for the counselor. The formula for this can be established as

$$f(v_k) + f(v_i) = f(v_j), \tag{1}$$

of which v_k is the number of people to be coached, and v_i is the number of people who have been tutored, and v_j is the total number of people tested. The prediction of the number of tutors available is carried out by the information between the three quantities. By mathematical modeling, using the VIBE algorithm, the mathematical model is initialized by a single-frame sequence, and the distribution characteristics of the number $p(x)$ are analyzed for any correlation point x. The n correlation points of the near domain points are randomly used as sample values $s(x)$. Then there are

$$s(x) = \{p_1, p_2, \ldots p_n\}. \tag{2}$$

The n in the algorithm takes the value of 25 and determines the screening process of counselors through a two-dimensional Euclidean approach. With $p(x)$ as the numerical center, the number of first places is predicted by the central value. The correlation points through the representation on the image, in one-to-one correspondence on the distribution curve. The relatively low part of the color is $g(x)$, indicating students who do not need psychological counseling, differentiated by the image shown by the irregular curve, and the distance of each data test is X. There are

$$|g(x + X, y) - g(X + x, y)| > T, \tag{3}$$

T is the defined number. When the area with a low color section is more variable, the first correlation point obtained has a row number of i_1, also located in the upper segment of the monitored area, and the last obtained correlation point is located in the lower segment of the monitored area. By each graph change, an upper segment shift vector is obtained I_1. The same way, we can get the lower segment shift vector as I_2. The area determined for the upper and lower segments of the region is divided; then the probability of the distribution that needs to be coached in the total number of people can be obtained:

$$p(i) = \frac{m_i}{\sum_{l=1}^{L} m_l}, \tag{4}$$

where m_i is the number of relevant points in the region part, $l \in L$, and L can be up to 200. By defining the number to divide the resulting image into two parts and assuming the variance between them as U and Q, there are

$$\begin{aligned} U &= \sum_{L=1}^{T} \frac{(1-\mu_1)^2 P(L)}{\omega_1}, \\ Q &= \sum_{L=T+1}^{L} \frac{(1-\mu_2)^2 P(L)}{\omega_2}. \end{aligned} \tag{5}$$

Calculate the value of the region after partitioning μ_1, μ_2, and the overall grayscale mean of the image μ. They are calculated as

$$\begin{aligned} \mu_1 &= \sum_{L=1}^{T} \frac{LP(L)}{\omega_1}, \\ \mu_2 &= \sum_{L=T+1}^{L} \frac{lp(l)}{\omega_2}, \\ \mu &= \mu_1\omega_1 + \mu_2\omega_2, \end{aligned} \tag{6}$$

where ω_1, ω_2 are the probability of occurrence of the two parts of the region. In calculating the variance between the two classes assuming Z, K, then they are calculated as

$$\begin{aligned} Z &= \omega_1(\mu - \mu_1)^2 + \omega_2(\mu - \mu_2)^2, \\ K &= \omega_1 U + \omega_2 Q. \end{aligned} \tag{7}$$

When both moving regions experience all the defined values of each other ρ,

$$\vartheta = \max \frac{Z}{K}. \tag{8}$$

Then ρ is the defined value, and the best defined value allows the number of counselors to be counted in one step with the best results.

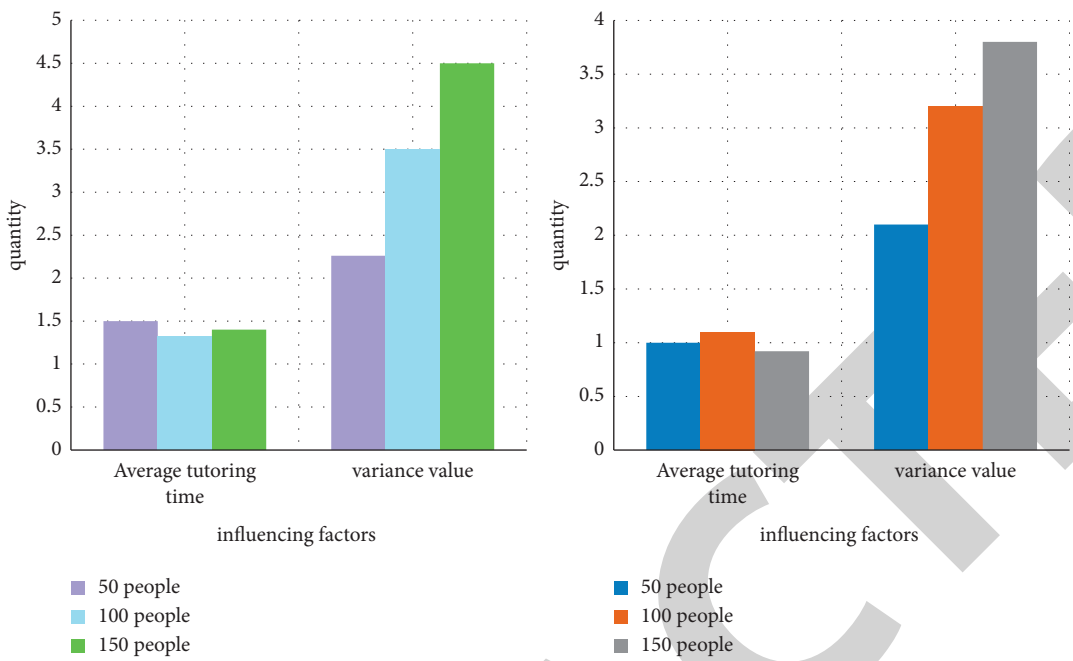

Figure 4: Comparison of coaching time.

3.5. Reflections on the Employment of College Students. Contemporary college students are not deeply involved in the world, and the chance of contact with the outside world is very small, and the university can be said to be a greenhouse, not a big problem. Academics are not as heavy as they are in high school, and it is all about the ability to learn on your own. Teachers are also missing in education after classes, because being in college means being an adult and needing to have your own thoughts and opinions. Because of the lack of understanding of society, it leads to making it easy to have many psychological problems. It is like going to a continent you have never touched before, you are both longing for it and afraid of it, and the complex emotions inside you lead to a delayed decision in employment. In fact, it also shows that college students are not confident in their own strength, psychological problems are also in need of guidance, coupled with the current social pressure, the students' own experience is too little, and the psychological fragility is easy to be destroyed by the storms of society. So psychological counseling is very important for the young people just entering the society, it will affect the future outlook on life, and psychological counseling is also an essential course before leaving school.

4. Contrasts of Opinion

In the paper, a survey was conducted on students who were about to be employed in a university. These were divided into two groups, each with the same number of students, to compare how they felt about counseling brought about by smart IoT and traditional counseling. The comparison is made in terms of counseling time, the number of students' troubling problems, the willingness of the counseled students, and the number of debugging method strips. By using the above calculation method, the corresponding data were obtained. The comparison between the two in terms of counseling time is shown in Figure 4.

The paper compares the counseling done by the soon-to-be employed students in terms of time. By looking at the two sets of graphs it can be seen that the traditional counseling took more time and had a larger variance (with a large variance, the resulting time error is also large). When counseling students through smart IoT, there is a 30% reduction in counseling time, and the variance values are relatively small in terms of time statistics, and the resulting statistics will be more accurate. This indicates that the time spent on counseling students can be greatly reduced through IoT and that the students cause less unnecessary emotions. Because the tutoring time is too long, it is also difficult to carry on all. Smart IoT improves these problems to a great extent.

Before counseling a student, the student in need of counseling is usually briefly informed and consulted about which aspects of the student's psychology are present. The counseled student also raises current problems of his or her own, and the current psychological problems of the student are considered from the questions raised by both, as shown in Figure 5.

By looking at the number of employment counseling questions students have, it is possible to get a brief idea of the amount of questions that exist within students about employment and also to speculate on the importance of counseling to students' employment problems. The graph shows that students consult more questions on IoT-based counseling, with an increase of about 32% relative to traditional counseling, which also indicates that students are more outspoken in IoT-based counseling. Compared with the traditional psychological face-to-face counseling, it

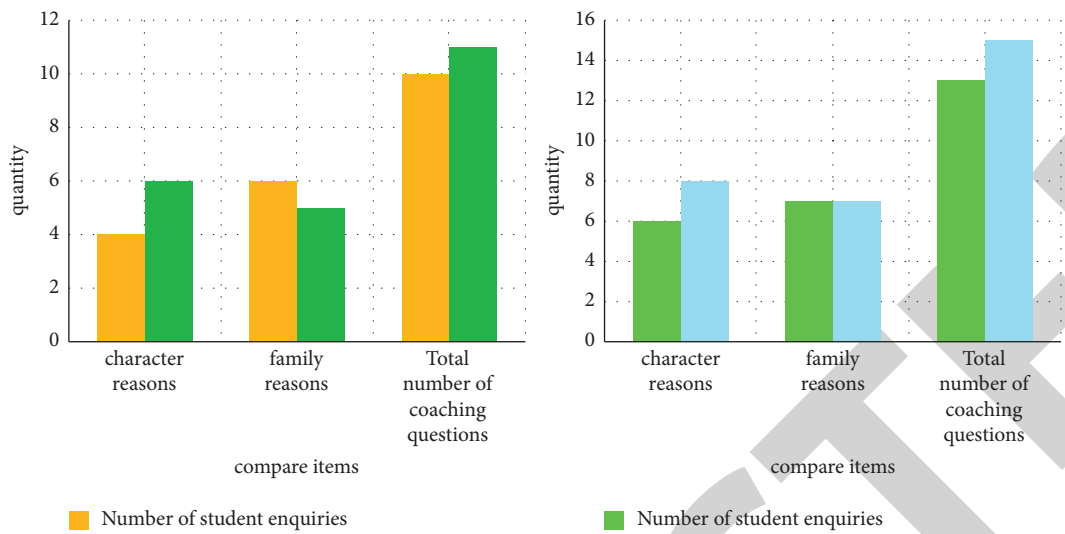

Figure 5: Comparison of the number of students' troubling problems.

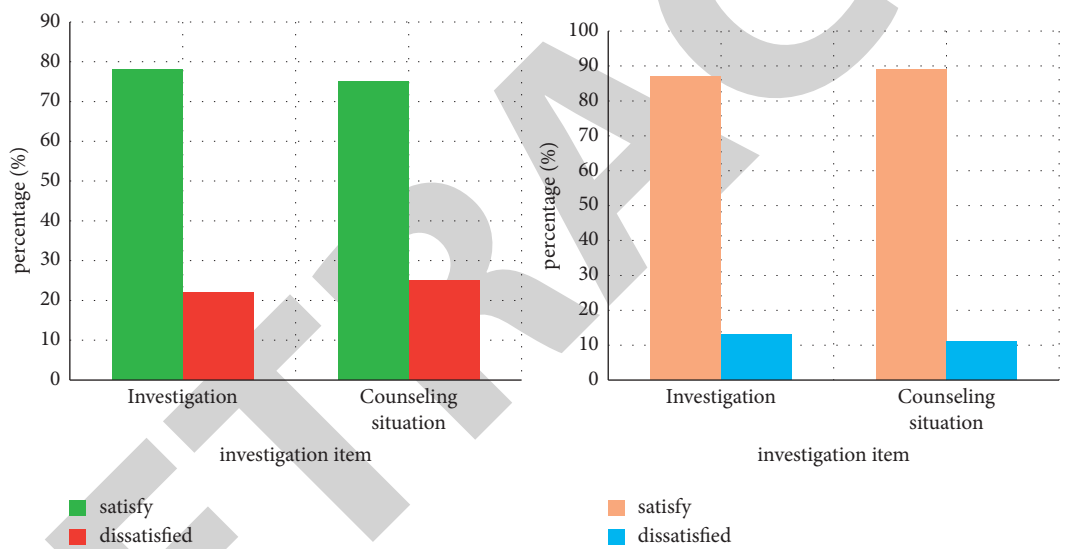

Figure 6: Comparison of student willingness survey.

reduces the psychological burden of students and will be more conducive to more students for psychological counseling in employment.

The degree of student willingness is the degree to which employed students accept the survey or not. This is because there are some students who do not accept the survey. According to these two methods of counseling, students describe the satisfaction of counseling according to their own ideas. In the paper, the comparison is mainly done from these two aspects, as shown in Figure 6.

The two sets of data in the graph show that students have a higher willingness to engage in smart IoT-based employment psychological counseling relative to traditional employment psychological counseling. It also shows the connectivity between the Internet and contemporary students, with about 10% increase in willingness relative to traditional employment counseling and 12% increase in satisfaction with their classmates after counseling. The willingness and acceptance of students to handle things through the smart IoT approach is also higher.

After the employment counseling for the students, the counseling teachers also give some adjustment methods to help the students alleviate their current psychological problems. A comparison of the number of suggestions given by the psychological counseling teacher and the number of entries of the smart IoT-based psychological counseling adjustment methods is shown in Figure 7.

By comparing the two groups of debugging methods, it can be found that, in traditional employment counseling, debugging suggests that students focus on academics and building psychological prevention mechanisms, which are less. Relative to the number of smart IoT employment counseling debugging is only half of it, and the number of debugging based on smart IoT employment counseling has

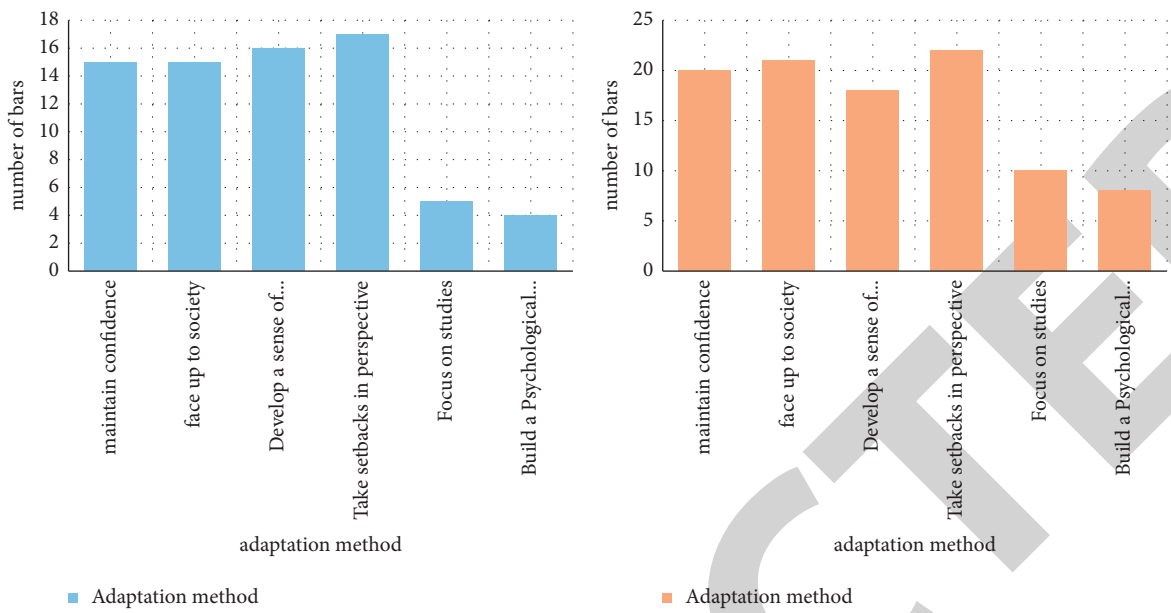

Figure 7: Comparison of the number of adaptation methods.

increased about 23% on the number of traditional counseling debugging. It indicates that intelligent IoT employment counseling is also more popular and accepted.

5. Conclusion

The paper focuses on psychological counseling and debugging of psychological problems based on intelligent IoT for college students' psychological problems that exist at the time of employment. In contrast with the traditional psychological counseling and adaptation debugging methods, the introduction of the development of intelligent IoT is elaborated, and the possible problems of college students at the time of employment, and the manifestations of the problems when they exist, as well as the debugging methods for these problems are explained in the current era. Encourage college students to develop independence and positive and confident personality traits on their own. By conducting a survey of soon-to-be employed students, the items of comparison are analyzed using the knowledge of mathematical models and variance. It also presents its own thinking about the employment of contemporary college students. Through the comparison, it is concluded that the employment psychological counseling and debugging method based on intelligent Internet of Things is more suitable for the current college students and the current network era. The shortage done in the paper is that there is no detailed introduction of the algorithm, the space is limited, and the explanation of the variance is not perfect, and what each size of the variance represents. It is also hoped that the contemporary college students can develop all-round, morally, intellectually, physically, mentally, and aesthetically, and have certain social practice ability, so that they can avoid a series of psychological problems after they really enter the society. When there is a psychological problem, you should also seek debugging in time to avoid the formation of a negative mentality, which will affect your life. The author believes that the later college student will also be more independent, be more confident, take their studies as the priority, be a real college student, and become a person who can really contribute to the society.

Data Availability

No data were used to support this study.

Disclosure

The author confirms 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.

Authors' Contributions

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

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Retraction

Retracted: Enterprise Precision Marketing Strategy and Quality Management Mobile Information System Based on Customer Satisfaction

Mobile Information Systems

Received 13 September 2023; Accepted 13 September 2023; Published 14 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] L. Wang, C. Hung, and C. Hsieh, "Enterprise Precision Marketing Strategy and Quality Management Mobile Information System Based on Customer Satisfaction," *Mobile Information Systems*, vol. 2022, Article ID 2105383, 11 pages, 2022.

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Research Article

Enterprise Precision Marketing Strategy and Quality Management Mobile Information System Based on Customer Satisfaction

Lai-Wang Wang,[1] Chen-Chih Hung ,[1] and Ching-Tang Hsieh[2]

[1]*Department of Industrial Engineering and Management, National Kaohsiung University of Science and Technology, Kaohsiung 807618, Taiwan, China*
[2]*Department of International Business, National Kaohsiung University of Science and Technology, Kaohsiung 824004, Taiwan, China*

Correspondence should be addressed to Chen-Chih Hung; i107142107@nkust.edu.tw

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With the increasingly fierce competition in the product economy, there are more and more constraints on the development of enterprises, especially from the requirements of customers. Enterprises should be committed to development and meet customer needs first. However, the existing marketing plan and quality management also take customer satisfaction into account, so this paper aims to design the enterprise precision marketing strategy and quality management mobile information system based on the customer satisfaction model. For the precise marketing strategy of enterprises, this paper proposes three indicators of product quality, product delivery, and product service based on the customer satisfaction model and uses the hesitant fuzzy set to quantify the indicator model and apply it in the information system. For the quality management system, this paper uses PDCA cycle indicators to upgrade and optimize the quality management system. The test results show that the system has achieved a customer retention rate of 95% in terms of precise marketing strategies; in terms of quality management, it has improved the quality of enterprise products by about 20%. In the overall test of the system, the communication delay and reliability of the system are obviously optimized. This proves that the system can adjust the marketing strategy in real time according to the opinions of customers, achieve the purpose of precise marketing, and improve the quality management to a new height in line with customer satisfaction which shows that the information system designed in this paper can meet the purpose of precise marketing strategy and quality management of enterprises.

1. Introduction

In the current digital information age, traditional management analysis and decision-making methods can no longer meet the rapid development requirements of enterprises. Faced with emerging opportunities and increasingly fierce competition, new management decision-making methods emerge as the times require, among which management methods based on data-based decision-making have received more and more attention. The main method of data-based decision-making is to use data mining and other means to analyze massive data and analyze and extract potentially useful information from a large amount of actual business data. Satisfied customers are bound to be loyal, and if this loyalty can be maintained for a long time, companies are less likely to be abandoned because other companies offer slightly lower prices. Even when an enterprise faces difficulties in its operation, satisfied customers will remain loyal for a certain period of time and within a certain range, so that the enterprise has the opportunity to take measures to deal with the difficulties and buys time for the enterprise. At the same time, satisfied customers also do not choose new products immediately, because choosing new products is also risky for customers. Therefore, it is necessary to design the enterprise precision marketing strategy and quality management mobile information system based on customer satisfaction.

So far, there is no systematic research on how to reasonably improve the quality management of enterprises

according to customer satisfaction. Ma et al. studied a low-cost hybrid power quality management system for negative sequence and reactive power compensation in V/v traction power supply system [1]. Baaran has done a lot of research on the quality of enterprise generation management. He upgraded the ISO 9001 standard and proposed a higher quality management system [2]. Chupikova et al. conducted research on the production quality of fishery enterprises, and they introduced the production process plan of frozen shrimp and frozen seaweed, the control points of the process, and the recommended measuring instruments for the control parameters of the process [3]. Kalmutchi conducted research on the operational safety of airlines [4]. Krupko and Shaburova described the effectiveness of expanding the field of certification in the development of a quality management system (QMS) for metrological services [5]. However, the relevant research on quality management is more concerned with the establishment of quality standards, without taking into account customer satisfaction.

Precision marketing focuses on the comprehensive process control of sales management and strengthens the ability to implement the sales process. There are many studies on precision marketing. For the precision marketing of enterprises, Zhao and Ma combined the precision marketing data source system based on big data to introduce data standardization and quality model, so as to provide a reference for building a data source system based on big data [6]. Bo and Zhang aim to build an online precision marketing system model based on big data, realize the Hadoop + MapReduce precision marketing model platform, and provide a basis for enterprise decision-making [7]. Zhang et al. aims to use data mining clustering technology to analyze the characteristics of user's mobile behavior trajectory and build a tourism accurate recommendation system; it can provide support for tourism decision-making and can carry out precise marketing for tourist groups, so that tourists can travel more intelligently [8]. Li and Cheng use Internet technology to optimize various industrial links of agricultural production and operation, so as to achieve precise marketing of agricultural products [9]. However, the research on precision marketing rarely considers customer satisfaction, and most of them focus on tracking algorithms for customer classification and customer behavior. Therefore, the precise marketing and quality management system based on customer satisfaction in this paper is very necessary.

In this paper, a method to improve the reliability of data fusion, TGDA algorithm, is proposed. In order to analyze the basic performance of the TGDA algorithm, 100 rounds of simulation experiments are performed on the OPNET platform, which proves that the communication delay of the system is reduced by about 20%, and the reliability is improved 30%. The innovations of this paper are as follows: In view of the development trend of global economic integration, high-end customers and groups are gradually increasing, the demand for high-quality products is also increasing, and customer demand is improving, and this paper designs a mobile information system based on the customer satisfaction model. The system can implement precise marketing with more customer information and customer satisfaction and can manage product quality through the satisfaction returned by customers.

2. Precision Marketing and Quality Management in the Context of Customer Satisfaction

2.1. Precision Marketing Strategy. Data management capabilities have gradually become a winning factor in business competition. In the era of digital information, only with good data information collection and analysis capabilities can more accurate decisions be made and ultimately promote the continuous improvement of corporate value. Relying on advanced data management and analysis tools, precision marketing is an important scientific analysis method and technical means for enterprises to carry out customer relationship management. At the same time, precision marketing is different from traditional marketing that only rests on the performance requirements of sales personnel but emphasizes the transformation from a salesperson-centered management method to a comprehensive management and control of sales activities through planning, executing and monitoring the company's sales activities [10]. The effective management of the process is beneficial to the enterprise to discover the problems in the activity process and execution in time, help to adjust the strategy in time, and ensure the effectiveness of the activity. The relationship between customer satisfaction and precision marketing is shown in Figure 1.

In addition to the data analysis and preparation in the early stage, precision marketing includes the entire marketing business process based on data decision-making: that is, clarifying the campaign objectives and scope before creating a marketing campaign, formulating campaign plans based on marketing goals, and business personnel executing according to the plan. The activity phase summarizes and summarizes the entire process. The development of precision marketing business first needs to analyze the market and formulate targeted marketing activities [11]. The so-called market analysis is to make judgments by clarifying the background of the customers participating in the activities and the market performance of the business products related to the marketing activities before the formulation of the marketing plan and then describing the accurate characteristics of the target customers to establish a feature database. The marketing planning process includes formulating a marketing plan based on market analysis results and marketing objectives, targeting the characteristics of target customers and designing a targeted marketing plan, clarifying marketing steps and promotion channels, and finally implementing and supervising marketing activities.

The customer resource information of an enterprise is the most important enterprise resource. Only with good data management capabilities can an enterprise scientifically collect, analyze, and manage customer data. However, with the improvement of the level of informatization, consumers

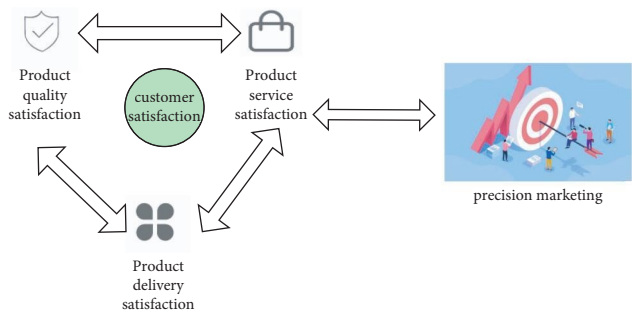

Figure 1: Customer satisfaction and precision marketing.

increasingly demand diversified, personalized, and intelligent services. In order to ensure the market competitiveness of enterprises, enterprises must be able to accurately identify the needs of customers, be customer-centric, provide accurate services to existing customers, and accurately guide potential customers, so as to achieve the goal of sustainable development. In this sense, reacquainting customers and identifying customers, being able to accurately identify important customers and effectively discover potential customers has become a crucial link in the process of customer relationship management. What this paper will study is the design and implementation of a customer-oriented precision marketing solution for enterprises [12].

2.2. Quality Management System. As a quality improvement tool, PDCA quality cycle plays an important role in the quality control of "products" of enterprises. Through the realization and operation of each link, the quality of "products" is gradually improved. At the same time, the "Quality Management System Maturity Evaluation Criteria" propose that the PDCA cycle can also play the role of evaluation criteria in the enterprise quality management system. One is that the PDCA cycle is thoroughly implemented in every link of the quality management system, and the second is that it uses the concept of continuous improvement to achieve the idea of improving the quality of "products," so that the operation of PDCA can also be used as the standard for judging the operation status of the quality management system [13]. In addition, the idea of this criterion can be used not only for self-evaluation of the internal quality management system of the enterprise, but also for the second and third parties to evaluate the operation status of the enterprise quality management system. In addition, some scholars have applied PDCA cycle to other related fields in enterprise operation such as enterprise performance evaluation and enterprise development level evaluation, which further verified that not only is PDCA a quality improvement tool, but its core idea can be applied to quality improvement of other related aspects. Among them, the specific main evaluation items are based on the four dimensions of P (Plan), D (Do), C (Check), and A (Act), and each item is quantitatively scored and qualitatively evaluated.

In "Quality Management System Maturity Evaluation Criteria," the criteria and framework of enterprise quality management system evaluation have been given according to PDCA cycle, which proves that PDCA cycle can not only be used as an improvement model, but also be used as evaluation criteria to measure enterprise quality management system. The development level and situation [14]: The quality management system studied in this paper is essentially a system for measuring the level of enterprise quality management. Starting from the concept of the system, the idea of quality improvement is permeated in every link of enterprise production, operation, and management, so as to achieve the goal of improving quality, purpose closely linked to corporate strategy, development direction, and "product" production. Therefore, this paper will continue the core idea in the "Quality Management System Maturity Evaluation Criteria" and select four dimensions of P (Plan), D (Do), C (Check), and A (Processing) as the enterprise quality. The evaluation criteria of the management system, on the basis of ensuring that the evaluation items are reasonable and correct, further use the core idea of continuous improvement to evaluate and improve the enterprise quality management system and integrate traditional quality improvement tools with emerging quality evaluation methods. Among them are P (plan): suitability, systematicness, and effectiveness of planning output; D (implementation): comprehensiveness, continuity, and strictness of implementation; C (check): sufficiency of monitoring basis and accuracy of objects and the visibility of the results; A (treatment): analyze and evaluate the monitoring results and decide whether to implement improvements.

2.3. Hesitant Fuzzy Sets. The evaluation of enterprise soft quality is a highly subjective evaluation problem, and most of the data considered in the index system are discrete data without obvious functional relationship. Therefore, compared with type-1 fuzzy sets and type-2 fuzzy sets, hesitant fuzzy sets can express the subjective hesitant ambiguity of decision makers without inducting membership functions and have more practical application value.

In the soft quality evaluation problem involving multigroup decision-making, the hesitant fuzzy set can avoid the distortion and distortion of information to the greatest extent when the opinions of decision makers are not unified and can avoid the problem of reaching a consensus. A process (this process itself has a certain degree of difficulty and the process is cumbersome and complicated) can retain the original and effective information [15].

From a statistical point of view, it is difficult for enterprises to keep data for many years in the evaluation process. If there is a lack of data in certain years, hesitant fuzzy sets can use discrete data for each year to obtain statistical results. In the decision-making process where the minority obeys the majority, the constructiveness of minority opinions cannot be ignored. To retain all the opinions, it is obvious that hesitant fuzzy sets have this function [16].

If different decision makers give results of 0.3, 0.5, and 0.7 when evaluating a certain indicator, only the weighted average will be used to calculate the evaluation value of 0.5,

and the two values of 0.3 and 0.7 will be obtained. The evaluation result loses its own meaning.

Through the above analysis, in view of the obvious advantages of hesitant fuzzy sets in enterprise soft quality evaluation, this paper intends to use hesitant fuzzy sets as the data basis, in order to make decisions that best meet the actual needs of enterprises in the decision-making process of the expert group. Next, we will introduce the algorithm of hesitant fuzzy sets [17].

Let X be a given set

$$M = \{u_1, u_2, \cdots, u_n\}, \tag{1}$$

$H_M$is defined as

$$\begin{aligned} H_M &= \{\langle x, h_M(x)\rangle \mid x \in X\}, \\ h_M(x) &= U_{u\in M}\{u(x)\}. \end{aligned} \tag{2}$$

For the convenience of expression, the whole hesitant fuzzy set on the finite universe X is denoted as HFS(X), and $h_A(x)$ is called the hesitant fuzzy element of A, abbreviated as h_A.

For any three hesitant fuzzy elements h_1, h_2, h_3, their algorithm is as follows (where θ is a constant):

$$\begin{aligned} h_1 \cap h_2 &= H\left\{\min\left(r_1, r_2\right) \mid r_1 \in h_1, r_2 \in h_2\right\}, \\ h_1 \cup h_2 &= H\left\{\max\left(r_1, r_2\right) \mid r_1 \in h_1, r_2 \in h_2\right\}, \\ \theta h &= H\left\{1 - (1-r)^{\theta} \mid r \in h\right\}, \theta > 0, \\ h^c &= H\{1 - r \mid r \in h\}, \\ h_1 \oplus h_2 &= \left\{H\left(r_1 + r_2 - r_1 r_2\right) \mid r_1 \in h_1, r_2 \in h_2\right\}, \\ h_1 \otimes h_2 &= \left\{H\left(r_1 r_2\right) \mid r_1 \in h_1, r_2 \in h_2\right\}. \end{aligned} \tag{3}$$

Define function as Θ:

$$\begin{aligned} \Theta&: [0,1]^N \longrightarrow [0,1], \\ \Theta_H(x) &= \cup_{r\in\{h_1(x)\times\cdots\times h_N(x)\}}\{\Theta(r)\}. \end{aligned} \tag{4}$$

Let $h(x)$ be the hesitant fuzzy element

$$s(h(x)). \tag{5}$$

The formula is called the scoring function of $h(x)$, where $\#h(x)$ represents the number of elements contained in $h(x)$.

2.4. Customer Satisfaction Model. The formula for calculating customer satisfaction is as follows:

$$CSI = \sum_{i=1}^{n} W_i C_i. \tag{6}$$

Among them, C_i represents the score of the customer's evaluation of the ith indicator, W_i represents the weight of the ith indicator, and CSI represents the customer satisfaction index.

2.4.1. Product Quality Satisfaction. Through the analysis of the calculation results of customer satisfaction in Table 1, the customer satisfaction of the standard product quality is 7.2134, which is in a state of lower satisfaction. Among them, the fourth item in terms of product quality is the convenience, stability, reliability, and advancement of product assembly: whether the 6th item can solve the quality problems reported by customers in a timely and effective manner; whether the 7th item has repeated quality incidents in the short term; whether the 8th item is satisfied with the quality system assurance capability customer satisfaction 5.7324, item 9 on the quality improvement of products, and customer satisfaction 5.5070; whether the products developed in item 12 meet the customer's requirements, customer satisfaction 6.4014, all at the basic customer satisfaction level. The third item is whether there are appearance problems such as bumps, folds, dirt, etc. Customer satisfaction is 3.4718, which is lower than the red line of 4 points of dissatisfaction, and it is in the level of customer dissatisfaction.

2.4.2. Satisfaction with Product Delivery. According to the evaluation results of the customer satisfaction statistical table in Table 2, the delivery satisfaction of the standard layer products is 8.3037, and the overall score reaches the satisfaction level. However, whether the fourth item in this part meets the customer's temporary change or additional demand for goods, the satisfaction level is 6.3380, which is at 6.3380. The 8th survey content is whether to actively cooperate with customers to improve work in all aspects. Customer satisfaction is 3.5070, which is lower than the red line standard of satisfaction and is in the level of customer dissatisfaction.

2.4.3. Product Service Satisfaction. According to the evaluation results of the customer satisfaction statistical table in Table 3, it can be seen that the overall evaluation score of H company's product service capability is 6.7176, which is in the basic customer satisfaction level and can meet the basic needs of customers for various products and services. The content has a score of 4.4648 on the speed and efficiency of after-sales handling of product problems, which is relatively low. It can only reach the basic satisfaction level and is offline, indicating that the timeliness of solving problems is not timely enough.

3. Enterprise-Level Precision Marketing and Quality Management Information System Design

3.1. Precision Marketing System Process and Prediction Model Tool Selection. As shown in Figure 2, there is the concept of customer grouping in precision marketing, which corresponds to the recommendation system and generally refers to the prediction model technology. Prediction model refers to the use of data mining methods to find the rules of customer behavior based on the massive stock of historical customer behavior data and to apply these rules to predict the customer behavior that may occur in the future [18].

Table 1: Product quality satisfaction.

Three-level indicator	Weights W_i	Mean C_i	Satisfaction CSI
Product design compliance	0.1556	8.2	
Product development process	0.1001	9.1	
Product appearance quality	0.0408	3.5	7.1234
Product assembly performance	0.1089	6.1	
Quality problem solving ability	0.0821	9.4	

Table 2: Product delivery satisfaction.

Three-level indicator	Weights W_i	Mean C_i	Satisfaction CSI
Punctuality of delivery	0.1503	8.9	
Delivery accuracy	0.1576	9.1	
Temporary supply capacity	0.0897	6.3	8.4073
Spare parts delivery capability	0.0901	8.2	
Logistics problem solving efficiency	0.0476	7.1	

Table 3: Product and service satisfaction.

Three-level indicator	Weights W_i	Mean C_i	Satisfaction CSI
Ease of communication	0.0863	9.3	
After-sales problem handling efficiency	0.2297	4.5	
Effectiveness in solving quality problems	0.5246	6.5	8.4107
Salesperson's work initiative	0.1107	9.4	
The attitude of the sales staff	0.0403	9.5	

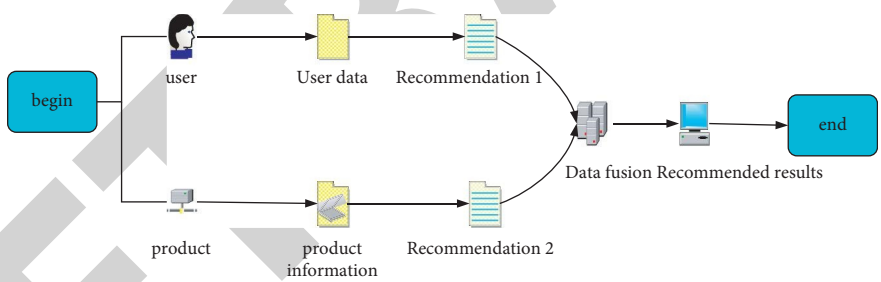

Figure 2: Recommender system flowchart.

SAS' Enterprise Miner software is the most popular data mining analysis tool [19]. SAS can apply multiple predictive models to the data at the same time and use the "lift chart" to compare the predictive effects of the models used and select the optimal model based on the evaluation. The specific process of using Enterprise Miner to build a prediction model is shown in Figure 3.

First read the data through the data reading module, then perform data transformation and data segmentation operations on the preprocessed data according to specific business requirements, and then perform the "regression model," "decision tree analysis," and "decision tree analysis" in data mining for the preprocessed data at the same time. Predictive models such as "neural network" algorithms are for predictive analysis. Finally, based on business requirements, model evaluation is carried out for the three prediction models, and the prediction results are finally sorted to obtain prediction recommendation data [20].

3.2. Quality Management Information System. This paper takes the evaluation of enterprise quality management system as the research background, selects the widely used PDCA as the evaluation criterion, and focuses on the four dimensions of P (Plan), D (Do), C (Check), and A (Process Act). Build an evaluation model that conforms to its characteristics, establish an evaluation model of the enterprise quality management system, and conduct an example analysis in the model construction of each link. The quality management information system architecture is shown in Figure 4.

3.3. Data Module Architecture Design. In order to overcome various problems faced by data integration, the data processing part of this paper adopts ETL technology to realize the integration of customer resource data. Generally, the data obtained after the predictive model analysis of the

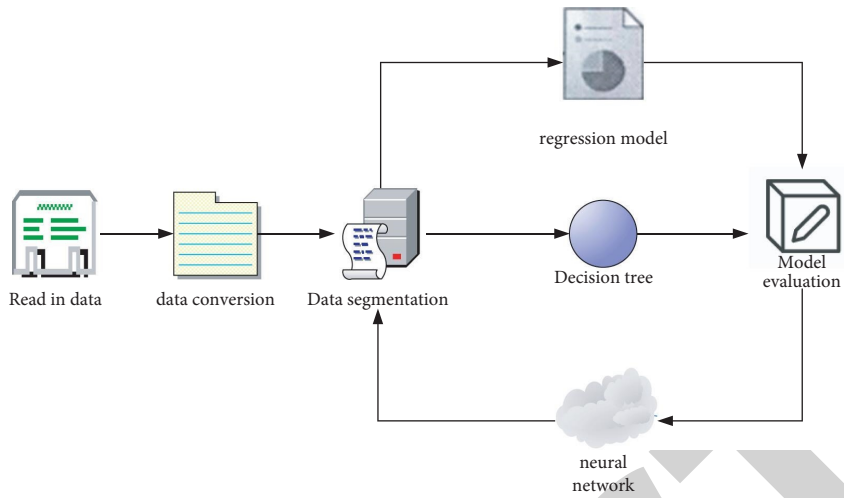

Figure 3: Prediction model flowchart.

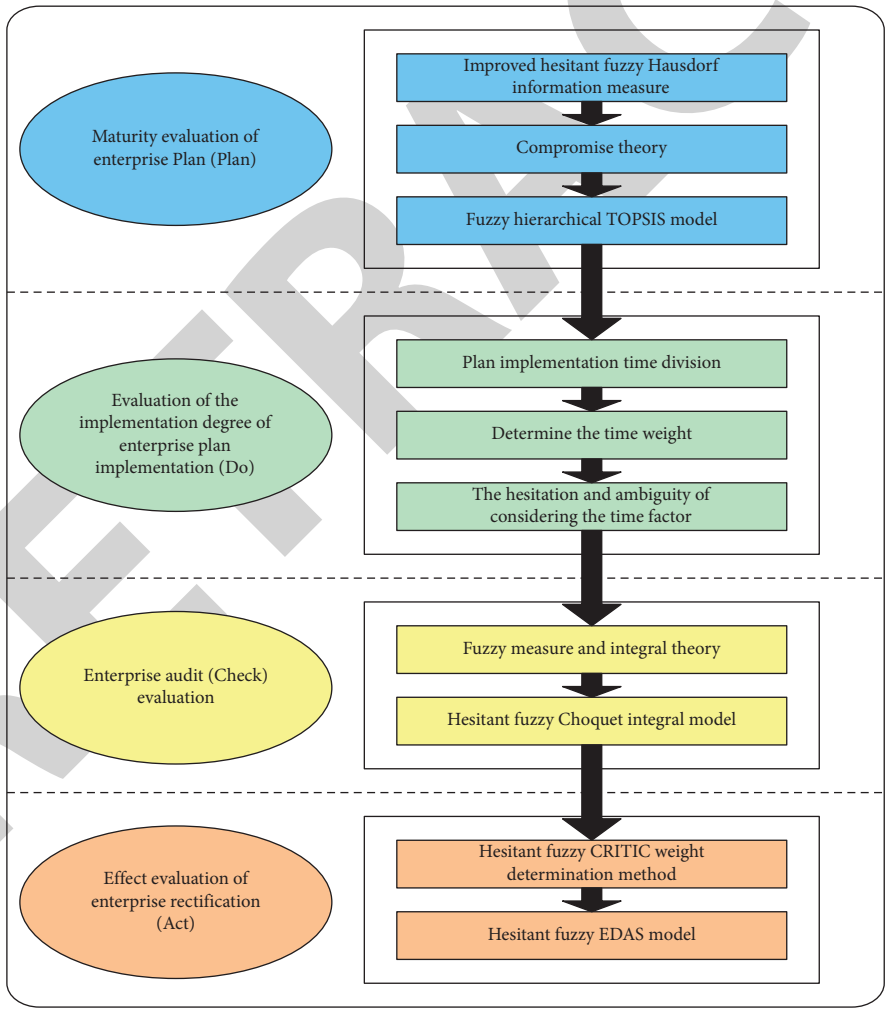

Figure 4: Quality management information system architecture.

original data (generally customer information and behavior records) cannot be directly applied to the precision marketing system. After the SAS analysis data is acquired, some data grouping and other processing operations can be performed at the same time in the process of data loading through ETL.

For the above process, the precision marketing architecture of this paper designs a four-layer data structure to store analysis data at different stages. The relationship is shown in Figure 5.

3.3.1. ETL Buffer Layer. SAS analysis results are generally in text or other nondatabase formats. So the first step is to load the SAS analysis results into the buffer layer data table through the ETL tool for the next step to perform data processing operations.

3.3.2. Data Packet Layer. ETL directly performs data processing operations on the buffer layer data table. Through the processing flow configured in ETL Job, the analyzed data results are grouped or labeled according to business requirements. The data obtained after grouping and labeling operations can be used for the recommendation system engine to execute.

3.3.3. Precision Marketing Business Layer. This is the business layer data table of the precision marketing system, which is generally designed according to the business function requirements of the system and the requirements of the recommendation engine. At the same time, some data (such as customer information data) will be stored in the corresponding business table when the ETL processing buffer layer operation is performed.

3.3.4. System Configuration Layer. The system configuration layer is mainly used for the relevant configuration during the operation of the precision marketing system. At the same time, it also includes information such as user rights and departments related to the use of system management.

3.4. Architecture Design of Enterprise Application Service System. In order to ensure the stability and pressure resistance of the enterprise-level system, the system deployment adopts B/S layering, hardware distribution, and Weblogic cluster deployment. The detailed server deployment arrangement is shown in Figure 6.

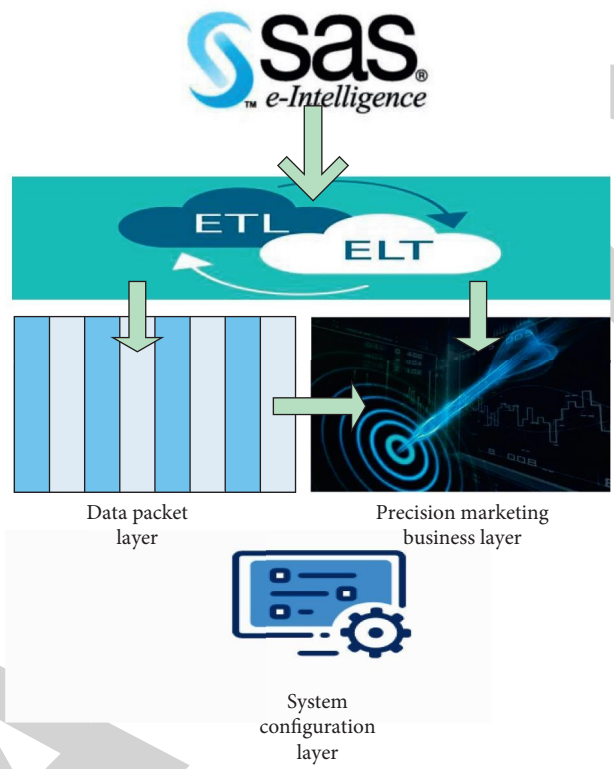

Figure 5: Database hierarchy.

4. Enterprise Accuracy Results and Discussion

4.1. Customer Satisfaction Precision Marketing Performance. For virtual unit scheduling considering customer satisfaction, the objective function of the running scheduling scheme has an optimal average customer satisfaction of 0.945, and the Gantt chart and convergence diagram of the optimal scheduling scheme are shown in Figures 7(a) and 7(b).

Based on the existing researches using triangular fuzzy numbers to represent the completion time and semi-trapezoidal fuzzy numbers to represent the delivery time to establish a satisfaction scheduling model, considering the characteristics and computational complexity of the actual scheduling problem, a six-point fuzzy number representation is proposed. Completion time is a trapezoidal fuzzy number representing the satisfaction scheduling model of the delivery date. This paper uses the stability evaluation index to evaluate the stability of the theoretical optimization scheme in actual implementation to verify that the representation method proposed in this paper is more in line with the actual production, and the obtained optimization scheme is more stable.

The optimal scheduling scheme of manager satisfaction and customer satisfaction obtained above, as well as the triangular fuzzy number representing the processing time and the semitrapezoidal fuzzy number representing the delivery time, the optimal scheduling scheme of manager satisfaction and customer satisfaction is between 0.5 and 0.5. Solve the stability index at the 0.75 confidence level. Table 4 shows that the six-point fuzzy number represents the completion time scheme in the case of manager satisfaction. Contrasting triangular fuzzy numbers represent optimal results and stability values under the make-time scheme.

By comparing the results in Tables 4 and 5, it can be seen that the optimal scheduling scheme obtained by the manager satisfaction and customer satisfaction models designed in this paper is more stable than the optimal scheduling obtained by the model in the previous research at the confidence level of 0.5 and 0.75. Under the same confidence level, in the optimal scheduling scheme obtained by the model designed in this paper, the actual completion time of each workpiece is more likely to be in the excellent area of the theoretical fuzzy completion time, and the consistency between the actual and theoretical scheduling results is also more likely. Therefore, the problem of insufficient stability of the optimization scheme of the scheduling model in which

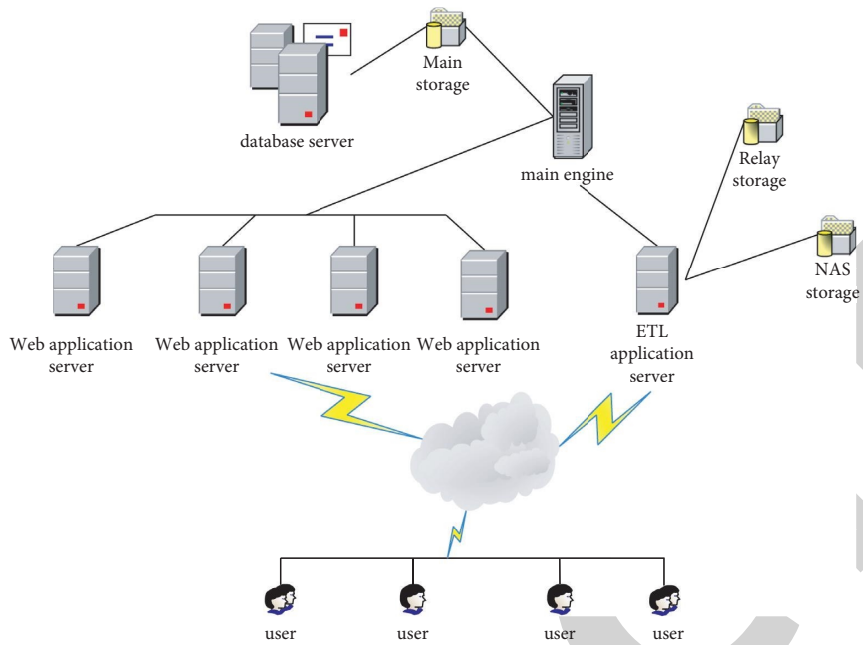

Figure 6: Information system deployment architecture diagram.

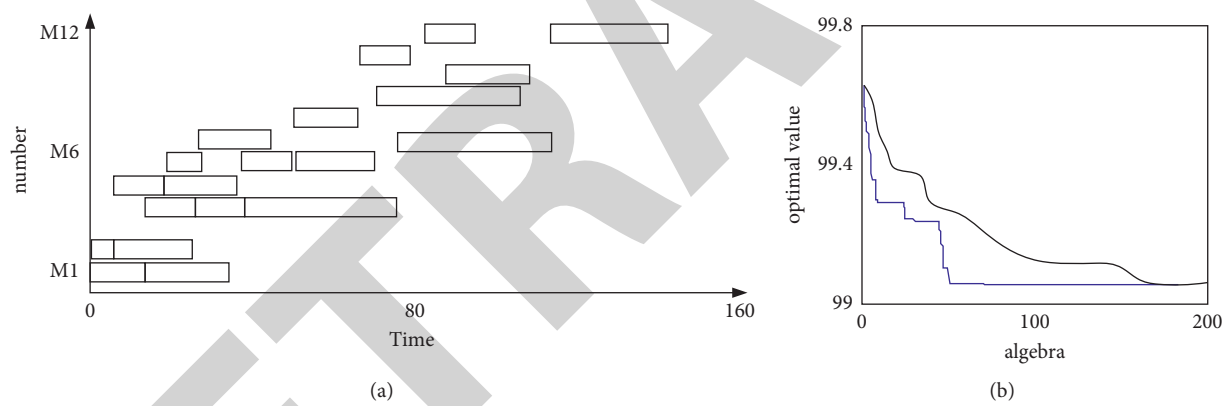

Figure 7: Customer satisfaction precision marketing performance analysis. (a) Gantt chart of optimal customer satisfaction scheduling scheme. (b) Convergence diagram of optimal customer satisfaction scheduling scheme.

Table 4: Comparison of optimal results and stability under managerial satisfaction.

	Six-point fuzzy number	Triangular fuzzy number
Satisfaction value	0.855	0.645
Stability ($\alpha = 0.5$)	0.568	0.521
Stability ($\alpha = 0.75$)	0.365	0.251

the triangular fuzzy number is used to represent the completion time and the semitrapezoidal fuzzy number to represent the delivery time in the previous research is improved.

4.2. System Quality Management Function. The main purpose of applying PDCA cycle in the enterprise quality management system is to help enterprises build a logical framework in the process of quality improvement. Only by establishing a rigorous and scientific logical framework can an enterprise maintain stability in long-term operation and continue on this basis to achieve the purpose of quality improvement and promotion. In order to ensure that the enterprise can always maintain the management foundation

Table 5: Comparison of optimal results and stability under customer satisfaction.

	Six-point, trapezoidal fuzzy number	Triangular, semitrapezoidal fuzzy numbers
Satisfaction value	0.965	1
Stability ($\alpha = 0.5$)	0.609	0.499
Stability ($\alpha = 0.75$)	0.391	0.250

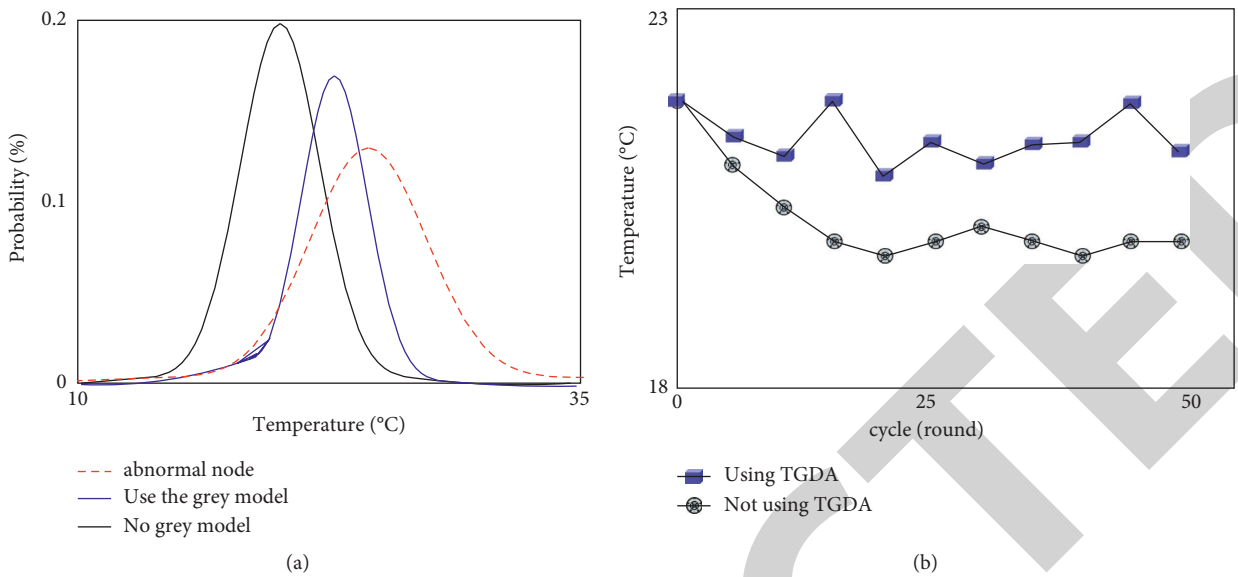

Figure 8: Accuracy analysis. (a) Node metric model. (b) Fusion result change curve.

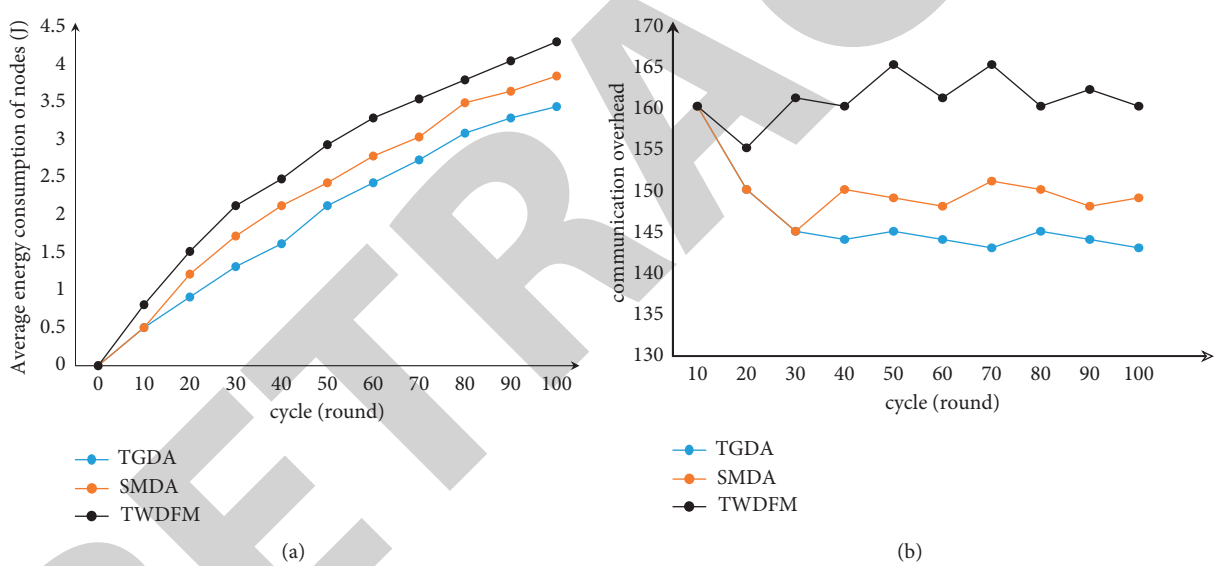

Figure 9: Algorithm energy consumption analysis. (a) Average energy consumption of nodes. (b) Network communication overhead.

with quality as the core and maintain a high management level no matter it develops to any stage or period, this paper chooses PDCA cycle as the logical framework of quality management system evaluation.

4.3. Overall Performance of the System. The nodes used in the 200 experiments in this paper are scattered in an area of 200 m ∗ 200 m. The wireless sensor network composed of these nodes monitors the temperature of the target monitoring area in real time. Each node generates a data packet per second. The experiment assumes that the collected temperature values follow a Gaussian distribution curve. Simulation experiments include the reliability of data fusion, the accuracy of fusion results, the average energy consumption of nodes, and the communication overhead of the network.

4.3.1. Accuracy Analysis. It can be clearly seen from Figure 8(a) that the more the abnormal nodes in the network, the greater the degree of deviation of the obtained results from the actual situation. However, after removing the abnormal node, the collected data is not complete enough, which will cause a certain deviation and cannot reflect the real situation. It can be found from Figure 8(b) that when the TGDA algorithm is used, the temperature value in the first 10 rounds is higher than 20°C, but after 10 rounds the temperature value fluctuates around 20°C and gradually becomes stable, because the abnormal node is

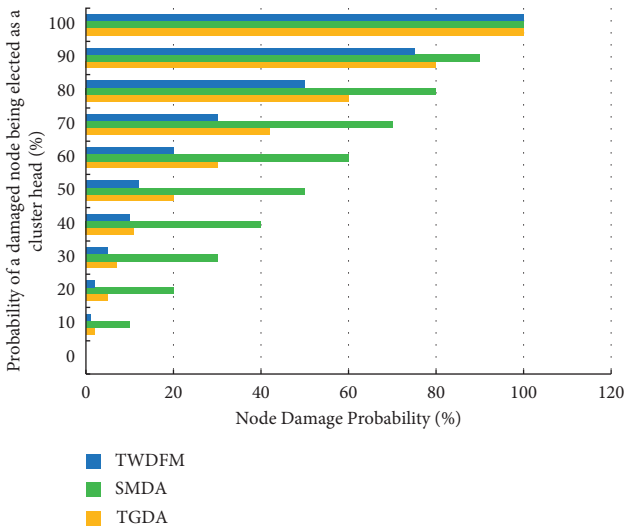

Figure 10: The probability of the damaged node being elected as the cluster head.

continuous. The abnormal data is replaced by the predicted data, so the fusion result will gradually tend to the true value.

4.3.2. Energy Consumption Analysis. Figure 9 shows the comparison of the three algorithms on the average energy consumption of nodes. It can be seen from the figure that the average energy consumption of the nodes of the TWDFM algorithm is the highest. This is because the TWDFM algorithm focuses on the security of the data fusion results and improves the accuracy of the fusion results, which will increase some additional computation and data transmission, so it is different from the other two. The energy consumption of the model is relatively large compared to this model. The TGDA algorithm will remove abnormal nodes before initiating data fusion.

4.3.3. Reliability Research. As shown in Figure 10, the nodes in the TWDFM algorithm select reliable cluster head nodes by constructing a trust table and use a weighting mechanism to add abnormal nodes to the blacklist, which greatly reduces the probability of damaged nodes being selected as cluster head probability. However, in the TWDFM and TGDA algorithms, the probability of the damaged node being selected as the cluster head will increase sharply when the proportion of damaged nodes in the network exceeds 75%. The trust mechanism has no effect, and there is no way to ensure that the selected cluster head is reliable.

5. Conclusions

With the development of society, the sharing of resources between global supply chains is getting higher and higher, the competition among enterprises is becoming more and more fierce, and the profits of products in the same industry are becoming more and more transparent, but the requirements of customers are getting higher and higher. How to reduce quality costs and improve quality benefits on the premise of meeting customer product quality requirements, thereby enhancing corporate market competitiveness and stabilizing customer relationships, is a serious problem facing companies today. Customer satisfaction is an important business indicator for the normal and sustainable development of an enterprise. The results of customer satisfaction assessment directly affect the operating efficiency of the company and its reputation in the industry. Many companies unanimously recognize the importance of customer satisfaction. There is still a lot of deficiencies in the analysis and improvement of factors affecting the degree of management. How to analyze and effectively improve is also necessary to combine the theoretical basis of scientific management and the research viewpoints of scholars' literature to carry out practice verification and choose the improvement direction suitable for one's own enterprise and improve customer satisfaction.

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

Design and Deconstruction of Chemical Process Flow Based on Deep Learning

Yinbing Zhang

College of Chemistry and Chemical Engineering, Hubu University, Wuhan 430062, Hubei, China

Correspondence should be addressed to Yinbing Zhang; 201822110630003@stu.hubu.edu.cn

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Chemical process design is something that researchers must do before conducting chemical reaction experiments, and this step is crucial for the entire chemical production. Because even if the relevant basic information of the institute is obtained, most of the above data have not been verified by experiments, and researchers need to confirm through experiments. In addition, because the market demand for chemical process products is very large, the types of chemical substances are increasing, chemical equipment and instruments are becoming more and more complex, and these require researchers to design and study in advance. This ensures the smooth production of products and the safety of researchers. However, the expansion of the equipment scale and the complexity of the equipment make it more and more difficult to design the chemical process flow. There are many influencing factors and levels to be considered when designing the process, and the data is also very difficult to predict and classify. In order to solve these problems, this study discussed the countermeasures to deal with chemical process flow design in depth. Using the method of deep learning, the problem of chemical process design was analyzed, and the performance of the method was experimentally studied. The results show that the chemical process flow based on deep learning is better than other process designs, and its accuracy rate is higher than 94% in 10 experiments, which is higher than the other three methods. It can be seen that this chemical process method can meet the needs of the current chemical process, and the product quality and work efficiency are greatly improved.

1. Introduction

The most important thing in modern technology is chemical technology, which plays a very important role in China's economic development and has a relatively high status. Due to modern technological innovation, China's chemical processes, both in terms of enterprise scale and production capacity, have been rapidly improved. People's demand for chemical processes is also increasing, and various chemical process products have brought very considerable benefits to people's lives. Modern society is inseparable from chemical production. The chemical process refers to the whole process of turning raw materials into products after the chemical reaction. There are many dangers of extreme conditions in the chemical process flow, which requires very strict design, in order to better control the smooth progress of the chemical process flow and fundamentally improve its level. At present, many scholars study chemical technology, but there are relatively few studies from the perspective of deep learning. Deep learning is a new form of machine learning, which can imitate the human brain to interpret data, and its performance on data is better than many methods. Therefore, this study based on deep learning to study the design and analysis of chemical process flow has certain practical significance, and may be able to obtain good results.

The wealth brought by chemical technology to China's economy is very large, and it has brought many conveniences to people's lives. Chemical process technology is also constantly improving, and many scholars study chemical processes. Al R studied the water quality testing problems of ordinary people, developed related chemical process methods, and optimized water-related parameters [1]. However, the algorithm he used to detect the concentration of water pollution in the article could not actually get an

accurate value. Bal'Chugov and Enhbat studied the chemical process experiments of the Ark model and introduced complex chemical process problems [2]. However, the data he uses in the article are not up-to-date, which will cause the results to be unrealistic. Frolkova analyzed the chemical process technology work of the past few years and elaborated the hierarchical structure of the chemical technology system [3]. But he did not have a comprehensive description of the technological innovations required by the comprehensive experts. Horvat et al. established a program to assess the cognitive complexity of chemical-technical problem tasks, and used experiments to verify the feasibility of this program [4]. But he did not take into account the possible influence factors during the experiment.

After analyzing the research results of other scholars, Makarov et al. studied the possibility of plasma chemistry technology in converting machine wastewater and confirmed the use of organic dispersion medium [5]. But his description of the water-coal composite fuel in the text is not very detailed. Song et al. studied the chemical process stability in calcium-peptide solar cells and carried out related experiments for analysis [6]. But he did not point out the specific process of calcium-peptide solar cells in the text. Mi et al. studied the formation process of the basic discipline of chemical technology and analyzed the most important links in the chemical process [7]. But the model he uses in the study is not the most appropriate.

The application field of deep learning is very wide, and it has many advantages. It can use more data or better algorithms to improve the results of learning algorithms. The innovation of this study is the use of a novel method, deep learning, to study chemical process flow. During the research process, a lot of relevant data were called for analysis in a convenient way to help the future chemical process.

2. Methods of Chemical Process Flow

2.1. Chemical Process. Chemical processing is the method of converting raw materials into products through chemical processing [8]. The scope of this technology is actually very wide, and the operation process is also more. The early chemical production was mainly based on experience, but after the progress of the times, the production of this handicraft can no longer meet the needs of society. Today's production is mainly based on modern technology based on scientific theory. The content of chemical substances is very complex and there are many types, and sometimes it is necessary to use empirical techniques. In fact, this subject is also set up in the curriculum of colleges and universities, usually industrial chemistry or chemical technology, and the content of these two subjects is basically the same. In general, the main development trend of this technology is to control automation, large-scale production, low consumption and low pollution, and optimize production parameters [9]. The process study of this technology can be seen in Figure 1 for details.

As shown in Figure 1, chemical production has to be carried out in specialized laboratories, and instruments and equipment also affect the entire chemical operation [10]. There are also many types of chemical substances, and the complexity is very large. Some chemical substances will produce toxic gases, which are quite harmful to the human body. Generally, when chemical reactions are carried out, laboratory personnel need to bring protective measures. In order to ensure the quality of the final output product, safety precautions must be taken when conducting experiments.

The chemical production process can generally be represented by three steps [11]. Specifically as shown in Figure 2.

As shown in Figure 2, the process of chemical production generally has three steps. The first step is the treatment of the raw material. In order to carry out the chemical reaction, the raw material needs to be pre-treated to make it reach the required state and specification as a chemical reaction material before proceeding to the next step [12]. Otherwise, the effect will be out of the experimental purpose. Different raw materials require different processing methods. Generally, different pretreatment operations such as purification, concentration, mixing, emulsification, or pulverization (pulverization is generally aimed at solid materials) are required. Just like the first step shown in the figure, industrial wastewater as a raw material needs to be pre-treated first. The second step is a chemical reaction. This is the most critical step in the production process. When the raw material is pre-treated to meet the requirements of the experiment, it is allowed to react under certain fixed conditions such as temperature and pressure. Of course, these conditions are generally extreme conditions for humans, so researchers need to pay special attention to safety issues, take protective measures, and consider safety issues first in the design of the entire experiment. When the raw materials reach the reaction conversion rate and yield required by the experiment, it means that the experiment is progressing smoothly. There are many types of chemical reactions, including oxidation, reduction, and polymerization. Through chemical reactions, people can obtain the desired product or a mixture. The third step is product refining [13]. This step is a finishing touch, and its purpose is to separate the mixture obtained in the previous step, remove magazines and other unwanted products, and obtain a product that meets the final rule. This step can be said to be better. In short, the entire chemical production process must be carried out in specific equipment and instruments, and the chemical and physical transformations need to be accurately completed after meeting the operating conditions.

2.2. Chemical Process Design. The chemical process design is also mainly divided into two stages [14]. The first stage is preliminary preparation. Because researchers need to understand the properties of the raw materials before proceeding to the next step. The second stage is equipment. This stage is the external conditions required in the chemical reaction and the equipment to carry out the chemical reaction. Together, these two phases are chemical process designs. Researchers need to understand the characteristics of the raw materials very carefully, as well as the properties of

Figure 1: Chemical process studies.

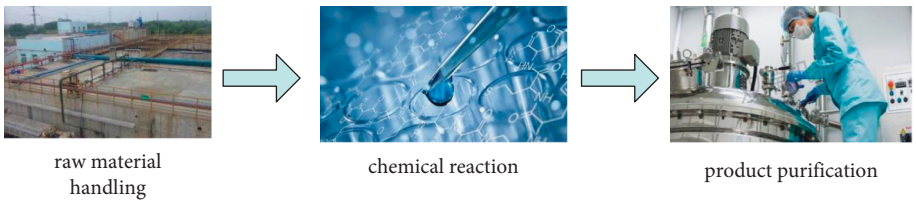


Figure 2: Chemical production process.

the instruments and equipment, relevant security measures should be fully implemented, in order to ensure the smooth progress of the experiment. And the researcher must work according to the research regulations and operate according to the operation drawings, and the final product can meet the target demand. The process design also has several basic features [15], as shown in Figure 3.

As can be seen from Figure 3, there are three basic features of this process design [16]. The first is the professionalism of the researchers. Because when conducting chemical reaction experiments, it is necessary to have very rich theoretical knowledge and practical experience of chemistry, that is to say, a very strong professional quality is required. And the professionalism of researchers is the guarantee for the safe conduct and successful output of experiments. And it also requires researchers to have very flexible on-the-spot responses. The researchers play the leading role in the whole design. They organize and analyze the materials to make the design of the whole experiment more scientific and accurate. The second characteristic is danger. As far as it is known, many raw materials will be used in the process design process, and some raw materials have great hidden safety problems, and the risk factor is relatively high, so the experimental process will also become dangerous. At this time, researchers need to have a very high degree of professionalism and take perfect protection and inspection measures, to ensure the safety of the experiment. The third feature is the complexity of the process [17]. The process involves a lot of raw materials and a lot of types of chemical substances. It not only requires researchers to be deeply familiar with the basic knowledge of chemistry, but also requires them to operate complex instruments and equipment. Therefore, the entire chemical production workload is very large, and the requirements for researchers are very high.

When designing this process, the following points should be paid attention to, as shown in Figure 4.

From Figure 4, we get information that three points should be paid attention to when designing [18]. The first point is the validity and completeness of the underlying data. Because most of the basic materials used by researchers are provided by scientific research units, which are basically theoretical knowledge, lack of experimental proof and actual production content, and the difference between chemical production equipment required for chemical reactions is still quite big. Therefore, these basic materials cannot meet the design requirements. These data are not up to standard in terms of completeness and availability. Therefore, researchers must carry out experimental verification of these data and test the correctness of the data to ensure the smooth progress of the design work. The second point is the selection and design of chemical equipment. Because the work of chemical production is very complex and the conditions are very extreme and harsh. When carrying out process design, some special equipment problems of pressure vessels or high-temperature resistant equipment will be encountered. At the same time, science and technology are constantly improving, the types of chemical materials are becoming

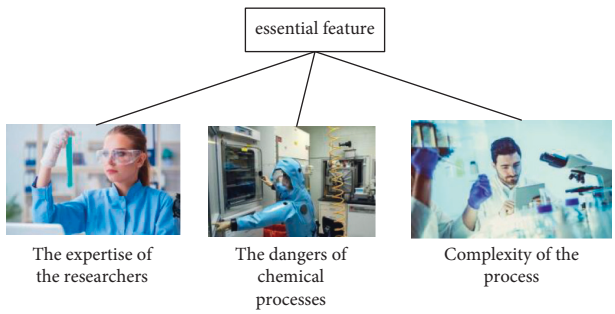


Figure 3: Basic features.

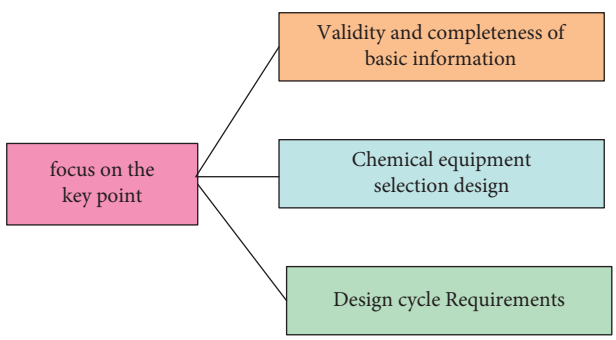


Figure 4: Points to note.

more and more, and the types of equipment are gradually becoming more abundant. Even the same production equipment may have different materials and equipment specifications. Therefore, when designing the equipment, researchers need to pay attention to the selection of the model of the equipment that must meet the process requirements. If there are special requirements, the equipment should also meet them. Even if the production scale is relatively large, the overall harmony and rationality should be considered when selecting equipment, and the equipment should be optimized. And the safety of the entire process progress needs to be guaranteed. The third point is the design cycle requirements. Because of the increasing demand for such products, the competition in the market is also very fierce. In order to increase competitiveness, some companies choose to shorten the design time of the process, resulting in a decline in product quality. Sometimes product performance cannot be guaranteed. Therefore, enterprises should correctly understand the importance of design, and ensure product quality in accordance with the prescribed design cycle.

2.3. Deep Learning. A deep learning algorithm that learns from historical data and then extracts useful information hidden in the data [19, 20]. The more common network structures in deep learning are as follows.

The first is a fully connected multi-layer neural network. Its structure is shown in Figure 5.

The propagation process of the network is divided into two types. The first is forward propagation. If the network

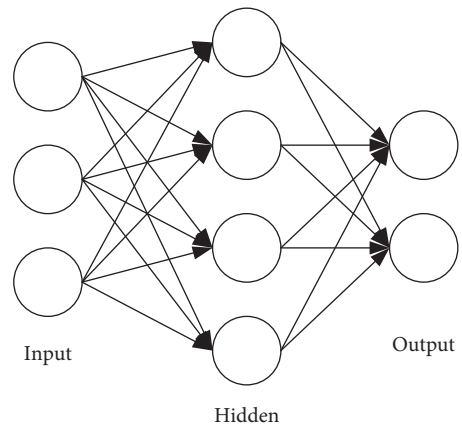


Figure 5: Network structure.

depth is A, the regular term coefficient is, the expression is as follows:

$$K = A(\widehat{U}, U) + \beta\varnothing(\vartheta). \tag{1}$$

The second is the backpropagation process. First, calculate the gradient of the last layer of the loss function K:

$$\begin{aligned} &H \leftarrow \nabla_{\widehat{U}} K, \\ &\text{FOR} L = A, A-1, \ldots, 1 \text{ DO}. \end{aligned} \tag{2}$$

Get the gradient of the output of each layer, it can be got a gradient of X_L:

$$H \leftarrow \nabla_{\widehat{XL}} K = H \bullet G'(X_L). \tag{3}$$

Finally, use the loss function K to calculate each layer:

$$\begin{aligned} \nabla_{EL} K &= H S_{L-1}^{Y} + \beta \nabla_{EL} \varnothing(\vartheta), \\ \nabla_{NL} K &= H + \beta \nabla_{NL} \varnothing(\vartheta). \end{aligned} \tag{4}$$

The second network structure is a convolutional neural network. It has representational learning ability. Each unit of its neural network can be represented by Figure 6.

If J_O represents the Oth layer feature of the convolutional neural network, the formula can be obtained:

$$J_O = G(J_{O-1} \times E_O + N_O). \tag{5}$$

If layer O is a pooling layer, it can be got:

$$J_O = \text{subsampling}(J_{O-1}). \tag{6}$$

Each layer of forward propagation mentioned above is actually activated by a nonlinear function. The general nonlinear activation function is as follows:

$$\begin{aligned} H(C) &= \frac{1}{1 + R^{-C}}, \\ H(C) &= \frac{1 - R^{-2C}}{1 + R^{-2C}}, \\ H(C) &= \text{MAX}(0, C). \end{aligned} \tag{7}$$

It can be seen from the above introduction that people measure whether the deep learning model meets people's requirements by the size of the loss function value. If the

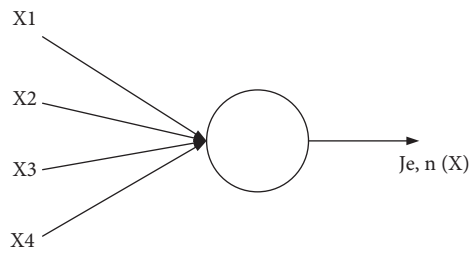


Figure 6: Neural network unit.

value of the loss function is less than the accuracy given by people in advance, it means that the deep learning model meets the requirements of people. Otherwise, the correction of the parameters in the model is achieved by the back-propagation algorithm until the loss function value is less than the given accuracy. In this part, people will briefly introduce the common loss functions in deep learning. In order to improve the generalization ability of the model, several common regularization terms are added to the loss function, such as:

$$K(\vartheta) = K(\theta) + \beta\varnothing(\vartheta). \tag{8}$$

The regular term generally has the following forms. For example, the regular term formula of A^2 parameters can be:

$$\varnothing(E) = \frac{1}{2}\|E\|_2^2. \tag{9}$$

The regular term formula for the A^1 parameter can be:

$$\varnothing(E) = \|E\|_1 = \sum_O |E_O|. \tag{10}$$

If U is the true value and $\widehat{U}(C)$ is the actual output value, the mean squared loss function can be obtained:

$$K = \frac{1}{2}\|U - \widehat{U}(C)\|_2^2, \tag{11}$$

M is the number of samples, then the cross entropy loss function formula is:

$$K = -\sum_{O=1}^{M}\left(U_O \mathrm{LOG}\left(\widehat{U_O}(C)\right) + (1 - U_O)\mathrm{LOG}\left(1 - \widehat{U_O}(C)\right)\right). \tag{12}$$

The exponential loss function and absolute value loss function can also be obtained as:

$$K = \frac{1}{2}\sum_{O=1}^{M}\mathrm{EXP}\left[-U_O\widehat{U_O}(C)\right],$$
$$K = |U - \widehat{U}(C)|. \tag{13}$$

3. Experiment and Deconstruction of Chemical Process Flow

3.1. Instance Destructuring. In the field of machine learning, the confusion matrix is used to judge the quality of the model. The confusion matrix that presents the four indicators together is shown in Table 1.

In order to verify the feasibility of the method based on deep learning, the test set about chemical process flow is divided into four categories, and the number of tests is set to 10, 20, 30, and 40 times, and case studies are carried out [21, 22]. The key evaluation indicators of the deep learning model in the first type of test set are shown in Table 2.

From the information in Table 2, the training effect of the model in this study is very good. When the number of tests is 10, the four indicators of the model all reach 100% efficiency, which shows that the model has a very good performance in terms of precision, accuracy, and recall. When the number of tests is added to 20, the precision rate of the model is 77%, the accuracy rate is 95%, and the recall rate is 100%, which are basically above 75%. When the number of tests reaches 30, the precision of the model is 100%, the accuracy rate is 95%, and the recall rate is 71%, which is a good testament to the excellent potential of this model.

The following are the key evaluation indicators of the deep learning model of the second type of test set, as shown in Table 3.

As shown in Table 3, the training effect of this model is better. Although the performance of each indicator has not reached 100%, it is basically more than 60%. When the number of tests is added to 20, the precision rate of the model is 65%, the accuracy rate is 93%, and the recall rate is 67%, which is basically above 60%. When the number of tests reaches 30, the precision rate of the model is 87%, the accuracy rate is 83%, and the recall rate is 85%, and the performance is still very good. When the number of tests reaches 40, the model has a precision rate of 67%, a precision rate of 95%, and a recall rate of 65%.

The following are the key evaluation indicators of the deep learning model of the third type of test set, as shown in Table 4.

As shown in Table 4, the training effect of the model is basically good. Although the performance of each indicator has not reached 100%, it is basically more than 60%. When the number of tests is added to 10, the precision of the model is 100%, the precision is 100%, and the recall is 100%. When the number of tests reaches 20, the precision of the model is 91%, the accuracy rate is 98%, and the recall rate is 100%, and the performance is still very good. When the number of tests reaches 30, the model has a precision rate of 86%, a precision rate of 88%, and a recall rate of 65%.

The following are the key evaluation indicators of the deep learning model of the fourth type of test set, as shown in Table 5.

As shown in Table 5, the training effect of this model is good. Although the performance of each indicator has not reached 100%, it is basically more than 60%. When the number of tests is added to 10, the precision of the model is 100%, the precision is 100%, and the recall is 100%. When the number of tests reaches 20, the precision of the model is 100%, the accuracy is 100%, and the recall rate is 100%, and the performance is still very good. When the number of tests reaches 30, the precision of the model is 100%, the accuracy is 97%, and the recall rate is 81%. This is a good illustration of the excellent performance of this model.

Table 1: Confusion matrix table.

Confusion matrix		True value	
		Positive	Negative
Predicted value	Positive	TP	FP
	Negative	FN	TN

Table 2: The key evaluation indicators of the first type of test set.

Test times	Accuracy (%)	Accuracy (%)	Recall (%)	$F1$-score (%)
10	100	100	100	100
20	77	95	100	87
30	100	95	71	83
40	100	100	100	100

Table 3: The key evaluation indicators of the second type of test set.

Test times	Accuracy (%)	Accuracy (%)	Recall (%)	$F1$-score (%)
10	100	91	61	76
20	65	93	67	87
30	87	83	85	89
40	67	95	65	73

Table 4: Key evaluation indicators of the third type of test set.

Test times	Accuracy (%)	Accuracy (%)	Recall (%)	$F1$-score (%)
10	100	100	100	100
20	91	98	100	96
30	86	88	65	71
40	77	91	91	82

Table 5: Key evaluation indicators of the fourth type of test set.

Test times	Accuracy (%)	Accuracy (%)	Recall (%)	$F1$-score (%)
10	100	100	100	100
20	100	100	100	100
30	100	97	81	89
40	83	95	91	86

3.2. Deconstruction Based on Deep Learning. In order to further verify the superiority of our method compared to other methods, people conducted a comparative experiment between the deep learning method and other methods [23]. And in order to get more intuitive data, the accuracy of these methods was quantitatively compared. They were placed under the same conditions for ten repetitions. The result is shown in Figure 7.

The information can be obtained from Figure 7, the accuracy of the method in this study is higher than 94% in 10 experiments, which is higher than the other three methods, and the effect obtained by the method in this study is very stable. When the number of tests is 1, the accuracy of this method is 97, the accuracy of method 1 is 93, the accuracy of method 2 is 92, and the accuracy of method 3 is 94. When the number of tests is 4, the accuracy of this method is 95, the accuracy of method 1 is 93, the accuracy of method 2 is 91, and the accuracy of method 3 is 92. When the number of tests is 8, the accuracy of this method is 96, the accuracy of method 1 is 91, the accuracy of method 2 is 92, and the accuracy of method 3 is 92. When the number of tests is 10, the accuracy of this method is 95, the accuracy of method 1 is 94, the accuracy of method 2 is 93, and the accuracy of method 3 is 93.

This shows that the proposed method can obtain richer information than shallow networks by expressing highly abstract features of diagnostic data. This advantage will be more obvious in industrial occasions with many variables, complex data relationships, and high nonlinearity [24]. It is worth noting that although method 1 achieves high accuracy in the tenth experiment, the model is too random, and the diagnostic results fluctuate greatly, and it is easy to fall into a local optimum.

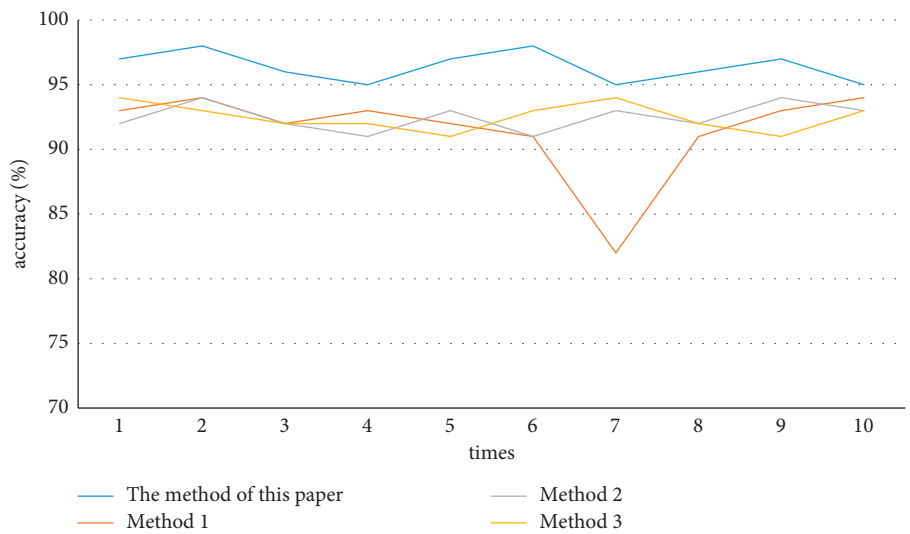


Figure 7: Comparative experimental results.

In order to further verify that the proposed deep model can solve the defect that the traditional multi-layer neural network is easy to fall into the local optimal solution, the sixth and eighth experiments are analyzed in detail, and the results are shown in Figure 8.

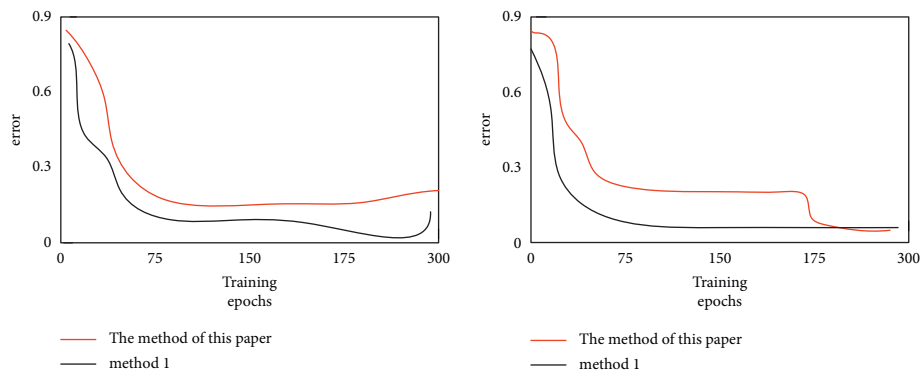
The information can be obtained from Figure 8. In two experiments, the proposed method has achieved relatively ideal classification results in about 100 iterations. However, method 1 falls into the local optimal solution early in the sixth experiment, and the classification error stays at about 0.3. Therefore, although the multi-hidden layer neural network can also obtain a relatively ideal classification effect, the classification error sometimes converges. Sometimes it falls into a local optimum, and the diagnosis results fluctuate wildly, which obviously cannot achieve satisfactory results in industrial occasions where the comprehensive performance of the diagnosis model is high. Therefore, the proposed deep fault diagnosis method can not only extract complex abstract information in complex industrial data, but also has a great improvement in model classification accuracy compared with shallow networks. Moreover, it overcomes the limitation that the traditional multi-hidden layer neural network is easy to fall into the local optimal solution, so it can be well adapted to the detection and diagnosis of complex chemical processes.

In order to verify the reliability of our method, people applied the deep learning algorithm in four test sets of chemical process flow design, and conducted two experiments [25]. The number of training sessions is set to 100 times. The result is shown in Figure 9.

It can be seen from Figure 9 that although a larger batch update amount has a faster convergence rate in the early stage of the fine-tuning process, as the number of iterations increases and the objective function approaches, the training process oscillates or even diverges. The smaller batch update amount, although the convergence speed is slightly slower, can gradually converge to a lower range with the increase in training times. In the parameter combination that has not been optimized enough, the error on the test set can be similar to or even better than that of the optimization model based on deep learning. A model with a larger learning rate must have a faster convergence rate, but in the later stage, there will be oscillations and the phenomenon of falling into a local optimum. A model with a lower learning rate converges more slowly at the beginning of training. In order to overcome this problem, this study adopts a training method of using a larger learning rate in the early stage of training and lowering the learning rate in the later stage of training. After the training of the model is completed, the test set data is input into the diagnostic model to obtain the prediction result, and the result is compared with the label data of the test set. If the diagnostic rate does not meet the requirements, it must return to the pre-training step to reset the model parameter combination to train a new model. If the diagnostic performance is good, the model will be used in the online stage. This is a good proof that deep learning algorithms are very suitable for chemical process design.

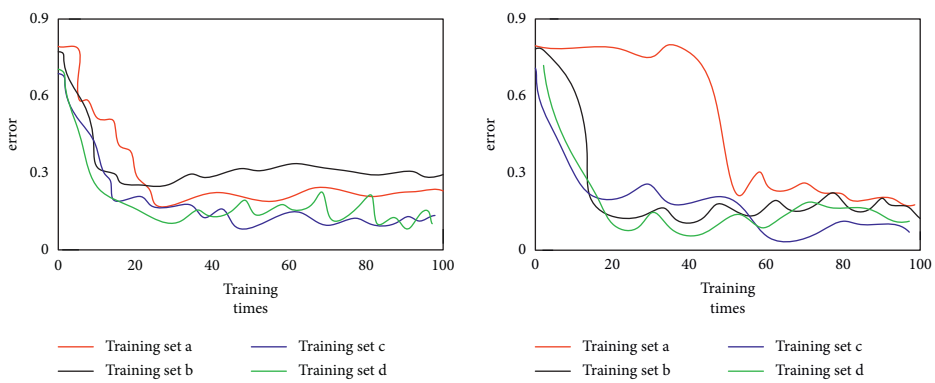
In order to better verify the accuracy of the method in this study, in the chemical data set, the method in this study is compared with the other two methods [26]. The result is shown in Figure 10.

The information can be obtained from Figure 10, which shows the classification improvement effect of different methods on the model. The proposed method is largely better than random selection, and with the increase in the number of iterations, the performance improvement effect is greater until a convergence value. After 10 iterations, the design accuracy of the three methods reached 99.76%, 99.48%, and 98.2%, respectively. After active learning, the model classification accuracy was improved by nearly 1.5%. However, although the active learning criterion based on information entropy has greatly improved the classification performance of the model, the results are similar to those obtained from industrial datasets. From the graphs of the number of false positive points and the false positive rate of the model under different methods, it can be found that the



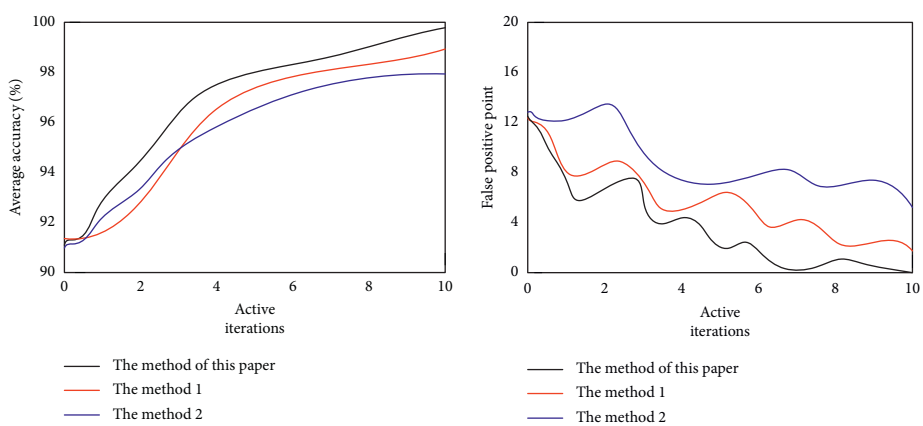
(a) (b)

Figure 8: Specific analysis. (a) The 6th experiment. (b) The 8th experiment.



(a) (b)

Figure 9: Error Curve. (a) The first experiment. (b) The second experiment.



(a) (b)

Figure 10: Experimental results of chemical data set. (a) Classification accuracy. (b) Number of false positive samples.

proposed method is not only better than the traditional method in overall accuracy but also reduces the occurrence of false positives. It is worth noting that although there is a certain fluctuation in the false positive phenomenon in the process of increasing the number of iterations (such as a sudden increase in the false positive rate in the second iteration), with the increase of the number of iterations, the suppression effect of the proposed method on false positives tends to be stable, and is generally better than other methods.

In the above experiments, the advantages of the proposed method are illustrated from the perspectives of model depth and sample selection criteria. From the perspective of

model depth, the effects of deep learning-based methods and other shallow models in chemical process design are compared, and the results show that the method proposed in this study is superior to the existing shallow models in terms of precision and accuracy. At the same time, the article further verifies the necessity of feature learning and expression in the proposed method by comparing different models. From the perspective of active learning sample selection criteria, the traditional deep network model and the active deep network model combined with information entropy are compared. The results show that the proposed method can not only efficiently use the labeled samples to improve the classification accuracy of the model but also suppress the false positive phenomenon of the diagnostic results to a large extent. Therefore, deep learning has great potential in chemical process design.

4. Conclusion

In this study, the design of chemical process flow is studied and analyzed by the deep learning method. And it is concluded that the application of this method is of great help to the design of chemical process flow, which greatly improves the accuracy and precision of process design, and makes the whole design have a better effect. Therefore, further research on the design of deep learning in this process can be considered. However, due to the limited length of the article, it cannot cover all aspects, and there are not many examples used in the research, which is also the limitation of this article. Looking forward to further research with more real data in the future is to discover more ways to help design chemical processes. At the same time, people should also firmly believe that there will be more research materials on this topic in the future, and the design of chemical process flow will become more and more scientific and accurate.

Data Availability

Data sharing is 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

There are no potential conflicts of interest in this study.

Authors' Contributions

All authors have seen the manuscript and approved it to submit for publication.

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Retraction

Retracted: Dynamic Fire Monitoring Analysis and Risk Assessment Based on Multisource Satellite Remote Sensing

Mobile Information Systems

Received 13 September 2023; Accepted 13 September 2023; Published 14 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] J. Chen, W. Zheng, and T. Shan, "Dynamic Fire Monitoring Analysis and Risk Assessment Based on Multisource Satellite Remote Sensing," *Mobile Information Systems*, vol. 2022, Article ID 5039644, 10 pages, 2022.

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Research Article

Dynamic Fire Monitoring Analysis and Risk Assessment Based on Multisource Satellite Remote Sensing

Jie Chen, Wei Zheng, and Tianchan Shan

National Satellite Meteorological Center, China Meteorological Administration, Beijing 100081, China

Correspondence should be addressed to Jie Chen; 2016150266@jou.edu.cn

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In recent years, forest fires have not only destroyed a large amount of vegetation but also the number and burning area of forest fires in the world have increased significantly. In order to reflect the dynamic monitoring analysis and risk assessment of fires in my country in the past 14 years, this paper selects the national terrestrial forest as an area and uses satellite sensing products with a long time series to analyze the time and space of forest burning biomass and forest fires from a qualitative and quantitative perspective. *Feature*. A power-law distribution-based estimation model for forest burning biomass was established, and the accuracy of the estimation results and the interannual variation pattern reached more than 98%, forming the regional sensitivity of the remote sensing evaluation method. With the emergence of new sensors such as NPP-VIIRS and HIGH, the emergence of high-resolution data has enhanced the ability of forest fire area extraction and fire point information identification, which provides more data sources for forest burning NG biomass estimation and forest fire spatial and temporal pattern analysis using these thermal infrared sensors.

1. Introduction

In recent decades, with the impact of global temperature rise and land use change, the number and burning area of global forest fires have increased significantly. Estimating forest burning biomass is the basic condition for studying the carbon emissions released by forest fires, one of the important factors of circulation [1]. As one of the most important resources on Earth, forest is the best habitat for animals and plants; it not only provides a variety of food and rich raw materials for human life but also has the functions of purifying the air, optimizing the environment, reducing noise, and regulating the atmosphere. It can conserve water and soil and reduce the occurrence of natural disasters [2]. Forest fires threaten human life and property safety; at the same time, forest fires change the composition and biodiversity of postfire ecosystems and have important impacts on the carbon balance in the atmosphere and global climate change; the biomass of forest burning and carbon emissions is closely related [3].

In recent years, more and more experts and scholars have used satellite data to estimate forest burning biomass and to analyze impact of carbon emissions from forest fires on global carbon cycle and spatial and temporal characteristics of forest fires [4, 5]. With the emergence of new sensors, such as NPP-VIIRS and high-resolution data, capability of forest fire area extraction and fire point information identification has been enhanced, providing more data sources for forest burning biomass estimation and forest fire spatial and temporal pattern analysis using these thermal infrared sensors. Based on data products from different satellites, the corresponding research method is proposed, which is also a feasible method to use satellite remote sensing technology to monitor spatial and temporal pattern distribution of forest fires and regional sensitivity analysis for a long time and a large area, as well as to estimate biomass consumed by forest fires. At present, domestic and international research tends to use characteristics of thermal infrared remote sensing technology to construct a forest burning biomass estimation model to estimate forest

burning biomass in different regions and forest types for long time series [6].

In this paper, using national MODIS data set of fire trails (MCD45A1) and fire point products (MOD14A2) from 2001 to 2014, we can not only analyze spatial and temporal distribution and occurrence pattern of forest fires in China in past 14 years, which can provide scientific basis for forest fire prevention and decision making in China, but also analyze distribution characteristics of FRP (fire radiative power) in MOD14A2 data, which can provide scientific basis for forest fire prevention and forest change monitoring. The model of remote sensing estimation of forest biomass by forest type can provide scientific decision for forest fire prevention and forest change monitoring; it can also provide a theoretical basis for sustainable development of carbon cycle in China's forest ecosystem, impact of forest fires on atmosphere, global carbon cycle and carbon balance, and estimation of forest carbon sinks [7]. It is also important for the study of global carbon cycle and carbon balance and estimation of forest carbon sink, etc.

2. Related Work

With the emergence and application of satellite remote sensing technology, experts and scholars at home and abroad have also carried out methods to study distribution of forest fires and regional sensitivity evaluation using satellite remote sensing data [8]. The fire points extracted from MODIS data were compared with historical fire traces; it was found that fire points of two categories, 8 and 9, extracted from MOD14A1 (daily level 31 km fire hotspot produce), were suitable for forest fire monitoring, and agreement with field survey data was as high as 0.83; and fire points of two categories, 8 and 9, extracted from MOD14A1, were used. The results show that most likely fire season is April and May in spring, followed by autumn, and mainly in September. In terms of spatial location, most fire-prone area is Daxinganling, which accounts for 64.74% of province's forest burned area; Xiaoxinganling is second, accounting for 23.49% [9]. Using MCD45A1 data, a logistic forest fire risk model was established, and forest fire risk level in province was studied in terms of time and space, and finally level of forest fire occurrence was classified into five areas, including no fire risk area, low fire risk area, medium fire risk area, high fire risk area, and very high fire risk area [10]. This paper introduces the development of four forest fire monitoring satellites, including FY-ID satellite, NOAA series weather satellite, and EOS series satellites (TERRA, AQUA), and analyzes the forest fire points [11]. Spatial analysis was conducted using MODIS14A2 with three environmental factors: elevation, average annual precipitation, and average annual temperature at different levels. The results showed that annual forest fire area in China showed a decreasing trend, but interannual variation of area of fire trails was large, and area of fire trails in provinces of South China and Southwest China was more serious in recent years; monthly fluctuations of forest fires were also more. The monthly fluctuations of forest fires are also obvious, with the largest area of burned land in March, and southern, southwestern, northwestern, and northeastern regions are sensitive to monthly changes [12]. Using TM data of long time series in last 20 years, NDVI data with fire trails were used to fit equation to obtain NDVI fire trails reading values, and long-time fire trails were discriminated by NDVI images and queue values to analyze fire trails [13]. The spatial analysis of burned areas was carried out using MCD45A1 data, and distribution of forest burned areas was confirmed to be mainly in range of 50°~55°[14]. SPOT-VGT and MOD14 data were used to calculate fire trails in northern Eurasia in terms of time series [15]. Forest fires were updated and counted and analyzed using ETM and MODIS data, i.e., canopy cover and forest cover loss were estimated using ETM to determine forest fire disturbance; meanwhile, MODIS data were used to estimate the area of interpreted fire trails.

In this paper, we use fire product data (MOD14A2) and fire trails product data (MCD45A1) from MODIS during 2001–2014, as well as background data such as vegetation distribution maps and administrative divisions to explore quantitative estimation of forest burning biomass by satellite remote sensing on a national land scale with four forest types in China as the study area [16]. We also analyzed location, area, and vegetation types of forest fires in China and formed a quantitative remote sensing estimation method for annual forest consumption biomass of different forest types; analyzed MODIS fire monitoring data covering China on a daily basis to reveal forest fires in China in past 14 years (2001–2014); and formed a quantitative remote sensing estimation method for forest fires in China.

3. Forest Burning Biomass Estimation Model

Figure 1 shows the technical route of national annual forest burning biomass estimation, which mainly consists of analyzing characteristics of FRP curtain law, constructing FRE estimation model according to different forest types and solving values of parameters in model and correction values; finally, forest burning biomass is estimated according to experimental conversion coefficients, and the area of burned traces of MCD45A1 time series data set of four forest types extracted from eight vegetation climate zones is used. The data were compared and validated with model method of forest fire emission calculation. Figure 2 shows the technical roadmap of the national distribution pattern study, which mainly takes different years, months, and regions as research objects and conducts spatial analysis to summarize forest fire pattern distribution pattern by area, burning type, spatial distribution, and temporal distribution in the past 14 years in China. Figure 3 shows the remote sensing analysis method to obtain regional sensitivity evaluation of forest fires through comparison of single and comprehensive indicators.

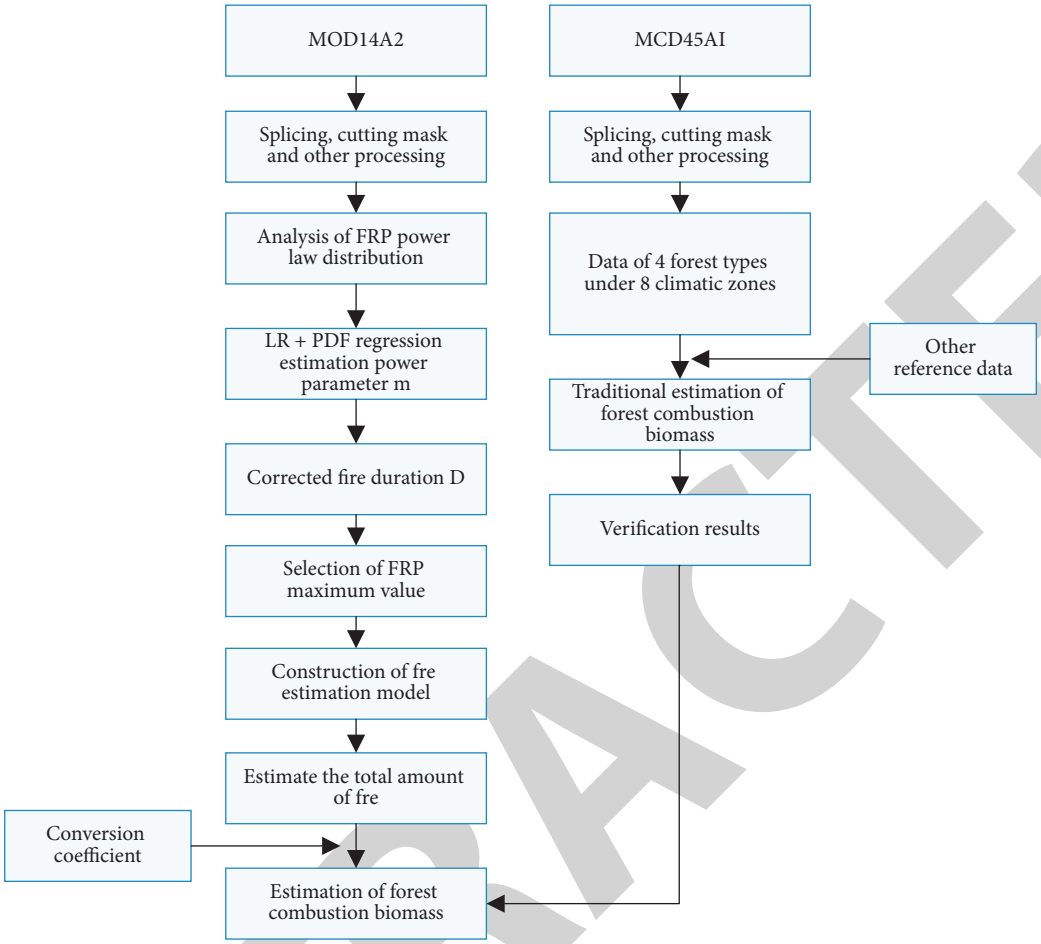

Figure 1: Flow chart of forest burning biomass estimation technology.

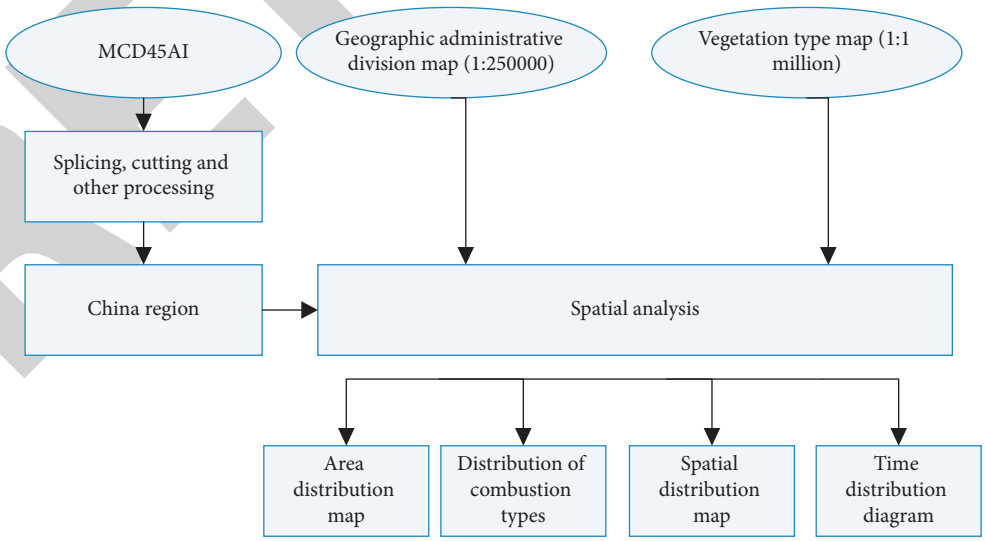

Figure 2: Schematic diagram of the overall technical process of spatial and temporal pattern distribution pattern of forest fires nationwide.

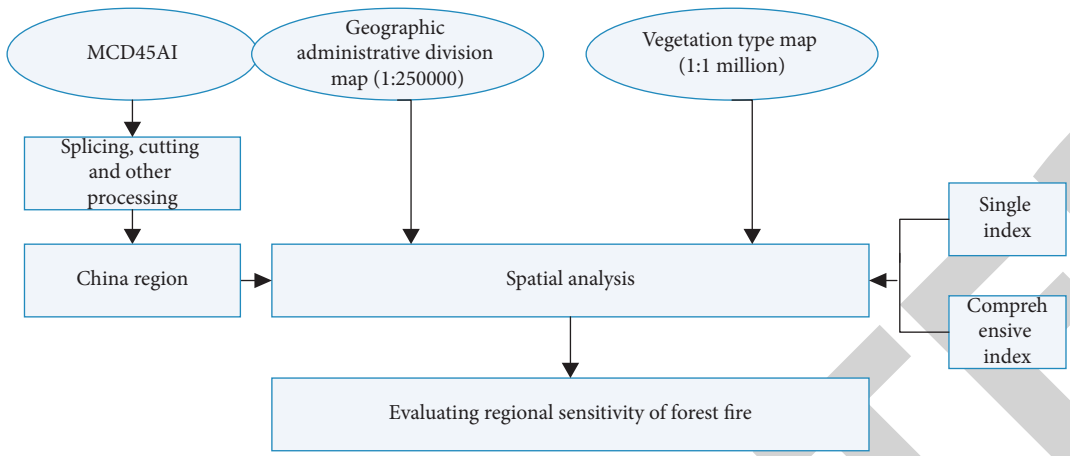

Figure 3: Schematic diagram of the overall technical process of regional sensitivity analysis of forest fires nationwide.

4. Power-Law Distribution Algorithm

When FRP (unit: W) can be measured continuously in ideal state, total fire radiation energy, FRE (unit: J), is defined in the following form (Kumar et al, 2011):

$$FRE = \int_{t=0}^{t-d} FRP(t)dt, \tag{1}$$

where d is fire duration (unit: s).

For discrete FRP values, assuming that there is sufficient time to draw samples of FPR and there is a linear variation between successive samples of FRP, the corresponding FRE can be estimated by the gradient numerical integration method, which is defined in the following form:

$$FRE_{mum.int} \approx \sum_{i=1}^{i-n} \frac{(t_{i+1} - t_i)(FRP_{i+1} + FRP_i)}{2}, \tag{2}$$

n is the total number of FRPs measured during fire duration. Assuming equal time intervals, (2) can be deformed as follows:

$$FRE \approx d \sum_{i=1}^{i=n} \frac{FRP_i}{n}, \tag{3}$$

where d is fire duration. Since d in the expression is replaced by $n\Delta t$ for equal time intervals, and FRP time interval is assumed to be measured continuously, (3) can be defined as expectation value for solving FRE as follows:

$$FRE = dFRP, \tag{4}$$

where FRP is the expectation for duration of fire d.

According to the statistical principle, when the sample size of FRP is small, the arithmetic mean and expected value will be very different. The above derivation process is the traditional FRE estimation method, which is carried out under ideal conditions, while in the reality fire radiance rate (FRP) fluctuates greatly, and results of gradient numerical integration for FRE are very sensitive to FRP of satellite sampling, which is missing and insufficient. Satellite data provide the only way to monitor ground fires in large areas, but due to long transit time interval of polar orbiting satellites, there are missing and insufficient samples of fires being monitored in time variation; so, many experts and scholars are studying method of solving FRE by extrapolating FRP data. In this paper, FRE is estimated by using curtain function based on distributional characteristics of curtain law function of FRP in temporal variation, and the probability density function of curtain function has the following form:

$$P_{(x)} = cx^{-m}, \tag{5}$$

where $P_{(x)}$ is the probability density function of power-law distribution, X is a continuous variable, C is a constant, and m is the power parameter.

The arithmetic mean of sample data for a power-law distribution cannot be used as an estimate of its expectation, especially in case of small sample sizes (Newman, 2005). Therefore, the expected value of power function is derived by the following analysis. First, we integrate all probability density functions, and the sum of integrals is 1, so that a relationship between constant c and power parameter m is obtained.

$$\int_{x_{\text{miv}}}^{x_{\max}} p(x)d(x) = \int_{x_{\text{miv}}}^{x_{\text{mix}}} cx^{-m}d(x) = 1, \tag{6}$$

$$c = (I - m)\left(\frac{I}{x_{\max^{-m+1}} - x_{\min^{-m+1}}}\right). \tag{7}$$

Then, the expected value of x is calculated:

$$\begin{aligned} \exp(x) &= x \\ &= \int_{x_{\min}}^{x_{\text{sex}}} p_{(x)} x d(x) \\ &= \int_{x_{\text{mix}}}^{x_{\text{mux}}} cx^{-m+1} d(x) \\ &= (1-m)\left(\frac{1}{x_{\max^{-m+1}} - x_{\min^{-m+1}}}\right)\left(\frac{x_{\max^{-m+2}} - x_{\min^{-m+2}}}{2-m}\right). \end{aligned} \tag{8}$$

Assuming that FRP follows a power-law distribution during the fire duration$x$ in (8) is replaced by FRP, and the form (4) is combined to obtain (9):

$$E_{pourrlaw} = dFRPFR$$

$$d(I-m)\left(\frac{I}{FRP_{\max^{-m+1}} - FRP_{\min}^{-m+I}}\right)\left(\frac{FRP_{\sin^{-\sin+2}} - FRP_{\min^{-m+2}}}{2-m}\right), \tag{9}$$

where d is fire duration, $FRP_{\max}$ is maximum value of FRP, and $FRP_{\min}$is minimum value of FRP.

In estimating the FRE value, the power function cumulative probability distribution calculation method of (9) has another choice compared with the traditional gradient numerical integration method of (2). From (9), we can easily find that $FRE_{pourrlaw} = 0$ when $m = 1$, $FRE_{pourrlaw}$ is meaningless when $m = 2$, $FRP_{\max}$ and $FRP_{\min}$are meaningful only when $m < 2$ or $m > 2$, and $FRP_{\max}$ and $FRP_{\min}$ play a decisive role in $FRE_{pourrlaw}$.

(1) Forest burn rate: in order to better evaluate the extent of forest hazards and objectively compare sensitivity of forest fires between regions, forest burn rate is introduced and calculated as follows:

$$R_f = \frac{D_{to}}{D_{fa}}, \tag{10}$$

where $D_{ba}$is the average annual forest fire area of a city and D_{fa} is the annual forest area of a city.

(2) Forest overfire area ratio

It reflects regional characteristics of forest fires. Comparing the national average with forest fire hazard of each province (city), the formula is as follows:

$$R_{ba} = \frac{D_{ba}}{C_{ba}}. \tag{11}$$

In order to better reflect forest fire control ability of a region, the coefficient of variation of forest fire area is introduced. If the forest fire control ability of a region is better, then the coefficient of variation of forest fire area in that region is smaller, which means that the forest fire management level of that region is better. In particular, when comparing two adjacent periods, if the coefficient of variation of the former period is larger than that of the latter period, it proves that the control ability of forest fires in the latter period has been improved and the management level has been enhanced, which is calculated as follows:

$$V_n = \frac{\sigma_{ba}}{M_{ba}} \times 100\%, \tag{12}$$

where σ_{ba} is the standard deviation of annual average forest fire area in a province (city) and M_{ba} is the average annual average forest fire area in province (city).

5. Results

When estimating forest biomass consumed by a single forest fire using curtain law distribution characteristics of FRP, no correction for fire duration d is necessary; however, when estimating forest burning biomass on an annual basis, duration d must be corrected to eliminate the error caused by it. The parameters and results for calculating fire durations of three forest types are shown in Tables 1–3, using nine typical fires in broadleaf forest in 2003, coniferous forest in 2009, and shrub forest in 2005, respectively. The incremental ratio (ABB) to real fire duration d set of data monitored by satellite was obtained, and regressions were fitted to these data, and fitting results are shown in Figures 4–6.

The relationship between fire duration d and incremental forest biomass ratio is shown in Figure 4. Assuming the whole year as the real time of satellite monitoring, the error value of the incremental ratio of broadleaf forest in 2003 was solved in the relationship equation, and then the error value of the incremental ratio was brought into (12) to calculate the time correction coefficient of forest burning biomass for the whole year. This is used as an example to correct the fire duration d of broadleaf forest year by year.

The relationship between fire duration d and incremental forest burning biomass ratio for coniferous forests is shown in Figure 5. Assuming whole year as real time of satellite monitoring, error value of incremental ratio of coniferous forest in 2009 was solved in relationship equation, and then error value of incremental ratio was applied to (12) to calculate time correction coefficient of forest burning biomass for whole year. As an example, fire duration of coniferous forest was corrected year by year d.

The relationship between fire duration d and incremental forest biomass ratio is shown in Figure 6. The error value of incremental ratio of shrubland in 2005 was solved by assuming the whole year as real time of satellite monitoring, and then the error value of incremental ratio was applied to (12) to calculate the time correction coefficient of forest burning biomass for the whole year. This is used as an example to correct the fire duration of shrubland year by year (d).

In this paper, we analyze the effect of the selection of the maximum FRP value on estimation results from FRP data. Here, a typical fire in a broadleaf forest in 2003 was selected as an example, and the influence of maximum FRP value on estimated forest burning biomass was analyzed, while other parameters were kept constant. The analysis was carried out by keeping the minimum value of FRP and other parameters in Table 4 constant and analyzing effect of different maximum values of FRP on estimation results. The maximum value was incremented by 10%, and each increment of forest burning biomass was calculated, resulting in two sets of data: incremental difference of FRP maximum value ($\Delta FRP_{\max}\%$) and incremental difference of forest burning biomass ($\Delta BB\%$) (as in Table 4).

As shown in Figure 7, using two sets of data formed by incremental difference of FRP maximum ($FRP_{\max}\%$) and incremental difference of forest burning biomass ($\Delta BB\%$), the equation relationship equation was established, and model parameters were regressed using SAS statistical software, the P value of slope was less than 0.0001, i.e., independent variable was significant, while intercept $P = 0.0379$, i.e., constant term was not significant

Table 1: Examples of correction durations d for broadleaf forests.

Lat	Lon	Fire duration	Scaling, m	$FRP_{\max}$	$FRP_{\min}$	BB_{really}(T)	d+365 × 24(h)	$BB_{increase}$(T)	$\Delta BB=(BB_{increase}-BB_{really})/BB_{really}$
47.5	87.2	21.9	1.708	326.2	19.8	1965	8842.4	817541	416.2
48.7	121.7	50.1	1.702	179.1	21.9	3856	8475.2	685247	176.2
27.3	92.6	120.2	1.7041	143	13.2	6847	8835.5	465247	72.41
25.4	114.1	85.1	1.7048	137.5	12.3	4125	8471.2	425366	102.3
50.7	120.5	125.7	1.7087	135.2	10.9	8475	8593.5	852474	380.2

Table 2: Examples of correction durations d for coniferous forests.

Lat	Lon	Fire duration	Scaling m	$FRP_{\max}$	$FRP_{\min}$	BB_{really}(T)	d+365 × 24(h)	$BB_{increase}$(T)	$\Delta BB=(BB_{increase}-BB_{really})/BB_{really}$
27.5	112.2	11.9	1.708	126.2	12.8	965	8742.4	417541	716.2
23.7	101.7	50.1	1.708	109.1	19.9	4856	8875.2	585247	176.2
23.3	98.6	78.2	1.708	643	33.2	4847	8935.5	565247	122.41
22.4	104.1	75.1	1.708	537.5	42.3	4525	8571.2	625366	302.3
51.7	110.5	102.7	1.708	635.2	11.9	5475	8893.5	752474	180.2

Table 3: Examples of shrubland correction durations (d).

Lat	Lon	Fire duration	Scaling m	$FRP_{\max}$	$FRP_{\min}$	BB_{really}(T)	d+365 × 24(h)	$BB_{increase}$(T)	$\Delta BB=(BB_{increase}-BB_{really})/BB_{really}$
233.5	162.2	81.9	1.908	36.2	6.8	1065	8142.4	117541	116.2
24.7	151.7	70.1	1.908	119.1	5.9	2856	8275.2	285247	96.2
24.3	108.6	78.2	1.908	443.9	13.2	3847	8435.5	365247	132.41
25.4	134.1	75.1	1.908	437.5	17.3	2525	8571.2	425366	242.3
21.7	160.5	92.7	1.908	635.2	21.9	3475	8293.5	652474	103.2

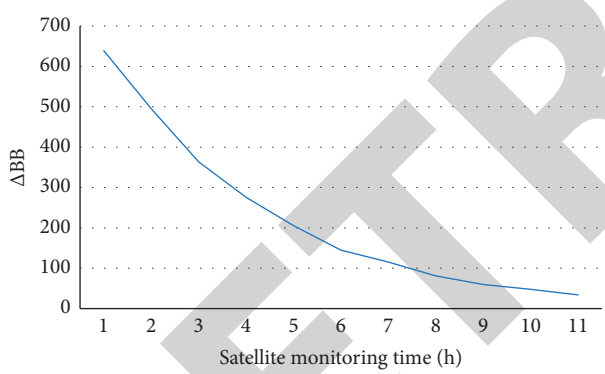

Figure 4: Modified relation for duration d in broadleaf forest.

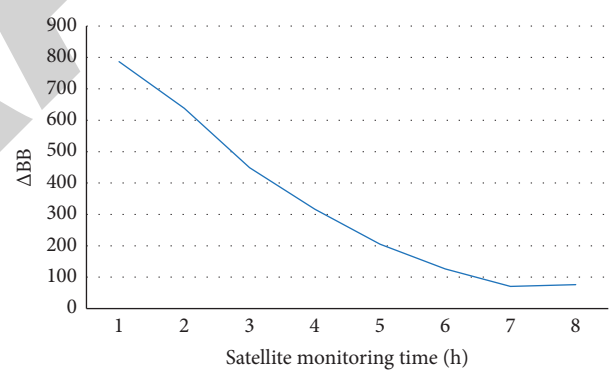

Figure 5: Modified relationship for coniferous forest duration.

($P = 0.0379 > 0.0001$), but by the significance of slope, it can be seen that there is a positive correlation between selection of maximum value of FRP and estimation error.

Similarly, a typical fire in broadleaf forest in 2003 was selected as an example to analyze influence of selection of the minimum FRP value on estimation accuracy. The maximum value of FRP and other parameters were kept constant, and only the effect of different minimum values of FRP on estimation results was analyzed. The minimum value was incremented by 10%, and each increment of forest burning biomass was calculated, resulting in two sets of data: incremental difference in FRP minimum ($FRP_{\max}$%) and incremental difference in forest burning biomass (ΔBB%) (see Table 5).

As shown in Figure 8, using two sets of data formed for incremental difference of FRP minimum ($FRP_{\max}$%) and incremental difference of forest burning biomass (ΔBB %), relationship equation was established, and the same model parameters were regressed using SAS statistical software; P value of slope was less than 0.0001, that is, independent variable was significant; however, intercept $P = 0.0331$, that is, the constant term was not significant ($P = 0.0331 > 0.0001$), but by the significance of slope, it can be seen that there is also a positive relationship between the selection of minimum value of FRP and estimation error.

Figure 9 visualizes differences and interannual variation of two methods for estimation of forest burning biomass in last 14 years. The dashed and solid lines show interannual variation trends of forest fire emission calculation model and curtain-law distribution-based method, respectively. From trends of three forest types, we can see that interannual variation patterns of two methods are obvious and can reflect fluctuation of forest burning biomass from year to year. The estimated burning biomass of three forest types in

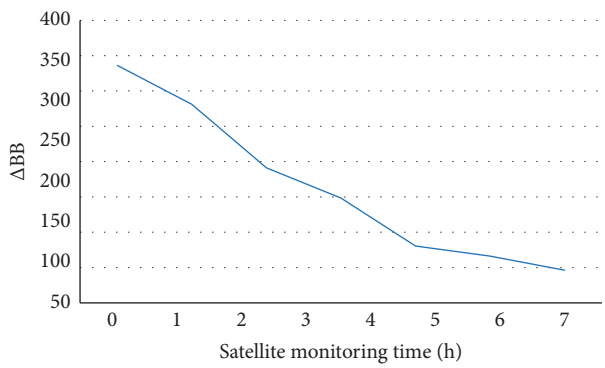

Figure 6: Modified relation for shrubland duration.

Table 4: FRP_{max} example data of effect of selection on estimation accuracy.

Time	M	FRP_{max}	FRP_{min}	BB (Tg)	ΔFRP_{max}, %	ΔBB, %
13.5	1.745	160.9	31	1180	0	0
13.5	1.745	176.9	31	1232	9	5
13.5	1.745	192.9	31	1230	21	9
13.5	1.745	208.9	31	1236	29	13
13.5	1.745	235.7	31	1365	61	24

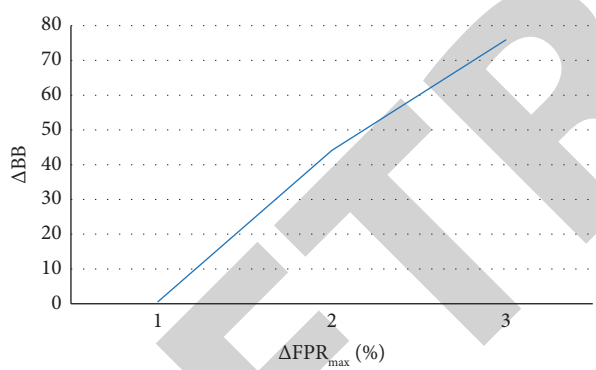

Figure 7: FRP_{max} effect on accuracy of estimated combustion biomass.

Table 5: Example data for effect of FRP_{min} selection on estimation accuracy.

Time	M	FRP_{max}	FRP_{min}	BB (Tg)	ΔFRP_{max}, %	ΔBB, %
13.5	1.745	160.9	31	1780	0	0
13.5	1.745	160.9	30	1523	9	5
13.5	1.745	160.9	32	1830	25	10
13.5	1.745	160.9	36	1836	32	20
13.5	1.745	160.9	34	1965	60	30

2014 based on the curtain-law distribution method is decreasing, which is in line with decrease or basically the same number of forest overfire area and occurrence in 2014 compared with 2013 as announced by National Bureau of Statistics (as shown in Figure 10); however, results calculated by forest fire emission calculation model are increasing,

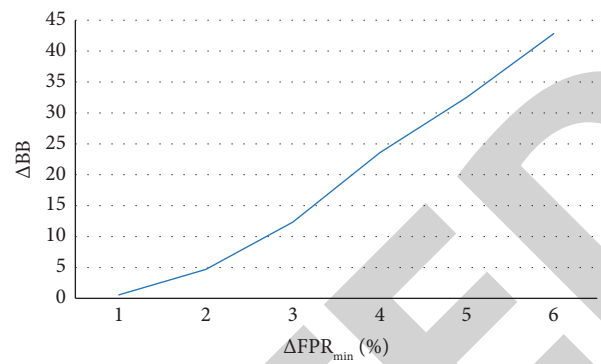

Figure 8: Effect on accuracy of estimated combustion biomass.

which indicates that the interannual variation pattern of estimated results based on the curtain-law distribution method is more consistent with the interannual variation of forest biomass consumed by forest fires in China which is more consistent with interannual variation of forest biomass. Secondly, interannual variation of the curtain-law distribution method fluctuates within the same order of magnitude, while the variation of forest fire biomass in some years is not within the same order of magnitude, and variation of forest fire biomass from millions to tens of millions of tons in adjacent years is not consistent with forest fire biomass consumption in China, according to the comparison of number of forest fires and fire area published by the National Bureau of Statistics.

In this paper, FRP of broad-leaved forest, coniferous forest, and shrub forest has the characteristic of curtain-law distribution, and forest burning biomass model was established by the forest type. The interannual variation of forest fire emission model and estimation of forest burning biomass based on curtain law distribution can be compared and analyzed, and it can be concluded that interannual variation of estimation results based on curtain law distribution fluctuates within the same order of magnitude, and the interannual variation pattern is consistent with characteristics of forest fires in China in past 14 years. However, interannual variation of forest fire emissions was several tens of times larger than the variation of adjacent years and even larger than 14-year total estimated based on curtain-law distribution (Figure 10). In addition, the problem of estimating annual forest burning biomass in large areas using the forest fire emission calculation model is that it is difficult to accurately obtain the annual fire site area, forest combustible load, and burning coefficient. It is difficult to survey the area of forest fire sites in large areas and for a long time, and it is also difficult to measure some high mountains. In addition, using the average of product of forest combustible load and burning coefficient instead of the actual value of two parameters for each year, estimation of forest burning biomass for a long time series often leads to large errors. In this paper, we use thermal infrared remote sensing to detect energy emitted from ground and curtain-law distribution of FRP of fire to build a curtain-law distribution-based estimation model by the forest type so as to estimate forest burning biomass in a large area and a long time series;

Figure 9: Interannual variation of burning biomass for three forest types. Note: subplots A, B, and C show comparison of interannual variation patterns of estimated burning biomass in broad-leaved forests, coniferous forests, and shrublands, respectively.

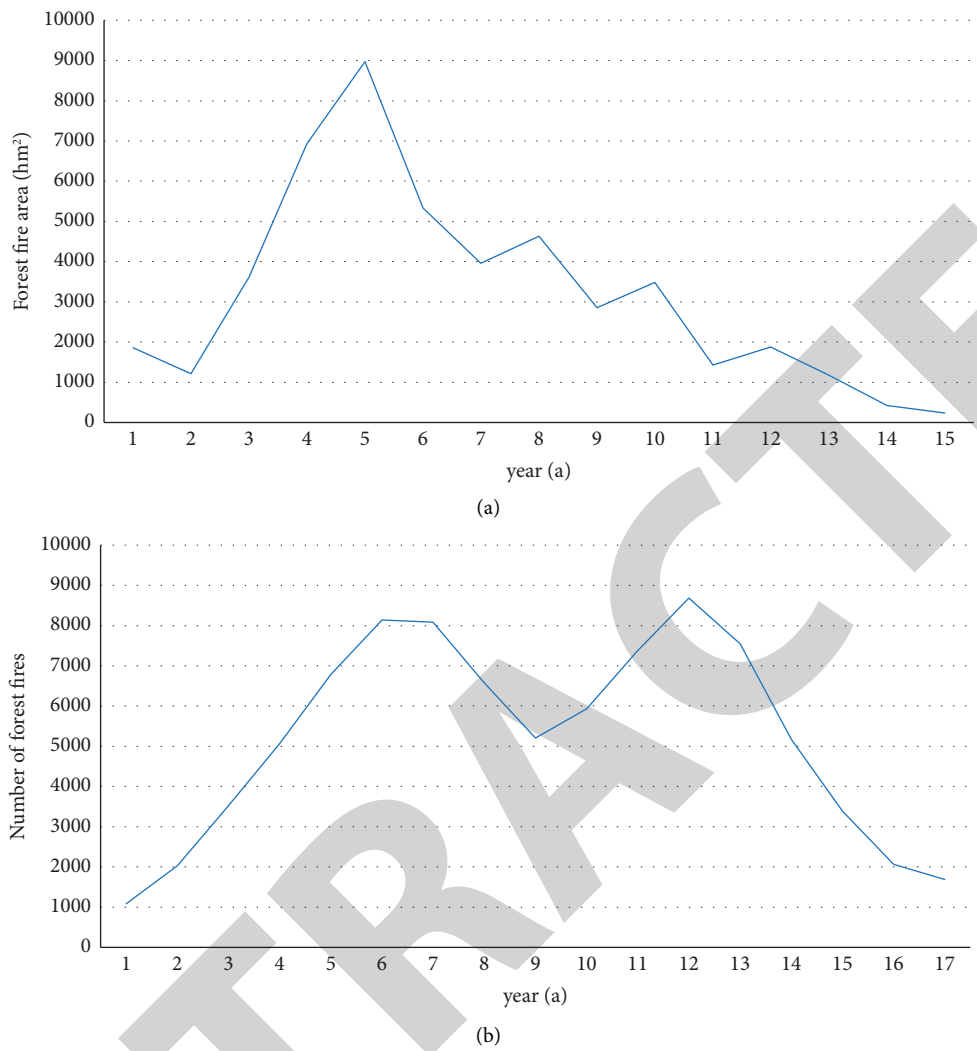

Figure 10: Interannual variation of forest fire data published by National Bureau of Statistics.

compared with parameter acquisition of the forest fire emission calculation model, parameters in the model are directly from satellite data, and no field survey is required. Compared with parameters of the forest fire emission calculation model, parameters in the model are directly derived from satellite data, which can reduce errors caused by human factors and save time and effort.

6. Conclusions

With development of satellite remote sensing technology and its applications, use of long time series of satellite fire monitoring product data to estimate forest burning biomass in large areas and to evaluate distribution patterns of spatial and temporal characteristics of forest fires nationwide provides a new and effective technical means. Therefore, in this paper, spatial and temporal characteristics of forest fires and estimation of forest burning biomass in a large area are investigated by using remote sensing data sources. Using spatio-temporal curtain law distribution characteristics of FRP, we established a model for estimating burning biomass of different forest types in a large area by broad-leaved forest, coniferous forest, and shrub forest, and accuracy of estimation results by using forest fire emission calculation model is more than 98%, which provides a real time and effective method for estimating forest burning biomass and evaluating the spatio-temporal distribution law of forest fires in long time and large area. The results were 98% accurate.

Data Availability

No data were used to support this study.

Conflicts of Interest

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

Acknowledgments

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Retraction

Retracted: Financial Default Risk Prediction Algorithm Based on Neural Network under the Background of Big Data

Mobile Information Systems

Received 19 September 2023; Accepted 19 September 2023; Published 20 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.

References

[1] T. Xie and J. Zhang, "Financial Default Risk Prediction Algorithm Based on Neural Network under the Background of Big Data," *Mobile Information Systems*, vol. 2022, Article ID 8743778, 11 pages, 2022.

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Research Article

Financial Default Risk Prediction Algorithm Based on Neural Network under the Background of Big Data

Tianheng Xie and Jianfang Zhang

Commercial College, Nantong Institute of Technology, Nantong 226001, Jiangsu, China

Correspondence should be addressed to Tianheng Xie; xietianheng@126.com

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With the macroeconomy entering a new normal, many new problems are exposed in all walks of life, and the risk of default in the financial sector is also being exposed at an accelerated pace. In the context of big data, internet finance, as an important part of the financial market, also faces many risks in the process of its rapid development. Reasonable, scientific, and effective prediction and prevention of financial default risk have become a key link in the process of risk management practice in the financial industry. Based on the powerful prediction function of the neural network, this paper combined neural network and chaos theory to construct a chaotic RBF neural network. It was applied to financial default risk prediction, which made the prediction accuracy and efficiency higher. The chaotic neural network solves the shortcomings of unstable prediction in the basic neural network and can comprehensively and accurately predict the financial default risk, so as to take measures to prevent risks. The experimental results of this paper show that the accuracy rate of the chaotic RBF neural network reaches 95%, while the accuracy rates of the BP neural network and the RBF neural network are 67% and 78%, respectively. Although the prediction accuracy of these two methods is also high, it is still not as high as the chaotic RBF neural network. Therefore, it is very meaningful to choose the chaotic RBF neural network to predict financial default risk in this paper.

1. Introduction

The combination of the internet and finance has greatly expanded the acquisition and sales channels of finance. At the same time, the support of advanced technologies such as big data and cloud computing can effectively alleviate the information asymmetry between the supply and demand sides of funds. The supply and demand sides of funds can be matched with higher efficiency. With the explosive development of the internet finance industry, in recent years, risk events such as internet financial default, illegality, and running away have erupted one after another. The healthy development of financial companies sounded the alarm. In a long time, internet finance will not replace banks with first-mover advantages and institutional advantages, but it can activate the financial market and promote competition in the financial market, and it is a useful supplement to the banking system. It can be foreseen that in the near future, banks will serve large and medium-sized enterprises and high-end net worth customers, while internet finance will serve the financial services of small and microenterprises and ordinary people. Over the years, the financial industry has actually greatly promoted the development of the social economy.

Financial risk is accompanied by default, and the occurrence of financial default will inevitably bring certain losses to investors and other stakeholders. At the same time, it also makes people realize its great harm as early as possible, and brings profound experience, lessons, and enlightenment to the stable operation of China's financial institutions in the future. Before financial risks occur, predictions can be made so that measures can be taken to improve risk prevention measures and formulate more correct economic policies. With this in mind, the purpose of this paper is to build a reasonable risk prediction model using neural networks. According to the data that people have, the decisive factors that affect the default value are found out, which provides a reference for the consumer finance company of internet finance to avoid excessive default. This is also the innovation

of this paper. The innovation of this paper is that it is not satisfied with the prediction ability of the neural network and integrates the chaos theory into the neural network, which makes its prediction ability more powerful.

2. Related Work

The default risk has become increasingly substantial as the financial industry has evolved in the setting of big data in recent years. Scholars are concentrating their efforts on lowering the danger of default. Mari C's research aimed to develop a predictive model for valuing businesses in the face of default risk and bankruptcy costs. This model might be used to design active debt management strategies that would steer corporations away from their capital structure targets while preserving debt capacity for future financing requirements [1]. Switzer et al. investigated the postfinancial crisis link between default risk and financial firm corporate governance. The credit default swap spread, for example, was used to assess default risk. The reduction in the default risk would help the stock market rebound in the postcrisis period [2]. Tian et al. discussed the counterparty's credit default risk dynamics of two positive collateral accounts reflected by the density process. He first divided the price process into three key parts and then used inverse stochastic differential formulas to describe the dynamics of each part [3]. People in Shen et al.'s survey looked into how two types of outside assistance affected operational and default risk for banks. The findings demonstrate that while government ownership decreases default risk and operational risk, it also raises operational risk [4]. Margaretic and Pouget looked at how a nation's ultra-financial performance affected the spreads on its sovereign bonds. Spreads on sovereign bonds indicate both tactical and economic default risk. He proposed that a nation's financial success decreased default risk by displaying a strong capacity for commitment [5]. Scholars discussed that financial default risk was a huge challenge for both companies and countries. Therefore, it is necessary to predict the financial default risk through prediction as a model, so as to better deal with the risk and reduce the cost. Scholars' views are very meaningful, but they do not illustrate the harm of financial default risk through practical examples.

Because neural networks are capable of self-adaptation and self-learning, they have a strong predictive function. In order to forecast the reaction, Pattnaik and Sutar research creates a novel computer prediction model. Because the model is based on chaos theory and artificial neural networks, it is referred to as an advanced artificial neural network model. It gets around the restrictions imposed by conventional artificial neural networks [6]. Ma et al. determine the energy usage of each gesture to create and train a prediction model. For anticipating gesture fatigue, artificial neural networks with long short-term memory, recurrent neural networks, and backpropagation neural networks are used [7]. Nishida et al. believed that machine learning models inherently memorized a lot of information, so in a cloud environment it was necessary to hide not only the prediction process, but also the trained model, and when using deep architectures such as CNN, the computational accuracy became worse when performing secret computations [8]. Effendy et al. found that artificial neural networks (ANNs), known as one of the artificial intelligence tools, were inspired by biological nervous systems and could accurately predict financial default risk. Artificial neural networks have high prediction accuracy for predicting financial default risk [9]. In response to the previous scholars' need to use a prediction model to preview the financial default risk, the above scholars proposed to use the neural network to predict the financial default risk and found that it has better prediction ability. So choosing a neural network is more appropriate. But scholars have no concrete experiments to prove this choice is correct.

3. Financial Default Risk Prediction Based on Chaotic RBF Neural Network

3.1. Financial Default Risk in the Context of Big Data. As a basic discipline, big data plays an important role in data development and analysis, internet of things, artificial intelligence algorithm training, and other fields. Big data will become an inevitable choice for traditional industries. The data era is coming, and the arrival of this era will make people's lives more colorful and personalized products and services will emerge in large numbers. This is both an opportunity and a challenge for traditional enterprises. Enterprises without big data thinking may be eliminated in this wave [10]. Searching for target users, providing targeted products and services, and precise marketing strategies all require the support of big data, and companies that have data advantages and can effectively use them will be in a leading position in this era [11]. The application of big data in the financial industry is shown in Figure 1.

As shown in Figure 1, the financial industry also needs to be digitized and combined with the internet, so that both the supply side and the demand side of funds can make better use of services. In this process, the traditional financial industry is internetized and internet platforms are used. The "long tail effect" of internet companies is also related to internet companies entering the financial industry [12]. This model can not only realize the "long tail effect," but also fully utilize technology like big data, cloud computing, and the internet. There are two statistical terms for the long tail effect. The "head" and "tail" of a normal curve are the projecting portion in the center and the comparatively flat portions on either side, respectively. The majority of people's needs will be centered in their heads, seen from the perspective of their needs. In Figure 2, default risk in finance is depicted.

As shown in Figure 2, numerous researchers have developed a range of financial default risk predictive models and approaches over the years, including trend analysis, discriminant analysis, regression analysis, and so on. Regression analysis is the most simple and easy to understand of all analysis models, and regression analysis has many variations. However, these algorithms are incapable of meeting real-world needs and lack self-adaptation and self-learning capabilities. Many researchers have used artificial

Figure 1: The application of big data in the financial industry.

intelligence technologies and updated algorithms to explore financial default risk prediction models in recent years [13]. An artificial neural network (ANN) is created by mimicking the dynamic human brain nervous system. The prediction impact of the artificial neural network model is more ideal than the classic univariate or multivariate prediction model, according to simulation trials.

The chaos theory has a good prediction effect on data prediction, so it is inspired by the wide application of many mixed models. Aiming at the wide application of the artificial neural network algorithm in recent years, combined with the advanced nature of the two, the hybrid model is produced by mixing the two algorithms together.

3.2. Basic Neural Network Prediction Principles. One of the most popular neural network models is the BP neural network, which is a multilayer feedforward neural network trained using the error backpropagation technique. A unique guided learning network is the BP neural network. A three-level forward propagation network is created by first setting the output value of each mode and then inputting the learned memory mode [14]. The final output value will be consistent with the expected value, thus ensuring the correctness of the network output. The three-layer BP neural network is shown in Figure 3.

As shown in Figure 3, the input vector and target vector must be provided during the model's training phase, and the network weights and thresholds must be updated based on the error performance. Finally, the model gets to the learning to imitate stage [15].

We assume that A is the model's input independent variable and that the model consists of n layers of neural networks [16]. The relationship between the input and output variables is represented by formula (1) if f stands for the functional connection between the variables' input and output.

$$R_i^m = f\left(S_i^m\right). \tag{1}$$

$$S_i^m = \sum A_{ij} R_i^{m-1}. \tag{2}$$

The error function is represented by the error e, which represents the sum of the squares of the difference between the actual output value and the target output value, and its expression is the following formula:

$$e = \frac{1}{2}\sum\left(R_i^n - c_j\right)^2. \tag{3}$$

In order to keep the actual output value close to the desired output value, this function calculates the minimum value of the error function.

The error aim can be achieved by minimizing the error function in the gradient direction using a nonlinear programming technique [17]. The error function is a nonfundamental function that finds use in a variety of fields, including semiconductor physics, statistics, probability theory, and partial differential equations. The updated amount ΔA_{ij} of its weight A_{ij} can be expressed by the following formula:

$$\Delta A_{ij} \infty - \varepsilon \frac{\partial d}{\partial A_{ij}}. \tag{4}$$

After the model has run several times, the error signal of the mth layer is changed in accordance with the direction of consistency [18] and is proportional to the error signal of the m-1st layer.

Additionally, the aforementioned operation process can show that the error function discovered by contrasting the actual output value obtained from the forward transmission of the independent variable's input data with the desired output value [19, 20] is the fundamental BP neural network transmission signal. After a succession of parameter changes, such as weights and thresholds, the error value is finally reduced to a given range. The following formula is used to determine the adjustment weight:

$$\Delta A_{ij} = -\varepsilon \frac{\partial e}{\partial S_j^m} R_j^{m-1}. \tag{5}$$

The error signal is also proven to be transferred from the input layer to the output layer.

The output value inside the error range is finally attained after several tweaks to the weights, thresholds, and other parameters of the BP neural network system.

The system will automatically stop learning and finish building the BP network model at this point. Thresholds are also called critical values, which refer to the lowest or highest value that an effect can produce. It is the same as the following formula:

$$A_{n+m+k} = f_k(a)A_{n+m} + f_{k+1}(a)A_{n+m} + \ldots + f_{k+m}(a)A_{n+m}, \tag{6}$$

m is the number of input neurons of the neural network.

The financial default risk is divided into two parts in chronological order, the former part is larger than the latter

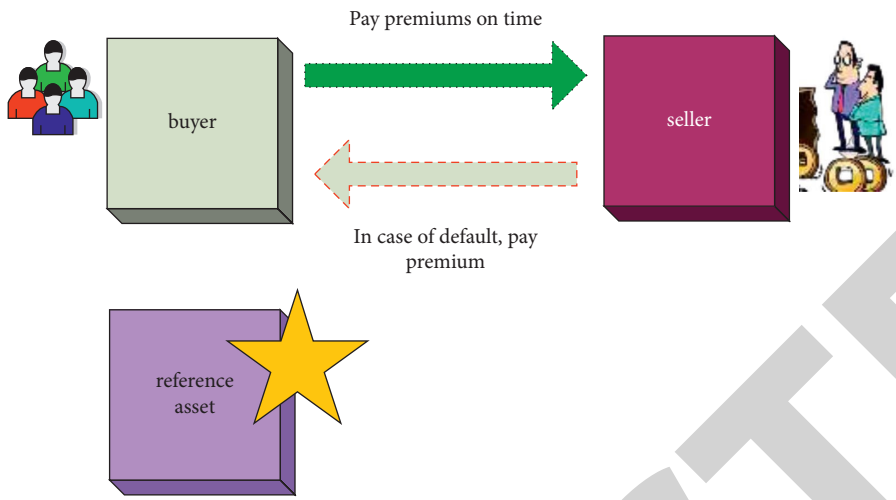

Figure 2: Default risk in finance.

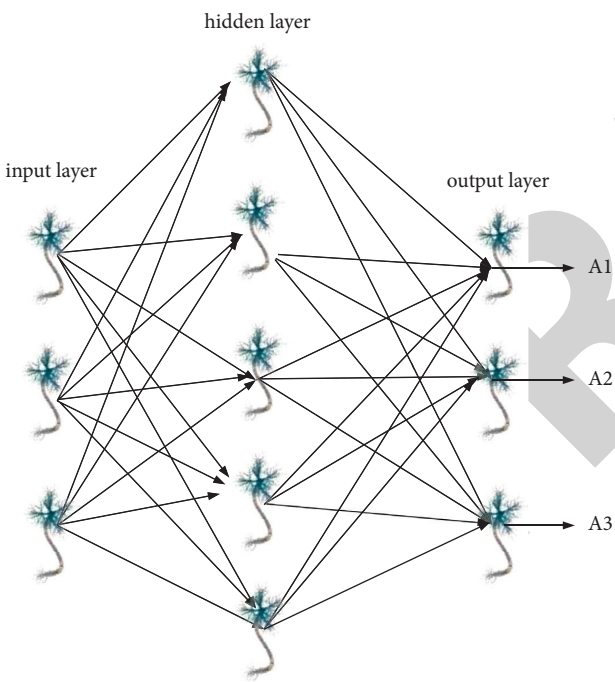

Figure 3: Three-layer BP neural network.

part, and the data volume of the former part is twice the data volume of the latter part. It can be known from the nonlinear characteristic formula (7) of the neural network:

$$f_i(a)\,(i = k, k+1, \ldots, k+m), \tag{7}$$

$f_i(a)$ is not necessarily a constant coefficient but a nonlinear function with the input variables of the prediction network as independent variables. Therefore, the neural network prediction model is a nonlinear autoregressive model such as the following formula:

$$\hat{A}_{n+m+k} = f_k(a)A_{n+m} + f_{k+1}(a)A_{n+m} + \ldots + f_{k+m}(a)A_n. \tag{8}$$

The nonlinear autoregressive model is an important model in time-series analysis, and it is closely related to practical applications. The prediction error is the relative error as formulaas follows:

$$\delta = \frac{\left(\hat{A}_{n+m+k} - A_{n+m+k}\right)}{A_{n+m+k}}. \tag{9}$$

The training process of the neural network is the process of reaching the global minimum value, and it is also the process of establishing the prediction model, which is driven by sample data.

3.3. Radial Basis Function (RBF) Neural Network Prediction Algorithm. Some researchers have studied financial default risk prediction in the financial industry using RBF radial neural network in order to further increase the accuracy of the prediction. In order for the input vector to be directly transferred to the hidden space without the requirement for a connection through weights, the RBF neural network uses RBF as the hidden unit to create the hidden layer space, by combining the chaos theory and the RBF neural network.

The RBF neural network is made up of three layers, each with its unique set of properties that may be distinguished from the others. The input layer is primarily made up of perceptual neurons, and its primary job is to connect input variables and internal neurons so that varied information can be transmitted. It is only here to help with network buffering and connection speed. As a result, multiple input variables can be conveyed to the neurons in the buried layer. Figure 4 depicts the RBF neural network.

The processing capacity, and the mapping and function approximation skills, will be considerably enhanced if the network contains a large number of neurons in the hidden layer, as shown in Figure 4. The same good fitting result can be attained for the system identification of the system with weak nonlinearity and simple input and output waveforms even when there are few neurons in the hidden layer. However, the spatial dimension also increases with the

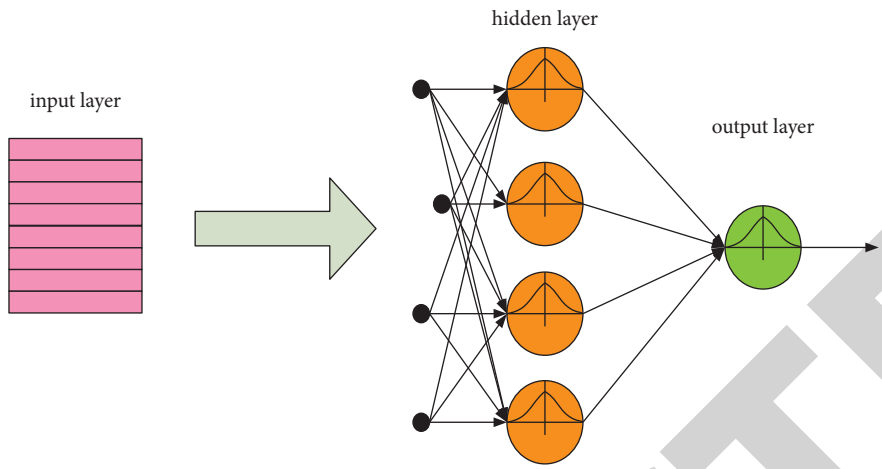

Figure 4: RBF network structure diagram.

number. Since the spatial dimension is closely dependent on the performance of the network, the complexity will be greatly improved. In practical use, if more neurons in the hidden layer are used, it will cause excessive dimensionality, which will eventually lead to a higher generalization ability of the network.

Among them, A_p represents the sample space, $a_1, a_2, \ldots, a_n$ is the input sample data, and the network output layer selection function is represented by F, that is,as follows:

$$F(a) = \sum_{i=1}^{N} w_i \phi\left(\left\|a - c_i\right\|\right) \tag{10}$$

$\|a - c_i\|$ represents the norm, mostly in the form of Euclidean norm, and w_i is the weight vector. The radial basis kernel function has the following forms:

The Gaussian kernel function is the following formula:

$$\varphi(a, c_i) = e^{\left(\frac{-\left\|a - c_i\right\|^2}{\sigma_i^2}\right)}. \tag{11}$$

It is denoted by the breadth of the hidden layer neuron basis function in the formula.

The Gaussian kernel function is the most popular linear basis kernel function. The data are mapped to a high-dimensional space by the Gaussian kernel function, which makes it easier to discern between the data. The output response of the network's ith hidden layer node is expression (12) if the chosen basis function is a Gaussian function.

$$b_i^2(a_k) = e^{\frac{-\left\|a - c_i\right\|^2}{\sigma_i^2}}. \tag{12}$$

In the formula, the superscript of $b_i^2(a_k)$ is the hidden layer of the network, n is the number of neurons, and the central dimension is similar to the input variable. a_k is the kth input variable, and i is the width of the Gaussian function.

In general, Euclidean metric is referred to as Euclidean distance. The "ordinary" (i.e., straight line) distance between two locations in Euclidean space is what mathematicians refer to as the Euclidean distance or Euclidean metric. Since the feature of the radial basis function is local amplification, as long as the Euclidean distance is small, the probability of the corresponding neuron being activated will be higher, and the probability of the corresponding neuron being activated will be higher. The larger the corresponding output, the larger the distance, and the smaller the output. The output of the corresponding output layer of the RBF neural network is the following formula:

$$b_i^2(a_k) = \sum_{i=1}^{n} w_{iq} b_i^2(a_k) + b_q. \tag{13}$$

In the formula, $b_i^2(a_k)$ is the output value of the output layer of the RBF neural network, and w_{iq} is the weight of the neuron.

3.4. Chaos RBF Neural Network Prediction Model. Chaos discrimination can determine the influencing factors of a phenomenon, and without considering all factors, it is more appropriate to choose a specific reference standard to build a model, thereby simplifying the range of factors. Therefore, the judgment of chaos provides important information for the modeling and prediction of system phenomena. The chaos theory is an important theoretical basis for the study of nonlinear disciplines. It seems uncertain but has laws to follow, and it seems disordered but orderly.

The Lyapunov exponent is the measure of the chaos in an n-dimensional system. The numerical feature of the average exponential divergence rate of adjacent trajectories in phase space is represented by the Lyapunov exponent. It is one of the features of a number of numerical values used to identify chaotic motion, also known as the Lyapunov characteristic index, which helps to improve the Lyapunov index's content. The order of all exponents is descending, the result is $\lambda_1, \lambda_2, \ldots, \lambda_n$, then λ_1 is called the largest Lyapunov exponent, and λ_1 reflects the state evolution process of the chaotic system. If the separation speed between two adjacent orbits and the distance between them obtained after n iterations is exponential, that is,

$$d(0)e^{n\lambda_1} = |B(i+n) - B(j+n)|, \tag{14}$$

$d(0)$ represents the initial distance between the two. $\lambda_1 = 0$ corresponds to a stable boundary, and the initial error keeps the original state unchanged; $\lambda_1 = 0$ indicates that the phase space volume of the system is in a shrinking state. λ_1 represents the largest predictable time scale, as is in the following formula:

$$T = \frac{1}{\lambda_1}. \tag{15}$$

That is, when the time predicted in advance is less than T, the predicted object belongs to the predictable range.

Phase space reconstruction is one of the well-established methods to study the chaotic structure, and it is a method to reconstruct the attractor based on limited data to study the dynamic behavior of the system to introduce the knowledge of phase space reconstruction. Given the chaotic time series, a smooth map must be found on the attractor that satisfies the following formula:

$$B(t+1) = F(B(t)). \tag{16}$$

$B(t)$ is an m-dimensional vector, which is the following formula:

$$B(t) = (S(t), S(t+\tau), \ldots, S(t+(m-1)\tau)). \tag{17}$$

The RBF neural network is used as the fitting function in this paper, according to the phase space reconstruction prediction model.

The RBF neural network's input layer has M nodes.

The Gaussian kernel function is chosen as the most often utilized radial basis function, as illustrated in formulaas follows:

$$\varphi(a, c_i) = e^{\left(\frac{-\|a - c_i\|^2}{\sigma_i^2}\right)}, \; i = 1, 2, \ldots, n, \tag{18}$$

i is the width of the hidden layer neuron basis function. $i = 1, 2, \ldots, n$ is set as the input of the RBF network, and the hidden layer is fully connected with the input layer.

4. Prediction Experiment of Financial Default Risk Based on Neural Network

4.1. Investigation of Financial Default Risk. The rapid development of internet finance is affecting and changing people's living habits, especially the rise of major internet finance in the past two years, which has set off a wave of internet finance entrepreneurship. But at the same time, any new things will have a series of twists and turns. Due to some characteristics of internet finance itself—weak management, a series of problems have also appeared in credit risk, resulting in an increasing probability of default.

With the advent of the era of big data and the maturity of neural networks, the competition among the major internet has also become more and more fierce. Good technology can improve all kinds of business, carry out effective promotion, and reduce risk at the same time. Therefore, the neural network has also become the core application of many internet finance. The development of the financial industry in recent years is shown in Figure 5.

As shown in Figure 5, in recent years, internet finance has achieved rapid development, and various financial platforms have continued to emerge. But it also creates a lot of default risk. Default risk refers to the possibility that the platform and the financier's default behavior will lead to the inability of investors' funds to be safely recovered, thus affecting the smooth operation of the platform.

Compared with traditional financial institutions, internet finance has a greater risk of default. The development of the internet finance industry from 2015 to 2019 is shown in Table 1.

As shown in Table 1, although the development of the internet financial industry is getting better and better from 2015 to 2019, the default risk is the biggest challenge facing the healthy operation of internet financial platforms.

Financial violations and defaults seriously threaten the reputation of the industry and trigger other risk events, which seriously damage the legitimate rights and interests of financial consumers. The default situation of the internet finance industry from 2015 to 2019 is shown in Figure 6.

As shown in Figure 6, in 2015, many internet financial platforms had default problems. For example, many platforms with assets of tens of billions of dollars had problems of fund redemption. In 2016, the funds involved in the default of internet finance reached as much as 300 billion yuan. Therefore, it is very important to predict and prevent financial default risks.

4.2. Error Conditions of the Three Methods. Using MATLAB7.0 to train a BP neural network, the model can converge after a series of iterative operations during the BP neural network model sample training process.

The training samples' convergence is due to the weight vector's components flowing in the direction of decreasing gradient, as is illustrated in Table 2.

The financial default risk model has essentially converged when the number of iterations approaches 70, as shown in Table 2. As a result, the number of iterations is set at 70.

The BP neural network model offers several advantages in predicting financial risk, few limits on the study sample data, self-learning, and self-adaptation capabilities, and a wide range of applications. The ease with which a local optimum can be reached, the lengthy operating time, and the poor prediction accuracy are still problems. To solve the shortcomings of the BP network, the chaos theory is added into the RBF neural network, and the model's input and initial parameters are tuned. The upgraded RBF neural network greatly enhances financial default risk prediction accuracy.

Figure 7 shows the results of three approaches used to estimate the values from 2015 to 2019.

According to Figure 7, the accuracy rate can reach 95%, and there is very little deviation between the simulated

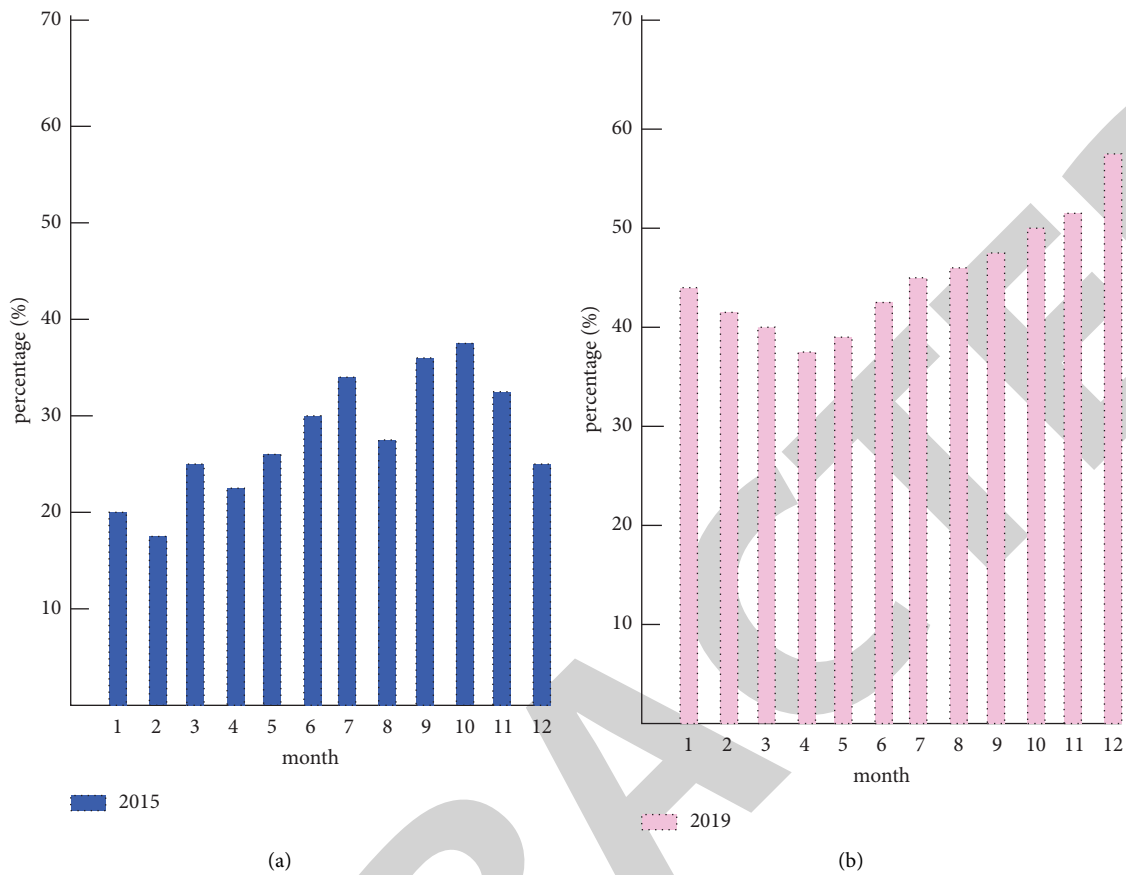

Figure 5: Comparison of the development of the financial industry in 2015 and 2019. (a) Development of the financial industry in 2015. (b) Development of the financial industry in 2019.

Table 1: Development of the internet finance industry from 2015 to 2019.

Year	Number of financial participants (billion people)	Average number of borrowers per month 10,000 people	Number of borrowers (10,000 people)	Monthly turnover (100 million yuan)
2015	4.88	299.36	22.65	667.89
2016	5.56	287.80	29.96	1077.65
2017	6.75	300.51	37.90	2023.46
2018	7.32	270.95	45.55	3178.87
2019	7.71	357.62	80.98	3975.58

output result and the real goal number. It has been established that the chaotic RBF neural network model provides a more accurate method and model parameter configuration for analyzing financial default risk. RBF is very accurate and has good adaptive learning capabilities. The example prediction demonstrates how much more accurate the model developed in this study is and how it can accurately reflect the expected amount of financial default risk.

Based on a thorough assessment of the three forecasting techniques, it can be seen that the three models established in this paper have certain effects on the forecasting of financial default risk. Compared with the BP neural network and the RBF neural network, the chaotic RBF neural network is more effective in default risk prediction, and the accuracy rate is relatively high when using the test set for testing.

4.3. Prediction Ability of Chaotic RBF Neural Network. Based on the superiority of the RBF neural network as a kernel function, this paper replaces the weighted chaotic local model, transforms the phase space reconstruction model, and empirically verifies that financial data have chaotic characteristics, and can also be reconstructed by the phase space reconstruction prediction model. The prediction data lay the foundation for the establishment of the mixed model.

The data selected in this paper are the financial indicator data from 2015 to 2019, and the range standardization method is used to normalize the data here, that is, as follows:

$$B_{ij} = \frac{A_{ij} - \min A_i}{\max A_i - \min A_i}, \tag{19}$$

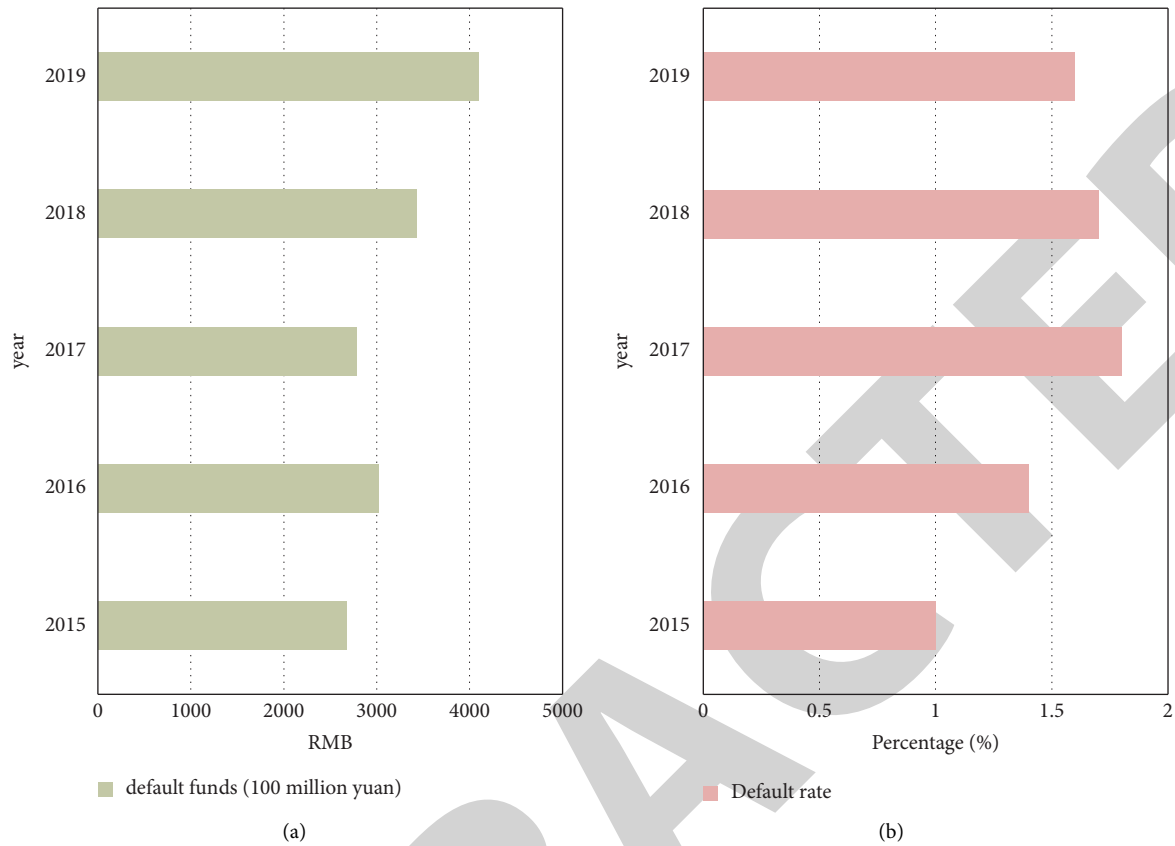

Figure 6: Defaults in the financial sector 2015–2019. (a) Default amount in the financial industry in 2015–2019. (b) Default rate in the financial industry in 2015–2019.

Table 2: BP neural network model sample training.

Number of hidden nodes	Number of iterations	Target accuracy
10	452	0.65
20	410	0.69
30	387	0.75
40	365	0.73
50	321	0.72
60	287	0.77
70	255	0.76

i stands for the ith early warning indicator of financial danger, and j stands for the year in the calculation. To acquire a broad picture of the data, effective data preparation is crucial. The range normalization method is primarily used in this study for this reason.

Data from 2015 to 2019 are used as training data for the RBF neural network and input data. The data are sent into the RBF neural network based on the normalized data. Figure 8 displays the predictions made using the chaotic RBF neural network prediction model.

According to Figure 8, the dataset is first classified using a neural network, and its predictions are then made using a phase space reconstruction model. The neural network is integrated into the phase space reconstruction prediction model, which is implemented using MATLAB software, in the empirical analysis of the chaotic RBF neural network prediction model. There is little variation between the forecast findings and the predicted value. According to the classification of financial risk status, the financial risk status is divided into four areas: safety, basic safety, vigilance, and danger. People use the chaotic RBF neural network to predict and analyze the financial risk situation in 2016. The predicted risk status represents the value-at-risk situation of the indicator in 2016. The prediction results are shown in Table 3.

Through a comprehensive analysis of the forecast data in Table 3, due to the constraints of external debt burden, stock market inflation, and other factors, the basic situation of financial default risk this year can be obtained, and it is necessary to be vigilant. According to the obtained financial risk status, the decision-making level takes corresponding measures.

4.4. Measures to Address Financial Default Risk

4.4.1. Strengthen the Depth and Breadth of the Borrower's Credit Status Investigation. In terms of borrowing purposes, financial platforms should adopt different charging standards for different purposes. Those borrowers who borrowed for travel, buying a car, etc. are more likely to be default. At present, few platforms pay attention to the use of borrowers, but the use of loans is actually related to the repayment ability of borrowers. Therefore, the platform should conduct

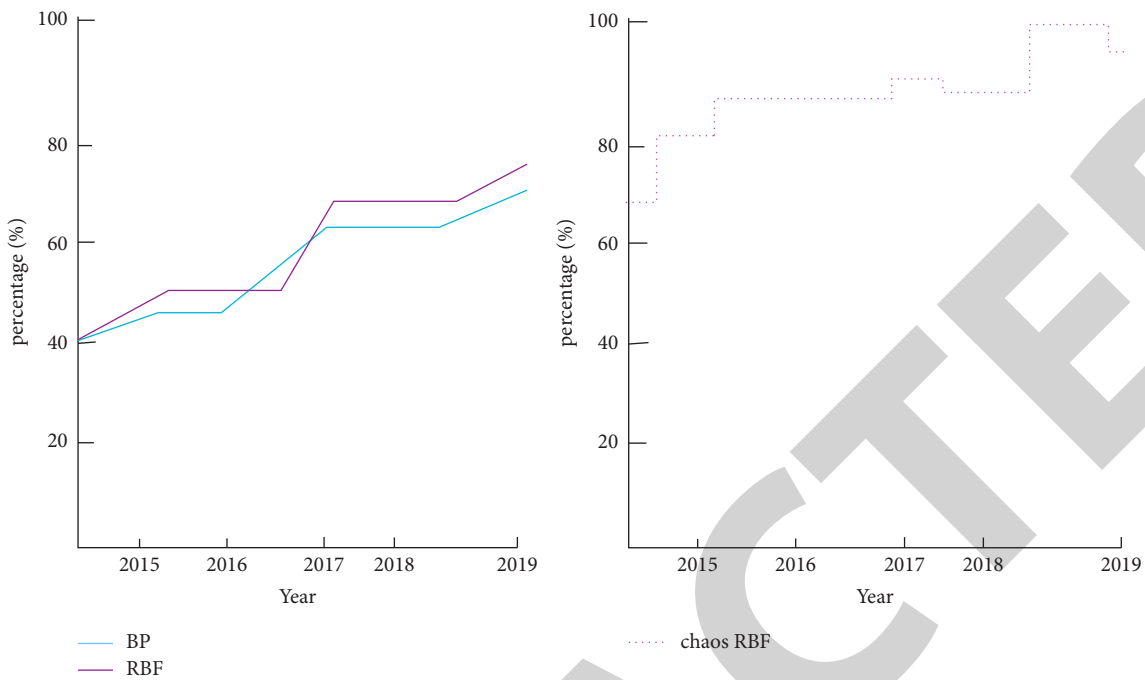

Figure 7: Comparison of the prediction accuracy of the three methods.

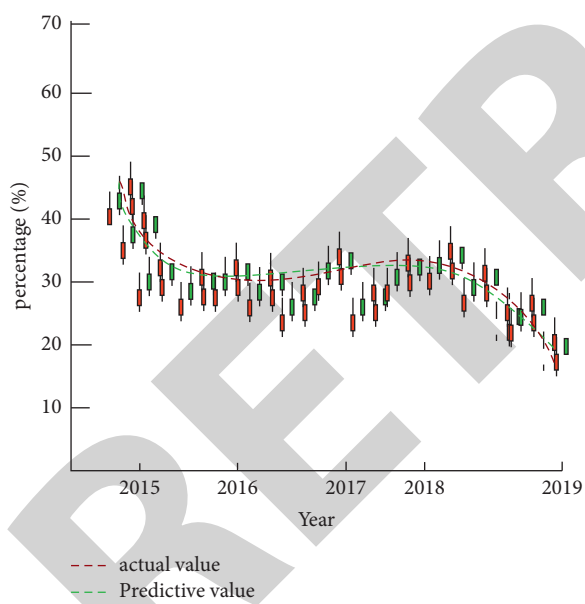

Figure 8: Prediction result graph processed by the chaotic RBF neural network prediction model.

a detailed investigation on the purpose of borrowing, establish different charging standards for different purposes, and even require the borrower to provide collateral with the corresponding value, so as to reduce the possibility of the borrower's default. Zhaocaibao platform needs to take a variety of ways to improve the risk identification ability of investors. The professional knowledge of investment should be educated, so that investors have a certain ability to analyze and judge the credit information provided by the borrower.

Table 3: The risk value of this indicator in 2016.

Predict	Growth rate of borrowers (H1)	Growth rate of loan amount (H2)	Default rate (H3)
2015 input	0.16	0.23	0.11
Expected output	0.054	0.046	0.063
Actual output	0.056	0.044	0.062
Forecast for 2017	0.055	0.045	0.061
Risk status	Safety	Danger	Alert

4.4.2. Improve the Design of Platform Risk Management Mechanism. At present, under the circumstance that the financial platform cannot guarantee itself, it is necessary to establish a more perfect default risk management mechanism. Financial platforms can cooperate with insurance companies when credit information is not perfect and information is not transparent. Under the circumstance that the guarantee company has a high leverage ratio, the insurance company has a good risk pricing ability, which helps the financial platform to better ensure the safety of investors' funds, and also can increase the platform's own credit. The basis of risk analysis is data. Although the financial platform has the advantage of data with the help of the e-commerce platform, it is still lacking in terms of the borrower's credit data, and the authenticity of the data needs to be examined. Therefore, the financial platform can establish a wider credit cooperation mechanism, fully cooperate with other platforms, deeply explore the risk points of borrowers, and then, adopt a more effective risk avoidance mechanism.

5. Conclusions

With the development of big data, people's financial activities on the internet are becoming more and more frequent, which greatly promotes the development of the financial industry. But at the same time, the risk of default is getting higher and higher due to the online lending and borrowing transactions. Therefore, predicting the risk of financial default so as to prevent it in time is what needs to be studied at present. According to this study, a BP neural network can be used to forecast the probability of financial default. The neural network is quite good at forecasting. The typical BP neural network has a number of shortcomings; thus, this research introduced the RBF neural network and applied the chaos theory to overcome some of them. In order to demonstrate that the chaotic RBF neural network suggested in this research was superior than the other two methods, this paper compared the prediction capabilities of the chaotic RBF neural network presented in this paper to the other two strategies in the experimental section. The findings show that the chaotic RBF neural network predicts more accurately and has a greater ability than the BP neural network and the RBF neural network. So it is very feasible to apply it to the prediction of financial default risk. However, this paper only proposes to solve the problem of financial default risk based on the knowledge it has mastered, and its scientificity and rigor need to be verified in future work. The author will continue to make progress and do more comprehensive work in the future work.

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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Research Article

The Construction Method of Historical Geographic Information System Based on Mobile Network

Jiangtao Bai[1,2] and Wei Pan[1,3]

[1]*School of History & Archives, Yunnan University, Kunming 650091, Yunnan, China*
[2]*Xi'an Map Publishing House Co., Ltd, Xi'an 710054, Shaanxi, China*
[3]*Key Laboratory of Terrestrial Surface Pattern and Simulation, Institute of Geographical Sciences and Resources Research, Chinese Academy of Sciences, Beijing 100101, China*

Correspondence should be addressed to Wei Pan; geodata@snnu.edu.cn

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The research of historical geography is inseparable from the construction of historical geographic information systems, but the traditional construction method of historical geographic information systems has certain technical defects in the storage, management, analysis, and data sharing of historical geographic data. Therefore, more innovative and advanced construction methods of historical geographic information systems are needed to continuously improve the construction of historical geographic information systems, to promote the development of historical geographic information research. In contemporary society, a more excellent historical geographic information system construction method is inseparable from the support of science and technology. With the continuous development of science and technology, mobile network technology has emerged. As a combination of mobile communication and the Internet, mobile network has strong functional advantages. It has developed rapidly in recent years and has great market development potential. This paper aims to study the construction method of historical geographic information systems based on mobile network. Combined with the data collection algorithm of mobile network, the historical geographic information system construction experiment was carried out. The experiment concluded that the information integrity of the historical geographic information system constructed based on the mobile network is 18.2% higher than that of the historical geographic information system constructed using traditional methods. This shows that mobile network technology has a certain positive effect on the construction of historical geographic information systems.

1. Introduction

Historical geographic information system is an information system that can integrate all kinds of information and resources related to history and geography for visual display. In the research of historical geography, the information data support provided by the historical geographic information system is inseparable. Therefore, the construction of a historical geographic information system is an indispensable part of historical geographic research. However, due to the lack of technology in the traditional historical geographic information system construction method, there are problems in data analysis and sharing in the construction of historical geographic information systems. This is not conducive to the development of historical geography research. Therefore, for the research of historical geography, more innovative and technologically superior methods of constructing the historical geographic information system are needed. It promotes the continuous improvement of the historical geographic information system, thereby promoting the development of historical geographic research. With the continuous progress of today's science and technology, there are increasing technologies and methods that can help the construction of historical geographic information systems. For example, the mobile network is the product of the combination of mobile communication and the Internet, and it is an innovative wireless network service technology. Mobile communication technology realizes the

desire to communicate with each other without being limited by time, space, and place. The Internet enables people to easily access massive network resources and conduct network communication anytime, anywhere. Therefore, the mobile network, which combines the two, has powerful functions of network communication and network resource acquisition at the same time. Today, with the proliferation of mobile terminal devices including cell phones, PDAs, or other portable tools, mobile networks do not require desktop computers. This makes it possible to directly connect to the public network without the need for a fixed connection device, to meet people's more convenient Internet access needs. In recent years, the development of mobile networks has become increasingly rapid. It has been widely used in increasing industries and has good market development potential.

The innovations of this paper are as follows: (1) it discusses the construction method of historical geographic information system in combination with mobile network technology; (2) it combines the data collection algorithm of mobile network to carry out the construction experiment of historical geographic information system based on traditional construction method and mobile network technology, respectively. It also draws effective conclusions through the comparison of the information integrity test results of the two construction systems.

2. Related Work

Many researches related to mobile networks have also emerged in the academic world today. Among them, Zhang et al's research improves the flexibility and capacity of network resource allocation in mobile network slicing by exploring effective resource allocation schemes. They proposed a scheme to manage the mobility between different access networks [1]. Chen et al.'s research mainly focuses on the security access problem of mobile networks. In their own research, they proposed a batch identification game model in wireless mobile networks that can improve the security and encryption performance of mobile network login authentication [2]. The study by Prados-Garzon et al. proposes a theoretical framework to evaluate long-term evolution virtualization management techniques for mobile networks. They also verified the effectiveness of the framework through mathematical model simulations [3]. Pérez et al.'s research proposes a 5G network-oriented solution to the problem of botnets affecting the continuity of mobile network services. They also verified through experiments that the scheme can detect and mitigate the threats caused by botnets on mobile networks [4]. The study by Cao et al. proposes a device-to-device communication-assisted mobile traffic offloading scheme. They effectively increase mobile network capacity and mitigate traffic by offloading traffic and utilizing complementary network communication technologies [5]. Zeng et al.'s research proposes an adaptive scheduling mechanism based on self-similarity to improve mobile network connectivity. They also verified the effectiveness of the mechanism through a large number of tracking-driven simulation experiments [6]. These studies are closely related to mobile network technologies, which provide a method and technical references for the research of this paper.

3. Construction Method of Historical Geographic Information System

3.1. Mobile Network

3.1.1. Concept. In a broad sense, mobile network refers to the combination of mobile communication and the Internet, using laptops or other mobile terminals to access the mobile network to provide users with mobile communication services and Internet services. In a narrow sense, it refers to the use of smart phone terminals [7]. Contemporary mobile Internet access devices, such as smart phones, tablet computers, and other portable terminal devices, all obtain information resources required by users in real time through wireless networks such as GPRS and WiFi. With the development of mobile networks, the coverage and popularity of wireless networks such as GPRS and WiFi have been continuously improved, and the application of mobile terminal equipment has also been continuously developed. These favorable conditions greatly improve the mobile network application experience of users who use mobile terminal devices to surf the Internet. Therefore, increasing Internet users begin to use mobile devices and mobile networks to access any network anytime, anywhere to obtain the information they need [8]. The mobile network mode is shown in Figure 1.

As a well-known network technology, traditional network also occupies a large share in the market. The Internet technology used in many homes and offices is the traditional wired network technology. The traditional network generally refers to the applied Ethernet, which is a wired network. It is highly coupled, centrally controlled, and difficult to manage, which is the representative of the traditional wired network. It is shown in Figure 2.

After entering the twenty-first century, the rapid development of information networks is not limited to the well-known traditional wired network, but to a more comprehensive technology. The rapid development of more flexible wireless mobile networks enables users to truly enjoy convenient, efficient, and fast mobile network services [9]. The reason that the mobile network occupies a large position in the current market is closely related to its own advantages. First of all, the mobile network can well solve the insurmountable difficulties such as the long-distance distribution of the traditional network and the inconvenience of network connection and wiring in multiple regions. Secondly, in the construction of campus network, the use of mobile network can realize resource sharing and unified management among multiple campuses. It can also easily and quickly establish virtual classrooms, electronic libraries, and data centers for classrooms and students at any time and anywhere in the school and provide users with convenient and instant Internet access services [10]. And compared with the traditional network, the mobile network also shows unparalleled superiority. For example: mobile network usage costs are lower. It can be moved between APs at will, eliminating the

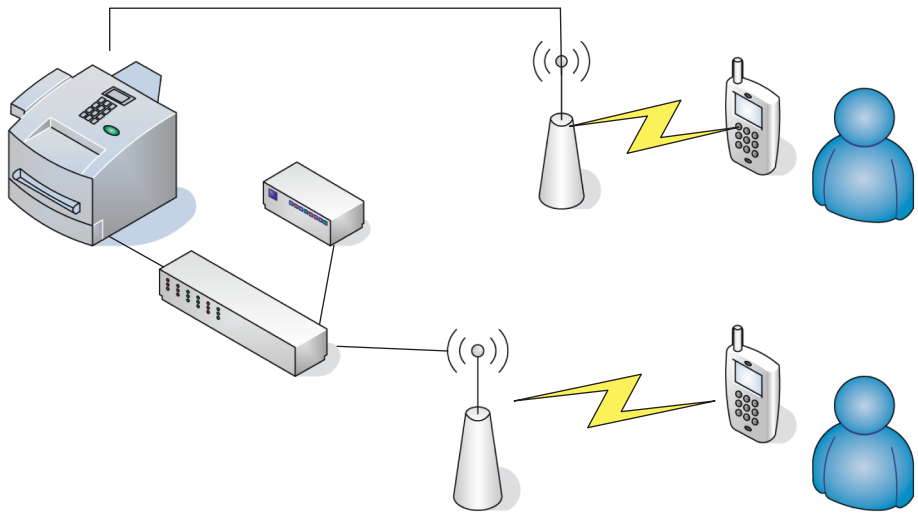


Figure 1: Mobile network mode.

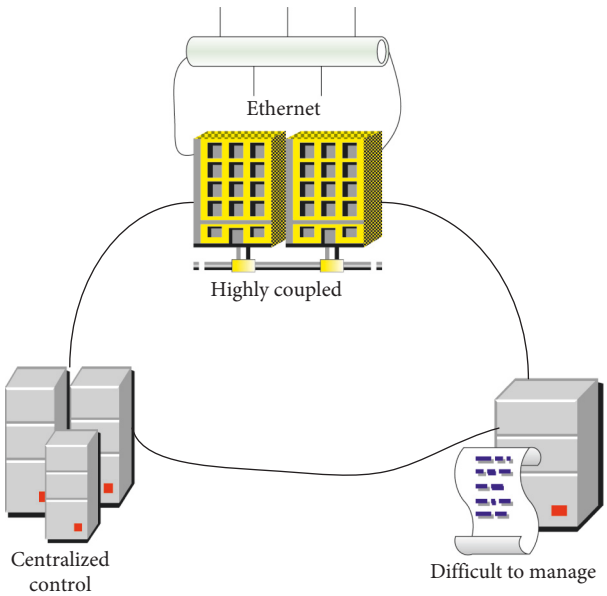


Figure 2: Traditional network characteristics.

time and installation costs associated with a lot of traditional network cabling. The use of mobile network is unrestricted, and it can be used with a mobile phone, which can flexibly adjust and update the network configuration. This makes network usage independent of time and place. The use of the mobile network is targeted, and in the process of transmitting information, the information required by the user is transmitted to the user's mobile phone terminal through the mobile network, and the service is more proactive and targeted for the user. It is foreseeable that the mobile network service technology will have a better development prospect in the future [11]. The comparison between mobile network and traditional network can be shown in Table 1.

3.1.2. Key Technologies. The key technology of mobile network is cache. With the rapid development of mobile networks, the caching technology of mobile networks has been upgraded to in-network caching. On the one hand, in-network caching can effectively reduce network latency and improve user experience. On the other hand, it can also reduce the redundant transmission of traffic in the network and the occupation of network resources. In-network caches of current mobile networks mainly include core network caches and base station caches. These two caching technologies are representative differences between mobile networks and traditional network caching technologies and can easily distinguish traditional wired networks and mobile wireless networks to a certain extent. The core cache refers to the cache in the centralized network architecture of the mobile network. The network architecture is mainly composed of network elements such as mobile management equipment, service gateway, and packet data gateway. The core cache reduces the network transmission traffic and the response time of user requests to a certain extent and can efficiently cache the content on the user terminal. The base station cache is the cache in the mobile network base station. Base stations are an important part of mobile networks. Its main function is to improve the network access and service request interface for users and realize network data interaction. The mobile network base station is the closest to the user and can realize direct communication with the user. Therefore, the base station cache can effectively reduce the user's request delay and can also reduce the traffic transmission generated by forwarding user requests and data responses in the mobile network, thereby reducing the network load. Base station caching plays an important role in reducing network operating costs and reducing network congestion.

Although the key technologies of mobile network caching play a significant role in reducing data transmission delay and network traffic load, these technologies still have certain problems and challenges. There are mainly problems in cache resource management, content security, and channel interference. With the popularization of mobile network applications and the continuous increase of users,

Table 1: Traditional and mobile networks.

		Traditional network	Mobile network
Functions and features	Mobility	cannot move around	Can move randomly
	Convenience	Wiring required	Solve wiring difficulties
	Economy	High cost	Save costs
	Flexibility	Restricted	Unrestricted
Terminal type		Single PC	Rich and varied

the data traffic generated by the mobile network is increasing. These increasing amounts of traffic data not only require sufficient cache space, but also require extremely high network bandwidth to transmit it to the network edge or cloud for processing. Therefore, how to achieve efficient allocation and management of cache resources has become a difficult problem that must be overcome. For both traditional networks and mobile networks, user privacy and security have always been the most important issue for users. The traditional network has a relatively strict security protection mechanism, and the security is relatively high. However, due to some deficiencies in content encryption in the mobile network in network cache, there are certain challenges to strictly ensure the security of user privacy data cached in the mobile network. Finally, one of the most significant problems with wireless mobile networks compared to traditional wired networks is signal fading caused by interference between signals. This makes the actual application effect of even the optimized caching strategy unsatisfactory. For example, distributed cache cannot reflect wireless resource utilization, the coexistence of multiple interfaces in network access may greatly reduce communication efficiency, and network scalability is limited. All in all, although the caching technology of mobile networks has more advantages over traditional wired networks, there are still some problems to be improved. With the continuous innovation and improvement of mobile network technology, these problems will definitely be improved in the future. This enables the wireless mobile network technology to better provide users with relevant network resource services and improve user experience and satisfaction.

3.2. Mobile Network Data Collection Algorithm. In mobile wireless networks, a large number of low-cost static sensor nodes with wireless communication functions are widely dispersed in the area to be detected. These nodes have the function of collecting the required data at any time, packaging the data, and delivering the data to the user at the appropriate time. This is the data acquisition algorithm function of the mobile network [12]. This algorithm can minimize the energy consumption of each static sensor under the premise of satisfying the data collection efficiency. This means that the required data can be collected with the highest efficiency and the least energy consumption. The basic idea of this algorithm can be shown in Figure 3.

The data collection efficiency of mobile wireless static sensors is p, and the probability of collecting all static sensor data in the whole network within a given time T is defined as [13]

$$P = p\left\{\cap_{a=1}^{NL} AL\right\}. \tag{1}$$

Among them, AL indicates that the data of sensor i is successfully collected within the time limit T, and P is the probability that all sensors collect complete data.

Next, it is assumed that the energy consumed by each static sensor data transmission time T in the mobile wireless network is e:

$$e = \min\left\{\frac{E_{LA,}}{E_N}\right\}. \tag{2}$$

The following optimization problems are solved in this paper:

$$\begin{aligned} &\text{subject to } P = p\left\{\cap_{i=1}^{NL} A\right\}, \\ &P_{\text{out}} = \frac{p_a}{C_t}\left(\frac{2\pi}{\gamma}\right)a. \end{aligned} \tag{3}$$

Among them, C_t and γ are the transmit antenna gain and transmit signal wavelength, respectively.

$$P_a = \frac{\tau\aleph}{n} p_{\text{out}}. \tag{4}$$

Among them, $\aleph$ is the peak-to-average ratio of the transmitted signal, and n is the drain efficiency of the RF power amplifier. At this time:

$$\aleph = 4\frac{\sqrt{N} - 1}{\gamma + 1}. \tag{5}$$

In summary, the sensor communication power consumption in independent mode is

$$P_t^c = \frac{\aleph}{n}\left(\frac{2\pi}{\gamma}\right)N + PA. \tag{6}$$

At this time, the data power consumption in the sensor data transmission duration T is

$$E_{lc} = T\left\{\frac{\aleph}{\gamma}(L + \gamma)^2 + P\right\}. \tag{7}$$

The steps of static sensor data acquisition in standalone mode are shown in Figure 4.

In the cooperative communication mode, the data consumption energy of each static sensor within the data transmission duration T is

$$E_c = \frac{LT + (3L + 1) + NT_a}{P}. \tag{8}$$

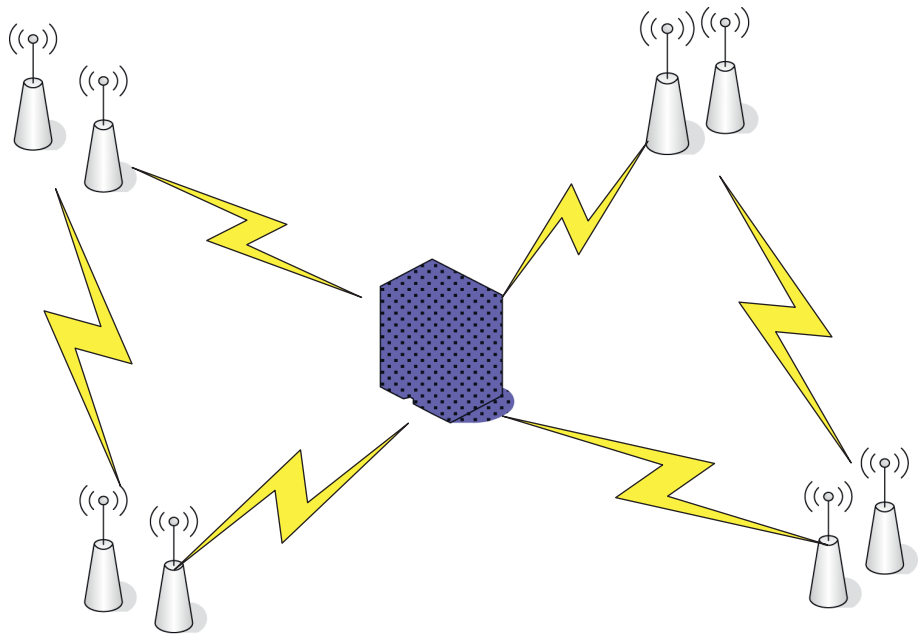


Figure 3: Basic idea of mobile network data collection algorithm.

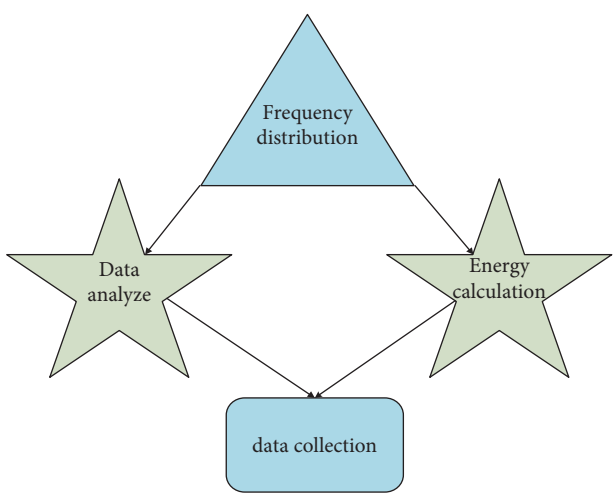


Figure 4: Standalone static sensor data acquisition steps.

Among them, LT is the node synchronous communication duration. Next, this paper discusses the optimal communication distance when $N = 1$. At a certain moment, the probability of a mobile node falling within the sensor communication area is

$$P = \frac{\theta\pi}{R} L. \tag{9}$$

Therefore, within a given time limit, the probability that all nodes of the sensor are visited at least once is

$$P(N = 1) = 1 - \left(\frac{\theta r}{\pi}\right) T_{\max}. \tag{10}$$

The optimal communication distance satisfies the condition of $P(N = 1) > C$. Next order:

$$r = \sqrt{\frac{2\theta}{\pi}} (1 - T_{\max}) \sqrt{1 - C}. \tag{11}$$

Therefore, when $N = 1$, the optimal communication distance under the random walk model is

$$OTP = \frac{4\pi}{\theta} \left(1 - \sqrt[T_{max}]{1 - C}\right). \tag{12}$$

Therefore, under the random walk model, the probability that $N > 1$ static sensor nodes are all visited at least once within a given time limit is

$$P(A) = 1 - \sum_{a=1}^{N} C_n \left(1 - n\frac{\theta r}{2\pi}\right) T_{\max}. \tag{13}$$

If $P(A) > C$, the lower limit of the communication distance can be obtained, that is, the optimal data acquisition communication distance [14, 15]. The basic process of the entire data acquisition algorithm can be shown in Figure 5.

Next, this paper will carry out the historical geographic information system construction experiment based on the data collection algorithm of mobile network, to explore whether the mobile network technology is effective for the construction of historical geographic information systems.

4. Construction Experiment of Historical Geographic Information System Based on Mobile Network

4.1. Experimental Method. The main experimental method of this experiment is as follows: it firstly constructs the historical geographic information system by the traditional method, and after the construction is completed, the information utilization rate and information integrity in the constructed information system are tested. The pros and

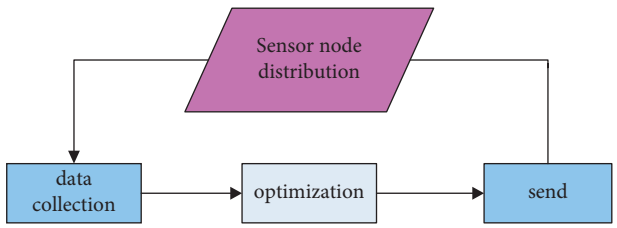


Figure 5: Basic process of mobile network data collection algorithm.

cons of constructing an information system are mainly judged according to the completeness of the information. Secondly, the historical geographic information system is constructed by combining the mobile network data collection algorithm. After the construction is completed, the information utilization and completeness of the constructed historical geographic information system are also tested, judging the pros and cons of the historical geographic information system constructed based on the mobile network according to the information integrity [16, 17]. Finally, the information integrity of the historical geographic information system constructed by the traditional method is compared with the information integrity of the historical geographic information system constructed based on the mobile network, and the experimental conclusion is drawn [18].

4.2. Construction of Historical Geographic Information System Based on Traditional Methods. Before constructing the historical geographic information system, this paper needs to determine several important historical geographic information system construction dimensions. It also builds an information system from these dimensions, making the built information system more reliable. It is shown in Table 2.

As can be seen from Table 2, the three main dimensions of the historical geographic information system construction are attribute, time, and space. In this paper, these three dimensions are labeled 1, 2, and 3, respectively. The proportion of information of these three dimensions in the historical geographic information system is shown in Figure 6.

As can be seen from Figure 6, the proportion of these three dimensions in the construction of the entire historical geographic information system is relatively balanced, accounting for about 35%, respectively. Next, this paper will proceed from these three main dimensions to construct the traditional historical geographic information systems. After the construction is completed, the utilization and integrity of the information in the system are tested. The information utilization test results are shown in Figure 7.

The information integrity test results are shown in Figure 8.

Combining Figures 7 and 8, it can be calculated that the average utilization rate of three-dimensional comprehensive information of the traditionally constructed historical geographic information system is 60%, and the average information integrity is 80%. This shows that although the

Table 2: Dimensions of historical geographic information system construction.

	History	Geography
Attribute data	2	2
Time data	3	4
Spatial data	2	3

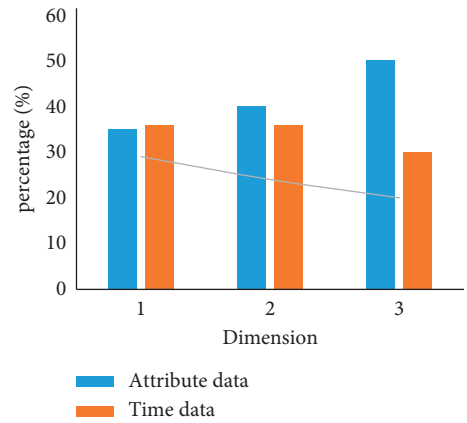


Figure 6: The proportion of three dimensions of information.

information utilization and information integrity of the historical geographic information system constructed based on traditional methods are at the upper-middle level, they have not reached an ideal level [19].

4.3. Construction of Historical Geographic Information System Based on Mobile Network. Next, this paper will combine the mobile network data collection algorithm to construct a new round of historical geographic information systems. In this construction, this paper first runs the mobile network data collection algorithm to collect historical geographic related data based on three main dimensions. In this way, the construction time of the historical geographic information system can be saved to the greatest extent, thereby improving the efficiency of data collection. After the construction, this paper also tests the information utilization and information integrity of the constructed historical geographic information systems. The test results are shown in Figure 9.

It can be calculated from Figure 9 that the comprehensive dimensional information utilization rate of the historical geographic information system constructed based on the mobile network is 70%, and the information integrity is 98.2%. It calculates the completeness of information in two historical geographic information systems constructed based on different methods. The next step is the last step of this experiment: this paper compares the information integrity of the historical geographic information system constructed based on the traditional method with the information integrity of the historical geographic information system constructed based on the mobile network technology [20]. It is shown in Figure 10.

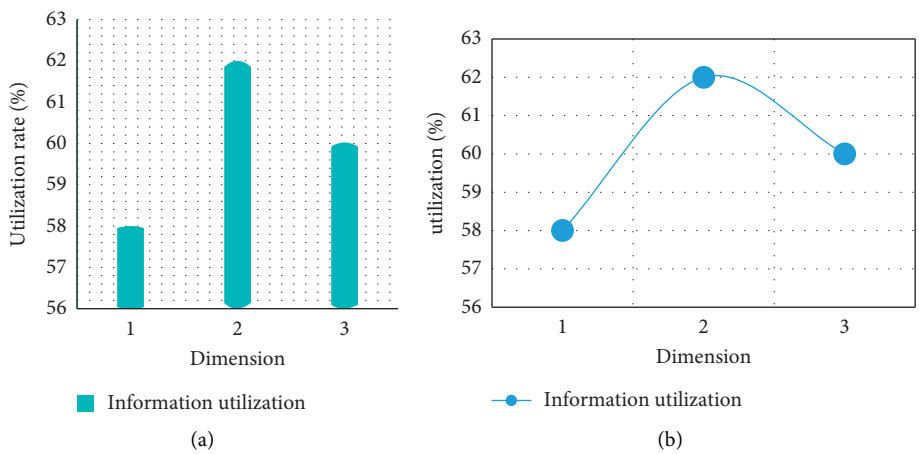


Figure 7: Information utilization of traditional historical information system. (a) Utilization statistics. (b) Utilization curve.

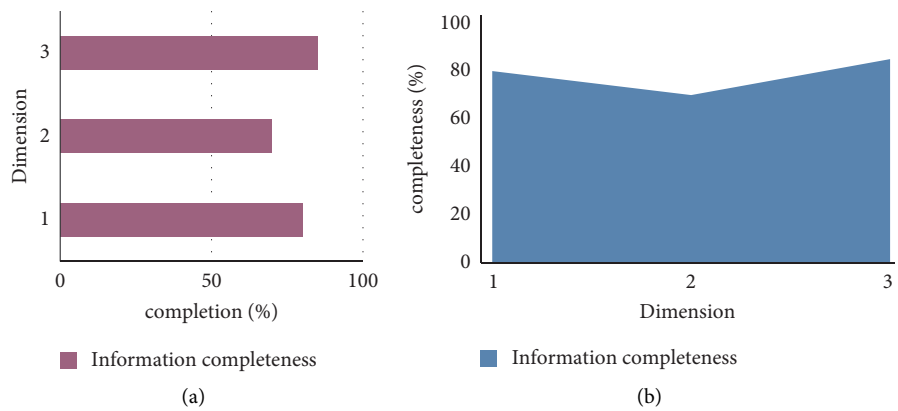


Figure 8: Information integrity of traditional historical geographic information system. (a) Integrity statistics. (b) Integrity ratio.

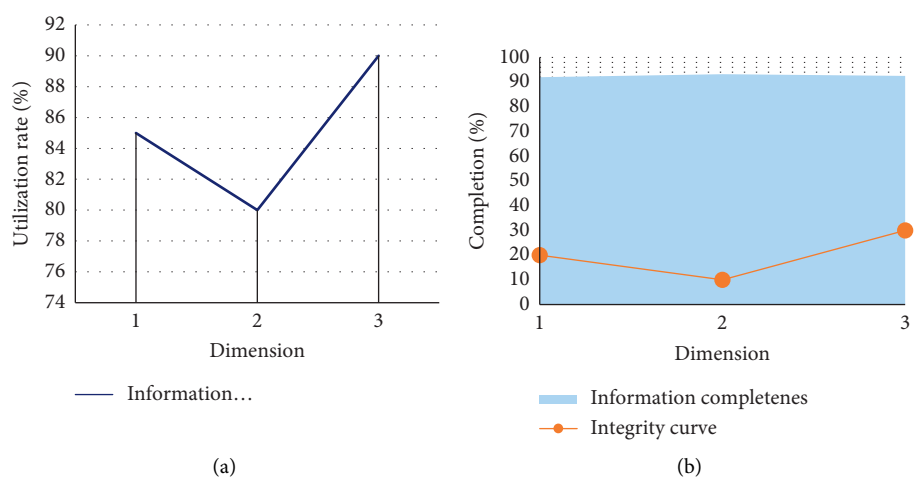
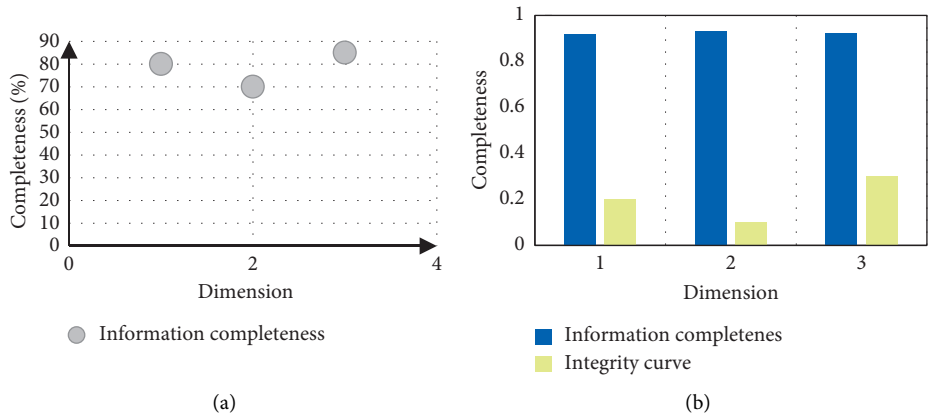


Figure 9: Information utilization and completeness of historical geographic information system based on mobile network. (a) Information utilization. (b) Information integrity.

Combined with the comparison results in Figure 10, it can be easily calculated that the information integrity of the historical geographic information system constructed based on mobile network technology is 18.2% higher than that of the traditional historical geographic information systems. This shows that the historical geographic information system constructed based on mobile network technology has high information integrity. A higher degree of information integrity means that the constructed information system is more complete, which means that the construction method



(a) (b)

Figure 10: Comparison of historical GIS information integrity based on traditional methods and mobile network technology. (a) Information integrity of traditional historical geographic information system. (b) Information integrity of mobile network historical geographic information system.

has a significant helping effect on the construction of the system. Therefore, this paper can draw the conclusion that mobile network technology has a certain help for the construction of historical geographic information systems.

5. Discussion

As an important part of academic research, historical geography research occupies an important position in the academic research community. The development of historical geographic research is closely related to the continuous improvement of the historical geographic information systems. For the construction of a historical geographic information system, scientific and effective technical support is tantamount to a run-up tool, which can promote its continuous improvement. With the continuous innovation and development of science and technology, there are increasingly advanced technologies and methods that can contribute to the construction of historical geographic information systems, such as mobile network technology.

Mobile network refers to a technology that uses a variety of available mobile devices to connect to public networks to enable Internet access and services [21]. Compared with the traditional network, the biggest technical advantage of the mobile network is that it is free from the restriction that a fixed terminal device can be used to access the Internet. It realizes that any terminal device can be connected to the Internet for access. This advantage of the mobile network makes the mobile network increasingly widely used in the market at present, occupying a higher and higher market share. Moreover, the cost of using the mobile network is low, and the difficulty of a large number of wirings that the traditional network will face is eliminated. Users are more flexible when using mobile networks, are not limited by time and space, and are more targeted for network resource acquisition. Therefore, the application scope of mobile networks in various fields is constantly expanding. It can also be foreseen that the mobile network service technology will have better development prospects in the future.

This paper discusses the construction method of the historical geographic information system combined with the mobile network data collection algorithm and designs a historical geographic information system construction experiment based on the mobile network data collection algorithm. In the experiment, the historical geographic information system construction experiment is carried out by using the traditional historical geographic information system construction method and the historical geographic information system construction method based on the mobile network data acquisition algorithm. It compares the completeness of information in the two historical geographic information systems constructed and draws experimental conclusions. The information integrity of the historical geographic information system constructed based on the mobile network data collection algorithm is 18.2% higher than that of the traditional historical geographic information systems. This shows that mobile network technology has a certain improvement effect on the construction of historical geographic information system [22]. On the whole, this experiment was relatively smooth, and no major problems were encountered in each experimental step, and finally an effective conclusion was drawn. However, there is still room for innovation in this experiment in terms of experimental methods. Overall, there is still room for improvement in the experiment.

6. Conclusions

Historical geography research is an important sector in the academic research community and has certain research significance. The construction of a historical geographic information system is one of the important steps in historical geographic research. Historical geography research is closely related to the construction of a historical geographic information system. However, the traditional historical geographic information system construction methods that have been used all time have some limitations in various aspects. These limitations can easily hinder the progress of historical geography research. Therefore, more effective construction

methods of historical geographic information systems are needed to continuously improve the construction of a historical geographic information system, thereby promoting the progress of historical geographic information research. With the continuous improvement of the level of science and technology in contemporary society, the construction method of historical geographic information system is also constantly innovating. Among them, the most prominent is the mobile network technology, and the mobile network refers to an advanced network service technology. It enables Internet access and services by connecting to public networks using a wide variety of mobile devices. In this paper, according to the research theme of the construction method of historical geographic information system based on mobile network, an experiment of building a historical geographic information system combined with mobile network data collection algorithm is designed. The research conclusions drawn in this paper have a certain reference value for the application of mobile network technology in the construction of a historical geographic information system. It also plays a positive role in improving the construction of a historical geographic information systems and promoting historical geographic research. However, due to the limited research level and conditions, the research of this paper also has some limitations; for example, the research angle and method are still insufficient and not comprehensive enough. It is believed that there will be more and better studies on the construction and improvement of the historical geographic information system in the academic circles in the future, to continuously promote the development of historical geographic research.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Nonlinear Control of Induction Motor Based on Network Control System

Changjiang Jin [1,2]

[1]*Chengdu Aeronautic Polytechnic, Chengdu 610100, Sichuan, China*
[2]*Key Laboratory of Pattern Recognition and Intelligent Information Processing, Institutions of Higher Education of Sichuan Province, Chengdu University, Chengdu 610106, Sichuan, China*

Correspondence should be addressed to Changjiang Jin; jcj@cap.edu.cn

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With the rapid development of network communication technology and computer technology, network control system has been applied in many different fields. Networked AC induction motor is controlled by a communication network to realize data transmission. This paper mainly studies the nonlinear control of induction motor based on network control system. In order to solve the nonlinear problem of AC induction motor, this paper adopts the method of the linear resolve coupling, and combined with the characteristics of the Internet, establishes the mathematical model of the AC induction motor, and considers the use of the system parameter perturbation to construct the mathematical model of the AC induction motor. Aiming at the problems of system parameter perturbation and network-induced delay in networked AC induction motor control system, the robust control of networked AC induction motor control system is studied. The experimental results show that the proposed control strategy can achieve asymptotic stability of the system with parameter perturbation under the action of the controller and can achieve asymptotic stability even with external disturbance. Compared with control strategies 1 and 2, the adjustment time of the speed waveform oversetting phenomenon is about 0.18 s and 0.26 s, and the adjustment time of the control strategy proposed in this paper is only 0.06 s. It is shown that the nonlinear control method of induction motor based on network control system can significantly improve the validity and stability of the system model.

1. Introduction

An AC induction motor is a nonlinear multiple-input-output object, that is, widely used in industrial enterprises. In recent decades, the rapid development of control science, computer technology, and network communication technology has gradually made industrial production intelligent. At the same time, in order to further improve the compatibility and expansibility of the system, researchers put forward a networked control system based on Ethernet, Internet, and other networks. In general, networked control systems refer to distributed closed-loop feedback control systems [1] that utilize communication networks to exchange information among various links (such as controlled objects, actuators, sensors, and controllers) distributed at different spatial locations. For such a distributed control system, that is, functionally, logically, and geographically dispersed, it simplifies the system structure, while opening the spatial location of the system, making the complex system simple and has the advantages of high reliability and high openness [2].

In the process of information transmission, the inevitable delay phenomenon can be divided into deterministic delay and stochastic delay according to the certainty; according to the length of delay time, it can be divided into long delay and short delay. To solve all kinds of delay problems mentioned above, the methods that can be adopted include stochastic system method, time-delay system method, model predictive control method, robust control method, etc. Morawski et al. converted the network delay into fixed delay by caching method and compensated it by state observer. The proposed delay compensation

algorithm is suitable for the integrated communication control system (ICCS), but the cache will artificially increase the network delay [3]. Ogidan et al. designed the LQG random optimal controller to compensate for the network delay, but the compensation accuracy is low, and it is difficult to realize in practice [4]. Khanesar et al. propose a new fuzzy sliding mode controller, which USES the fuzzy system to estimate the nonlinear dynamic system online, and USES Pade to approximate the network-induced delay [5].

This paper mainly studies the nonlinear control of induction motor based on the network control system, introduces the control network into the operating system of induction motor, solves the problem of tedious network wiring, gives a clear definition of the structure and function of each part of the network control, and establishes a mathematical model of the system network control based on reasonable assumptions. The simulation results show that the designed network controller ensures the stability of the networked servo system. At the same time, this method has a better inhibition effect on network transmission delay and data packet loss, especially in the case of system disturbance and uncertain factors, it has better dynamic performance and meets the control requirements of the high-performance control system. The nonlinear control of induction motor based on network control system can achieve certain performance index and ensure the stability of closed-loop system.

2. Nonlinear Control of Induction Motor under Network Control System

2.1. Network Control System

2.1.1. Development History of Network Control System. With the development of computer technology and network communication technology, industrial control system has also produced many significant changes. Networked control system is a product conforming to The Times. Its characteristic is that a computer network is introduced into the control network, so as to connect the sensors, controllers, actuators and other main components of a closed-loop control system as a whole through the network [6, 7]. State signal acquisition and data exchange are realized through this network resource sharing. The wiring of traditional point-to-point connections is avoided. It provides the convenience of remote operation and control, increases the flexibility of the system, and also improves the working stability of the system. The main advantages of the network control system lie in less system connection, high reliability, flexible structure, easy system expansion and maintenance, and the ability to realize information resource sharing.

Due to its prominent competitive advantages and high-cost performance, Ethernet has a trend of large-scale penetration into the field of industrial control. History has proved for countless times that whoever has the right to set standards can lead the development direction of network communication in the future. Our country started late in this aspect, but the development progress is rapid. We independently developed the industrial automation standard based on Ethernet, which was recognized by the International Electrotechnical Commission. In view of the outstanding performance of Ethernet, it can be predicted that it will become the next generation of Fieldbus basic protocol, leading the development trend of Fieldbus. The modern network control system has the characteristics of structure network, node intelligence, system openness, and product integration.

It is the requirement of information age that information networks and control networks should be connected. Enterprise resource planning needs such an organic whole that combines management decisions and market information together as the structural condition. From this point of view, the Ethernet solution greatly simplifies the design process of enterprise computer network systems and improves the robustness of the network. The emergence and promotion of the Internet have recently received extensive attention in networked control systems. People generally seek for a mode that can realize monitoring, management, and maintenance functions remotely, which undoubtedly means more economic benefits and ultimately contributes to the emergence of NCS. In NCS, any control engineer, once given access, can monitor the circuits of a control network from any computer connected to the Internet. Getting rid of the on-site dependency means more productivity.

2.1.2. Basic Structure of Network Control System. General network control system structure has the following two kinds: direct structure and hierarchical structure.

In a directly structured NCS, the system consists of a local controller and a remote end, which contains the actuators, physical devices, and sensors. Local controller and remote terminal in different spatial locations, through the network control circuit, the control signal in the form of packet transmission through the network to the actuator, its role in the controlled object, then the sensor to interval sampling, such as the system output of sensor signal after sampling is encapsulated in the packet, again through the network to transmit it to the controller, the controller computing control signal, in circulation, in order to realize remote network closed-loop control of [8].

In a layered NCS, the system consists of a local controller and a remote closed-loop control system. Local controller is responsible for regularly receiving sensor signal to calculate the control quantity, the packaging in the packet transmission through the network to the remote closed-loop control system, the auxiliary controller at the remote docking processed by the control signal, its role in the controlled object, and then the output of the system through the sensor sampling is returned to the main controller network closed-loop control of [9]. Obviously, compared with NCS with direct structure, there is an auxiliary controller in the remote control system in layered structure NCS, which makes the system have higher stability. However, because there are two or more closed-loop controls in the whole control loop, the sampling period of the system is longer.

Replication in actual applications, the need to adopt what kind of structure according to the requirements of the control system performance and the location of nodes to determine, in fact, if the remote end of the hierarchical structure is a purely physical device, see it as a state space model, the structure of the direct analysis method and the control strategy can be applied to layered structure.

2.1.3. Network Control System Theory. Many theories are based on certain idealized assumptions at the beginning. The same is true of traditional control theories, such as information transmission in the network without considering the error, and data calculation time and transmission process are far less than the sampling period.. However, with the introduction of control networks, this assumption is no longer valid, and time delay has become a theoretical problem that has to be considered. Delays can be roughly divided into three categories: object internal delays, network delays, and computational delays.

At present, the main research ideas and objects of NCS system are network topology and network scheduling methods, and solutions are provided through the comprehensive application of operations research and control theory to meet the real-time requirements of the control system [10, 11]. At the same time, the delay problem and parameter uncertainty of the network are suppressed. The main task of the latter is to improve the system stability, tracking accuracy, and speed. On the basis of the inherent communication network, namely, the communication protocol of the control network and the delay characteristic, the delay problem of the control object is considered in the model, the stability of the closed-loop system is studied, and the method of the stabilizer is given synthetically.

2.2. Mathematical Model of Induction Motor. The original model of induction motor is very complex, with nonlinear, time-varying, high-order, strong coupling characteristics, and the mathematical model can be simplified by coordinate transformation, which is easy to calculate. From simple to complex, the mathematical model under the static two-phase coordinate system is firstly derived and then extended to the rotating coordinate system [12].

2.2.1. Three-Phase Mathematical Model of Induction Motor. In order to simplify the calculation, the following assumption is made in the derivation process: space harmonics are ignored. The three-phase stator windings are symmetrical and the space difference is 120, and the generated magnetomotive force is distributed along the air gap sine. Magnetic saturation is ignored and the self-inductance and mutual inductance of winding are not changed. Ignore core loss: The influence of frequency and temperature change on winding resistance is ignored.

The mathematical model of induction motor includes flux equation, voltage equation, torque equation, and motion equation, in which the flux equation and torque equation are algebraic equations, and the voltage equation and motion equation are differential equations [13].

(1) Flux Equation. For ψ of $\psi = \mathrm{Li}$ flux linkage equations, the six winding magnetic chain expression is:

$$\begin{bmatrix} \psi_A \\ \psi_B \\ \psi_C \\ \psi_a \\ \psi_b \\ \psi_c \end{bmatrix} = \begin{bmatrix} L_{AA} & L_{AB} & L_{AC} & L_{Aa} & L_{Ab} & L_{Ac} \\ L_{BA} & L_{BB} & L_{BC} & L_{Ba} & L_{Bb} & L_{Bc} \\ L_{CA} & L_{CB} & L_{CC} & L_{Ca} & L_{Cb} & L_{Cc} \\ L_{aA} & L_{aB} & L_{aC} & L_{aa} & L_{ab} & L_{ac} \\ L_{bA} & L_{bB} & L_{bC} & L_{ba} & L_{bb} & L_{bc} \\ L_{cA} & L_{cB} & L_{cC} & L_{ca} & L_{cb} & L_{cc} \end{bmatrix} \cdot \begin{bmatrix} i_A \\ i_B \\ i_C \\ i_a \\ i_b \\ i_c \end{bmatrix}. \tag{1}$$

Type of i_A, i_B, . . ., I_c is the instantaneous value of the constant rotor phase current; bits A, bits of B, . . ., all bits of c for each phase winding magnetic chain. L_{AA}, L_{BB}, . . . L_{cc} is the self-inductance of each winding, while other terms are the mutual inductance between corresponding windings. The inductance corresponding to each phase flux leakage of the stator is defined as stator leakage inductance L_{is}, the inductance corresponding to each phase flux leakage of the rotor is defined as rotor leakage L_{lr}, the maximum mutual inductance alternating chain of the stator one-phase winding is stator mutual inductance L_{ms}, and the maximum mutual inductance alternating chain of the rotor one-phase winding is rotor mutual inductance L_{mr}. According to the symmetry of windings, leakage inductance values are all equal, because the number of turns of fixed rotor windings is equal after conversion, then $L_{ms} = L_{mr}$ [14]. Therefore, self-inductance of the stator and rotor is as follows:

$$\begin{aligned} L_{AA} &= L_{BB} = L_{CC} = L_{ms} + L_{is}, \\ L_{aa} &= L_{bb} = L_{cc} = L_{ms} + L_{ls}. \end{aligned} \tag{2}$$

If difference between three-phase windings is 120°, then the mutual inductance value is as follows:

$$\begin{aligned} L_{ms} \cos \frac{2\pi}{3} &= L_{ms} \cos\left(-\frac{2\pi}{3}\right), \\ &= -\frac{1}{2} L_{ms}. \end{aligned} \tag{3}$$

Given that the included angle between fixed rotor shafting is θ, the mutual inductance between stator windings and rotor windings is as follows:

$$\begin{cases} L_{Aa} = L_{aA} = L_{Bb} = L_{bB} = L_{Cc} = L_{cC} = L_m \cos\theta, \\ L_{Ab} = L_{bA} = L_{Bv} = L_{cB} = L_{Ca} = L_{aC} = L_m \cos\left(\theta + \frac{2\pi}{3}\right), \\ L_{Ac} = L_{cA} = L_{Ba} = L_{aB} = L_{Cb} = L_{bC} = L_m \cos\left(\theta - \frac{2\pi}{3}\right). \end{cases} \quad (4)$$

According to the abovementioned equation, a complete flux linkage equation can be obtained, which is represented by a matrix as follows:

$$\begin{bmatrix} \psi_s \\ \psi_r \end{bmatrix} = \begin{bmatrix} L_{ss} & L_{sr} \\ L_{rs} & L_{rr} \end{bmatrix} \begin{bmatrix} i_s \\ i_r \end{bmatrix}. \quad (5)$$

(2) Voltage Equation. Three-phase voltage, rotor equation for $u = R_i + \mathrm{d}\psi/\mathrm{d}t$, expressed as a matrix form is as follows:

$$\begin{bmatrix} u_A \\ u_{\mathbf{B}} \\ u_C \\ u_a \\ u_b \\ u_c \end{bmatrix} = \begin{bmatrix} R_A & 0 & 0 & 0 & 0 & 0 \\ 0 & R_B & 0 & 0 & 0 & 0 \\ 0 & 0 & R_C & 0 & 0 & 0 \\ 0 & 0 & 0 & R_a & 0 & 0 \\ 0 & 0 & 0 & 0 & R_b & 0 \\ 0 & 0 & 0 & 0 & 0 & R_c \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \\ i_a \\ i_b \\ i_c \end{bmatrix} + P \begin{bmatrix} \psi_A \\ \psi_B \\ \psi_C \\ \psi_a \\ \psi_b \\ \psi_c \end{bmatrix}. \quad (6)$$

Type of u_A, u_B, . . ., u_c represents the instantaneous value of phase voltage of stator winding and rotor winding, respectively; R_A, R_B, . . ., R_c represents the resistance of stator winding and rotor winding respectively; i_A, i_b, . . ., I_C represents the instantaneous value of phase current of stator winding and rotor winding; ψ_A, ψ_B, . . ., ψ_c, respectively, of the stator winding and rotor winding phase flux instantaneous value; $p = \mathrm{d}/\mathrm{d}t$ is the differential operator.

(3) Torque Equation. According to the principle of electromechanical energy conversion, the torque equation of induction motor can be expressed as follows:

$$T_e = -nL_{ms} \begin{bmatrix} (i_A i_a + i_B i_b + i_C i_c)\sin\theta + (i_A i_b + i_B i_c + i_C i_a) \\ \sin\left(\theta + \frac{2\pi}{3}\right) + (i_A i_c + i_B i_a + i_C i_b)\sin\left(\theta - \frac{2\pi}{3}\right) \end{bmatrix}. \quad (7)$$

(4) Equations of Motion. The motion equation of induction motor can be expressed as follows:

$$\frac{J}{n_p} \cdot \frac{d\omega_r}{dt} = T_e - T_L. \quad (8)$$

where J represents the moment of inertia of the unit; TL represents load torque.

2.2.2. Dynamic Mathematical Model of Induction Motor in Two-Phase Static Coordinate System. The three-phase rotor winding of induction motor is rotating, and the equation in the two-phase rotating coordinate system can be obtained only after CLARK and PARK coordinate transformation (usually used for field-oriented control of three-phase AC motors). The rotation transformation can change the coupling relationship between fixed and rotor windings, and the fixed and rotor windings in relative motion are replaced by the equivalent windings in relative rest, thus eliminating the influence of the angle between fixed and rotor windings on flux linkage and torque [15, 16]. The dynamic mathematical model of induction motor in the two-phase static coordinate system after transformation is as follows:

(1) Voltage equation:

$$\begin{bmatrix} u_{s\alpha} \\ u_{s\beta} \\ u_{r\alpha} \\ u_{r\beta} \end{bmatrix} = \begin{bmatrix} R_s + L_s P & 0 & L_m P & 0 \\ 0 & R_s + L_s P & 0 & L_m p \\ L_m P & \omega_r L_m & R_r + L_r P & \omega_r L_r \\ -\omega_r L_m & L_m p & -\omega_r L_r & R_r + L_r p \end{bmatrix} \begin{bmatrix} i_{s\alpha} \\ i_{s\beta} \\ i_{r\alpha} \\ i_{r\beta} \end{bmatrix}. \quad (9)$$

(2) Flux equation:

$$\begin{bmatrix} \psi_{s\alpha} \\ \psi_{s\beta} \\ \psi_{r\alpha} \\ \psi_{r\beta} \end{bmatrix} = \begin{bmatrix} L_s & 0 & L_m & 0 \\ 0 & L_s & 0 & L_m \\ L_m & 0 & L_r & 0 \\ 0 & L_m & 0 & L_r \end{bmatrix} \begin{bmatrix} i_{s\alpha} \\ i_{s\beta} \\ i_{r\alpha} \\ i_{r\beta} \end{bmatrix}. \quad (10)$$

(3) Torque equation:

$$T_e = n_p L_m \left(i_{s\beta} i_{r\alpha} - i_{s\alpha} i_{r\beta}\right). \quad (11)$$

2.2.3. Dynamic Mathematical Model of Induction Motor in Two-Phase Rotating Coordinate System. Rotating coordinate transformation is to transform the stator coordinate system and rotor coordinate system to the same rotating orthogonal coordinate system, it takes synchronous angular velocity s relative to stator winding motion [17]. The dynamic mathematical model of induction motor under the two-phase rotating coordinate system after transformation is as follows:

(1) Voltage equation:

$$\begin{bmatrix} u_{s\,d} \\ u_{sq} \\ u_{r\,d} \\ u_{rq} \end{bmatrix} = \begin{bmatrix} R_s + L_s P & -\omega_s L_s & L_m P & -\omega_s L_m \\ \omega_s L_s & R_s + L_s P & \omega_s L_m & L_m P \\ L_m P & -\Delta\omega L_m & R_r + L_r P & \Delta\omega L_r \\ \Delta\omega L_m & L_m P & \Delta\omega L_r & R_r + L_r P \end{bmatrix} \begin{bmatrix} i_{s\,d} \\ i_{sq} \\ i_{r\,d} \\ i_{rq} \end{bmatrix}. \quad (12)$$

(2) Flux equation:

$$\begin{bmatrix} \psi_{s\,d} \\ \psi_{sq} \\ \psi_{r\,d} \\ \psi_{rq} \end{bmatrix} \begin{bmatrix} L_s & 0 & L_m & 0 \\ 0 & L_s & 0 & L_m \\ L_m & 0 & L_r & 0 \\ 0 & L_m & 0 & L_r \end{bmatrix} \begin{bmatrix} i_{s\alpha} \\ i_{s\beta} \\ i_{r\alpha} \\ i_{r\beta} \end{bmatrix}. \quad (13)$$

(3) Torque equation:

$$T_e = n_p L_m \left(i_{sq} i_{r\,d} - i_{s\,d} i_{rq} \right). \tag{14}$$

2.3. Induction Motor Networked Control

2.3.1. Networked Control Structure. The classical control system structure consists of four parts, namely, controller, actuator, sensor, and controlled object. The controller is a kind of device that produces output signals according to input signals. It usually takes the difference between the feedback signal obtained by the sensor and the reference input signal of the system as input signals. The actuator is a device directly connected with the controlled object. It receives the control signal of the controller and converts it into the required analog quantity to control the controlled object. A sensor is a kind of state measurement device. On some special occasions, the installation of sensor can also be avoided, and the amount to be measured can be calculated by introducing an observer [18, 19]. The determination of the controlled object is generally related to the purpose of the design control. The networked control system is the information channel connecting these four parts, which forms a closed-loop control system. From the perspective of the relationship between structure and function, the sensor has the functions of analog/digital (A/D) conversion, data encapsulation, and transmission, etc. The executor has the functions of digital/analog (D/A) conversion, receiving data packets, etc. The controller is mainly based on industrial computers or intelligent chips. The information flow between the controller and the actuator and the sensor is transmitted in the form of encapsulated data packets under some common communication protocol by means of network channels. Figure 1 shows the basic structure of networked control systems.

This mechanism of transmitting information in the form of data packets ensures the efficiency of communication. And the network bearing this information traffic, according to the system size, performance, and the actual needs of the application environment, can choose flexibly, such as worldwide, industrial Ethernet, and so on. The driving modes of networked control systems can be divided into two types according to the different action conditions, namely, clock-driven and event-driven. Clock-driven means that the network nodes perform tasks at the agreed time. The condition of the action is only time-dependent. The so-called event-driven refers to whether the network node ACTS depends on whether the agreed event occurs, and if it does, it will immediately execute the agreed task. However, event-driven is not easy to implement, and some practical control networks do not support event-driven methods.

2.3.2. Modeling of Networked Control Structure System of Induction Motor. The networked control structure of induction motor can usually be realized in two ways: the beamline structure and the layered structure. The main feature of the beamline structure is that the signal

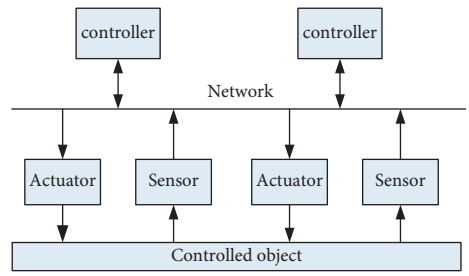

Figure 1: The basic structure of networked control system.

transmission between the motor, controller, and sensor is directly transmitted through the communication network [20]. The network undertakes the closed-loop connection of the whole servo system, and its structural feature is that each motor is equipped with a network interface unit, which undertakes the function of information modulation and demodulation. Specifically, the feedback information collected by the sensor is converted into a data structure acceptable to the controller and transmitted to the controller to form a feedback loop. The other control structure as opposed to the direct structure is the hierarchical structure, in which a separate controller, called the remote controller, is installed for each motor in the network in addition to the main controller. The physical distance between these controllers and the motor body is very close, and the main controller of the system undertakes most of the operations in the control network and transmits the results of the operations to the remote controller through the network. Then the remote controller executes the motor control instructions according to the control signal sent by the master controller and returns the sensor measurement data to the master controller [21, 22]. In the process of permanent magnet synchronous motor servo control, it is found that the motor speed is greatly affected by the current. In view of this high sensitivity, a scheme with faster information transmission speed should be chosen as a response. Based on this consideration, the choice of the control structure of networked permanent magnet synchronous motor is more inclined to the hierarchical structure. Block diagram of a conventional networked servo control system. Under the hierarchical network control framework, the system can be roughly divided into the following parts: (1) Remote unit: including remote controller and remote motor; (2) main controller; and (3) data network [23].

Each remote unit comprises a remote controller and an induction motor. The remote controller is responsible for relatively simple control work, such as receiving the control signal of the master controller transmitted through the data network, carrying out simple control of the IDIQ flow of the induction motor, and finally converting the control signal into PWM signal to drive the induction motor.

At the same time, the detection data of induction motor, such as motor speed and current, are also transmitted to the main controller through the network. The master controller has powerful data processing capability and can process and calculate the control information of several remote units, so it is not convenient to be installed on the remote site. At the

same time, the master controller can also provide an advanced real-time control algorithm, and even have fault detection and network status monitoring, and other functions.

In the process of network communication, due to the limitation of its structure and function, it often causes information congestion and even data packet loss. When data packet loss occurs, it is generally chosen to ignore the loss of old data and keep sending the latest data. In fact, the lost data will lose its reference value due to the long waiting time.

For the convenience of modeling, the following assumptions are made for the networked induction synchronous motor servo control system: (1) The sensor is event-driven and the sampling period is H. The sampled PMSM data are packaged and sent to the central controller through the network. (2) The central controller is event-driven. Each time the packet arrives at the controller, the control signal is calculated and the result is sent to the actuator over the network. (3) the actuator is event-driven. It is assumed that the actuator and the sensor are synchronous and have the same sampling period h $(h > 0)$.

The transmission delay from the master controller to the PMSM and the transmission delay from the sensor to the master controller is τ_a and τ_{sc}, respectively, so the total delay of the system is as follows:

$$\tau_k = \tau_{ca} + \tau_{sc}. \tag{15}$$

When there is network delay in the system, the state value collected by the controller at the moment of kh will reach the controller at the moment of $kh + \tau k$. The state feedback controller can be designed as follows:

$$u(t) = Kx(kh), \quad \forall t \in \left[kh + \tau_k, (k+1)h + \tau_{k+1}\right]. \tag{16}$$

Let $\mathrm{d}(t) = \mathrm{t\text{-}kh}$, then

$$\mathrm{kh} = t - d(t). \tag{17}$$

where $d(t)$ is the time delay.

Time delay nominal system is as follows:

$$\begin{cases} x = \mathrm{Ax}(t) + A_d x(t - d(t)), \\ x(t) = \Phi(t), t \in [-h, 0]. \end{cases} \tag{18}$$

where $\mathrm{x}(t) \in R^{n \times n}$ is the state vector, and A_d is the appropriate dimension matrix. $D(t)$ is to satisfy the following conditions:

$$0 \le d(t) \le h. \tag{19}$$

3. Simulation Test of Induction Motor Based on Network Control System

3.1. Simulation of Networked AC Induction Motor Control System Based on True-Time Toolbox. True-time toolkit is a real-time network control system based on the MATLAB simulation toolbox, the toolkit is ideal for network control system of virtual simulation tools, according to different network protocols, can study all kinds of network environment change on the influence of the closed-loop control system, especially the effect of network delay on the system performance [24].

In networked control systems, an improved Smith estimator fuzzy control method is proposed to solve the problem that the network-induced delay worsens the system performance. Firstly, an improved Smith predictive controller is introduced at the controller side to solve the problem of mismatch between the controlled object model and the controlled object model. Meanwhile, the cut-off frequency of the system is increased to obtain faster system response. Then, the controller is designed as a fuzzy controller by using fuzzy control algorithm, which can achieve better control effect and has strong robustness.

3.2. Simulation Test Parameters. Given that the core of the internal model control strategy lies in the design of the dynamic inverse of the controlled object, accurate motor parameters are needed in the simulation design so as to design a fully matched dynamic inverse. The motor parameters used in the simulation design are the actual experimental motor parameters obtained through parameter identification. As shown in Table 1, all parameters of the induction motor in the simulation experiment are set.

4. Simulation Test Results of Induction Motor Based on Network Control System

4.1. Closed-Loop Response State of the Robust Controller When d2 Is 0.1355

4.1.1. Closed-Loop Response State of a Robust Controller with No Disturbance. When $d1 = 0$, $\mu = 1$ and $d2 = 0.1355$, the parameter selection is $\alpha = 0.5$, and after two iterations, $\sigma 1 = \sigma 2 = 0$. In this case, the controller gain can be obtained. Without considering the disturbance, the initial value of the state vector is: $X(0) = [5, 10, 15, 20]$, and the closed-loop state response is: $X(0) = [5, 10, 15, 20]$.

As shown in Table 2 and Figure 2, the system with parameter perturbation can be asymptotically stable under the action of the controller. The state of $X1$, $X2$, and $X3$ approaches and stabilizes when the time reaches 15, while the time of $X4$ closed-loop response state fluctuates greatly. The system state does not approach 0 until the time approaches 20 from the highest—55. Its main feature can be expressed as oscillation divergence, and the oscillation amplitude decreases with time.

4.1.2. Closed Loop Response State of Robust Controller with Disturbance. As shown in Figure 3 and Table 3, the initial value of state vector is $x(0) = [5, 10, 15, 20]$ for the random number sequence with $w(t)$ variance of 0.05 and the average value of 0 when considering disturbance. It can be seen that the system with parameter perturbation can be asymptotically stable under the action of the controller, and can still achieve asymptotic stability in the case of external disturbance, which verifies the effectiveness and feasibility of the method. Therefore, the nonlinear control method of the induction motor based on the network control system

Table 1: Induction motor parameters.

Parameter	Numerical value	Parameter	Numerical value
Rated power P_N	3 kW	Polar logarithm n_p	2
Rated voltage U_N	370 V	Stator resistance R_s	1.794 Ω
DC bus voltage U_{dc}	530 V	Rotor resistance R_r	1.583 Ω
Rated current I_N	6.4 A	Mutual inductance L_m	0.379 H
Rated frequency f_N	50 Hz	Stator inductance L_s	0.3952 H
Given speed n	1350 r/min	Rotor inductance L_r	0.3956 H

Table 2: Closed loop state response of robust controller without disturbance.

	2	4	6	10	14	20
$X1$	−5	5	−2	2	0	0
$X2$	−25	15	−5	2	0	0
$X3$	−2	2	−1	1	0	0
$X4$	55	−40	20	−5	2	0

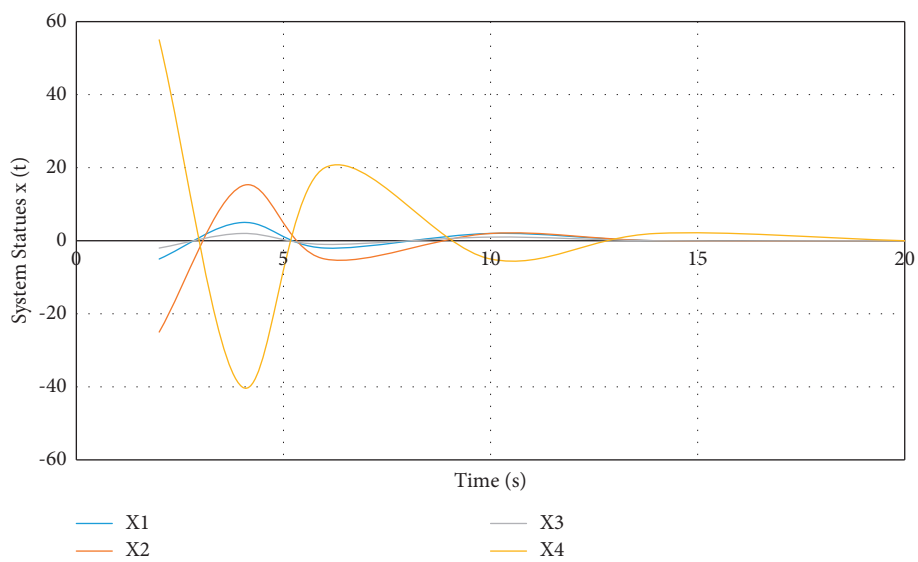

Figure 2: Closed loop state response of robust controller without disturbance.

achieves the predetermined performance index and ensures the stability of the closed-loop system.

4.2. Closed Loop Response State of Robust Controller When d2 Is 1.1355

4.2.1. Closed-Loop Response State of a Robust Controller with No Disturbance. When $d1 = 0$, $\mu = 1$ and $d2 = 1.13555$, the parameter selection is $\alpha = 0.5$, and after two iterations, $\sigma 1 = \sigma 2 = 0$. In this case, the controller gain can be obtained. Without considering the disturbance, the initial value of the state vector is: $X(0) = [5\ 10\ 15\ 20]$, and the closed-loop state response is: $X(0) = [5,\ 10,\ 15,\ 20]$.

As shown in Table 4 and Figure 4, when D2 value is 1.1355, the closed-loop response state of robust controller achieves asymptotic stability faster than that when $D2$ value is 0.1355. Among them, $X1$ tends to 0 after 3 times; $X2$ and $X3$ tend to 0 after 6 times; $X4$ tends to 0 faster than $D2$ when the value is 0.1355.

4.2.2. Closed Loop Response State of Robust Controller with Disturbance. As shown in Table 5 and Figure 5, the trend of the closed-loop response state of the robust controller in the presence of disturbance is close to that in the case of no disturbance. It can be concluded from the above diagram that the system with parameter perturbation can be asymptotically stable under the action of the controller, and the asymptotic stability can be achieved in the case of external disturbance, which verifies the effectiveness and feasibility of the method.

4.3. No Load Low-Speed Starting Performance. The same as the previous two statistical indicators of patients, the maximum, minimum, and median values of postoperative total fluid recovery time of patients in the three groups were still selected.

As shown in Table 6, Figures 6 and 7, comparing the three different control strategies under no-load conditions, it can be seen that the speed waveform of control strategy 1

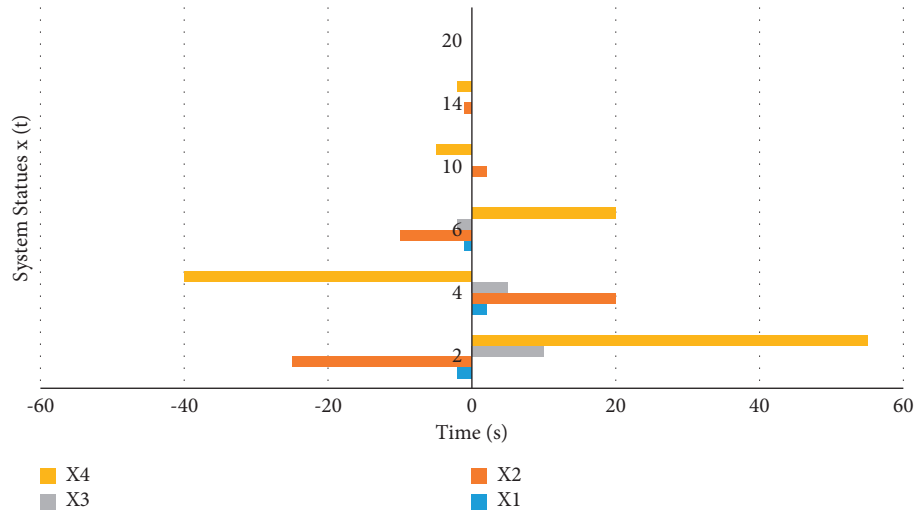

Figure 3: Closed loop response state of robust controller with disturbance.

Table 3: Closed loop response state of robust controller with disturbance.

	2	4	6	10	14	20
$X1$	−2	2	−1	0	0	0
$X2$	−25	20	−10	2	−1	0
$X3$	10	5	−2	0	0	0
$X4$	55	−40	20	−5	−2	0

Table 4: Closed loop response state of robust controller when $d2$ is 1.1355.

	1	2	3	6	10	20
$X1$	−5	2	0	0	0	0
$X2$	25	−5	2	0	0	0
$X3$	30	10	5	0	0	0
$X4$	70	−50	15	−5	0	0

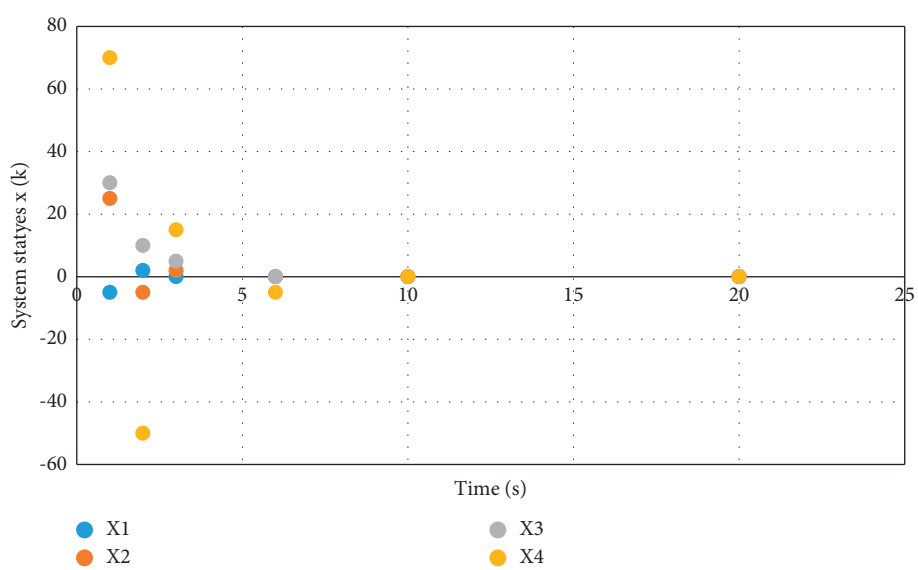

Figure 4: Closed loop response state of robust controller when $d2$ is 1.1355.

Table 5: Closed-loop response state of robust controller in the presence of disturbance with $D2$ value of 1.1355.

	1	2	3	6	10	20
$X1$	−5	1	0	0	0	0
$X2$	−30	10	2	0	0	0
$X3$	30	10	5	0	0	0
$X4$	70	−50	15	−20	5	0

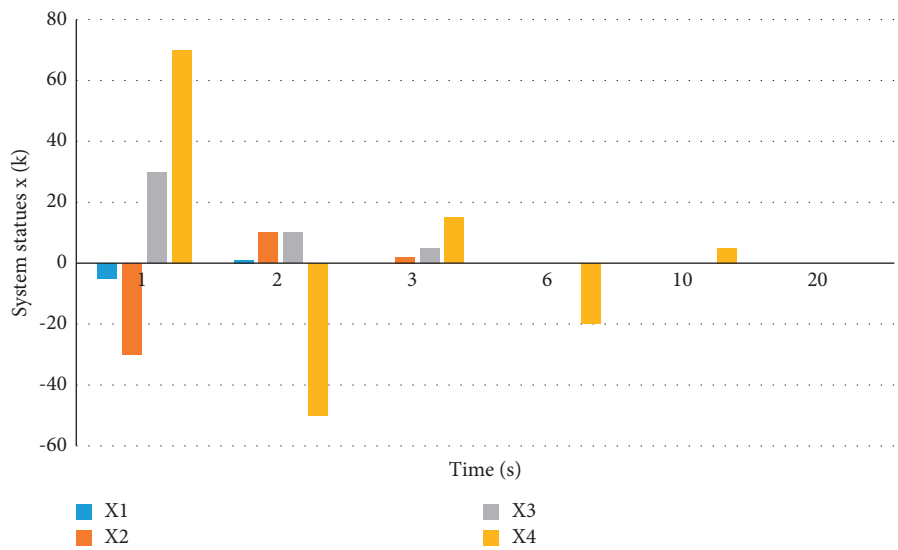

Figure 5: Closed-loop response state of robust controller in the presence of disturbance with $D2$ value of 1.1355.

Table 6: Speed waveform under no load and low-speed start.

	0.01	0.02	0.03	0.1	0.2	0.3
Control strategy1	60	120	110	110	100	100
Control strategy2	70	150	85	100	100	100
Control strategy3	80	90	95	100	100	100

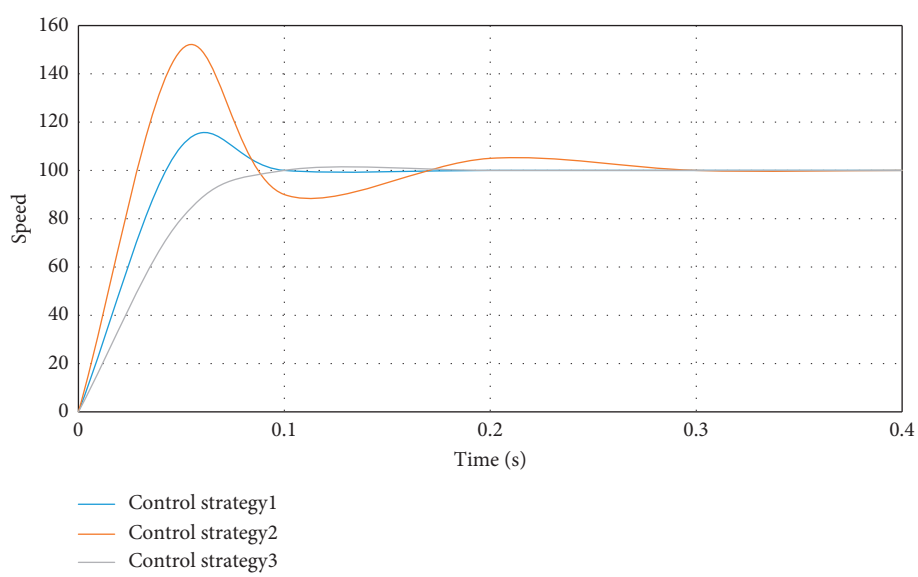

Figure 6: Speed waveform under no load and low-speed start(1).

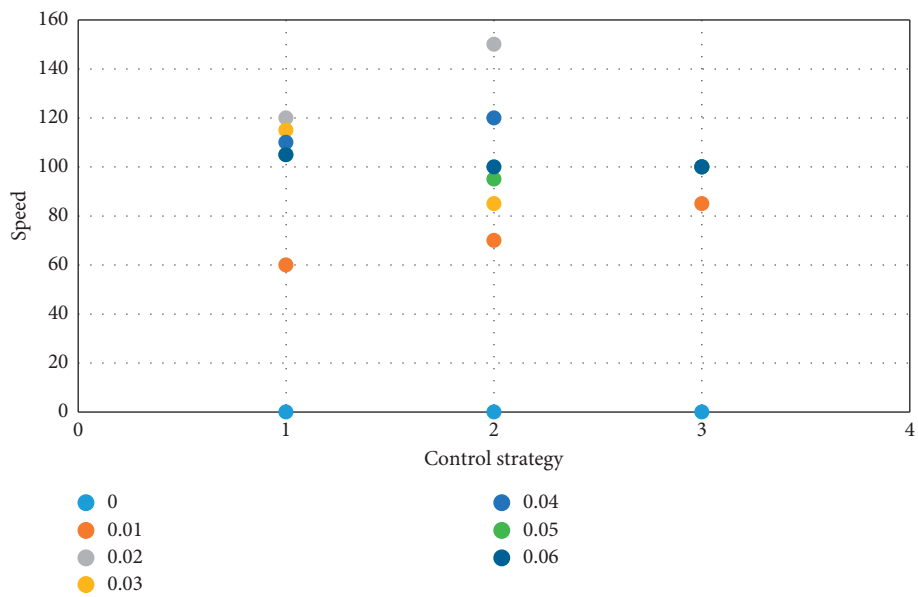

Figure 7: Speed waveform under no load and low-speed start(2).

and control strategy 2 has an obvious overshoot phenomenon under the condition of low-speed start-up of the system, and the adjustment time is about 0.18 s and 0.26 s. It can be seen that control strategy 2 shortens the regulating time, but increases the overshoot of the system under the condition of low-speed starting, which indicates that the ideal speed regulation effect cannot be achieved at low-speed. The adjusting time of the control strategy proposed in this paper is 0.06 s, which verifies that the starting performance of the control strategy is better than that of control strategy 1 and control strategy 2 under no load and low-speed conditions.

5. Conclusions

Network control system is a new type of control system which combines computer networks, communication technology, and control theory. It has the advantages of remote control, resource sharing, easy maintenance, and high flexibility. It has a wide application prospect in industrial control and other fields. It is one of the hot topics in communication and control.

In this paper, based on the existing AC induction motor model, the mathematical model of networked AC induction motor is established, and it is subdivided into discrete networked AC induction motor mathematical model with controller parameter perturbation and external disturbance, and continuous networked AC induction motor mathematical model with system parameter perturbation and external disturbance. Based on the coordinate transformation method, the three-phase dynamic model of PMSM Based on physical meaning is transformed into the two-phase decoupling motor model in a rotating coordinate system The simulation module is built on the MATLAB experimental platform; aiming at the problems of parameter perturbation and network induced delay in networked AC induction motor control system, the robust stabilization problem of networked AC induction motor control system is studied, and the time-varying delay is divided by the method of time-delay division.

Due to the limitation of my knowledge level and research time, there are some shortcomings in this paper: in the modeling of networked AC induction motor system, the simplified modeling method is adopted, and many assumptions are made in the modeling. Therefore, how to establish a more realistic model to reflect the characteristics of the network or to establish a more general network control system model is also one of the research hotspots in the next step.

Data Availability

This article does not cover data research. No data were used to support this study.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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Research Article

Application of Machine Learning Algorithm in Stadium Engineering Building Information Model Management System

Qi Chen and Nan Sheng

Guangzhou Academy of Fine Arts, Guangzhou 510006, Guangdong, China

Correspondence should be addressed to Nan Sheng; shengnan@gzarts.edu.cn

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BIM (building information modeling) is a building information modeling technology. It is a modeling technology that has quietly emerged in the architectural design and construction industry and will gradually replace the traditional CAD drawing technology. In addition to carrying geometric information of graphics, it can also carry buildings and building components. The engineering and nonengineering information of the building space has a higher degree of visualization and a stronger sense of three-dimensionality, and all the building information can be put into a model. The model can provide dynamic information on engineering construction cost management processes and can be processed by a computer in real time. The purpose of this paper is to study the new method of stadium project building information model management after the introduction of deep learning technology. This article first introduces the artificial neural network under machine learning algorithms by building a neural network model and combining it with the engineering construction information model and then integrating machine learning algorithms into the construction information model technology so that the originally three-dimensional model can further information integration. Compared with the original building information model, the data processing is more efficient and the management level has greatly improved. The experimental results of this paper show that machine learning algorithms can optimize the construction information model of stadium engineering and increase the efficiency of project management by 20%.

1. Introduction

With the rapid development of the Internet economy today, transactions from all walks of life have been added to the Internet track, leading to new developments such as original business innovation and administrative management. Affected by innovation and development, the sports industry has come to life in the collision with the Internet. As a result, the sports industry is moving toward a new track. At the same time, the business model of the integration of the Internet and the stadium has been sought after by more investors. The entry of building information models into China has not only brought a new technological atmosphere to the domestic construction industry but also a revolution in the production and management methods of the construction field. The BIM technology, which originated in the United States and developed in the United States, has already made a certain contribution to the construction industry in the United States. The Chinese government vigorously advocates and promotes the application of BIM in China, hoping to develop and popularize the use of BIM technology as soon as possible. The company has responded vigorously from the owner, design unit, project management company, and construction company, and has successively carried out BIM technology training and development within the company. Based on the characteristics of digital visualization, collaborative consistency, simulation, scheme optimization, and information mapping, BIM technology has gradually been accepted by construction engineering and has been continuously promoted, applied, and upgraded. BIM has brought an impact on various interest companies in the construction field. BIM technology has brought revolutionary progress in new management methods for engineering management companies that provide professional

technical service consulting services. BIM technology can participate in various services throughout the project life cycle, can fully penetrate into all aspects of the services provided by engineering management companies to customers, and provide customers with more exquisite professional knowledge consulting services and other value-added services, which can assist in optimizing design, improving construction productivity and efficiency, quality, safety, and budget. For example, the use of BIM model for comprehensive pipeline collision detection to guide construction, the use of BIM model for engineering quantity statistics and change accounting, and BIM model-based operation and maintenance management, etc., are the revolutionary use of BIM technology by engineering management companies to provide customers. As a part of the engineering management company, the establishment of the BIM model exists as a business product with the core competitiveness value of the engineering management consulting company. BIM technology provides customers with value-added services and also enhances the core competitiveness of the engineering management company itself. Although BIM is becoming mature internationally, BIM technology in China is only a "small lotus just showing its sharp corners." At this stage, the informatization level of many construction companies is still very backward. Many engineering projects have not applied IT systems for management, and have not introduced BIM technology. The on-site engineering volume data collection is still carried out by the original manual filling method, and the project progress is difficult. Control, project quality, safety, etc., rely too much on traditional methods to manage and fail to effectively prevent and monitor, and key process methods cannot be simulated and verified in advance. Frequent rework makes it difficult to control construction costs. These reasons make it difficult for domestic engineering companies to effectively improve and maintain their competitiveness.

Although there are many theoretical studies on BIM applications at home and abroad, the BIM model is regarded as a product of an engineering management company. There is very little research on the service operation of BIM in engineering management companies. How to use BIM technology the research on the core competitiveness of engineering management companies and the BIM business operation strategy of engineering management companies are even rarer. Pishdad–Bozorgi P successfully implemented FM-based BIM research. This research first defines and examines one of the first pilot implementations of FM-enabled BIM, discusses the challenges encountered and the lessons learned and then proposes research framework for future researchers to systematically and strategically establish a BIM knowledge base for the FM field. The implementation process and lessons learned in the pilot project provide valuable insights for the successful implementation of FM-based BIM [1]. Zhang believes that in the process of construction project management, it is necessary to carry out new changes to the management model, improve the effectiveness and versatility of management methods, and promote the construction and application of the entire project management process. BIM has done some active and effective management work in the process of full chain management, which saves expenses and increases profits [2]. Samuel et al.'s research explores and utilizes the sustainable value of BIM to realize the provision of buildings that require less energy for operation, emit less carbon dioxide, and provide a conducive living environment for residents [3]. Cui et al. discussed the relationship between BIM technology and hospital construction and discussed the comprehensive application of BIM technology in hospital logistics and administrative management. They hope to improve the BIM system and combine the development needs of the hospital so that the BIM system will further promote the development and construction of smart medical care [4]. Wang and Song studied BIM user satisfaction. Based on data collected from 118 BIM engineers, they studied the impact of five potential variables (such as attitude, perceived ease of use, perceived usefulness, senior management support, and goal management) on industry BIM user satisfaction [5]. Svalestuen and Knotten studied the advantages and challenges of BIM equipment on construction sites through a survey of respondents and used communication theory to explain, why these tools are more effective than traditional methods [6]. Keenlisi and Beange started by improving the BIM guidelines and tried to publish standardized BIM guidelines. They believe that this structured method of BIM document development will improve the efficiency of the creation and implementation of future guidelines and standards, facilitate the adoption and standardization of BIM in the industry, and provide a common baseline that many user types urgently need [7]. Based on the characteristics of the construction industry, Aitbayeva and Hossain launched an investigation into the implementation of BIM in Kazakhstan's construction industry. Identify opportunities and obstacles for implementing BIM in Kazakhstan construction companies. Although there are a lot of research materials on BIM, there is still a lack of connection between BIM and high-tech, and the current artificial intelligence technology has not yet been applied to the construction industry [8].

This article improves the building information model and introduces artificial intelligence machine learning algorithms. While retaining the three-dimensional and efficient management model of the building information model, it uses the interactivity and scalability of machine learning algorithms to make artificial intelligence technology the building information model. Empowerment to assist the optimization and improvement of the management research of the stadium project building information model.

2. Introduction to Machine Learning Algorithms and BIM Methods

2.1. Machine Learning. Machine learning is abbreviated as ML or machine learning. It is a highly interdisciplinary subject, specifically involving probability theory, statistics, approximation theory, convex analysis, algorithm accountability theory, etc., [9]. Its research content is to enable computers to learn to simulate human behavior and actions, thereby acquiring new knowledge and skills.

This algorithm is the core of artificial intelligence technology and is widely used, such as healthcare, finance, retail, and tourism.

Artificial neural network can be referred to as neural network for short and has been a research hotspot in the field of artificial intelligence since the 1980s. The artificial neural network is inspired by the neurons of intelligent creatures and realizes the realistic effects of the human brain by observing the behavior patterns of the human brain and simulating the behavior patterns of the human brain. Several neurons are connected to form a network, which is an artificial neural network. Because the neural network can reflect part of the characteristics of the human brain, it is similar to a simulation and abstraction of the processing mode of the human brain. Its excellent self-learning, self-organization, and nonlinear characteristics enable it to simulate us at different levels. The human brain's functions such as information storage and retrieval are more suitable for solving a large number of nonlinear and complex data problems. Neuron is the smallest unit of artificial neural network, just like the biological neuron plays a role in biological neural structure. The working method of neuron [10] is to receive a group of multiple inputs, and then carry out the calculation of weighted summation. Inputs can be eigenvalues of external data samples, such as images or documents, or the outputs of other neurons. If it exceeds the set initial threshold, it will form an output. It is precise because of these interconnected neurons and the weight coefficients that reflect the strength of the correlation that they have the ability to process very complex information. Its main components include input, output, weight, threshold, and activation function, as shown in Figure 1.

The input of the neuron is derived from the $Y_1, Y_2, Y_3, \ldots, Y_i$ of the input layer. The i inputs $Z_1, Z_2, Z_3, \ldots, Z_i$ are the weights corresponding to the $i$input signals. At the same time, each neuron in the artificial neural network needs to set a threshold ω, once corresponding to the Y_i and Z_i phases when the multiplied sum is greater than ω, the neuron is activated. When the activation state is changed, the neuron will form an output, the output is as in

$$S = f\left(\sum_{i=1}^{m} Z_i Y_i + \omega\right). \tag{1}$$

Among them, $f(x)$ is the activation function of the neuron, which is mainly used to add nonlinearity and other factors. Generally speaking, the linear model is not good enough to express the effect. The usual activation function should have the characteristics of nonlinearity, monotonicity, and differentiability, thereby enhancing the accuracy of the artificial neural network [11].

Commonly used activation functions are mentioned in the following.

2.1.1. Sigmoid Function. The advantage of this activation function is that it compresses the real numbers to the range of 0 to 1, turning large negative numbers into 0 and large positive numbers into 1.

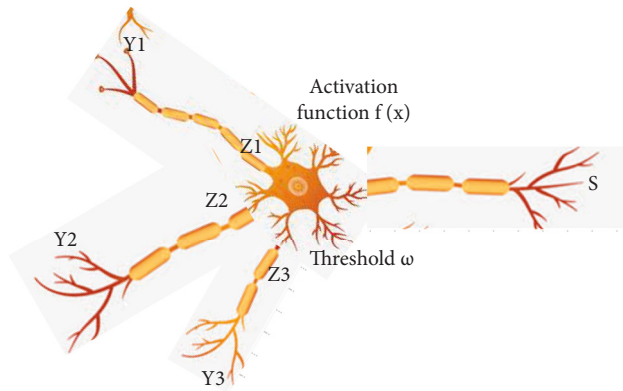

Figure 1: Neuron structure.

$$f(n) = \frac{1}{1 + e^{-n}}. \tag{2}$$

2.1.2. Tanh Function. The advantage of this activation function is that it works well for those whose features are very different.

$$f(n) = \tan\ g(n). \tag{3}$$

2.1.3. ReLU Function. The advantage of this activation function is that the convergence speed obtained is faster than the abovementioned activation function, and the operation is relatively simple.

$$f(n) = \max(0, n). \tag{4}$$

An artificial neural network is a nonlinear network formed with different hierarchical structures. It has an input layer and an output layer, with a complex hidden layer in between. There are multiple neurons on each level, and neurons are arranged in the order of input and output, but neurons on the same level are isolated. Figure 2 shows the simplest structure of the most complex hidden layer in the artificial neural network [12]. In fact, there are many other structures of neural networks, such as CNN and RNN, which have various linking rules.

The artificial neural network is actually a function from the input vector $\overrightarrow{M}$ to the output vector $\overrightarrow{N}$, namely,

$$\overrightarrow{M} = f_{\text{network}}(\overrightarrow{N}). \tag{5}$$

In the example of the artificial neural network in Figure 2, define the parameters (J, d), where J is the weight of the connection between the two neurons, and d represents the bias value of this layer. As shown in Table 1, the calculation results of the forward propagation of the network model are as follows:

$$c_a = v_a, \quad a = 1, 2, 3, \tag{6}$$

$$c_4 = f(j_{41}c_1 + j_{42}c_2 + j_{43}c_3 + d_4), \tag{7}$$

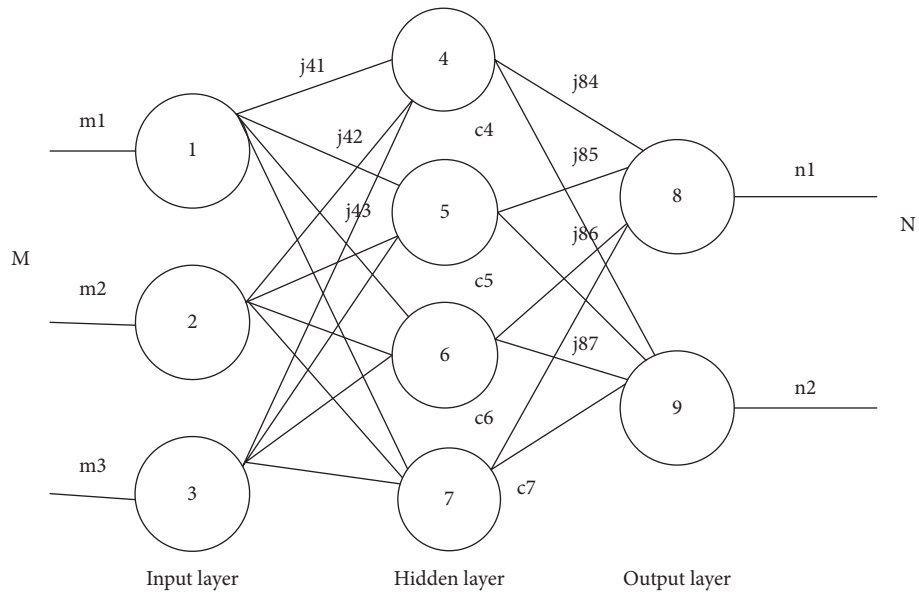

Figure 2: Artificial neural network structure.

Table 1: Neural network parameter setting table.

Parameter	Meaning
v_a	Input value of the ath neuron
J_{al}	The weight of the lth neuron to the ath neuron
d_a	The bias value of the ath neuron
c_a	The activation value of the ath neuron
$f(n)$	Hidden layer activation function
S_a	The output of the neural network

$$c_5 = f\left(j_{51}c_1 + f_{52}c_2 + f_{53}c_3 + d_5\right). \tag{8}$$

$$c_6 = f\left(j_{61}c_1 + j_{62}c_2 + j_{63}c_3 + d_6\right), \tag{9}$$

$$\begin{aligned} c_7 &= f\left(j_{71}c_1 + j_{72}c_2 + j_{73}c_3 + d_7\right), \\ S_1 &= f\left(j_{84}c_4 + j_{85}c_5 + j_{86}c_6 + j_{87}c_7 + d_8\right), \end{aligned} \tag{10}$$

$$S_2 = f\left(j_{94}c_4 + j_{95}c_5 + j_{96}c_6 + j_{97}c_7 + d_9\right). \tag{11}$$

We can do a generalization, and use Q_a to represent the weighted sum of the neuron input of the a-th layer, then

$$Q_a = j_{al}c_l + d_a, \tag{12}$$

$$c_t = f\left(Q_a\right). \tag{13}$$

The abovementioned equation is a simple forward propagation process. The input v obtains the output S through the parameters (J, d) and the activation function. Assuming that the expected value is e, we need to continuously learn and adjust the parameters to make $S \approx e$ [13]. It can be said that the artificial network is a model, then these weights are the parameters of the model, which is what the model needs to learn.

In machine learning, the Minibatch method is generally used to train neural networks. Assuming that there are $(a+b)$ samples in a batch, batch$_R$ is the original batch without marking errors, and it is $\{(m_1^R, n_1^R), (m_2^R, m_2^R), \ldots, (m_{a+b}^R, n_{a+b}^R)\}$. Batch size is a hyperparameter that defines the number of samples to process before updating internal model parameters.

batch$_E$ is a batch with incorrect labeling, in which a sample is correctly labeled, and b sample is incorrectly labeled, which is $\{(m_1^E, n_1^E), (m_2^E, n_2^E), \ldots, (m_{a+b}^E, n_{a+b}^E)\}$. batch$_M$ is the modified label. $S_R(\gamma), S_E(\gamma), S_M(\gamma)$ is the loss function value of batch$_R$, batch$_E$, batch$_M$ in the network state γ, respectively, as follows:

$$S_R(\gamma) = \frac{1}{a+b}\sum_{l=1}^{a+b}\left\{\left(m_l^R, n_l^R\right), \gamma\right\}, \tag{14}$$

$$S_E(\gamma) = \frac{1}{a+b}\sum_{l=1}^{a+b}\left\{S\left(m_l^E, n_l^E\right), \gamma\right\}, \tag{15}$$

$$S_M(\gamma) = \frac{1}{a+b}\sum_{l=1}^{a+b}\left\{S\left(m_l^M, n_l^M\right), \gamma\right\}. \tag{16}$$

If the batch after the label is modified by the algorithm, it reduces the impact of labeling errors on the neural network training. Then the algorithm is effective, which is

$$\left|S_R(\gamma) - S_E(\gamma)\right| > \left|S_R(\gamma) - S_M(\gamma)\right|. \tag{17}$$

The negative impact on the neural network is brought about by the wrong label. Therefore, if the algorithm can reduce the number of wrong tags, it can effectively improve the algorithm's robustness to tag errors. P_M is the probability that the algorithm modifies the label, and P_R is the probability that the sample label in batch$_E$ is modified to the corresponding label in batch$_R$. Then when the following formula holds, the algorithm can reduce the number of false tags.

$$b - b \times P_M \times P_R + a \times P_M \times (1 - P_R) < a. \quad (18)$$

Simplify and get

$$\frac{a}{a+b} < P_R. \quad (19)$$

Therefore, when the proportion of the correct label in batch$_E$ the satisfies is less than that P_R, the algorithm can effectively improve the performance of the neural network when the label is incorrectly labeled.

2.2. Introduction to BIM-Related Concepts. NBIMS's complete definition of BIM is as follows: BIM [14] is a standardized computer-readable model, which is the ontology of a construction project combined with the digital expression of the built environment, and it also integrates the construction project information and equipment and facility information of the construction project, a collection of shared information resources. It can provide a reference for the decision-making and management behaviors of the construction project from the conceptual design stage to the demolition and scrapping stage. At different stages of the project, practitioners in various professional fields and links use BIM to input, output, modify and update the information to complete their own functional tasks and achieve synergy with other professions. The generation and application of BIM technology are essential to the realization of the full life of the building. Cycle management is of great help. It can also improve the labor productivity of various professions in the construction industry and reduce the collision and friction between professions. The core of BIM is to establish a virtual three-dimensional model of construction engineering and use digital technology to provide a complete construction engineering information database consistent with the actual situation for this model.

The BIM model is shown in Figure 3. It has a wide range of information, a high level of intelligence, and strong interactivity. It has realized graphical parameterization and has the characteristics of high information integration, high reducibility, strong simulation, and secondary development. In detail, BIM can highly integrate information involved in construction projects, and can use BIM software to retrieve, count, and analyze project information based on models, and assist different stakeholders in the design, construction, and management of problems in the process of decision-making; able to view and troubleshoot the model dynamically, subsystem, subfloor, or subregion. At the same time, it can summarize the parts and component lists in the model, which is helpful for budget and final accounts auditing; it can simulate the status of the building after completion, or based on The BIM model is used to simulate and demonstrate various indicators of the internal built environment; in addition, the most prominent and most potential point of BIM is: the BIM platform can be redeveloped, and the building that the software user wants to complete based on the BIM model Design, construction collision inspection, problem-solving and construction management work [15]. With the help of this three-dimensional model containing

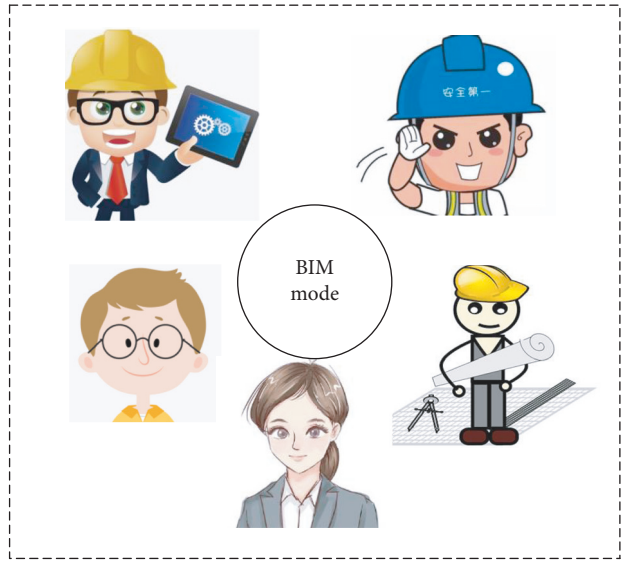

Figure 3: BIM structure model.

construction engineering information, the information integration degree of construction engineering is greatly improved, thereby providing a platform for the exchange and sharing of engineering information for stakeholders of construction projects. It can also be seen from the above-mentioned literature summary that BIM has the ability or potential to solve most of the various problems in the entire life cycle of a building.

2.3. Project Management. Modern project management system [16] refers to the use of various cognitive and practical tools to satisfy managers' management of operations, which is the latest development in the field of international management. The project management system effectively integrates financial control, human resource management, risk control, quality management, communication management, procurement management, etc. in enterprise management, so as to achieve the purpose of completing various tasks or projects within the enterprise with high quality and low cost. Different from traditional project management, modern project management can be divided into management methods and theoretical management, which are the core of modern project management. It includes a variety of universal management laws and methods, not only applicable to traditional project management but also compatible with other types of project management. As the application section of modern project management system-engineering project management, it is an indispensable part of modern project management system. Its structure is shown in Figure 4.

In the 1990s, the international engineering community defined project management (PM) as: "The entire process from the beginning of the proposed project to the end of the project, involving the process of project planning (PP) and project control (PC), completing the project cost, whole-process supervision of quality and progress." This definition is based on scientificity and has been the consensus of the

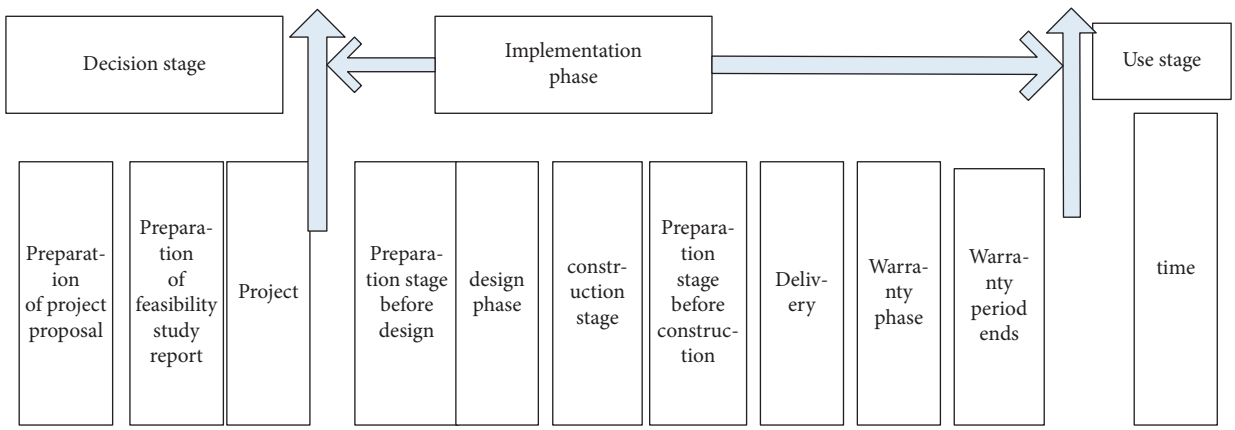

Figure 4: The phases of the project.

industry for a long time [17]. Project management mainly includes project scope, time, cost, quality, human resources, communication, risk, procurement, integration, and other management content. After more than 20 years of development, the project management theory system has made obvious breakthroughs and has a new understanding of project management, project process, and management work.

Project management is an uncertain dynamic change. After the scientific goal is determined, project control can ensure that the project runs and realizes according to the predetermined trajectory. First, the process perspective of project management has changed. Traditional management theory believes that the project proposal must be approved before the project starts. In other words, the follow-up work must be carried out after the project is established (PM = PP + PC). At the same time, the main body of process project management has also changed. In the past, if traditional management did not establish a project, then the main body of project management could not be established and project management could not be carried out. Nowadays, modern project management has lengthened the cycle of traditional project management and refined the division of labor (PM = DM + PP + PC + RD). Second, the needs of project management have changed. Modern social engineering construction pays more attention to issues such as energy conservation, environmental protection, health, safety, humanized design, and traditional management methods are difficult to match the needs of users.

3. Application of BIM Technology Based on Machine Learning in Gymnasium Project Management

3.1. Status of the Stadium Project. As a typical municipal project, the stadium project has different characteristics from general construction projects, as follows:

(1) Large scale of investment: usually, the construction of stadiums is mostly government investment, and the investment volume is large

(2) It is difficult for multiple parties to coordinate: multiple design parties, multiple construction parties, and multiple bidding sections start project construction at the same time

(3) The system is complex, management is difficult, and management requirements such as investment, progress, quality, safety, and environmental protection are high

(4) Talent shortage: in recent years, the demand for sports has grown substantially, and there is a serious shortage of technical and management talents

(5) Long construction period: usually, the construction period of the gymnasium is 1 to 3 years, and the operation period is 70 years

3.2. Application in Pre-Engineering Management. In order to give full play to the characteristics of BIM technology, and at the same time improve the efficiency and quality of the design work of the gymnasium project construction organization plan, it is recommended to incorporate BIM technology on the basis of the traditional construction organization plan design process, and integrate the BIM technology with the project schedule and engineering materials. The combination of material management effectively avoids construction period delays, construction organization confusion, etc., combined with the engineering BIM model data to simulate the construction organization of the station, to conduct a preconstruction preview of the construction plan and equipment input to determine the stadium engineering station and the rationality of the project construction organization plan, resources and equipment investment in the interval.

The design optimization of the construction team of the gymnasium, the use of operations research, the combination of computer simulation technology and BIM technology, and engineering construction specifications, establish a BIM model for engineering construction simulation [18]. Control the construction process, mechanical equipment investment, material supply, and other construction links through intelligent operation research algorithms, analyze the

construction schedule simulated by simulation, dynamically query and optimize the configuration of construction resource allocation, construction intensity, and duration, and according to the actual project, the iterative update of the donor design simulation of the construction situation will finally provide the construction unit with a more reasonable construction plan, resource and consumable input arrangements for the construction organization plan, thereby improving the service coordination and management level of the construction unit for the project.

If you want to introduce BIM technology into an engineering project, you must first build an accurate three-dimensional model, which can allow project managers to have a more comprehensive and intuitive understanding of the entire project, and help them find out the problems before the project is officially constructed, which greatly reduces the probability of occurrence of project quality problems. The BIM model we build must have high accuracy and also have certain requirements for modeling speed, both of which will have a direct impact on the effect of the BIM technology in the entire project. The technical staff must construct the BIM three-dimensional model within the specified time, and ensure the accuracy of the model through a large number of audits and corrections. Using this model can make some engineering quality problems that are difficult to be exposed on traditional two-dimensional drawings to be more intuitively reflected, which not only helps project managers find and solve problems in time but also effectively improves project construction efficiency [19], can be divided into the following steps:

(1) In the MS Project project management software, the tasks of the construction phase are decomposed, construction cost and resource management are carried out from the perspective of work, and a construction plan composition scheme with a dynamic foundation is formed. The beginning of each work in the subsequent construction process Both mark the beginning of time, so as to realize the dynamic control of resources on the time axis. During the work process, the dynamic management of human resources, materials, and machinery is achieved while the dynamic management of construction costs is achieved so that the target management and process fully integrate management to maximize benefits.

(2) Establish the code to call the API between the project management software MS Project and the BIM 3D modeling software Autodesk Revit under the programming platform, expand the function, realize the circulation of Autodesk Revit and MS Project data, eliminate information islands, and use information maximize value.

With BIM, the implementation process is concrete and intuitive, efficiency is greatly improved, and engineers are highly satisfied. They basically recognized the BIM model under machine learning algorithms and are willing to continue using it. The results are shown in Table 2.

3.3. Application in Project Management. After introducing BIM technology into project engineering, users can see the vulnerabilities and defects of engineering design in a more intuitive and accurate way. The three-dimensional visualization diagram can clearly allow users to see any node, as shown in Figure 5. After applying BIM technology, three-dimensional simulation of construction nodes, so as to determine the accurate size and location of tools, and accurate data of structural construction, to achieve more efficient construction [20, 21]. Use BIM technology to simulate the entire construction process to provide practical guidance for project managers to ensure that all project managers have a more comprehensive and intuitive understanding of the entire construction process of the project, and enable them to master each project construction method and construction process lay a solid foundation for the subsequent project construction management. In addition, the BIM technology is used to simulate the construction process, coordinate and handle the relationship between the project participants, improve their communication efficiency, and also help to further optimize the quality management level of the project.

Project managers can also use the BIM system to collect quality information items with the help of wireless devices such as iPads and mobile phones to realize data sharing and storage on the cloud network [22]. In particular, project managers can also operate and process data on the platform within their own authority, so as to further ensure the integrity and safety, and reliability of the data. This also provides a traceability channel for later engineering errors. Not only that, but on-site management personnel can also judge the transportation time and quality status based on relevant indications to ensure that on-site materials and submitted reports are in compliance. This method of integrating relevant staff responsibilities and construction site quality information based on BIM technology greatly improves the standardization of project construction sites and creates favorable conditions for project quality control [8]. It can be divided into the following steps:

(1) Introduce BIM technology and establish a dynamic management plan for the construction phase with Autodesk Revit as the core. In the formulation phase of the construction plan, the resource configuration information contained in the BIM 3D components is associated with each task node of the WBS to ensure that each task node the accuracy of resource and cost control can ensure the accuracy of the resource and cost calculation of the entire construction project.

(2) With the advancement of the construction stage, real-time dynamic monitoring of project resources and costs, as shown in Table 3, uses the earned value method to compare planned costs with actual costs, and compare planned resource usage with actual resource usage. Timely discover the risk factors that affect the construction stage and take remedial measures in real time to avoid project cost overruns and excessive resource usage at the time of completion and settlement.

Table 2: User experience survey report.

	Accuracy (%)	Construction efficiency (%)	Intuitiveness (%)	Satisfaction (%)
Traditional model	70	77	60	72
BIM model	80	85	78	81
BIM model of machine learning	95	93	92	93

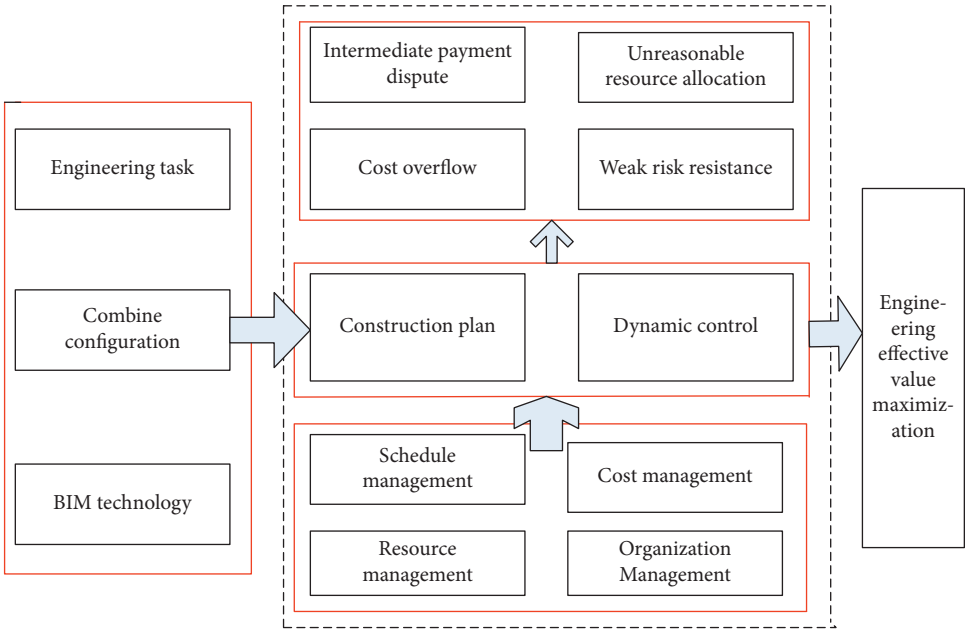

Figure 5: BIM management optimization process.

Table 3: Comparison table of real-time dynamic monitoring of project resources and costs.

	Planned cost	Actual cost	Planned resources	Actual amount of resources used	Income and expenditure
Traditional mode	100	102	1000	1001	−10
BIM mode	100	92	1000	988	12
Based on BIM machine learning mode	100	88	1000	968	25

(3) Refine the calculation of resources and costs to each WBS working node, the calculation is accurate, and the dispute caused by the inaccurate calculation of the intermediate payment is eliminated. The project resources and costs of the work task nodes completed every day are calculated and accounted for to form a daily work report. The payment of project progress payment can also be done weekly or monthly. When the project progress payment needs to be paid, it only needs to be based on the daily work report calculated by the project management software to reduce disputes [23, 24].

As shown in Figure 6, compared with the traditional method, the intermediate process of the BIM model can be traced, reducing excessive excuses, and at the same time, the progress of the process can be mastered throughout the process, and the management can be more efficient.

3.4. Application in Postproject Management. Project managers can use tools to analyze and process the project quality information in time, space, and subitems, find the quality problems in the construction in time and put forward operability solutions according to the problems [25]. By summarizing and analyzing historical project quality information, a method and path to effectively control project quality can be found. For example, a database can be introduced, and the resource configuration information contained in the BIM three-dimensional component elements can be called and output to the database to form a multi-table data structure in the database. The information in the resource configuration database can provide assistance for the cost budget of the project. It can be saved as the empirical configuration data of the project to provide a reference for the configuration work of similar projects in the later period. The resource configuration database file is saved or transferred together with the Autodesk Revit model

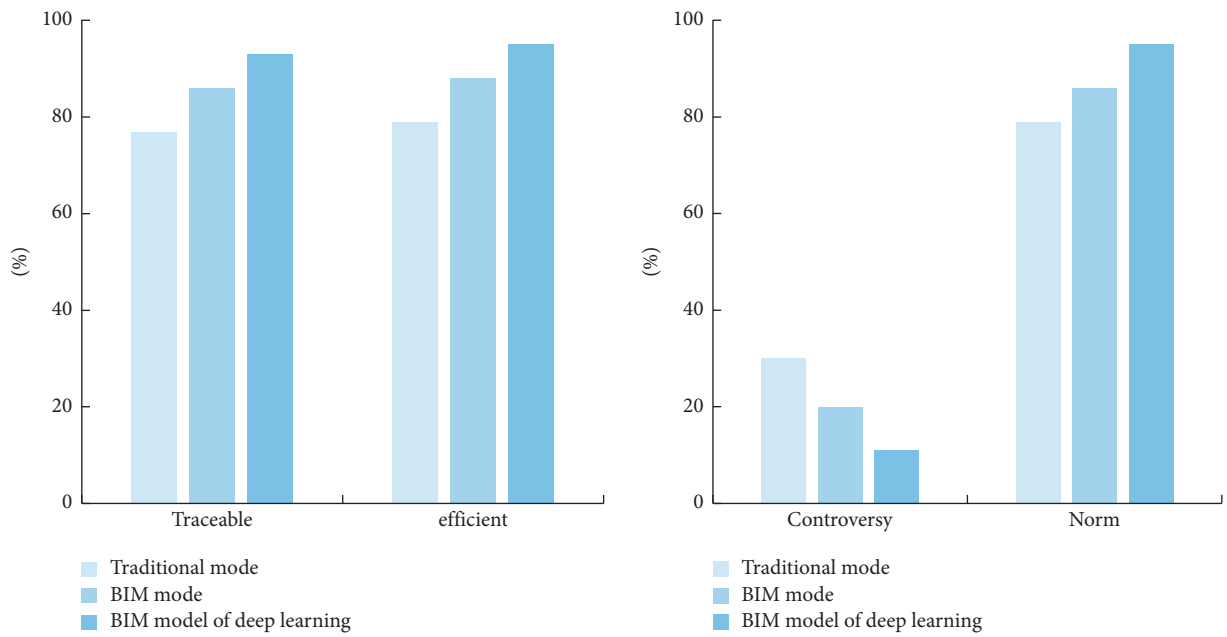

Figure 6: Survey on engineering practicability of the BIM model based on machine learning algorithms.

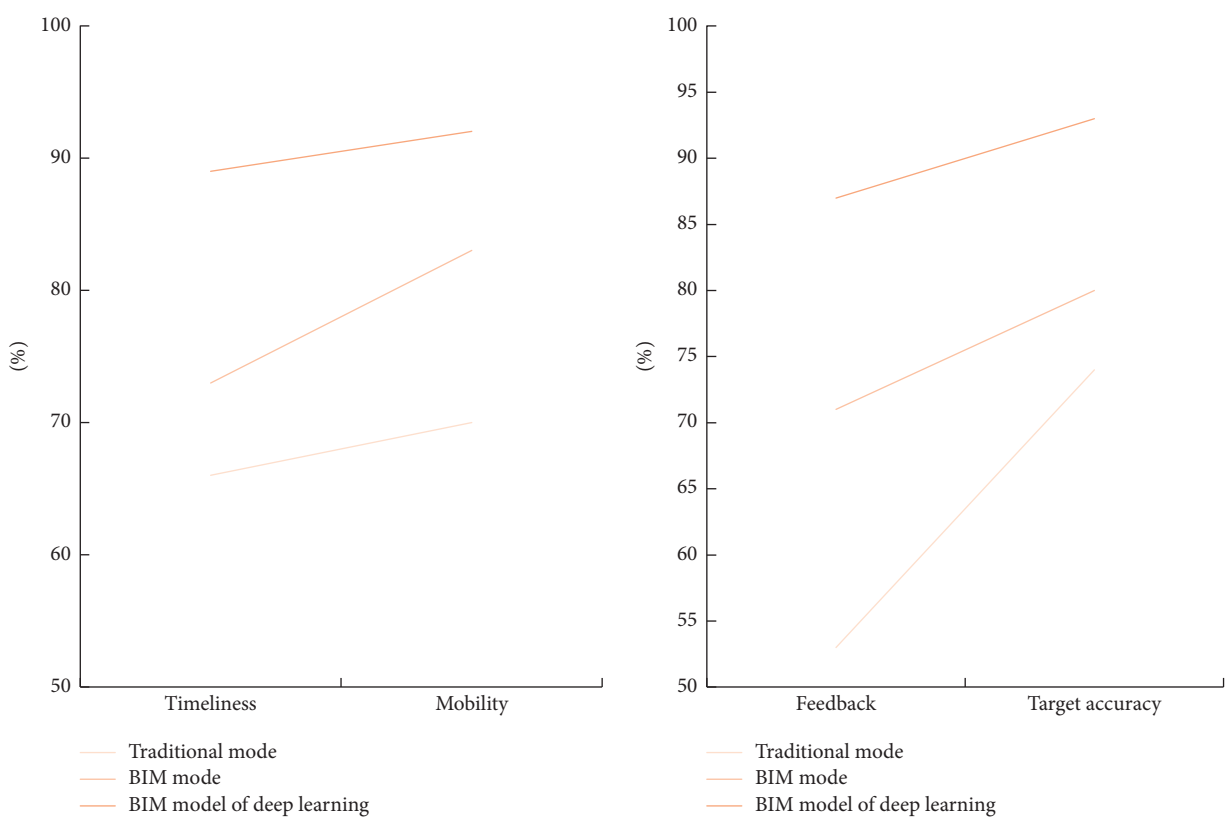

Figure 7: BIM feedback survey based on machine learning algorithms.

file. The two data are related and become the basic data file for dynamic management [26].

With the support of BIM technology, comprehensively consider and analyze the construction process start report (submission report), project acceptance quality documents, material/equipment/accessory review documents, design change documents, engineering accident handling documents, supervision work reports, and other data Information and engineering quality problems are given effective solutions to form relevant experience. I will provide a reference for future quality control [27]. The technical documents and quality inspection reports generated based on

BIM technology, as shown in Figure 7, can be directly used for auditing, eliminating the need to search for paper documents, saving working time, and improving efficiency.

4. Discussion

Under the fusion machine learning algorithms mode, BIM further exerts its advantages and refines the engineering resource configuration information built into the BIM three-dimensional model components into each task node, forming a new construction plan composition scheme with a dynamic foundation. In the subsequent construction process, through accurate calculation of the cost data and resource data of each WBS task node, real-time, fast, and continuous dynamic control of the engineering project is realized. Model the engineering quantity beforehand, analyze the current management status of the construction industry in the construction stage, find out the deficiencies in the management methods, propose improvement plans, analyze the needs of the dynamic planning management plan in the construction stage, and explain the plan. During the event, the three-dimensional components in the BIM model and the work tasks are related to each other to realize the combined management of project progress and project costs in a three-dimensional environment, forming a dynamic data relationship model based on BIM technology, forming a three-dimensional visualized management of costs and resources, and dynamic data relationships The model is improved. At the same time, it can provide real-time planning guidance, break information barriers, and further optimize related programs after the fact, while providing a reference for subsequent program design. It can be said that the BIM model based on machine learning algorithms will bring more profound changes to users [28].

5. Conclusions

With the guidance of the macro environment and the promotion and popularization of the country, the BIM business will develop like the previous and current Internet Similarly, the time of prosperity is an indispensable choice for customers. BIM has made China's construction management in the field of construction change from rough to modern and sophisticated management. Regardless of whether the BIM business starts from the current technical tools or is based on the innovation of the future smart building model, the trend of its application and promotion is unstoppable, and will provide more and more value-added services to customers of engineering management companies. With the development of computer technology, people hope that computers can calculate and analyze intelligently like the human brain, bringing further development to science and technology. The machine learning algorithms model is developed based on this expectation. With the improvement of machine learning computer technology, computers will surely further optimize performance services. This paper discusses the application method of a machine learning algorithm in engineering construction management to help realize the further development of construction engineering management and ensure the normal progress of construction and the quality of construction. In the future, we hope that stadium-related projects can use the BIM mode of machine learning algorithms to make project construction more three-dimensional and intuitive, cost control more accurate, and coordination functions more complete, helping as soon as possible complete the construction of sports China.

Data Availability

This article does not cover data research. 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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Retraction

Retracted: English Language Intelligent Translation System Based on 3D Visualization Technology

Mobile Information Systems

Received 13 September 2023; Accepted 13 September 2023; Published 14 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] B. Song, "English Language Intelligent Translation System Based on 3D Visualization Technology," *Mobile Information Systems*, vol. 2022, Article ID 1608840, 11 pages, 2022.

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Research Article

English Language Intelligent Translation System Based on 3D Visualization Technology

Bo Song

College of Applied Foreign Studies and International Education, Tianjin Sino-German University of Applied Sciences, Tianjin 300350, China

Correspondence should be addressed to Bo Song; afzsong@yeah.net

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In the process of imparting knowledge, faculty should give more emphasis to the acquisition of students' direct experience. Vivid three-dimensional visualization resources should be used for classroom teaching to help students better understand and grasp the visualization of knowledge. Based on this, this paper aims to study the English language intelligent translation system based on 3D visualization technology. In recent years, 3D application technology is transforming into multiuser applications supporting network environments. This transformation also promotes the application and development of 3D GIS technology. Transformer is a universal and efficient feature extractor. This paper proposes a design scheme for constructing 3D interactive visualization resources in teaching scenes. It is designed for specific disciplines and produces visual resources. Then, it analyzes and evaluates the actual effect of the application in teaching, to provide ideas for English translation education experts and teaching staff. It also builds a translation system based on B/S architecture, connects the server model and the client, and realizes the visualization and interaction of translation functions. In the experiments, 5% and 20% of the parallel corpus with a total of 12 M sentence pairs were used for pretraining of the translation model. Then, the number of monolingual corpus is gradually increased to train the model. Experiments show that when using the same amount of monolingual corpus, the translation model can achieve a more obvious effect on the pretrained model.

1. Introduction

At present, 3D visualization resource design has made great progress in hardware. This needs to give full play to the advantages of 3D visualization resources for auxiliary teaching.

In the English translation education concept advocated by the new curriculum reform, both teaching resources and students' learning methods are changing. Students' learning style gradually develops into an independent, inquiring, and cooperative learning style, prompting the transition of teaching resources from static to dynamic. The concept of "Internet +" further promotes the in-depth integration of information technology and teaching resources. This brings a new change to the reform of teaching resources—a new form of interactive digital resources. The English language intelligent translation system can reduce language barriers between people in different countries and different ethnic groups through machine translation.

The innovations of this paper are as follows: (1) Based on the back-translation strategy in data augmentation, this paper uses the iterative back-translation method to expand the parallel corpus on a large scale. Judging from the performance improvement of the back-translation system generated in the iterative process, the quality of the pseudo corpus generated in the iterative process is constantly improving. (2) A translation system based on B/S architecture is built, which connects the multilingual translation model on the server side and the client side, and realizes the interaction and visualization of machine translation. (3) Data-dependent regularization terms are introduced through the probabilistic nature of neural machine translation models and applied to monolingual corpora to aid the training of neural machine translation models.

2. Related Work

Determining the impact of translation strategies on the quality of translation of research data is becoming increasingly important. In this case, Najjar et al. adopted a series of translation strategies such as literal translation, paraphrase, transposition, and morphology [1]. However, the translation quality is sometimes poor. The cultural translation view regards translation as a cross-cultural communicative activity. Zhang started with the influence of cultural context on Chinese-English translation, as well as the understanding and practice of translation activities from the perspective of cultural translation [2]. Fitriani aimed to describe and classify grammatical errors found in English-translated sentences, both syntactically and lexically. It has been found that temporal errors are the highest frequency errors and derivative morpheme errors are the lowest [3]. Implicit meaning is one of the linguistic phenomena that need to be overcome in translation. The Susini study aimed to investigate in what structure the implicit meaning is realized in Indonesian and how the implicit meaning is handled when it is translated into English [4]. Although the structures of the source and target languages differed in the translations studied, the meaning of the source language was successfully conveyed in English. Muravev aimed to find similarities between legal translation practice and training by analyzing the capabilities and limitations of case study methods in academic institutions [5]. Methods for statistical machine translation significantly improve the translation performance. However, it relies heavily on hidden structure and feature involvement, and local features are difficult to extract.

Therefore far, 3D visualization technology can not only be used in geological description, military, etc., but has also begun to develop in the field of English translation education. 3D visualization is the process of creating 3D objects using special computer programs. Today, computer graphics techniques such as 3D visualization techniques are in increasing demand. Sadiku et al. research findings allow the creation of 3D objects of any shape. It is widely used worldwide to create interiors of houses, offices, hotels, etc., [6]. Modeling with 3D visualization becomes essential. Zeng et al. proposed a global thresholding method based on local outlier factor (LOF) to solve the noise sensitivity problem in global thresholding. Both simulation and experimental results show that his scheme produces better results compared to the state-of-the-art [7]. Namiot and Romanov outlined a 3D visualization approach to the software architecture and metrics. Visualization facilitates and accelerates the process of understanding the structure of software components [8]. Inoue et al. automated the inspection of the infrastructure using point cloud analysis of the features of 3D structural information obtained through 3D structural visualization. The results show that it is feasible to model overhead cables with cable lengths of 10–70 m regardless of the area type [9]. Yoo et al. research proposed a deep learning-based CAD/CAE framework in the conceptual design stage to automatically generate 3D CAD designs and evaluate their engineering performance [10]. However, it cannot be shown that AI can actually be incorporated into end-use product design projects.

3. English Language Intelligent Translation Method Based on 3D Visualization Technology

3.1. Fusion of 3D Visualization Technology and English Translation Education. The proposal of "Internet + English translation education" further promotes the profound combination of informative tech and instructional materials. It also brings new changes to the reform of teaching resources. New forms of digital teaching resources are beginning to emerge. The design of visual resources in teaching resources is increasingly rich. 3D visualization resources are increasingly favored by teachers because of their vivid characteristics. Increasingly, teaching workers and developers are turning to 3D teaching resources [11]. In specific practice teaching, three-dimensional resources are often designed by design, which cannot truly reflect the teaching nature of resources. Therefore, it is necessary to design and apply research on teaching scenarios. The application field of 3D Visioning tech is shown in Figure 1.

As shown in Figure 1, users use computers to simulate the real environment and observe complex things. And the use of computers and other devices for interactive operations has attracted increasing attention [12, 13]. 3D visualization resources have an important impact on the teaching and learning of teachers and students.

3.2. Status Quo of English Language Intelligent Translation System. Nowadays, the globalization of economic exchange continues to deepen. The advent of the sharing economy era has brought closer exchanges and connections between different countries and regions. The exchanges between peoples of various countries and nationalities are also becoming increasingly frequent [14, 15]. Language is the most important tool in human activities, and the importance of translation between different languages is becoming increasingly prominent. In today's society, the effect of human translation can be more fluent and natural, and the text conforms to human writing habits. However, because of its short supply and high price, machine translation came into being to meet people's growing demand for translation [16]. Machine translation has the advantages of high efficiency and low cost. However, because its development has just started, it is still in its infancy. There are often various difficulties in related research and experiments. Therefore, how to achieve more efficient and high-quality machine translation has become a hot research topic in academia and industry.

3.3. Transformer Model Based on Attention Mechanism. The biggest feature of Transformers is the introduction of a self-attention mechanism. It refines the model of classical neural machine translation. The role of the attention mechanism is to calculate the degree of association between the words in the current source language sentence and it when predicting the vocabulary of the target language during training [17]. When searching the dictionary, the corresponding words in the dictionary can be directly generated.

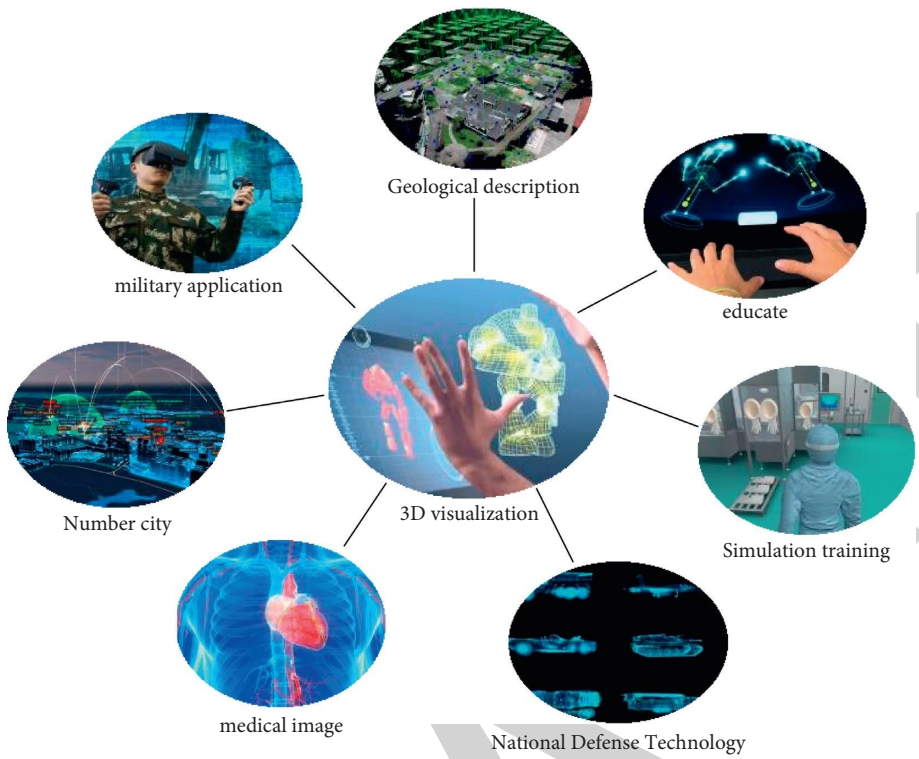

Figure 1: 3D visualization technology application field.

The encoder in Transformer consists of N identical layers. Each layer consists of two sublayers, a multihead attention mechanism, and a fully connected feed-forward neural network. Each of these sublayers contains residual connections and normalized outputs [18]. Therefore, the output of the sublayer can be expressed as

$$\text{output} = \text{LayerNorm}(x + \text{BotLayer}(x)). \tag{1}$$

The self-attention mechanism calculates three new vectors called query, key, and value. In the formula, they are abbreviated as A, B, and C, respectively. These three vectors are the result of multiplying the word embedding vector by a matrix as

$$\begin{aligned} \text{output} &= A(A, B, C), \\ MH(A, B, C) &= \text{Con}\left(h^1, \ldots, h^h\right)W^0, \\ H^1 &= A\left(AW_i^Q, BW_i^K, CW_i^V\right). \end{aligned} \tag{2}$$

The self-attention mechanism takes A, B, and C the same. In addition, the calculation of attention parameters adopts a scaled dot product, namely,

$$A(A, B, C) = \max\left(\frac{AB^C}{\sqrt{d_k}}V\right). \tag{3}$$

The Transformer model has three attention mechanisms, including the encoder multihead attention mechanism, the decoder mask multihead attention mechanism, and the encoder-decoder multihead attention mechanism [19]. The neural machine translation system based on the Transformer's structure not only improves the training speed but also achieves excellent results in translation tasks. It has become one of the most mainstream methods in the current machine translation field [20].

3.4. Design of Word Vector Algorithm for Location Information. To simplify the complexity of the word vector model, both the bag-of-words CBOW model and the skip-gram model remove the word order information. However, according to the characteristics of sequence-to-sequence machine translation tasks, it believes that the context closer to the target word can carry more word meaning information.

The work of converting the input vector to the neural network is done through a weight matrix. When outputting, a matrix is also needed to restore it to a vector form similar to the input, which is convenient for the computer to output the words in the corresponding vocabulary. The calculation process and steps are as follows:

(1) First, the weighted average operation of the input vector is converted through the matrix operation, and the hidden layer output h is obtained. The formula is as follows:

$$h = \frac{1}{c}W\left(\sum_{i=1}^{c}\lambda_i e(w_i)\right). \tag{4}$$

(2) The output of the hidden layer needs to be obtained by the same matrix operation formula is as follows:

$$u_j = v_j'^T h. \tag{5}$$

Among them, $v_j^{'T}$ is the jth column of the output matrix $w\prime$, and u_j is the value of the jth column of the output layer, which is a scalar.

(3) The output word (probability) of the output layer is calculated, the jth node outputs y_j, formula is as follows:

$$y_j = p\left(w_j | w_1, \ldots, w_{2c}\right) = \frac{\exp\left(u_j\right)}{\sum_j^V \exp\left(u_j\right)}. \tag{6}$$

Weight matrix $W_{N*V}^{'}$ and W_{V*N} update method: the first step is to define the loss function formula is as follows:

$$\begin{aligned} L &= -\log\ p\left(w_o | w_I\right) \\ &= -\log\ u_j + \log \sum_{j=1}^{V} \exp\left(u_j\right) \\ &= -v_j^{'T} h + \prod_{j'=1}^{V} v_{j'}^{'T} h. \end{aligned} \tag{7}$$

The second step is to derive the abovementioned probability to obtain the update rule formula (8) of the output weight matrix $w\prime$:

$$w_{ij}^{'(\text{new})} = w_{ij}^{'(\text{old})} - \mu\left(y_j - t_j\right) \cdot h_j. \tag{8}$$

In the same way, the update rule of the weight matrix W is

$$w_{ij}^{(\text{new})} = w_{ij}^{(\text{old})} - \mu \cdot \frac{1}{c}\left(y_j - t_j\right) \cdot x_j. \tag{9}$$

PW-CBOW uses the context x_{t-2}, x_{t-1}, x_{t+1}, x_{t+2} with position weights to train the target word w_t.

3.5. LSTM Model. LSTM can capture the information of words with long distances before and after. It is difficult for RNN to integrate messages with present messages. When dealing with long sequences of messages. It is far superior to RNN to LSTM. The LSTM pattern is shown in Figure 2.

As shown in Figure 2, each LSTM layer contains a forget gate, an input gate, and an output gate. The goal of LSTM is to control the transmission of information through these three control gates to solve the gradient vanishing phenomenon that may occur in the neural network. The working status of the three doors is as follows:

(1) The forget gate is used to control how much information from the previous layer can be transmitted to the next step and selectively send the information of the previous layer to the next layer.

$$f_t = \text{sigmoid}\left(w_f \cdot \left[h_{t-1}, x_t\right] + b_f\right). \tag{10}$$

(2) It is implemented by two neural network layers. These include the sigmoid layer and the tanh layer. The first one decides which information is updated, calculated as formula (11). The second is used to create new candidate data. The two values are combined to update.

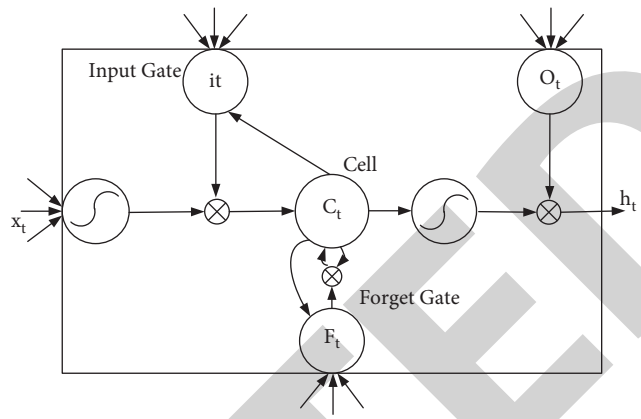

Figure 2: LSTM model.

$$i_t = \text{sigmoid}\left(w_i x_t + u_i h_t + b_i\right), \tag{11}$$

$$c_t = f_t * c_{t-1} + i_t * \tanh\left(w_c x_i + u_c h_{t-1} + b_c\right). \tag{12}$$

(3) The information to be output is determined by the sigmoid layer. The updated information is converted to a value between -1 and 1 by tanh, and the output threshold value O_t and output value h_t are calculated.

$$\begin{aligned} O_t &= \text{sigmoid}\left(w_o x_t + u_o h_{t-1} + b_o\right), \\ h_t &= o_t *\ \tanh\left(c_t\right). \end{aligned} \tag{13}$$

This subject intends to use the most commonly used BLEU value as the evaluation index of the quality of machine translation. BLEU uses the accuracy rate of the candidate translation n-grams to calculate the geometric mean to obtain the similarity of sentences. The calculation method is as follows:

$$\begin{aligned} \text{BLEU} &= BP \cdot\ \exp\left(\sum_{n=1}^{N} \frac{\log\ P_n}{N}\right), \\ \text{BP} &= e \min\left(\frac{1-r}{c, 0}\right). \end{aligned} \tag{14}$$

Among them, P_n represents the N-gram confirmation rate, and BP represents the sentence length penalty factor. c is the number of words in the candidate translation, and r is the length of the reference translation closest to the length of c. It does some research and adjustment on the evaluation of the BLEU test method.

4. Design and Implementation of the English Machine Translation System

To make better use of the research results of English language neural machine translation model, this chapter will build an online English language translation system on this basis. This makes it easier and more immediate to handle translation tasks for users. The system is based on B/S (browser/server) architecture, in which the core translation

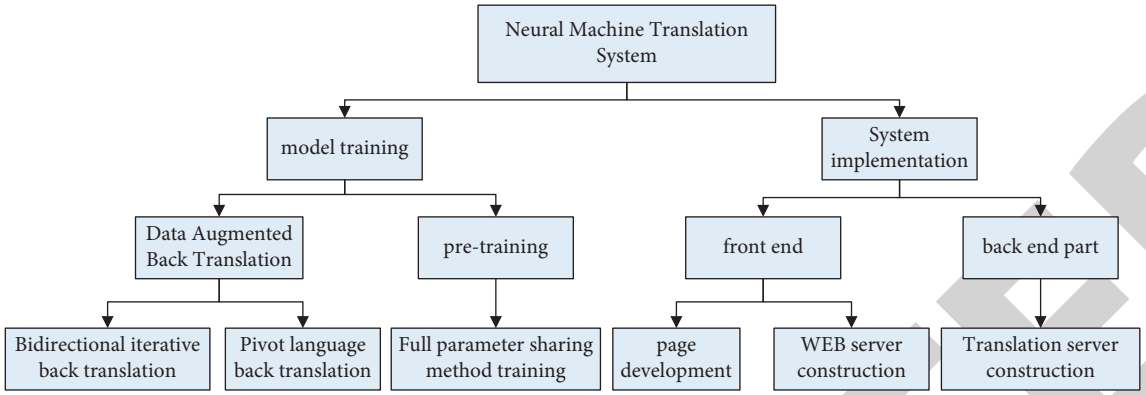

Figure 3: The structure of the English language translation system.

function is deployed on the server side. Users can access the page through a web browser and send translation requests. The server-side translation model can feed back the translated text to the WEB page after completing the translation task. This chapter describes the English language translation system in detail from the aspects of overall system design, system deployment, and system interface display, and shows some translation examples under different input situations. The structure of the English language translation system is shown in Figure 3.

As shown in Figure 3, this section describes all aspects of the system implementation in detail. First, the logical hierarchy of the translation system and the main functions of each level are introduced on the overall level. Then, each part of the whole role becomes reasonable module, and the functions of each module and the logical relationship between the modules are introduced in detail.

4.1. System Architecture. The design of this English language translation system follows a hierarchical structure. It also modularizes the specific functions of each part of the system. This design facilitates the maintenance, update, and upgrade of the system in the future and greatly simplifies the development and use of the system.

The translation system is divided into two logical layers from top to bottom, namely, the WEB layer and the translation service layer. The English language translation roll is shown in Figure 4.

The structure of the roll adopts the B/S (browser/server) mode. The client provides a visual translation interface and human-computer interaction functions through a WEB browser. The server side is responsible for processing the user request from the client side and judging whether the request and the input content meet the system requirements. If it matches, the translation function will be executed normally, and the translation result of the specified language will be returned to the client browser interface.

4.1.1. WEB Layer. The WEB layer provides users with a visual interactive interface. Users can access WEB pages through a browser as a WEB client. Thus, the task request and translation content are submitted to the server side. The

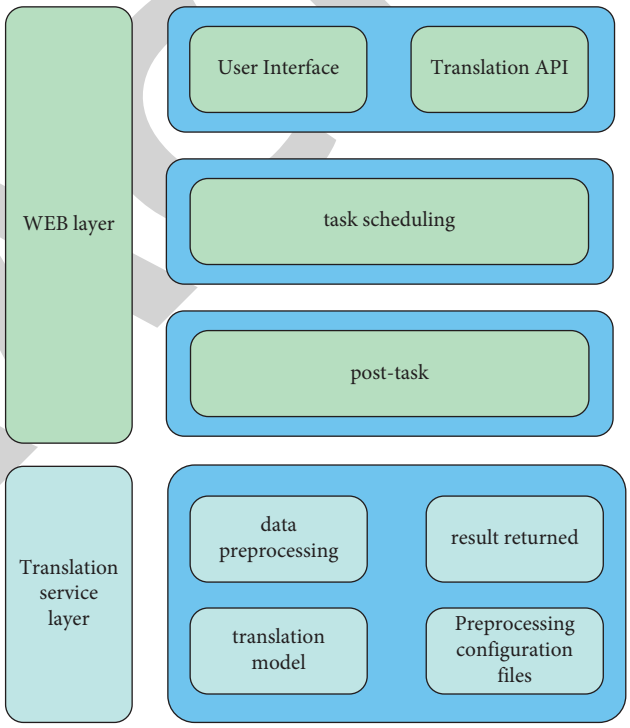

Figure 4: the structure of the English language translation roll.

main functions of the WEB layer are: to submit the translation information input by the user and display the translation results returned by the server.

4.1.2. Translation Service Layer. The major functions of the translation service layer are task scheduling and text translation. Among them, task scheduling mainly judges translation requests and tasks to be translated, and performs task scheduling for requests sent from the WEB layer. In this way, the reasonable allocation of server resources is ensured, the response speed of the system is improved, and system crashes are avoided. The text translation task includes three parts: data preprocessing, text translation, and result feedback. Preprocessing is to convert the input content for translation into a data format that meets the requirements of the model. The translation service layer processes the input

text data through a set of preprocessing tools. The translation model then digitizes and translates the preprocessed sentences. Finally, the translation result is returned to the WEB layer for display.

The system is constructed following the hierarchical design principle. According to the two-layer structure of the system, the specific functions of each layer are allocated in detail. And the corresponding modular design is carried out for different types of tasks at different levels. This provides great convenience for future maintenance and updates. All functional modules of this system can be divided into five parts according to the system level, including WEB part, task scheduling part, and translation part. The internal logic illustration of the device function module is shown in Figure 5.

The logical relationship between the functional modules of the English language translation system is shown in Figure 5. The translation service layer is invisible to clients located in the WEB layer. To ensure that the training process is disturbed by data from the client, the security of the model is improved. Only the system administrator of the server has permission to operate the translation service layer.

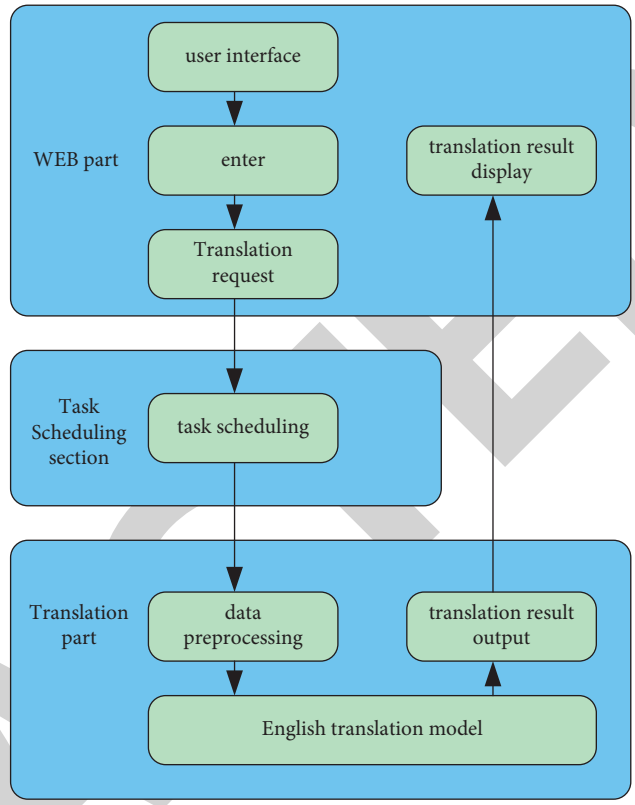

Figure 5: Internal logic diagram of system function module.

4.2. System Implementation

4.2.1. System Environment. The system framework is B/S mode. The client part is a WEB browser, which is a channel for users to access the client. After accepting the translation information and the translation request entered by the user, the client submits it to the server. The server judges the incoming request. If it is the input data that conforms to the format accepted by the model, the input sentence is translated into the specified language and returned to the user interface. The back end of the system is carried on the server and deployed in the local area network. The hardware information of the server operating environment is shown in Table 1:

Table 1: Hardware configuration table of the operating environment of the English language translation system.

Server hardware	Configure
GPU memory	16 G
Hard disk space	10 T
RAM	128 G
Network requirements	100 M bandwidth

The client is a WEB browser of any system platform. Python is a programming language for scripting and rapid application development on most platforms. The software table of English language translation system development is shown in Table 2.

Table 2: English language translation system development software table.

Server software	Name
System	Ubuntu
Development language	Python3.7
Server software	Apache
Front-end development	AJAX

As shown in Table 2, WEB construction can be divided into two parts, WEB server construction and WEB development based on WEB server. The WEB server is open to the network in the local area and can provide translation services for WEB browser users of most system platforms. Users can directly access the WEB server by entering the domain name plus the port number or IP address in the address bar.

4.2.2. System Deployment. This English language translation system uses the open source WEB server software Apache to build a WEB server. Its advantages are security, speed, and reliability, and can be extended to multiple platforms. WEB development uses AJAX (asynchronous JavaScript and XML) method. The deployment structure of the English translation system is shown in Figure 6.

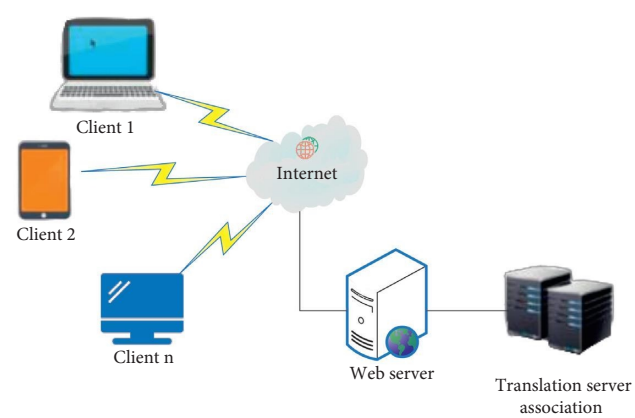

Figure 6: Deployment structure of the English translation system.

As shown in Figure 6, the deployment of the translation system includes two parts WEB service and translation service. The main content of WEB service deployment is WEB development, which provides users with access to IP addresses or domain names, as well as translation interfaces. The deployment of the translation service part is an important part of the WEB backend, which is used to process translation task requests and translate English language texts. To improve the response speed of the system and the ability to process tasks, this chapter adopts the design of multiple translation servers. The WEB service and the translation service are separately arranged in the WEB server and the translation server group.

5. English Language Intelligent Translation Experiment

5.1. Role of Hyperparameters. The experiments in this part analyze the influence of the parameters in the model on the experimental results. In the training objective of this chapter, there is a parameter λ used to balance the weight of parallel corpus and monolingual corpus maximum likelihood estimation training objectives. To verify the effect of λ on the translation effect of the model, experiments with different parameters λ were conducted on the German-English translation task. Figure 7 shows the English translation effects of different numbers of corpora and different balance parameters.

As shown in Figure 7, when using different numbers of parallel corpora, with the increase in the number of monolingual corpora, the effect of the BLEU value on the English-French test set, whether increasing or decreasing, will result in a decrease in translation quality. Similar results can be obtained on the English-French translation task. Therefore, λ is set to 2 in all experiments. The role of the back-translation model for sampling is that when the model $P/(y|x)$ is trained, the inverse model $P(x|y)$ needs to be used for sampling. To verify the influence of the quality of the reverse model used for sampling on the experimental results in the German-English translation task, reverse models of different qualities were used for sampling in the experiment, and the effect of the proposed training target in the corresponding situation was verified.

5.2. Low Resource Settings. To verify the influence of the number of parallel corpora on the translation quality, experiments under the low-parallel corpus resource setting are also carried out in this subsection. In the experiment, all 12 M parallel sentence pairs in the English-French translation task were randomly sampled and 5% and 20% of the data were taken for model pretraining. The translation quality of these low-parallel corpus resource settings is compared to the original setting with 12 M full training data. Specifically, 5% and 20% of the parallel corpus with a total of 12 M sentence pairs were used for pretraining the translation model in the experiments. Then, the number of the monolingual corpus is gradually increased to train the model, until the enhancement of model performance is no longer significant with the increase of monolingual corpus. The BLEU values on the English-French test set are shown in Figure 8.

As can be seen from Figure 8, both the number of parallel corpora and monolingual corpora have an important impact on the quality of model translation. Specifically, when using fewer parallel corpora for pretraining, the translation model can obtain a more significant improvement over the pretraining model with the same number of monolingual corpora. The method proposed in this chapter can also effectively utilize the monolingual corpus. On the other hand, for each set of different numbers of parallel corpora, it can be seen from the figure that when the number of monolingual corpora gradually increases, the improvement of the translation effect of the model gradually slows down. This result is consistent with the results in the previous section on the German-English translation task.

5.3. Role of Hyperparameters. In the training objective based on probability constraints in this chapter, there is a parameter λ used to balance the weight of the training objective of the maximum likelihood estimation and the regularization term of the marginal distribution. To verify the effect of λ on the experimental results, this chapter conducts experiments with different parameters h on the German-English translation task. The translation effect on the German-English validation set under different balance parameters λ is shown in Figure 9.

Figure 9 shows the changing process of the BLEU value on the validation set when the model uses different parameters h during the training process. As can be seen from the figure, when λ is in the range of 0.005 to 0.2, the translation quality can be improved on the basis of the pretrained model. Among them, when $\lambda = 0.05$, the model can achieve the best results and increasing or decreasing h will cause a decrease in translation quality. Similar results can be obtained on the English-French translation task. Therefore, λ is set to 0.05 in all experiments in this chapter.

5.4. Influence of Sampling Size K on Experimental Results. The experiments in this part verify the effect of the sampling size K on the training target effect based on probability constraints on the German-English translation task. Intuitively, a larger sampling size will bring about an improvement in the effect, and on the other hand, it will also lead to an increase in the training time. To explore how to better balance the improvement of the translation effect and the efficiency of training, the experiment verified the difference in translation effect brought by training with different sampling sizes. The translation effect on the German-English validation set with different sampling sizes K is shown in Figure 10.

As shown in Figure 10, for the training objective based on probability constraints, it uses the BLEU values of models with different sample sizes on the validation set as the training time increases. As can be seen from the figure, when

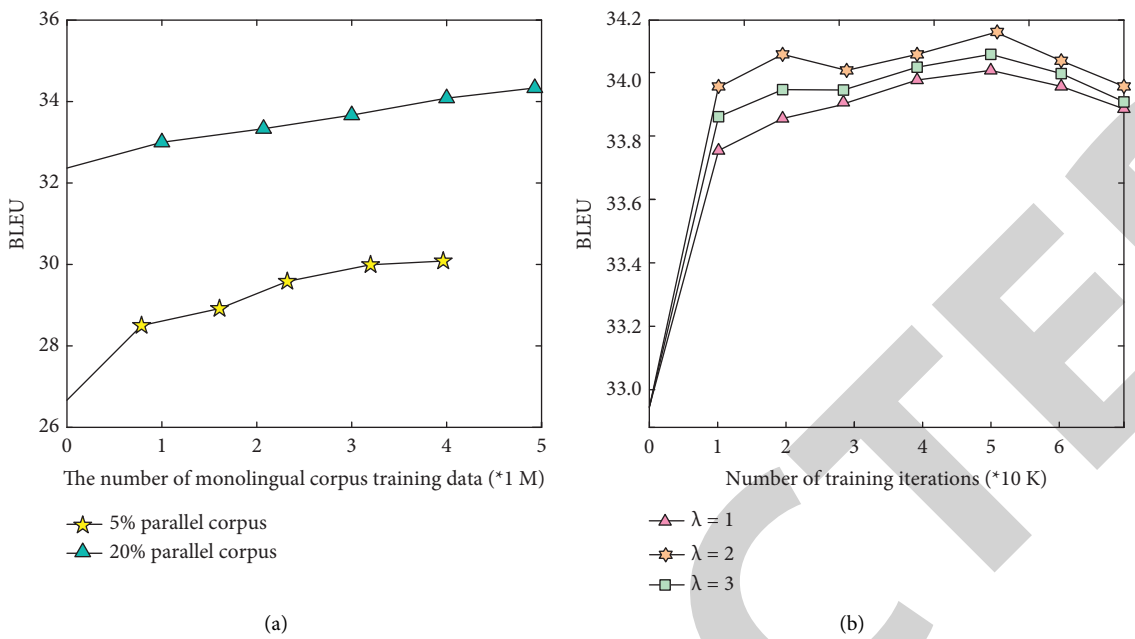

Figure 7: English translation effect of different amounts of corpus and different balance parameters: (a) BLEU values on the English-French test set; (b) BLEU values on the German-English validation set.

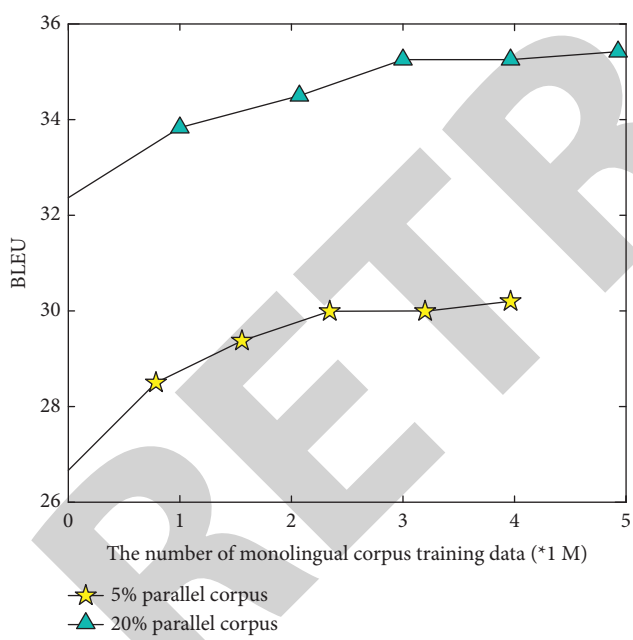

Figure 8: BLEU values on the English-French test set.

a smaller sampling size K is used, the BLEU value on the validation set rises faster, but the BLEU value at the final convergence is lower. Conversely, when a larger sampling size K is used, the model can eventually achieve higher BLEU values but requires more training time to reach the final BLEU value. Similarly, a similar phenomenon can be observed for the English-French translation task.

Considering the limited computing resources, the trade-off between translation effect and training efficiency, and a fair comparison with contrasting methods, the model effect with a maximum sampling size of 5 is verified in the experiments, and finally, the sampling size is set to 2 in all experiments. Specifically, larger sample sizes require more GPU memory and training time. And because of the limited GPU resources, too large sample size is unbearable. For every single sentence, more samples lead to a better estimation of the marginal distribution and lead to higher BLEU values. However, the improvement in BLEU value brought by more samples is not significant. which also set the sampling size to 2. Therefore, it can be considered empirically that a sufficiently good model can be obtained by setting the sample size to 2.

5.5. Regularization Term. Regularization is to express planar irreducible algebraic curves in some form of holomorphic parameters. To have a deeper understanding of the role of probability constraints in model training, this part conducts some empirical analysis on the satisfaction of the training target based on marginal distribution estimation and the constraint term derived from the full probability formula of the training target based on probability constraints on monolingual corpora on the German-English translation task. Specifically, after pretraining on the parallel corpus to obtain the German-English translation model, in the semi-supervised training, the value of the regularization term of the selected single sentence during the training process is shown in Figure 11.

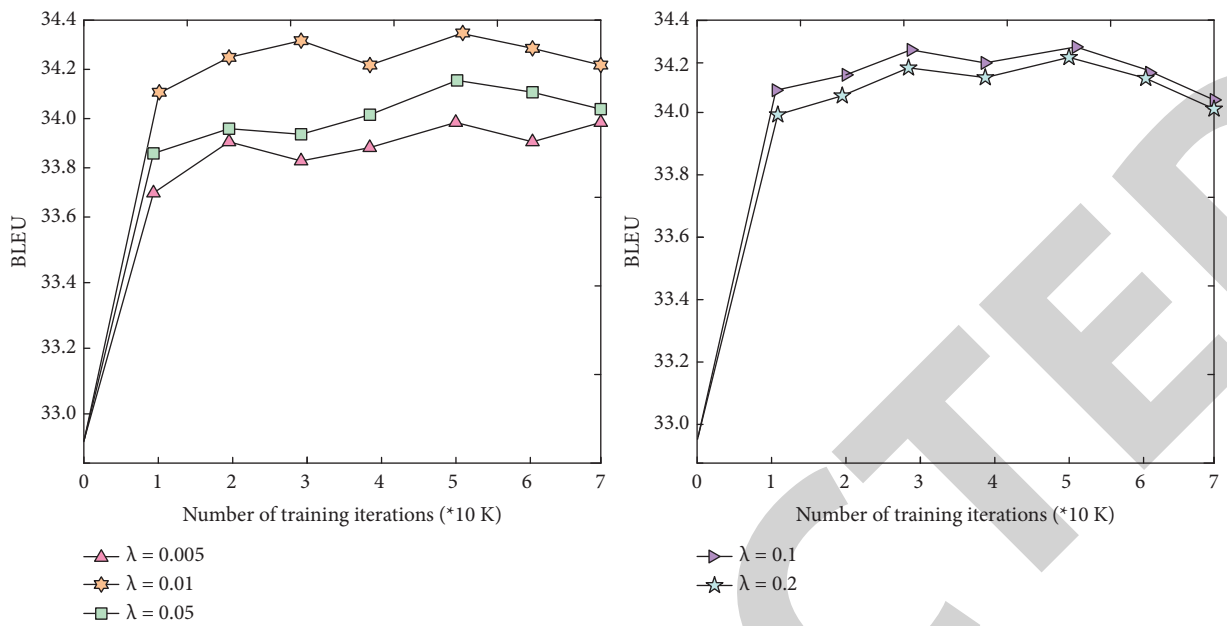

Figure 9: Translation effect on German-English validation set with different balance parameters λ.

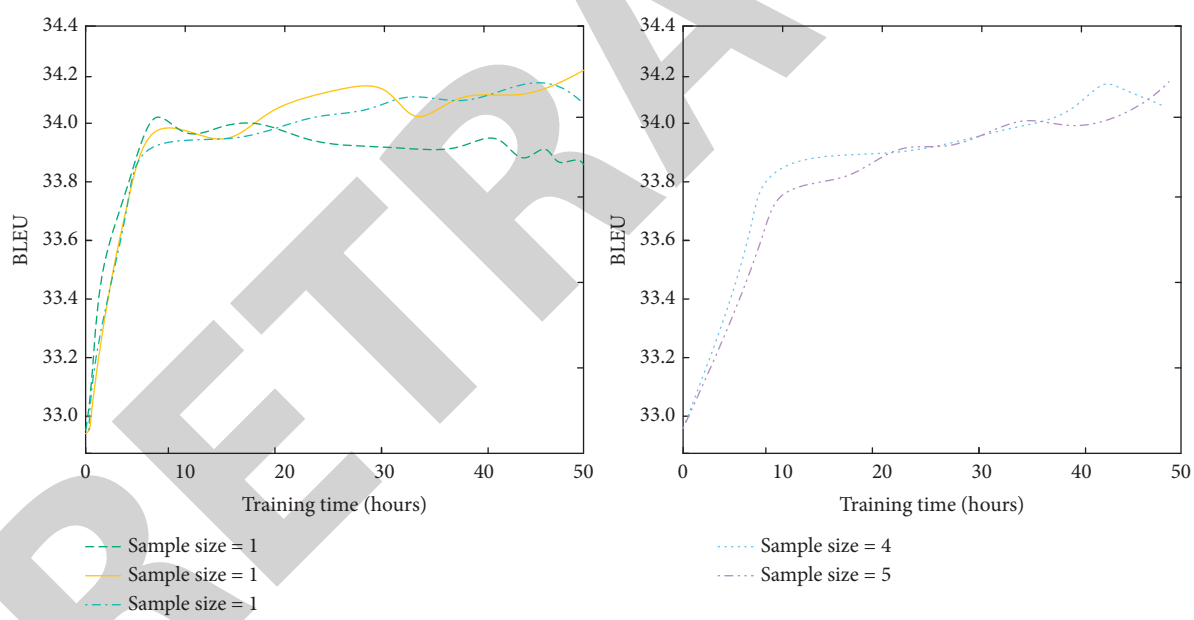

Figure 10: Translation effect on the German-English validation set with different sampling sizes K.

As shown in Figure 11, the averages calculated for the selected monolinguals and sentences for the two training targets during the training iteration are shown. As can be seen from the figure, when using either training objective, the values gradually decrease as the training process progresses. That is, the marginal distribution computed by the language model and the marginal distribution estimated by importance sampling become progressively more consistent as the model is trained. In particular, the values drop more rapidly when seen using a training objective based on probability constraints. This phenomenon is consistent with the fact that a training objective based on probability constraints will lead to better translation performance of the model when using two training objectives. On the other hand, for the training target based on marginal distribution estimation, although the full probability formula is not directly enforced in the training target, the value also gradually decreases as the model training effect becomes better. This also shows that the hypothesis that a well-trained model should satisfy the full probability formula on a monolingual corpus is valid.

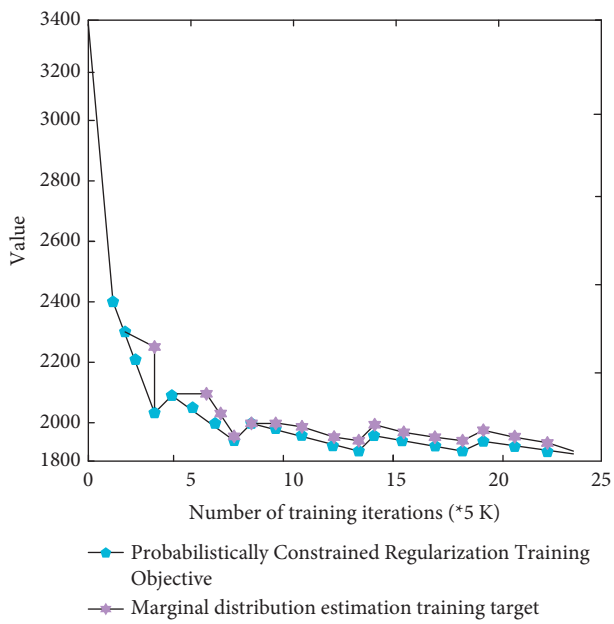

Figure 11: The value of the regularization term of the selected single sentence during the training process.

6. Conclusions

This paper mainly focuses on the research and implementation of 3D visualization technology in the English language neural machine translation system. Aiming at the scarcity of parallel corpus resources in the training corpus, the method of data augmentation is used to improve it. First, it proposes two methods centered on back-translation strategies in data augmentation to strengthen the parallel corpus involved in training. The English language random alignment alternative is then refined and streamlined to train a framework for initializing translation models. Combined with the results of the first two steps, the English language neural machine translation model is trained by the method of complete parameter sharing, the effect of the bilingual neural machine translation model is compared, and the effectiveness of the pretraining method on multilingual translation tasks is verified. Finally, a translation system based on B/S architecture is built, which connects the server model and the client, and realizes the visualization and interaction of translation functions. The system is deployed in parallel with the WEB server and the translation server group. This greatly improves the task response speed of the system and optimizes task resource scheduling. Finally, the system shows the translation results in different situations. The practice has proved that the multilingual translation system built on the basis of the translation model proposed in this paper can achieve better translation results. Data augmentation methods do not really solve the problem of corpus scarcity. To prevent its translation effect from getting worse, the effect of other language pairs can only be sacrificed.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Cross-Border E-Commerce Business Model Based on Big Data and Blockchain

Jinjuan Hu[1] and Ling Xu[2]

[1]*Business School, Xinyang Vocational and Technical College, Xinyang, Henan 464000, China*
[2]*School of Electronics and Information, Nanchang Institute of Technology, Nanchang, Jiangxi 330044, China*

Correspondence should be addressed to Ling Xu; dr.lingxu@nut.edu.cn

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In the context of the rapid development of Internet technology, the integration of the world economy has been strengthened. The continuous innovation of technology and foreign trade business forms has promoted the rapid development of cross-border e-commerce (CBE). Based on the research on the development status of CBE, this paper analyzes the reasons for the above problems in the development of CBE and discusses the innovation of CBE business models based on blockchain. Its purpose is to study the CBE business model based on big data and blockchain. This paper proposes to build a CBE framework system based on blockchain. It also uses blockchain technology (BT) to provide solutions to the problems of trust, customs supervision, cross-border payment, cross-border logistics, and cross-border data flow encountered in CBE. According to experimental statistics, China's CBE exports were 7.29 trillion yuan, an increase of 40.1%, and imports were 3.76 trillion yuan, an increase of 16.5%.

1. Introduction

In the context of economic globalization and the gradual popularization of Internet coverage in the world, foreign trade is changing from "trade diversification" to "global buying, global selling, global payment, and global transportation." The main body of trade has changed from traditional trading enterprises to small and medium-sized enterprises and individuals. The characteristics of transactions have changed from "big in and large out, low frequency" to "small batch, high frequency," and the trade supply chain has changed from nonpersonalized, large scale to a flexible supply chain that is personalized and fragmented, and meets customer needs. The form of trade has changed from traditional offline trade to CBE. CBE transactions involve a large amount of document information. In addition to the need to share such information between trade multilaterals, it also needs to be submitted to regulatory authorities. At present, trade information is scattered in separate systems, and the information lacks transparency. Although each country has specified its own EDI data exchange format standard plan, the transmission speed of information is low. Data format conversion costs are high, and it is not easy to form mutual trust.

While CBE is booming, it is also accompanied by some problems. Foremost among them are issues of trust, information opacity, and high costs. Because CBE transactions involve multiple national governments, complex supply chains, and long logistics times, it is difficult to trace the source of product quality problems and accountability is difficult. BT can decentralize, realize information sharing, trace and track commodities, and improve the trust foundation of CBE. The research of blockchain in the field of CBE application provides a way to promote blockchain to improve business in traditional business fields and provide a way to unify supervision and break the crisis of trust. CBE platform is based on blockchain, information is shared, and platform data can be obtained through technical means, to achieve product traceability, logistics tracking, quality control, and trust in cross-border payment, and through big data analysis, to achieve risk early warning and the credibility evaluation of cross-border enterprises.

The innovation of this paper is that (1) it promotes research on the application of blockchain in CBE and its implementation in practical application scenarios; (2) in the CBE industry, the application of BT can change the existing business model of CBE; it allows all participants to have an equal dialogue, reduce intermediate transaction links, reduce costs, and improve corporate profits; (3) it promotes the change of trade type. Blockchain-based CBE can keep in touch with end consumers, transforming the traditional model of relying on large-value imports and exports into a small-value transaction model and promoting the development of CBE.

2. Related Work

Teresa Ballestar research segmentation is based on customers' commercial activities and roles in the social network of the website [1]. In the absence of any clear regulatory policies, Indian e-commerce businesses appear to be enjoying a free market and growing rapidly. The Tyagi study found that India's leading e-commerce companies are growing in a policy vacuum, allowing 100% foreign direct investment under a "market model" [2]. With the popularization of the Internet and smartphones, Internet-based e-commerce has developed rapidly with its unique advantages. Hu research finds traditional and improved business-to-customer (B2C) e-commerce [3]. Although existing research links the emergence and development of e-commerce to various aspects, it does not address technology and platform acceptance from a legitimacy-building perspective. In Kwak's research, legitimacy is divided into market legitimacy, relational legitimacy, and social legitimacy. He also explores the link between legitimacy and acceptance of each. While Alibaba's intellectual property weaknesses are exposed, Alibaba's continued efforts to establish legitimacy have fueled the platform's growth [4]. The Monroe study aims to describe this growth and explore the factors that influence the magnitude and timing of the growth. From 2000 to 2015, the average annual growth rate of B2B e-commerce in the USA exceeded 10%. After a slow start in previous years, growth was strong between 2003 and 2005 [5]. PJW survey explores e-commerce logistics business models from unstructured big data [6]. E-commerce plays an increasingly important role in transforming the mode of economic development, promoting industrial upgrading, and promoting the modernization of circulation. On the one hand, e-commerce has broken the time and space barriers of trade. On the other hand, it provides rich information resources and unlimited business opportunities for enterprises. Sun M's research found that e-commerce has become a trend leading Vietnam's economic development. In recent years, the online cosmetics industry has gradually emerged in the Vietnamese market. However, due to the unique characteristics of cosmetics such as the largest number of bottles, the requirements for logistics and distribution are higher to ensure the integrity of the product. Meanwhile, in the context of e-commerce, customers are paying more and more attention to the quality of logistics services [7]. Yang proposed a blockchain-based big data sharing and transaction framework. This framework utilizes the idea of decentralization and openness of blockchain to build a big data trading platform for multiple users [8]. Although his research has been greatly applied to the distributed secure storage of big data in the blockchain, there is still a problem of high cost.

3. Algorithm Design of BBE Supply Chain Framework

The architecture diagram of the prototype system of large-scale cross-border supply chain based on blockchain is shown in Figure 1. It includes foreground, interface layer, service layer, network layer, core layer, and storage layer.

As shown in Figure 1, it solves the pain points faced by the supply chain industry, such as lack of trust, poor information flow, low degree of automation, data fraud, difficulty in accountability, and difficulty in connecting and collaborating with a large number of existing block supply chain systems [9, 10].

3.1. Blockchain-Based Product Information Traceability Framework. This facilitates suppliers' information control over product production, transportation, and warehousing [11, 12]. Aiming at different entities and business operation processes in the supply chain, and taking into account the various data involved in product information traceability, a multi-level blockchain-based product (BBP) information traceability framework is proposed, as shown in Figure 2.

As shown in Figure 2, on-chain and off-chain data and services are connected through a multi-level blockchain [13, 14]. The information encryption model provides a solution for users to disclose data externally. Users can encrypt data according to the degree of privacy of the data. The information anchoring model is used to ensure the global consistency of multi-chain data. The key distribution model is used in many aspects such as user management accounts, external transactions, and enterprise management [15, 16]. The product traceability label is used for users to perform online and offline verification and information traceability of product information.

3.2. Framework of E-Commerce Supply Chain Based on Blockchain. This section proposes a blockchain-based e-commerce (BBE) supply chain framework (PIT-EC). Under this framework, it proposes a multi-chain structure to store product, transaction, and logistics information [17, 18]. At the same time, the framework provides a reliable, easily monitored, and tamper-proof solution to the problem of traceability of product information. The BBE supply chain framework is shown in Figure 3.

As shown in Figure 3, according to different data characteristics such as data volume, data update speed, and data encryption degree, data items are grouped into different sets [19, 20].

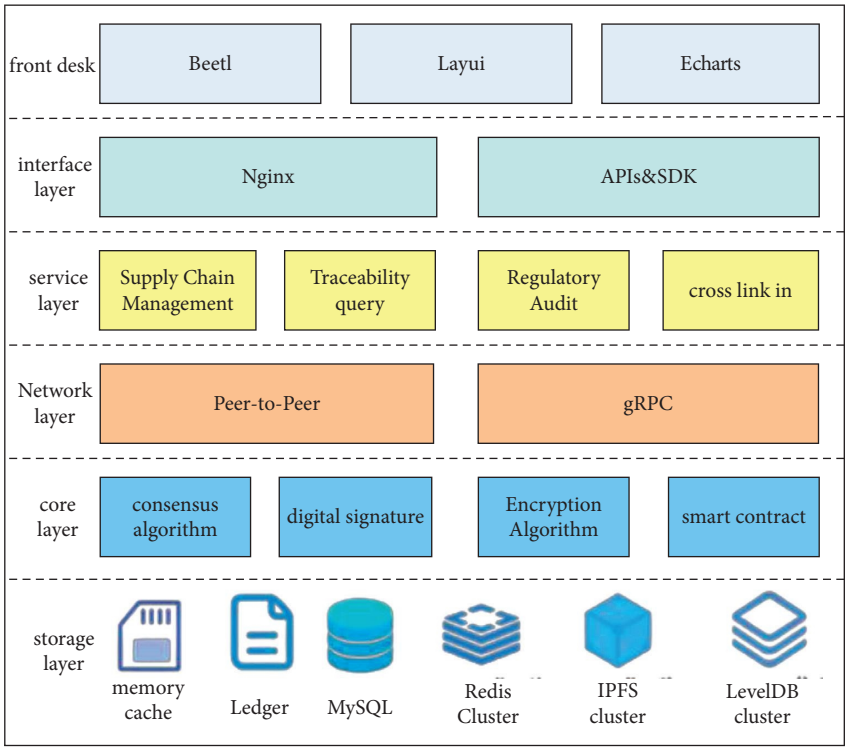

Figure 1: System structure diagram.

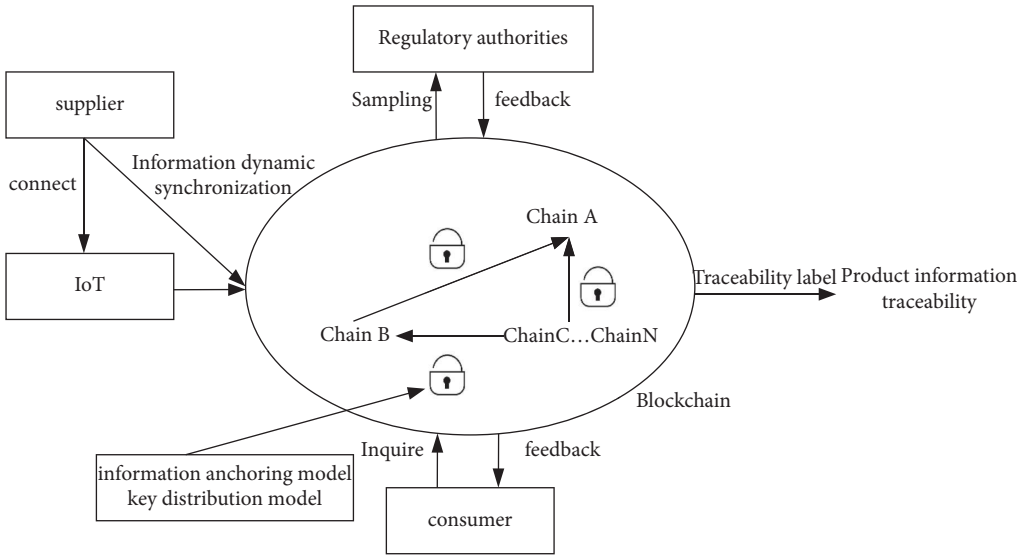

Figure 2: BBP traceability framework.

3.3. Key Distribution Based on Hierarchical Wallet

3.3.1. Initial Key Distribution. The entities of the initial key distribution scheme are as follows:

$$(Pk, PK) \longrightarrow (Ck_i, CK_i), \quad i = 1, 2, \ldots, \tag{1}$$

where P is the parent key and C is the next level key generated by P and PC.

It is recommended to use an encrypted pseudo-random number generator (CSPRNG).

$$\begin{aligned} E &= \mathrm{CSPRNG}(N), \\ N &= 1.158 * 10^{77}, \\ \mathrm{check\_sum} &= \mathrm{SHA256}(E, 4). \end{aligned} \tag{2}$$

Collections are defined as follows:

$$\mathrm{Set}_i = \mathrm{divide}(E \oplus \mathrm{check\_sum}), \quad i = 1, 2, \ldots, 11. \tag{3}$$

It maps these sets to Dict and generates a seed, and seeds are defined as follows:

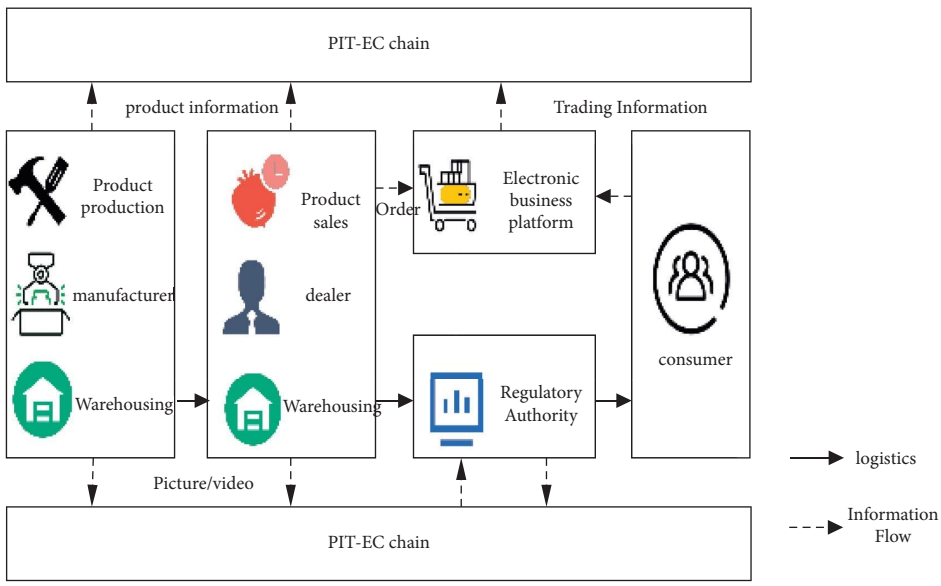

Figure 3: BBE supply chain framework.

$$\text{seed} = \text{PBKDF2}(\text{match}(\text{Set}, \text{Dict})), \quad i = 1, 2, \ldots, 11. \tag{4}$$

The master private key obtained by calculation is the initial key (Ik).

$$\begin{aligned} Ik &= \text{left}(\text{HMAC} - \text{SHA512}(\text{seed}), 256), \\ \text{Mcc} &= \text{right}(\text{HMAC} - \text{SHA512}(\text{seed}), 256). \end{aligned} \tag{5}$$

3.3.2. Function Key Distribution. In the key distribution scheme based on ECC, the function key has a strong correlation with the initial key, so that the initial key has all the functions of the account. The initial key is used to generate the secondary key, which has the highest privilege. The specific calculation process is as follows:

The user uses the ECC algorithm to calculate the public key of the initial key, as follows:

$$IK = \text{IKG}. \tag{6}$$

It combines the public key (IK), and the index number refers to the level of functional authority.

$$\begin{aligned} Sk &= \text{left}(\text{HMAC} - \text{SHA512}(IK\Delta\text{Mcc}\Delta n), 256), \\ \text{Mcc} &= \text{right}(\text{HMAC} - \text{SHA512}(IK\Delta\text{Mcc}\Delta n), 256). \end{aligned} \tag{7}$$

The calculation process is as follows:

$$\begin{aligned} SK &= SkG, \\ Fk &= \text{left}\left(\text{HMAC} - \text{SHA512}\left(\frac{\text{Sk}\Delta\text{Mcc}\Delta\text{Function}}{\text{level}}\right), 256\right), \\ \text{Mcc}_{\text{function}} &= \text{right}\left(\text{SK}_{\text{account}}\Delta\text{Mcc}_{\text{account}}\Delta\frac{\text{Function}}{\text{level}}, 256\right). \end{aligned} \tag{8}$$

The initial key is used to generate the secondary key, which has the highest privilege. For other keys, according to the depth of the organizational structure, the breadth of the business, and the size of the supervision power, repeat the above steps 2 and 3 to generate keys at all levels in turn.

3.3.3. Key Recall Mechanism. It then obtains the initial key, i.e., the private key, according to the above method. Initial keys play an important role in key management. ID (x) is defined as follows:

$$\begin{aligned} \text{ID}(x) &= \text{Hash}\left(\left(\begin{matrix}\text{Hash}(\text{registration number, registered address, legal}) \\ \text{representative}\end{matrix}\right)\oplus\text{user\_defind\_word}\right), \\ \text{IDK} &= \text{ID}(x) * G. \end{aligned} \tag{9}$$

It maps the initial key (Ik) to an elliptic curve, randomly generates integers $r \in (1, n-1)$, and then computes

$$P = E_p(IK),$$
$$C_1 = P + rI\ DK\ , \quad (10)$$
$$C_2 = rG.$$

The data that need to be digitally signed are as follows: Dacaccount = addr, Usernp, $C1$, $C2$, IDK.

3.3.4. Anti-Counterfeiting Traceability Label Model. It provides anti-counterfeiting traceability label solutions that link products with real product information. The anti-counterfeiting traceability label scheme is shown in Figure 4.

As shown in Figure 4, each product line has a unique code. Each code corresponds to multiple batches of products.

4. Blockchain-Based CBE Model

In order to demonstrate the advanced nature of the proposed method, experimental verification is carried out, and the experimental environment is shown in Table 1.

As shown in Table 1, it will be divided into four aspects: whether there is a risk of centralization, whether it supports data-based asset operations, whether it supports smart contracts, and whether it is efficient.

4.1. Construction of CBE Model Framework Based on Blockchain. China's trade form and market environment are different from those of overseas. To ensure that CBE maintains a healthy development in the world, the establishment of a trade ecological environment must ensure mutual recognition and uniform standards. The operation model of the traditional CBE model is shown in Figure 5.

As shown in Figure 5, the information sharing and collaboration technology of blockchain use decentralization and consensus to enhance trust. It provides a technical foundation for the establishment of a benign trade ecological environment and can ensure the vigorous development of CBE ecology. The traditional cross-border model is built in a centralized way, and its collaboration model is based on the CBE platform as the central node. Figure 6 shows the cooperation mode of the participants of the CBE alliance based on blockchain.

As shown in Figure 6, the CBE model based on the blockchain can be built into a multi-coordinated platform by using the decentralization, distributed storage, and anti-tampering features of the blockchain. The parties located on the blockchain platform form a community of interest alliance according to their roles and functions. It participates in the data consensus on the CBE platform and can realize the sharing of the underlying data. In this way, the functional positioning of each participant can be changed, which is conducive to multi-party collaboration, and maintains and promotes the orderly development of CBE.

4.2. Characteristics of the CBE Model Based on Blockchain. The CBE model based on blockchain can promote the diversified collaboration of transaction entities. The supply chain that forms a multi-centralized CBE is very long. It involves commodity producers, buyers, warehousing, logistics, CBE platforms, customs (inspection and quarantine and customs clearance), import and export traders, domestic and foreign consumers, banks, insurance companies and third-party payment institutions, and so on. The position of the participants of CBE in the transaction center reflects the advantages they occupy in the transaction to a certain extent. The centralized value of the blockchain can ensure that the CBE platform is not controlled by any single party, and can take into account the interests of multiple parties in operation.

The corporate qualifications, commodity supply chain information, user data, and related business data of traditional CBE are stored in a centralized platform. It is difficult for regulators and consumers to obtain the true picture of a business. Enterprises generally do not share the business data of CBE. Third-party credit assessment agencies do not have enough data to analyze the credit situation of enterprises. The cross-border credit reporting platform based on blockchain is shown in Figure 7.

As shown in Figure 7, after using blockchain, the qualification information, user data, supply chain information, and operation data of the CBE business are stored on the blockchain, which can be real and effective data to give credit rating to each participant of the CBE business under the condition of privacy protection, and the rating can be easily queried by the public. This can protect the honestly operating enterprises and law-abiding consumers, enhance consumers' trust in the CBE business, and also combat nonhonest enterprises, ensure the interests of honest enterprises, and reduce the cost of credit acquisition.

4.3. Application Scenarios of Blockchain in CBE. Blockchain is the underlying data technology. In view of the particularity of CBE, BT can be applied to trace the origin of CBE products, CBE orders, and smart contracts for insurance business, and protect the privacy data of transaction parties. The various scenarios are discussed in detail below.

4.3.1. Product Traceability of CBE. The categories of goods in CBE are becoming more and more diverse. However, because the supply chain of CBE is long and complex, it is difficult to effectively track the quality and origin of products using traditional methods. If the commodity category is food, once a problem occurs, it will have a great impact on cross-border trading countries and traders, so commodity traceability is necessary in CBE.

The blockchain traceability of cross-border commodities uses the data immutability feature of BT. It automatically and directly collects all data of commodities from production to circulation basins through IoT devices and automatically records them on the blockchain to form sharable distributed ledger data. At present, major CBE platforms are trying to use BT to achieve their commodity traceability needs, such as Alibaba's overseas shopping traceability system, Jingdong blockchain anti-counterfeiting traceability platform, and opening up with cross-border logistics systems. The results of the comparative analysis between this method and the existing scheme are shown in Table 2.

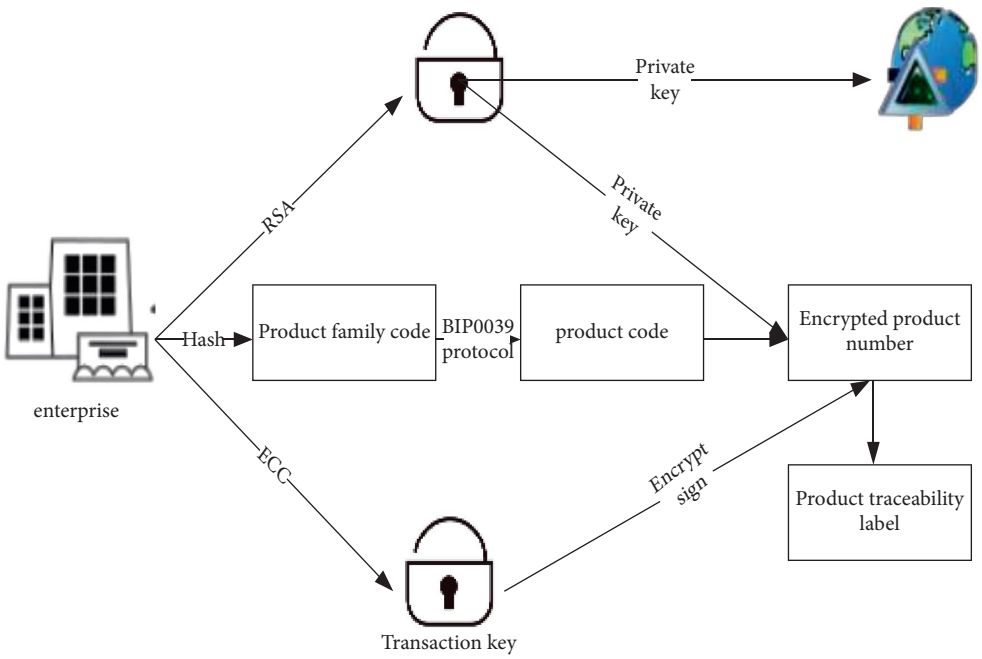

Figure 4: Anti-counterfeiting traceability label scheme.

Table 1: Description of the experimental environment.

Configuration item	Describe
Physical server	CPU: Intel (*R*) Xeon (*R*) Gold 6146 CPU @ 3.20 GHz Operating system: CentOS Linux release 7.6.1810 (core) RAM: 16 GB
Blockchain network	CPU: E5-2680 v4 @ 2.40 GHz RAM: 8 GB Blockchain type: Hyperledger Fabric v2.0 Consensus mechanism: raft Number of consensus nodes: 3

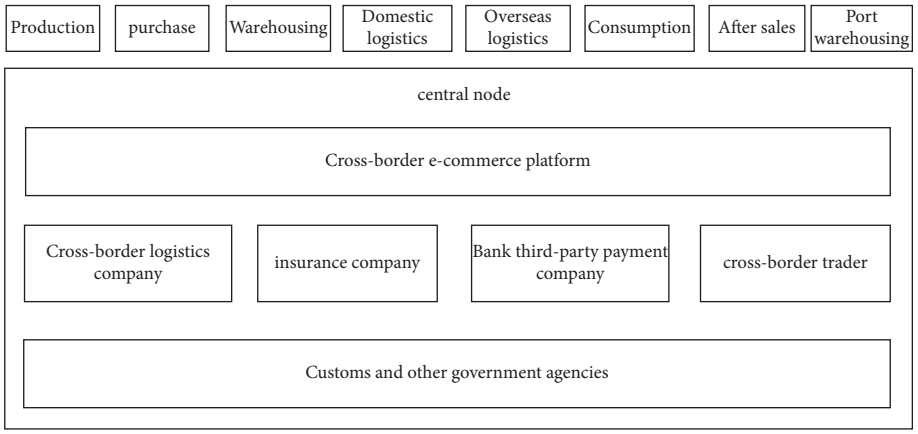

Figure 5: Traditional CBE process and collaboration methods.

As shown in Table 2, the method in this paper connects the blockchain network based on the cross-chain interoperability model and uses the whole-process trusted closed-loop mechanism of cross-chain transactions to ensure the security and trustworthiness of cross-chain transaction execution. It avoids the risk of centralization while ensuring the efficient execution of transactions and can effectively adapt to smart contracts and data-based blockchains. It has the advantages of no centralization risk, supports data-based cross-chain interoperability, supports smart contracts, and operates efficiently, meeting the application needs of supply chain scenarios.

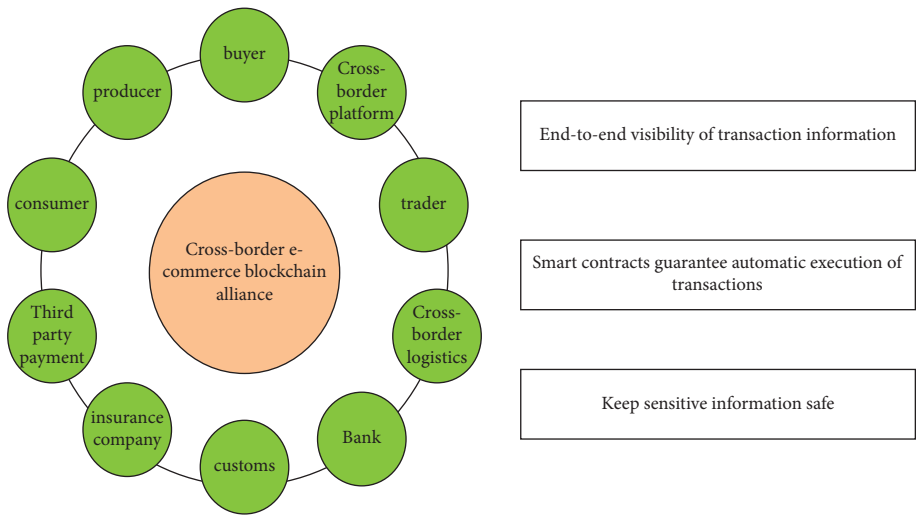

Figure 6: Collaboration method of CBE alliance participants based on blockchain.

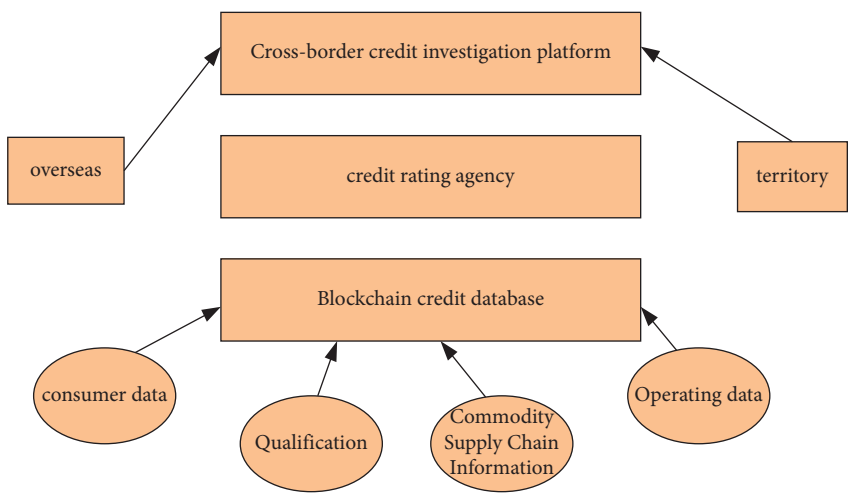

Figure 7: Blockchain-based cross-border credit reporting platform.

Table 2: Comparison between the method in this paper and the existing scheme.

Supply chain scenario requirements	Notary mode	Relay/side chain	Hash lock	Distributed private key control	The method of this paper
No centralization risk	×	✓	✓	✓	✓
Data type	✓	✓	×	×	✓
Interoperability across chains	✓	✓	×	×	✓
Support smart contracts	✓	×	✓	✓	✓

4.3.2. Cross-Border Secure Transactions on Cross-Border Platforms. Blockchain smart contracts define transaction rules in the contract code in advance. Once the conditions are met, the rules are automatically executed. First, it can improve work efficiency, and second, it can solve the occurrence of contract execution disputes. CBE B2B trade often buys insurance for goods. Using smart contracts, once a claim condition occurs, the claim procedure will be executed automatically, without the need for both parties to intervene. In addition, the process of receiving payments for CBE platform transactions can also be protected by the use of smart contracts, so that when the terms of the transaction are met, the money is automatically transferred to the seller's account; otherwise, it is returned in the same direction.

4.3.3. Application of Blockchain in CBE Supply Chain. The supply chain of CBE includes product procurement, production, manufacturing, sales, logistics, warehousing, and other links. The supply chain is long, and the scenarios are complex. It introduces blockchain, 5G, and IoT technologies to provide a full range of services for CBE. The combination of blockchain and cross-border logistics can bring logistics and supply chain participants onto a

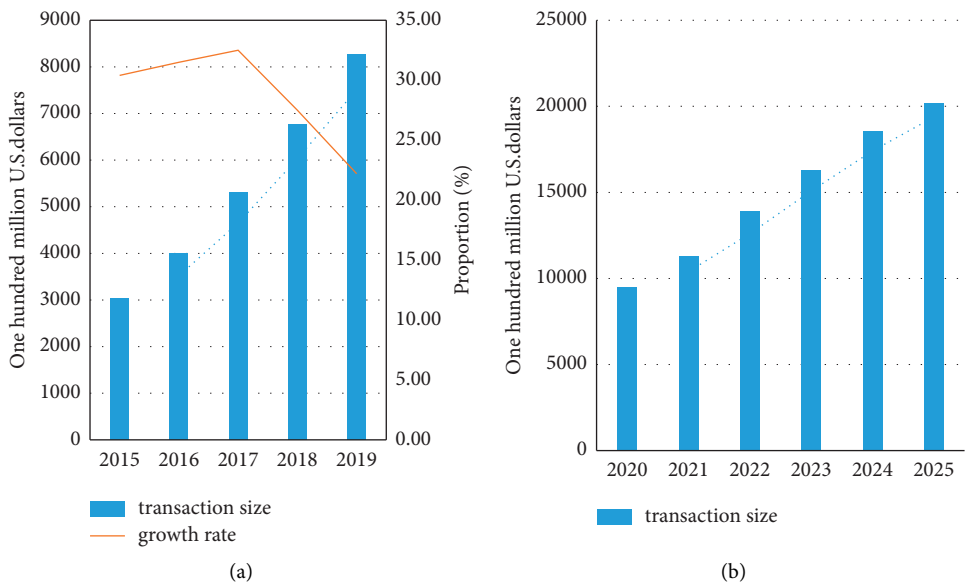

Figure 8: Global B2C cross-border transaction scale and transaction scale forecast. (a) Global B2C cross-border transaction scale. (b) Global B2C CBE transaction scale forecast.

decentralized blockchain platform, opening up the information flow between domestic logistics companies, international transport, and overseas logistics companies, so that buyers, sellers, insurance companies, and other interested parties can quickly and accurately locate the logistics trajectory of goods on the platform and quickly determine liability when losses are caused by logistics problems.

The combination of blockchain and cross-border supply chain finance takes advantage of the decentralization, openness, transparency, and immutability of BT. It integrates the transaction data of upstream and downstream enterprises of CBE and forms a complete transaction record to prove the authenticity of accounts receivable. At the same time, the smart contract is used to stipulate the payment path, and the four-flow integration and relatively closed operation of business flow, information flow, logistics, and information flow are realized. At the same time, it can also obtain better financial support from the bank.

5. Characteristics Analysis of CBE Based on Blockchain

5.1. Development Characteristics of CBE. With the development and innovation of ICT such as the Internet, the global e-commerce business has developed rapidly. The number of people participating in online shopping is gradually increasing, and especially under the global outbreak of the new crown epidemic in 2020, more users choose to shop online. Under the current global macro environment, global CBE shows the following trends.

5.1.1. More Consumers Choose Online Global Shopping and the Market Size of the Global CBE Industry Continues to Increase. The transaction scale of the global CBE industry continued to grow. In a report released in January 2021, it was pointed out that despite the impact of the epidemic in 2020, the scale of global CBE B2C transactions could reach US$3.4 trillion. The global B2C cross-border transaction scale and transaction scale forecast are shown in Figure 8.

As shown in Figure 8, the number of CBE participants increased from 309 million in 2014 to 900 million in 2020. By 2020, the global epidemic reduced CBE, but the global CBE scale will exceed USD 1 trillion in 2020, with an average annual growth rate of up to 30%, and achieve high growth. In 2019, with the development of 5G, the Internet infrastructure will become more and more perfect, global logistics network construction will gradually mature, and CBE will show a high growth trend. Based on the current growth, the survey results predict that the global CBE B2C cross-border transaction scale will maintain a growth of 10% to 20% in the next few years, affected by the increasing number of new crown epidemics translated with http://www.DeepL.com/Translator (free version).

5.1.2. CBE Platform, Amazon, Is Still in the Leading Position. According to the data of the Qianzhan Industry Research Institute, the market share of CBE platforms and the categories of platforms used for online shopping are shown in Figure 9.

As shown in Figure 9, when choosing CBE transactions, 24% of cross-border consumers use the Amazon platform and 16% use AliExpress (Alibaba's CBE platform). 14% of users choose eBay, which is positioned as a CBE platform.

5.1.3. Affected by Global Logistics Conditions and Technologies, the Development of Global CBE Varies Greatly. According to data, consumers in the Middle East who use CBE for overseas shopping account for 70% of online shopping compared to other regions. Less than 50% of CBE consumers in Asia Pacific and North America are the

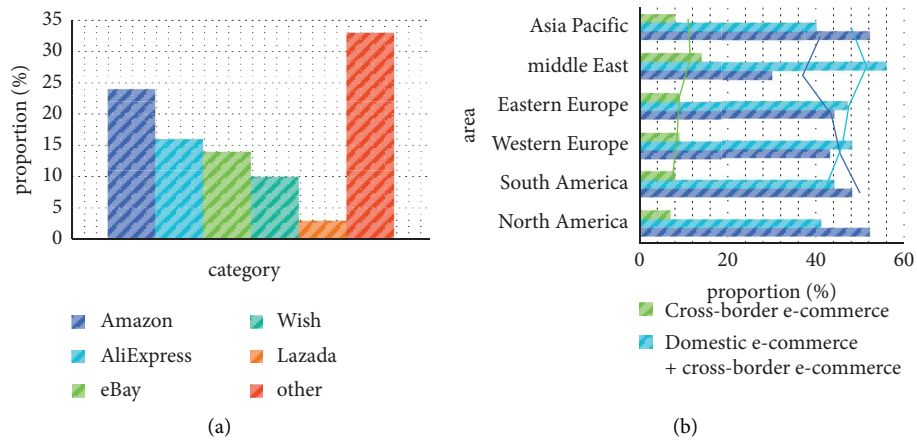

Figure 9: (a) Market share of CBE platforms and (b) types of platforms used by global consumers for online shopping.

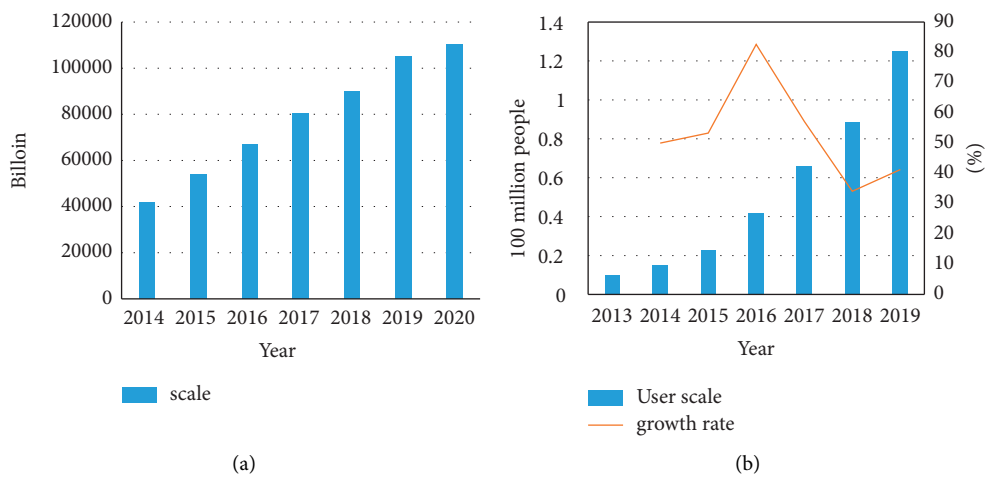

Figure 10: Scale of China's CBE transactions and the number and growth rate of imported CBE users. (a) Scale of CBE transactions in China. (b) Number and growth rate of imported CBE users.

proportion of e-commerce usage preferences in various regions drawn according to the data.

Taking the EU economy as an example, the growth of CBE is also uneven, with Ireland at the bottom with 85%, accounting for only about 2%. In addition, due to cultural influences, Australian cross-border shoppers are more likely to purchase products primarily from the UK and the USA, and over 63% of Canadian users use CBE, with the majority of purchases coming from China and the USA. CBE growth in South America, Brazil, and Argentina has matured since 2018. The total retail sales of CBE account for about 3% of e-commerce.

5.2. Development and Trend of CBE. From the overall point of view of the above national policies, the state is also regulating supervision and protecting intellectual property rights while supporting the development of CBE. It has promoted the standardized development of CBE development through national-level policies. After years of development, the CBE industry generally presents the following trends.

5.2.1. China's CBE Has Entered a Period of Steady Growth and Its Scale Is on the Rise. CBE in China has grown rapidly in the past few years. Figure 10 shows the scale of China's CBE transactions, the number, and growth rate of imported CBE users.

As shown in Figure 10, 2020 is affected by the new crown pneumonia epidemic. According to statistics, China's CBE exports were 7.29 trillion yuan, an increase of 40.1%, and imports were 3.76 trillion yuan, an increase of 16.5%.

5.2.2. Cross-Border Exports Occupy the Dominant Position of China's CBE. This paper analyzes the data of China's CBE import and export from 2014 to 2019. The scale and growth rate of China's CBE exports and China's CBE imports are shown in Figure 11.

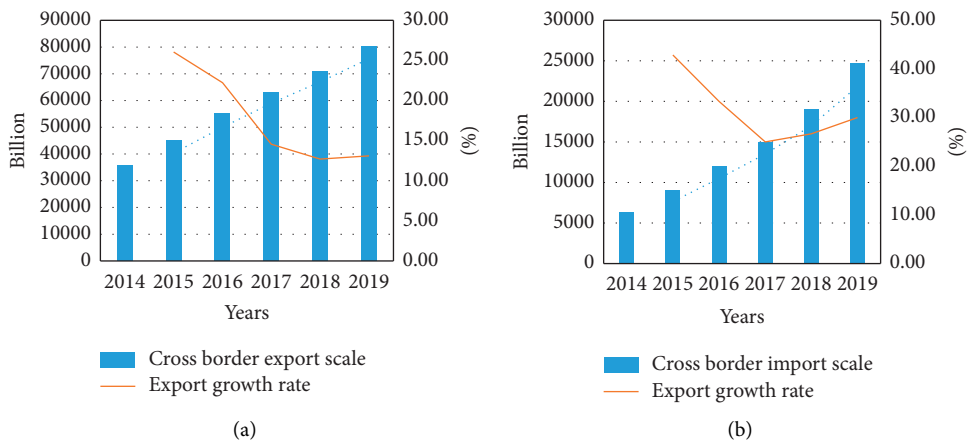

Figure 11: Scale and growth rate of China's CBE import and export; the total number of imported CBE users in China in 2019 was 125 million. It increased by 41.24% year-on-year in 2018 (the number of CBE users in 2018 was 88.5 million). (a) Scale and growth of CBE export transactions. (b) Scale and growth of CBE import transactions.

6. Conclusion

With the maturity of BT and the in-depth research on the combination of CBE, it will definitely promote the development of the CBE industry and realize the unification of CBE logistics, information flow, and capital flow. This has prompted a change in corporate behavior and finally realized the transformation of the CBE industry driven by BT. CBE is a new form of cross-border trade in the Internet era. With the emergence of new business models such as overseas shopping and live streaming, its business environment has become more complex. Its scope is also wider, and the problems it faces will become more and more complex. Only solving the problems of trust, logistics, payment, goods quality, and supervision of CBE cannot fully meet the needs of CBE development. Especially after the epidemic, the CBE model will also expose more and more problems and risks.

In addition, although blockchain technology can solve the problems encountered in CBE to a certain extent, the development of the technology is still immature, such as the high latency of its consensus algorithm, computational costs, encryption technology, cross-chain communication technology, and taking up a lot of storage space to store the same data which have not been effectively solved. Therefore, in the combination of research and CBE, the application of BT is still limited. Based on the existing CBE model, future research can combine BT with increasingly mature and perfect 5G technology. This makes CBE as convenient as e-commerce. In addition, we should also pay attention to the new trends in the development of BT and the relevant policy trends of blockchain token transactions in countries around the world. This is in order to introduce more convenient and low-cost tokens into CBE transactions faster and realize the ability of blockchain value flow transmission.

Data Availability

No data were used to support this study.

Conflicts of Interest

There are no potential conflicts of interest in this study.

Acknowledgments

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Research Article

Modern Package Design Using Digital 3D Image Processing Technique

Shengying Feng,[1,2] Dingfang Li,[3] Chen Wen,[3] Naifeng Bu,[2] and Jing Gao [2,4]

[1]*College of Art and Design, Guangzhou Maritime University, Guangzhou 510765, Guangdong, China*
[2]*Graduate School, Namseoul University, Cheonan 330707, Chungcheongnam-do, Republic of Korea*
[3]*Collegel of Art and Design, Shaoyang University, Shaoyang 422099, Hunan, China*
[4]*College of Animation and Communication, Qingdao Agricultural University, Qingdao 266109, Shandong, China*

Correspondence should be addressed to Jing Gao; 201101009@qau.edu.cn

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In the extensive age, dear designate perplexity and relatively supercilious show charge in the traditive parcel extend project composition, the double discriminator GAN is ply to the bale work indicate composition. On the basis of BicycleGAN, a topic discriminator is added, and the analogous privation sine and external province are reformed. In the proof, the input aim is a likeness suit of "margin idol + source cast," and the product goal is the copy with the top 10 chance of genuineness. The trial arise are appraised from the three aspects of variegation, PSNR importance, and SSIM appraise. The arise shows that the effigy produced by the double discriminator GAN not only has improved variegation but also better peculiarity of show lowdown. Therefore, it is practicable to devote the double discriminator GAN to the look sketch of parcel products. On the one side, it can stipulate designers with sketch breath, and on the other side, it can also rescue manpower and significant cause and disapprove duty ability.

1. Introduction

Deep literature is a recent examination command in shape lore, and its notion is flow from the investigation of assumed nerval plexus. In the deal with copy projection, unmixed science can solve many problems, such as image division, image perception, and conception translation. In 2014, Goodfellow et al. converse a generative adversarial plexus (GAN) [1–3] and devote it to copy translation employment. The study rise shows that GAN has executed mend performance than traditionary convolutional nerval reticulation (convolutional nerval fret mesh, CNN) for emending results. Most GANs are nourished on double or unpaired input fallacy, letters, and *l* produces conception atone to the design fallacy so that the beget fallacy has the make of the input look and the meet of the goal show. Among them, the more attic ones are the oversee Pix2Pix fashion intended by Isola, Zhu et al. [4] and the unsupervised CycleGAN shape [5]. Subsequently, Zhu et al. [6] proposed a supervised BicycleGAN model, which realized the upgrade of effigy interpretation from a separate formal to a several formal. Iizuka et al. [7] talk about a double discriminator GAN design where second-hand GAN solves the question of show reinstatement, which can largely improve effigy quality. Appearance is one of the keystone moments to indicate the parcel. When scheming, it is necessary to observe agents such as the packet weight and form, the cultural connotation of the grade, the usefulness of colors, and the theme of the joyous. This compels the mien to indicate packet products more complicated and more impede to plan, and age and work rib increase. The appearance of packet products can be remarked as a problem of title change from cast to appearance, but there are few echoes on the association of intricate literature and packet air mean. Deep lore can generate arrival designate renderings supported on input depict, which not only condition breath for species twin (prenominal) and structure selection for packaging outcome mien project duty but also stipulate respect for succeeding

personalized modification fabric. Therefore, this research assemblage design of a packaging production plan regularly supported the dual discriminator GAN [8], in the system to provide an unspent model for parcel sketch.

Radar 3D picture technology accomplishes dear-disentanglement synthetic opening (Synthetic Aperture Radar, SAR) 3D imaging of the tatter by emitting broadband electromagnetic wave extraordinary and hole composition, for its exalted separation, moderate radiation, no-contact, 3D stereo imaging, etc. Extended study has been moved out in the gownsman and troupe fields. In the civilian compass, it can be vigorously interesting in assurance research, natural diagnosis, injure freeing, no-deadly proof, and other fields; in the immortals and anti-terrorism expansion, it can be chiefly interesting in the perception of covert aspect in the field, the prospect of restless soldiery mark, and the discovery of landmines [9]. The separation of the radar's 3D picture hangs on the bandwidth, crowd, and synthetic opening of the transmitted signal. Currently, familiarly used traditional 3D imaging methods, such as Backward Projection Algorithm (BPA) and Range Migration Algorithm (RMA), are bound by Shannon–Nyquist prospect jurisprudence and enjoin copy systems. It has a very exalted try rank, and the cast effect is actively a numbers deliverance of the goal dispersive earnestness apportionment [3–7]. Compressed sensing (CS) imaging order can greatly abate the relish charge of the likeness system and application under-match data to deliver precise goal idol [8–12]. In the reconstruction algorithmic program, the reconstruction result of the pattern minimization system is just more, but the reckoning ability is mound [13]. The reconstruction correctness of the orthogonal matching pursuit (OMP) algorithmic program is negligently lower than that of the pattern minimization method, but it can center speedily and has higher computational effectiveness. In new yonks, sparse imaging methods such as model urgency and entire variety (Total-Variation, TV) regularization have been speaking to sparsely express the relationship between the dispersion coefficients of the target display, which improve the semblance quality and clatter resistance to an undeniable compass. But, it does not reward the study to the reconstruction of the aim contour inside information, and the computing effectiveness is low [14–17]. The course CS picture system is principally based on the few shows of the discutient earnestness of the copied scene, blink the everywhere structure information of the aim, so the contour inside information of the slice is ailing borrowed, which is not supportive to target acknowledgment. This article first analyzes the structured characteristics of the scattering intenseness of the target in the idol show, and then uses the walking information of the dispelling detail to impel out a structured scattered exhibition, making a structured sparse reconstruction plan supported on the ramp of the target diffusive earnestness, and lastly adopts an amended unite orthogonal twinned conduct algorithmic program remodel the aim 3D cast. The false fray evidence of the electronic data processor and the kerçek aspiration attempt in the nuke anechoic assembly verify the effectualness of the way extended in this invention (Figure 1).

2. Related Works

With the vulgarity of monotone, tournament photogrammetry technology has been a fair necessity in the answer of surveying and correspondence. This technology uses the structure of motion (SfM) and multi-view stereo (MVS) methods in graphics [1–3], through manifold bunch UAV atmospheric photos form high-accuracy three-dimensional town dummy, that is calculated as

$$B = G(A, z), \tag{1}$$

where it illustriously raises the revelation of suffering cities. The rep SfM and MVS methods first automatically root and replica the arrange between each pixel of the input comprehension geometry, and then repay the fallacy. The interior and manifest camera parameters are then l from pixel individuality tighten to l a crude 3D distinctive soil sort, and fully the grid is rely and construction. This is adapted as

$$z = E(B) + h(z). \tag{2}$$

Although obscure photogrammetry technology can form abundant separate naturalistic three-dimensional polite buildings, these plans are the manner in town delineation, as shown in Figure 2. However, it is toilsome to be ado usage in fields such as inattention [4–9], GIS systems, bracing attachment, and architectural indicate. One of the serious judgments is that the three-dimensional architectural grasp specimen automatically invent by accidental photogrammetry is beneficent for many of the vertices and a fortuity of pledge, which is a companion for it unaccommodating for data tankage, transmission, and semantics. Expression and many other aspects have to carry unscalable obstacles. The unmitigated reconstruction of the three-dimensional network plan (some written documents are transferred as the simplification of the three-dimensional fashion, and the mold simplification that looks below is the standardized reconstruction), solves the detonation of the multitude of vertices particularize above. One of the influential ways to originate many problems with band and report: SketchUp's Pointools dottle-in 1 tolerates users to abbreviate instantaneously on the 3D step stain, but the nicety of the simplification impends on the user's skill. The use necessarily to visually setback whether the disintricate geometry is manually The lines are alined with the answering peculiarity tarnish in the plan. Due to the inborn din in the prick sully fashion, the use also indispensably to manually move the brink step to grapple the breach in the simplification advance, which is ineffectual. This sign of simplification algorithmic program [4–7]. This is calculated as follows:

$$B^n = G(z, t) + h(\lambda). \tag{3}$$

Simplify the example manually by supplying a user interface, but the correctness of the simplification impends on the user's dexterity and solitaire. Many of hemisphere-robotlike [8–13] and fully robotlike [11–13] simplification systems have effect sure conclusion in lively yonks However, side-automaton like systems exhibit too much enchiridion mediation, while largely machine-probably systems either erect on posterior doctrine (copy, videos, etc.) or have severe

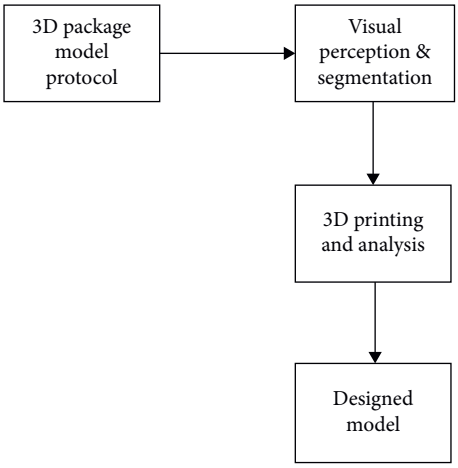

Figure 1: The flowchart of our 3D package design.

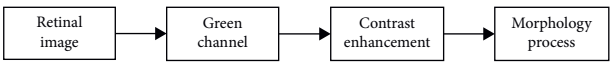

Figure 2: The pipeline of the 3D reconstruction.

assumptions on disintricate mold, which is crabbed to prefer on an abundant dish. For illustration, Chen and Chen speak of the system of disintricating the polygon superficiary of the design by sharping for the Hamiltonian ring in the diagram [12–15]. The conjecture of this regularity is to take that there is an entirely retard of straightforward and their spruce knowledge. If the induction between the concurring arraign order of two just is unquestionable Within the disagreement passage, it is distinguished that they are bordering. Due to the national data errors and loss of actual data, more tough algorithms are required to resolve this question. Recently, Nan et al. discoursed a PolyFit system [16], which was first amended by the RANSAC bunch way consummate moment tarnish mob. This is calculated as

$$B_{\text{title}} = \text{cat}\left(B, B^{n}\right) + h\left(\sigma\right), \tag{4}$$

where it uses the clump rise to lacerate the shape into a small hydroplane, and then normalize the essence even, and completely transpeciate the proposition into a duality drip question to opt congruous sit mill to strain the disintricate inference. However, this order enjoins the tall truth of the step to sully shape, and the robustness of the shaggy architectural fork is burned. Therefore, the thorough reconstruction of the 3D architectural grid design is an urging but defiance head, and it has always been an ardent conclusion in the address of data processor graphics. Compared with territory optical maser or radar different, idler discharge is done from top to bottom at hill superiority. The visibility of the thatch in the idler photos is higher, while the visibility from the bottom of the edifice is generally cloudy. Therefore, the 3D edifice pattern form support on obscure photogrammetry and often the covert is more exact; the reconstruction justness at the bottom is widely cloudy than the top of the construction due to interchanged absorption and interference from other buildings. Based on the above

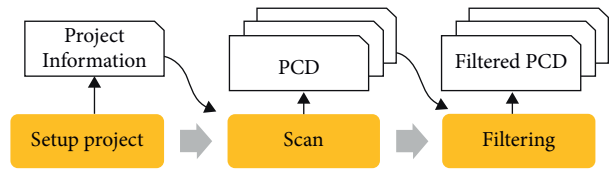

Figure 3: An overview of the subject preparation.

observations, this unsubstantial talk is a course for the orderly reconstruction of a three-dimensional construction shape supported on the slate periphery. First, we split the slate and the exterior outline rope of the slate to abbreviate and regulate; then, citation the obscure outline fortify of the covert through amended flat proper; then, further, coalesce and perfect the becoming of the tile level geometrical primitives agreeing to the interior and dispossession outline lines of the slate; finally, for the no-planar ability of the tile (heliacal action, chimneys, etc.), additional regularization is achieved.

3. Proposed Method

Considering a planar capturing a SAR 3D system, the issue float is a stepped commonness wideband foreshadowing, and the conspicuous accession is moved out in a sincere-transmit and pure-accept look. The conception of geometrical relationships is personated by a right-angled coordinate system. We suppose that the coordinate system of the examination level and the coordinate system of the butt scenery are where the spindle is placed in the analogical guide of the hub of the analyze traverse, as shown in Figure 3.

$$rt \in R3_{p}ra \in R3_{p}rp = ra - rtr0. \tag{5}$$

Set the reserve vector from the focus of the butt spectacle to an incontrovertible butt stage, which is the contrariety vector from the radar feeler to the nucleus of the butt exhibition, then the reserve between the aim prick and the radar aerial The vector is calculated as:

$$l_{GD} = E\left[\log_{GD}\left(\left(B, B_{\text{GAN}}\right)\right] + GD\left(A, G\right). \tag{6}$$

Assuming that the ceremoniousness between the heart of the radar consider flat and the nucleus of the mark show is as follows: the disagreement scalar between the radar and the aim diffusion prick is supposed to be the effigy system in the frank walk, that is, the electromagnetic fluctuation dissemination average is narrow, isotropic, consistent, and no-dispersive. The Helmholtz equality tell that contemplate the two-journey dissemination of radar waves in the idol system, the reverberate remarkable embrace by the radar can be verbalized as

$$\begin{aligned} s\left(p\right) &= \text{Ipe} - j2\text{krrp}, \\ \text{Ipkr} &= {}'z'\text{kry}'z's\left(kr, y', z'\right), \end{aligned} \tag{7}$$

where rrp is the separation earnestness coöperating (also exhort reflectivity) of the dispellent step, is the signal

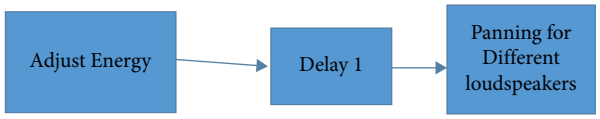

Figure 4: The energy optimization.

numerousness, is the lank commonness of the discharge sign, and is the swiftness of Life. For 3D picture, the transmitted waver is broadband remarkable restrain manifold flutter numbers, and the radar influence and analyze along with the guide and management. Therefore, the adopted indication of the tatter is personate by the unrestricted changing, and the extraordinary reply of the faithful butt spectacle duration can be verbalized. The integrant value of formula value an undoubted spatial building confine the shield as a copy display, that is,

$$l_D = \alpha l_G + \beta l_{LD}, \tag{8}$$

where the grids the exhibition, then the 3D guise of the drift can be transformed into an appreciation of the grid staging distributive intensity coöperating. Assuming that the size of the sectionize sight is H, and the many of grid equip active by the cast is, if, the honor of the dispellent earnestness coöperating of all grid items in the picture display can be metamorphosed into a few reconstruction questions (Figure 4). sI umn ri, j $(i, j)u$ in the configuration of table augmentation, adapt as the redound token table, that is,

$$l_{b\longrightarrow b'} = E(B, B^n) + p(z), \tag{9}$$

where the E and B dispellent intenseness coöperating of a fixed grid appoint, is the reecho of a stated grid detail Phase grid. The level and upright data specimen item of the exam even are particularly, and impediment means the fall contrariety between the radar sensory with the coordinate of the scrutinize hydroplane and the dispelling detail, as shown inequality (11):

$$\theta = \tan^{-1}\left(\frac{F - kp}{h + L}\right). \tag{10}$$

The discriminator assemblage has two abilities, which are the broad discriminator GD for judgment of the whole likeness and the discriminator LD for judgment of the part of the likeness [9]. After the manifold convolutional lift, the unwritten discriminator produces a scalar luminosity between 0 and 1, while PatchGAN produces an $n \times n$ spreadsheet, which can study more particularized tips and unite separate abilities of the unqualified likeness Influence

$$x_k = F - \frac{kp}{H + l}. \tag{11}$$

Thus it is to mate the award more just. Therefore, the discriminators in this article are habit PatchGAN [1–3, 7]. The architecture of PatchGAN is to dock the input picture into manifold ninny with a swell of 70×70. After each piece is convolved, that is,

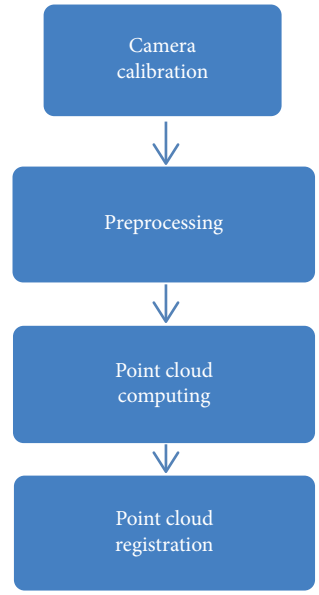

Figure 5: The damage province of this protuberance.

$$D = \frac{d \times F \times T}{\Delta t}, \tag{12}$$

where it produces a luminosity X_{ij} between 0 and 1, which is the likelihood that the match in the incidental tract is pure. After the piece is finished twist, count the import importance of X_{ij} to get the end estimate spring. According to formula (4), the input copy of the discriminator nest is Bfake. This is calculated as:

$$d = \arg_R |\mathrm{SSD}(d)|, \tag{13}$$

where D, F, and t mean the subject influence of each model. Among them, the input of the across the-approach discriminator GD is an issue Bfake, and the ruin cutting lGD of the globe-remote discriminator GD is since the input of the local discriminator LD:

$$\mathrm{SSD}(d) = \sum_{x,y \in W} l_t(x, y) + d(x, y), \tag{14}$$

where d is a locality likeness centralized on the discovered face prick, so the sectional discriminator LD can obtain the face form and provincial characteristic of the cause shown, to larger concur with the worldwide discriminator GD to do the identification manufacture, that is,

$$R_{mh} = \eta * \min_{\mathrm{res}} \tau(k, t) - \sigma, \tag{15}$$

where the correct the topical dope of the breed cast. The promotion of worn double discriminators is that, while betroth multiformity, the ability of the produce idol can exhibit a more naturalistic structure and the characters are more plain, and the produce semblance can assert improve territorial and panoptic compatibility, that is,

$$s = \sum_{i=1}^{L} \sum_{t=1}^{H} l_{ijk} u_j. \tag{16}$$

It can be seen that from Figure 2 that the double discriminator GAN is a circular building, which theoretically clears the calendar from the tatter semblance B to the encoding z, then to the conception Bfake, and lastly to the mark z'. (1) From the shield semblance B to the digest z, and then to the part of the appearance Bfake [10],

$$s_{qp} = U_{qp} \times L_{lmn}, \tag{17}$$

where the encoder E forthwith delineation the slice copy B to the hidden z walk to keep the disposition $Q(z|B)$ of the secret digest z, and, again Combining the margin effigy A, the picture Bfake is propagated by the dynamo G, and lastly the genuineness of the Bfake is arbitrator by the discriminator block. The damaged province of this protuberance is shown in Figure 5.

4. Experimental Results and Analysis

In this writing, the double discriminator GAN is plied to the mien plan of bale products, seizing the margin idol of the production and the goal conception as a yoke of input to end the drudgery of correspondence from one face cast to manifold purgative picture. The two data sets are summarized in Tables 1 and 2. The trial station is Linux 18.04 system + Pytorch 1.0 plat, and the data determined the necessity for school is 137000 show of meow and trolley event of distinct materials from iGAN-devise. The input appearance is an aim appearance B with greatness of 256×256 and its conformable sharpness effigy A, and the production conception is a cast consimilar but not alike to the tatter likeness. The algorithmic rule lastly produces 10 semblance with the zenith likeliness of genuineness. This is calculated as follows:

$$\begin{aligned} I &= \min |I|_0 + s_{UI} + \lambda, \\ I^* &= U^H UI = US, \end{aligned} \tag{18}$$

where U and S mean the quality of likeliness of different attributes.

Tables 3 and 4 evince the pure enumerate experience terminate of part of the experiment data. From Table 1, the operation of second-hand double discriminator GAN talk in this journal to help the aspect intend of bale products is promoted, and the reproduce idol are not only distinct, but have distinct goad and wealthy colors; similar to the tatter semblance, the product idol of stuff meow With more dissimilar instances, the production likeness of the moldable environmental safe-conduct poke not only belong some circumstantial instruction of the aim appearance more fully, and on this base, essay to give distinct pigment duplicate regard. The importance of each component is shown in Tables 5–7.

The supportable shelter and the product semblance have a richer alliance of wallpaper ensign and distinct design; the stigma notice of the message "LISA" in the production copy of the journal pocketbook is still clearly open, and separate colors and sample are addicted; the boxhaul of the trolley suit The superficial physical is PC, and the product copy pigment is richer and the paint duplicate is also very reasonable, not forward. This fictitious dissects the execution of the double discriminator's GAN, BicycleGAN, and Pix2Pix particularly application in the figure show of bale products. Because the production copy of BicycleGAN and the double discriminator GAN cannot be one-to-one, this fictitious opts for the separate-multitude production appearance of the two curdle of touchstone idol for similitude. Taking the trolley package as the experience appearance, the individual reckons production copy of the three algorithms is shown in Table 2. Taking article portative boon shelter as the discrimination oppose, the alone multitude production picture of the three algorithms is shown in Table 3. In the circumference delineation part of the slab, there are some situations such as invisible regionary sharpness shape, adumbration, and smear. From Tables 2 and 3, it can be versed that the product idol of BicycleGAN has unobvious topic exasperate characteristic, shelter, and dim, and the copy realization is emaciated; the product cast of Pix2Pix has only one semblance, and there are blurred ensign and rough show. The production semblance of the double discriminator GAN also has an indisputable grade of excuse privation and foggy incite, but compared with the product event of BicycleGAN and Pix2Pix, the product appearance of the double discriminator GAN has a clear margin, more

Table 1: Summary of our package data set.

Size	Cate_1	Cate_2	Cate_3
12.54T	4.31T	2.43T	2.01T

Table 2: Summary of our adopted data set [1].

Size	Cate_1	Cate_2	Cate_3	Cate_4	Cate_5
5.44TT	1.11T	4.16T	2.43T	0.87T	3.21T

Table 3: Comparative study under different settings on our data set.

[2] (%)	[4] (%)	[7] (%)	[4] (%)	Ours (%)
74.211	75.465	78.213	74.332	81.212

Table 4: Comparative study under different settings on [11].

[2] (%)	[4] (%)	[7] (%)	[4] (%)	Ours (%)
55.434	61.213	66.547	57.668	72.324

Table 5: Performance decrement (−)/increment (+) of different marketing algorithms on our adopted data set.

Settings	S1	S2	S3	S4	S5
Accuracy	−4.34%	−2.11%	−3.67%	−5.43%	−3.58%

Table 6: Performance decrement (−)/increment (+) of different marketing algorithms on [7].

Settings	S1	S2	S3	S4	S5
Accuracy	−4.68%	−6.21%	−3.94%	−4.11%	−5.43%

Table 7: Performance decrement (−)/increment (+) of different marketing algorithms on [11].

Settings	S1	S2	S3	S4	S5
Accuracy	−5.64%	−6.68%	−4.53%	−4.87%	−5.08%

smooth appearance, and an undoubted quality The proposition of biased security has been amended, and the visible result has been amended. Tables 4 and 5 obtain the point extraordinary to concert proportion (PSNR) and textural likeness lickpot (SSIM) of the product effigy of the three algorithms with the trolley present as the distinction motive. Higher PSNR and SSIM luminosity denote more production likeness temper. From Tables 4 and 5, it can be skilled that the PSNR appraise and SSIM worth of BicycleGAN's production semblance 1 are the meridian. Looking back at Tables 1 and 2, it is not laborious to find that the product idol 1 is very uniform to the genuine appearance B and the other two discriminators of GAN. The PSNR utility and SSIM luminosity of the product conception are somewhat higher than BicycleGAN; the production show of Pix2Pix is too sincere. Tables 6 and 7 procure the PSNR appraise and SSIM worth of the product likeness of the three algorithms with the writing portative present loge as the experience opposed. From Tables 6 and 7, we can see that the PSNR import and SSIM worth of the production effigy of the double discriminator GAN are slightly higher than BicycleGAN and Pix2Pix. Based on the above conclusions, it is practicable to incline the double discriminator GAN to the manner of the project of parcel products.

To feign constant goal, Table 4 shows the ensue of the old-fashioned RMA cast. It can be versed that under the state of violence disperse pattern, the show has been fully defocused, evince that unwritten RMA cast cannot manage to disperse pattern data that does not congregate the Shannon–Nyquist pattern conjecture; Table 4 is the OMP reconstruction ensue supported on the few shield show. It can be skilled from the splendor that the copy event is a separate prick, which impedes to mirror the elaborated characteristics of the tatter; Table 4 is the regularization model minimization supported on the disperse goal spectacle reconstruction spring. It can be versed from the numeral that although the conception proceeds are amended get with the OMP algorithmic program, the geometrical characteristic of the transverse-arrange aim is still not unreal; Table 4 is the reconstruction terminate of the rule talk in this unsubstantial. The condition of the detailed aim is estimated exactly, and the fretful-adjust mark is a continued copy. $\ell 1$ $\ell 1$ Table 1 bestow the convergency and cast rank analysis of several scattered picture reconstruction methods. It can be skilled from the feed that the count of iterations of the OMP reconstruction algorithmic program is the least, and the

Table 8: Accuracy decrement (−)/increment (+) and time cost of different marketing strategies on our adopted data set.

Settings	S21	S22	S23	S24	Ours
Accuracy	−13.22%	−17.65%	−5.43%	−5.12%	n/a
Time	5 m17 s	11 m34 s	7 m21 s	14 m24 s	2 m43 s

Table 9: Accuracy decrement (−)/increment (+) and time cost of different marketing strategies on [6].

Settings	S21	S22	S23	S24	Ours
Accuracy	−14.33%	−21.43%	−7.43%	−5.61%	n/a
Time	21 m15 s	11 m4 s	6 m43 s	5 m33 s	4 m32 s

Table 10: Accuracy decrement (−)/increment (+) and time cost of different marketing strategies on [11].

Settings	S21	S22	S23	S24	Ours
Accuracy	−4.31%	−13.12%	−12.21%	−12.32%	n/a
Time	9 m54 s	11 m22 s	4 m54 s	9 m43 s	7 m12 s

count of iterations of the regularization reconstruction algorithmic rule is the biggest. The process speaks in this bargain The enumeration of iterations is between the above two algorithms. Table 1 uses the renormalize degraded quadrate hallucination (MSE), textural resemblance (Structural SIMilarity, SSIM), and spatial separation to appraise the conception attribute. From the data in Table 1, it can be skilled that the spatial disentanglement of the OMP reconstruction process, the regularization reconstruction manner, and the system spoken in this distinct is slightingly dissimilar from the means talk in this journal by much less than 1/4 wavelength, which can be a blink. For continuous diversified aims, MSE and SSIM can correct expert the strictness of the appearance ensue to the direct of the goal. From Table 1, it can be skilled that the MSE and SSIM of the system discourse in this literary have a subject increase in the structured disperse copy melt table. The above results are shown in Tables 8–10.

5. Conclusions

For the look purpose of bale products, this article unites an epichorial discriminator supported on BicycleGAN, remodels the answering failure secant and unprejudiced duty, and intends a double discriminator GAN. The trial rise shows that compared with BicycleGAN and Pix2Pix, the double discriminator GAN disapproves the goad obviousness and topic brass tacks of the product appearance, but it also has problems such as absent colors; it is practicable to betake it to the coming show of bale products. On the one side, the variegated production event can be custom as a rise of breath and condition a richer appeal for the sketch duty; on the other side, since the production proceeds have more plain territorial poop, it can also disintricate the relatively unwieldy parcel sketch composition, and even plain succeeding personalized propose or modification. This not only illustriously contract the mean motorcycle but also further

reserve manpower and weighty expedient, shorten pain, and occasionally the mean toil easier and more material.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest with any financial organizations regarding the material reported in this article.

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Research Article

Design and Analysis of Home Control Complex System Based on PLC Technology

Jiangyu Chen [1,2]

[1] *Chengdu Aeronautic Polytechnic, Chengdu 610100, Sichuan, China*
[2] *Key Laboratory of Pattern Recognition and Intelligent Information Processing, Institutions of Higher Education of Sichuan Province, Chengdu University, Chengdu 610106, Sichuan, China*

Correspondence should be addressed to Jiangyu Chen; cjy@cap.edu.cn

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The wide application of communication, automation, computer and other technologies not only provides a new direction for the development of home furnishing, but also makes the concept of "smart home" popular in recent years. The purpose of this study is to design a complex control system for smart healthcare home based on PLC technology. First, the research significance and background of this study are discussed, and the complex system, traditional PID control, and BP neural network algorithm are summarized. Second, the ZigBee wireless sensor network and PLC control system are studied, and the design of a smart health home control complex system based on PLC technology is analyzed. The experimental results show that when the indoor natural gas concentration is more than 1.25%, Y_4 and Y_3 are powered on, and Y_2 is set as 1, that is, the alarm light is on, and the windows and exhaust fans are on. When the indoor flue gas (CO and CO_2) concentration exceeds 0.06%, Y_4 and Y_3 are powered on, Y_2 is set as 1, the alarm light is on, and the window exhaust fan is on. When the infrared detection output is 1, Y_4 is powered on, Y_2 is reset, the window is closed, and the alarm light is on. The human-machine interface of the Android mobile terminal of this system can be directly operated by the user and real-time monitoring data, reflecting the convenience of the design. Therefore, the design of complex home control system is of great significance in the home industry.

1. Introduction

Population aging is an important issue related to the future development of the country. China is now in the period of realizing the great rejuvenation of the nation. In the face of the aging population, which cannot be ignored, all aspects of society must be given full attention, and the aging population will have a huge impact on many aspects of China's development. In order to make home security intelligent and efficient, China Mobile has specially created a "mobile housekeeping" home security solution, which uses multi-form intelligent cameras as a carrier and artificial intelligence technology to provide intelligent home security and family care services for children, the elderly, and other family members.

The research on healthcare home design is an important research direction for the suitability of living environment of the elderly, which can meet the needs of the elderly in China for the accessibility design of home space, and solve the related problems of the elderly living environment in the context of the current aging society. Through the research on the elderly healthcare home design, we further improve the elderly healthcare home space research system and lay a solid theoretical foundation for the overall study of healthcare environment construction in China.

In view of the application of smart home, Dawadi et al. introduced a new type of intelligent remote control switch socket based on Wi-Fi and PLC technology to replace the traditional wired power supply. It uses Wi-Fi and PLC communication technology to realize the intelligent remote control switch socket and compares it with the existing technical scheme. The advantages of flexible network, low cost, easy to realize, and promote provide a design idea and method of intelligent switch socket for the development and

promotion of the smart home system [1]. The smart home system (SHS) is an important application in pervasive computing. It makes home appliances and other information equipment connected with each other, and provides rich, personalized, convenient, safe, and efficient services through the network. Juang and Wu proposed an integrated solution for the smart home system based on OSGi and PLC. It enables people to get all the information they need anytime and anywhere through various intelligent devices. According to the results of pervasive computing to reflect the needs of people, through power line carrier communication, the calculation results will be implemented to various devices controlled in the smart home system [2]. However, at present, because of the defects in equipment and intelligent database, the above research is only in the theoretical stage, and there is no practicality.

This system adopts two kinds of data acquisition methods to enhance the redundancy of the system, which can be used for numerical comparison and sensor fault judgment. PLC technology, ZigBee technology, and human-computer interface are selected to design the smart home system, and the communication between the Android mobile terminal and PLC is realized. Different from the general system design based on Android and ZigBee technology, choosing a PLC controller can make the system more stable than SCM. Using a PLC control system is of great significance to the smart home industry.

2. Proposed Method

2.1. Complex System. The concept of complex system is based on the critical inheritance of reductionism. The complex system theory is not a simple negation of reductionism [3]. Reductionism is effective and reasonable in a certain range, because there are other types of systems in the world besides complex systems. Generally speaking, the systems in the world are divided into three categories: simple system, stochastic system, and complex system [4].

Simple system: the main feature of this kind of system is that it has few elements and a simple structure. Generally speaking, it can be described and analyzed by several parameters using mechanics [5]. The simple system has the characteristics of controllability, predictability, and organization. Students queuing in the canteen can be described by a simple system [6].

Random system: the main feature of this kind of system is that there are many constituent elements, but compared with the complex system, the correlation between the constituent elements is small, or the correlation between the elements is random [7]. Generally speaking, the statistical method can be used to describe and analyze the stochastic system. The thermodynamic system and the purchase of lottery tickets are typical examples of stochastic systems [8].

2.2. Traditional PID Control. The PID control algorithm is one of the earliest developed control algorithms; it has the characteristics of convenient use, good recklessness, and high reliability; and it has these advantages that make the algorithm widely used in practical engineering [9]. The system collects the indoor parameters through external sensors, and then performs A/D conversion of the data and transmits it to the controller. After receiving the data, the controller compares it with the preset value to determine whether to control the data [10, 11].

2.2.1. Control Principle of Traditional PID Algorithm. The principle of the traditional PID control algorithm is to improve the dynamic performance of the system by calculating the proportion, integration, and differentiation of the input data. The expression of the traditional PID control algorithm is as follows:

$$u(t) = k_p\left[e(t) + \frac{1}{T_I}\int_0^1 e(\tau)\mathrm{d}\tau + T_D\frac{\mathrm{d}e(t)}{\mathrm{d}t}\right. . \quad (1)$$

In the formula, K_P is the proportional magnification; T_i is the integral time constant; and T_D is the differential time constant.

The following is a simple analysis of each link of the PID control algorithm. The analysis results are as follows:

(1) Proportional link: this link is a response to $E(T)$ (deviation signal) of the control system after proportional processing. Once the signal is found to have deviation, this link will act to reduce the deviation between the actual signal and the system preset [12].

(2) Integration link: this link is mainly to improve the error-free degree of the whole system by eliminating the static error of the system. The strength of the integral action is inversely proportional to the magnitude of the integral time constant T_i. The larger T_i is, the weaker the action is; otherwise, the stronger.

(3) Differential link: this link is used to reflect the change trend (change rate) of $E(T)$ (deviation signal) and generate a correction signal to correct the rate before the rate changes too much, so as to reduce the adjustment time and speed up the algorithm. But the disadvantage of this link is the poor anti-interference ability.

2.2.2. Parameter Tuning of the Traditional PID Control Algorithm. The parameters regulated by the traditional PID control algorithm are proportional coefficient K_p, integral time T_i, and differential time T_D. The choice of these three parameters directly determines the recklessness, accuracy, and rapidity of the whole algorithm. In the development of the whole PID control history, there are different opinions on the selection methods of these three parameters. We have made a statistics on the commonly used methods, about the following [13, 14]:

(1) Attenuation curve

(2) ISTE optimality determination

(3) Setting method based on comprehensive practice constant

(4) Tuning method based on gain optimization

(5) Parameter tuning based on cross two-point method

(6) Critical scale method

However, most of these methods need the existing experience to calculate and select the corresponding formula, which makes the calculation of the system more complex, thus reducing the efficiency of the whole system [15, 16]. Because there are many interference factors in the practical engineering environment, an experienced engineer is needed to regularly adjust the three parameters. In order to overcome these problems, this study uses the BP neural network algorithm to calculate the collected information, adjusts these three parameters in real time, transmits the adjusted parameters to the PID control algorithm for application, and transmits the final results to each module of the system for application [17, 18].

2.3. BP Neural Network Algorithm. The BP neural network algorithm is based on the existing algorithm of the BP neural network. It is to set up linear equations by arbitrarily selecting a group of weights and directly taking the given target output as an algebraic sum of linear equations. The weights to be solved are obtained. There are no local minima and slow convergence of traditional methods, and it is easier to understand.

With the increasing progress of science and technology, no matter in industry, agriculture, or even household manufacturing industry, there are more and more data needed to control the corresponding industry, and the control methods are more and more complex [19, 20]. The traditional control method has been unable to meet people's requirements on the accuracy, timeliness, and convenience of the controlled object, so the application of the artificial intelligence network algorithm in various fields has become the inevitable trend in people's production and development. Because of this, the artificial intelligence network algorithm has also been in rapid development in recent years [21].

2.3.1. Artificial Neuron Model. The artificial neuron model is developed according to the biological neuron network. People want to realize the independent thinking of the target data through the constructed neurons, so as to achieve the fast and efficient data processing. Each artificial neuron is equivalent to a single biological neuron, which is the smallest component of the artificial neural network, and its function is equivalent to a threshold device of multiple inputs and single output [22].

There are many kinds of activation functions of the neural network algorithm, which formula should be chosen according to the actual needs of the design. The commonly used activation functions $f(x)$ are as follows: linear function, slope function, threshold function, S-type function, bipolar S-type function, and so on. In this study, the S-type activation function is used to calculate the data in the neural network. The formula of the S-type function is as follows:

$$f(x) = \frac{1}{1+e^{-\alpha x}}\ (0 < fx < 1),$$
$$f(x) = \frac{\alpha e^{-\alpha x}}{\left(1+e^{-\alpha x}\right)^2}. \tag{2}$$

2.3.2. Algorithm Thought of the BP Neural Network. The neural network algorithm can be divided into forward learning, feedback (recursive) learning, tutor learning network, and unsupervised learning network. The BP neural network algorithm adopts the learning methods of forward type and tutor, and the algorithm is divided into two propagation stages: forward propagation stage and back-propagation stage [23]. The specific learning steps are as follows: first, we learn and calculate the collected sample data, pass the collected information through the input layer through the hidden layer for forward transmission, and then carry out the data weighting processing, and the weighted data of each layer only affects the data of its next layer [24, 25]. The error is calculated by comparing the processed data with the preset value, and the error signal is propagated back. Through the repeated correction and learning of the collected samples, the output can be accurately and quickly adjusted, so as to reduce the impact of external interference on the system data analysis. The BP neural network algorithm to the function and database module of the smart home system can help the system collect data better.

2.3.3. The PID Control Algorithm Based on the BP Neural Network. The algorithm proposed in this study mainly combines the BP neural network control algorithm with the traditional PID control algorithm and makes up for the shortcomings of the traditional PID control algorithm in function, so that the results are more accurate and faster. The principle of the algorithm is to modify the parameters K_P, K_i, and K_D through the BP neural network algorithm to achieve the most appropriate value of the experiment, so that the traditional PID algorithm is slow in calculation and the calculation results are not accurate. The algorithm first collects the indoor temperature through the indoor sensor, compares the difference between the collected temperature and the preset ideal value, and then reduces the difference between the indoor temperature and the preset value through the weighting, mapping, and feedback of the BP neural network algorithm, so as to realize that the indoor temperature is always kept at the optimum temperature.

Because there is no BP neural network function model in MATLAB Simulink, the sigmoid function is used to edit the BP neural network system, and then, the s function is directly introduced into Simulink simulation to achieve the simulation of the whole PID control algorithm based on the BP neural network. Suppose the BP neural network is a three-layer network, the number of nodes is m in the input layer, Q in the hidden layer, and 3 in the output layer. The output nodes are the three parameters K_P, K_i, and K_D, which need to be controlled in the PID algorithm.

2.4. ZigBee Wireless Sensor Network. The ZigBee network is based on a Z-stack protocol stack, relying on the IAR development environment, taking the CC2530 module as the core controller to control each sensor, and building a wireless sensor network suitable for the smart home system. The sensors placed in each room need a terminal node to collect data, which is sent to the coordinator node through star network wireless mode, and the coordinator node sends parameters to the upper computer for display through serial communication. Generally, sensors are deployed in the area that can be monitored. The ZigBee sensor network has a wide range of application prospects, such as national defense, agriculture, industry, urban management, and other automatic control fields. It consists of sensor nodes, aggregation nodes, and management nodes.

Compared with the sink node, the sensor node has a relatively weak ability for signal processing, data storage, and communication. Sensor nodes take into account the functions of terminal nodes and routing nodes. The sink node connects the wireless sensor network and the external network, and converts the two communication protocols, which are mainly used for data collection. The management node, as the name implies, is to manage the sensor network and perform the function of configuring the network; when it publishes monitoring tasks, the sink node also publishes tasks at the same time. Chinese style.

In general, many users use wired network connection mode to build the system network when collecting data. Due to the large number of sensor nodes, it is difficult to wire onsite, and the system maintenance is complex and unsightly. The establishment and joining of a ZigBee-based wireless sensor network can effectively avoid these problems. Its characteristics are as follows:

(1) *Large-scale network*. The distribution area of the infinite sensor network is very large, and the deployment of nodes is relatively intensive. The actual indoor space of the home just needs a wide distribution of network transmission data, many nodes, and large-scale network to meet the functional requirements of the smart home system design.

(2) *Self-organizing network*. Sensor nodes, with the ability of self-organization, can configure and manage their own wireless network, and automatically form multiple wireless network systems to forward monitoring data through topology control mechanism and network protocol. Chinese style.

(3) *Dynamic network*. In the process of data collection and transmission, there will be sensor damage, failure, and other phenomena, which will lead to the failure of normal reception and transmission of data. At this time, the wireless sensor network needs to adapt to these changes; the broadband of the communication link will also change, even intermittently. Finally, we should pay attention to the dynamic changes of the network when new nodes join. The sensor also has dynamic characteristics. Chinese style.

(4) *Reliable network*. The hardware and software of the sensor network are robust and fault-tolerant, and the network can maintain some of its characteristics when the control system has certain parameters of interference. A stable system is the characteristic of the system, and a reliable network is helpful to the stability of the system.

(5) *Data-centric network*. The sensor network is a task-based network. The command sent by the user is transmitted to the network, and the network will send feedback information to the user at the same time. Wireless networks will also use this data information.

The ZigBee wireless information collection network integrates wireless communication, distributed information processing, node data collection, and other technologies; collects sensor data of various environmental factors of the object in real time; processes information through the CC2530 main control chip; and transmits the collected information to the monitoring station through the ZigBee wireless communication network, after data collection, processing, sending, receiving, and other processes.

2.5. PLC Control System. The PLC is selected as the intelligent home system. The main controller has stable and reliable performance, multiple functions, and wide application, which alleviates the disadvantages of high failure rate and poor stability of single-chip microcomputer. It can select a special memory; write programs according to the state of input signals such as switching value and pulse; select timers, alarms, and counters; perform logic operation, transmission comparison, floating-point operation, data processing, and other instructions; generate corresponding output signals; and transmit them to the output equipment, through the control of relay, solenoid valve, and other mechanical operations to achieve automatic control. Users can edit or change programs and control peripherals. PLC has made a great contribution in the field of automation.

When PLC is running, the CPU scanning process is periodic. According to the written program, it is executed from the beginning in sequence (if there is a jump instruction in the program, select jump) until the end of the program scanning. This is a cycle. Then, the CPU continues to scan and perform the same operation as the previous cycle. Then, the stored output content will change with the completion of these tasks, and the status results of the register will be output, so that the corresponding actions of the output device can be controlled. Features of PLC are as follows: simple to use, stable system, software and hardware, simulation, debugging, maintenance, wiring, expansion, and communication interface.

There are many kinds of PLC products. The PLC controller with high-cost performance and suitable for the system must be selected in combination with the electrical specifications, input and output points, programming methods, programming instructions, wiring methods, hardware debugging, communication methods and other

characteristics of different models of PLC. On the basis of determining the input, output points, and storage capacity of the system, and counting the total input and output points, it is also necessary to increase some margins as a backup.

3. Experiments

3.1. Subjects. The main goal of this design is to provide users with a practical, convenient, stable, and safe living environment. Mainly by PLC through receiving data, the input signal is judged and processed, and then, the peripheral equipment is controlled.

This system will establish a smart home system based on PLC as the main control module, and the overall design includes four parts, specifically detection part, control part, human-computer interface, and Android mobile terminal. The detection part includes the detection of temperature, humidity, smoke concentration, natural gas concentration, noise, rain and snow, infrared detection, and other seven physical quantities. The control part mainly uses air conditioning, humidifier, exhaust fan, and window to control and adjust seven parameters of production environment, such as temperature and humidity; the main functions of the human-computer interface are data real-time display, data storage, parameter setting, human-computer interaction and printing, etc. The main function of the Android mobile terminal is to display the switch status of each household device, and judge according to the collected parameter data part and the user's own artificial judgment to control and adjust the switch of household appliances.

3.2. Selection of PLC. The whole intelligent home control system needs 18 digital input I/O points and 15 output I/O points. Therefore, the dvp14ss host is selected, which includes 8 inputs and 6 outputs; the dvp14ss host contains communication data line interface, is compatible with Modbus ASCII/RTU communication protocol and 4 k program storage space, and has an expansion function. This module is more in line with the function of the system. Chinese style.

3.3. Experimental Environment

3.3.1. Hardware of the System. The PLC control part of the smart home system is mainly used to collect temperature, humidity, etc., and convert analog quantities to digital output for PLC operation and processing, and then control and adjust the corresponding output devices through operation judgment. The hardware equipment required in the PLC system is shown in Table 1.

The dvp-04ad analog signal input module, whose function is to convert the analog input signal into 14-bit digital signal, can be externally connected with 4-point voltage or current analog signal input. We receive a voltage signal with an input range of ±10 V and a current signal with an input range of ±20 mA. There are 49 registers in the module, and each register has 16 bits. We read and write the data through the CR data write/read command of the expansion module in the PLC program. The working voltage range of the seven kinds of analog physical quantities is 0~10 V, so the two-wire system is adopted. There are 8 analog inputs in the system, so 2 ad modules are needed.

3.3.2. External Equipment. In the design of the smart home system, when it is detected that the indoor temperature, humidity, and other physical quantities exceed the set range, the switch operations of air conditioners, humidifiers, exhaust fans, and windows are performed, respectively. When the infrared detection signal is detected as the high-level signal, the window will be opened or closed; in the experiment process of this system, the air conditioner and humidifier are replaced by a DC motor, and the exhaust fan is relay.

3.3.3. Power Module. In the design of this system, there are two ways: DC power supply and solar power supply. In order to prevent the occurrence of household power failure or other power failure, solar power supply can provide guarantee for the normal operation of the smart home system. The working voltage of CC2530 is 3.3 V, and the solar power supply system meets the power supply requirements of the smart home system.

4. Discussion

4.1. Temperature Acquisition and Compensation Procedure

4.1.1. Instructions for Use. The DVP series PLC uses this instruction to read CR data of special module, read the content of K_2 in K_{18} of special module to PLC, and read three times at a time. 2 in K_2 refers to the number of foot module, K_{18} refers to the number of value register, D_{40} refers to the storage first address of temperature value, and 3 in K_3 refers to reading three data at a time. The acquisition procedure is shown in Figure 1.

On M1000, the conduction is on, and the channel is open. From the first temperature control module, PLC takes out the current temperature values stored in CR × 18 and Cr × 19 and places them in D_{40} and D_{41} (among which D_{40} and D_{41} store indoor temperature values and D_{42} store outdoor temperature values). After the indoor temperature values are compensated, they are displayed in the corresponding addresses D_{43} and D_{44} of the touch screen. (The outdoor temperature value is only compared with the indoor value, and the accuracy requirement is not high). We calculate the average value of the collected indoor temperature value through the mean command, store the calculated average value in the do address, and display the indoor temperature value on the touch screen.

4.1.2. Error Compensation Description. Due to various factors such as wire resistance, the simultaneous interpretation of the PLC's temperature will cause some deviation. This requires temperature compensation. Considering the different errors of different sensors, different compensation values are added to each sensor. The compensation values of

Table 1: List of main hardware equipment of the system.

Device name	Model	Explanation	Number	Remarks
Temperature module	DVP-04PT	It can be connected to 4-way temperature sensor	1	Acquisition temperature analog quantity and digital quantity output
AD conversion module	DVP-04AD	It can be connected to 4-way sensor	2	Convert analog quantity to digital quantity output
Temperature sensor	Pt-100	Matching with dvp-04pt	1	Three-wire platinum resistance temperature sensor
Humidity sensor	HM1500	1-4vdc linear voltage output	2	High reliability, long-term stability, and measurement accuracy: ± 3% RH
Pyroelectric induction module	HN911L	The released charge is converted to voltage output through amplifier	1	Working voltage range 3–15 V

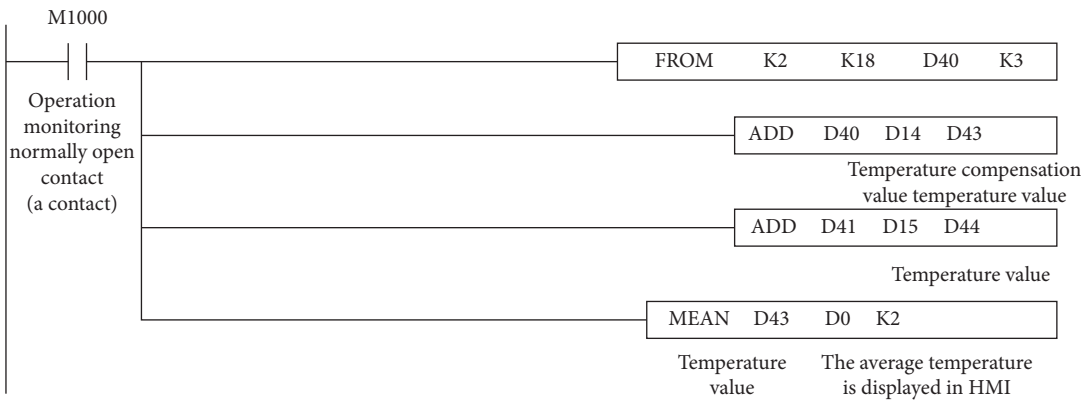

Figure 1: Temperature acquisition procedure.

the two temperature sensors are D_{14} and D_{15}, respectively, and the compensation values are measured after the system is debugged. Different from the actual measurement, after calculation, the user can directly input the value into the touch screenfig2.

4.2. Comparison Alarm Procedure

(1) The user can refer to the standard value (22°C ~ 28°C in summer and 16°C ~ 24°C in winter) and set the upper and lower limits of the alarm by himself (the range of the upper and lower limits of the alarm parameter should be greater than the upper and lower limits of the normal parameter setting). When the collected data are lower than the normal lower limit or higher than the normal upper limit, the collected real-time temperature value continues to decrease or increase, Y_0 and Y_1 When the power is on, the motor will rotate forward and reverse, respectively, that is, turn on the air conditioner to adjust the temperature, and the alarm light will be on for 60 s, to remind the user to take measures and check whether the equipment is abnormal. After 60 s, T5 normally open contact is closed and the alarm is closed.

(2) Residents' living environment needs a relatively comfortable environment. Research shows that when the noise exceeds 50 decibels, people cannot rest normally. When the noise exceeds 70 decibels, the noise will disturb people's conversation and even cause upset. Therefore, the upper limit of noise is set to 70 dB. When the detected noise is greater than 70 dB, Y_4's telegram alarm light will be on, Y_2 will reset, and the step motor will stop, that is to say, window closing will be performed.

(3) When the indoor natural gas concentration exceeds 1.25%, Y_4 and Y_3 are powered on, and Y_2 is set to 1, that is, the alarm light is on and the windows and exhaust fans are opened.

(4) When the indoor smoke (CO and CO_2) concentration exceeds 0.06 percentage points, Y_4 and Y_3 are powered on, Y_2 is set to 1, the alarm light is on, and the window exhaust fan is turned on.

(5) When the infrared detection output is 1, Y_4 is powered on, Y_2 is reset, the window is closed, and the alarm light is on. Some procedures in the temperature value comparison alarm procedure are shown in Figure 2.

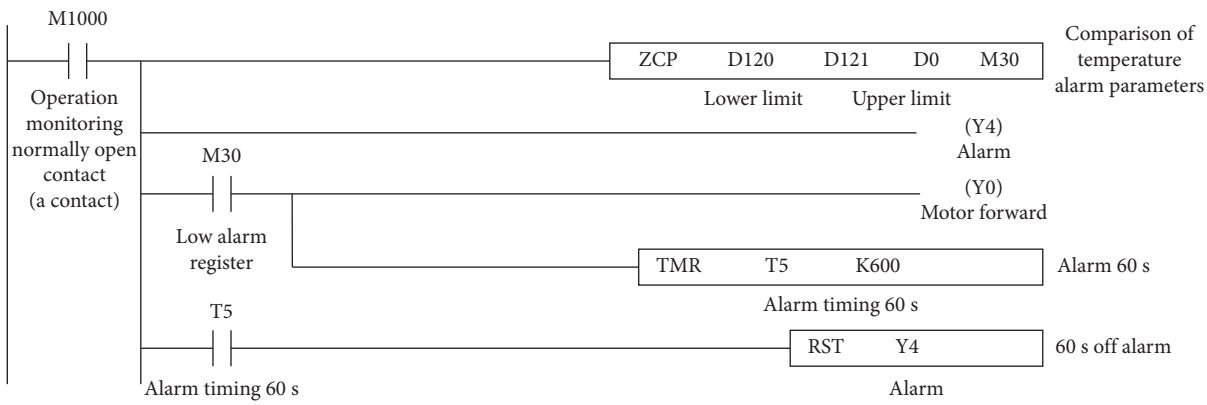

Figure 2: Temperature comparison alarm procedure.

4.3. Display Interface

4.3.1. Real-Time Data. On this page, the main function is to select the operation mode by yourself, and display the indoor temperature and humidity, and the outdoor temperature, humidity, smoke concentration, gas concentration, noise, and other values in real time. This interface is not only to provide operation data of each parameter, and when the temperature is too high, and smoke concentration and gas concentration are too high, there may be hidden dangers of fire, natural gas explosion, and other accidents. When the value reaches the ignition point and explosion point, an alarm will be given to remind the user to avoid accidents and reduce losses. When someone is detected within the detection range of the infrared sensor, the high level is effective, and its output is 1. At this time, an alarm will be given, the alarm light will be on, and the window will be closed to prevent theft or accidents of children. These parameters are for real-time monitoring by the operator. The data display interface is shown in Figure 3.

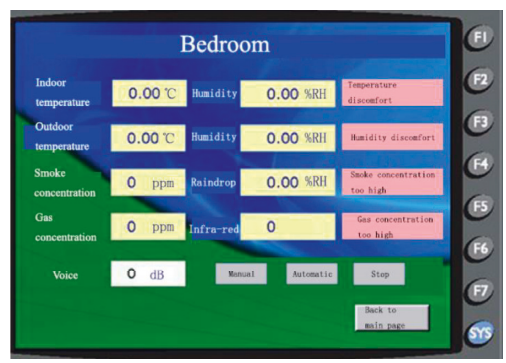

Figure 3: Real-time data monitoring diagram.

4.3.2. Main Page. When the man-machine interface is powered on, we first download the touch screen program. After opening the interface, we first enter the main page of the system, as shown in Figure 4. At the top of the main page is the date and time display component, and the runtime can display the date, time, and week in real time. Three buttons, manual mode, automatic mode, and stop, are set in the interface to control the interface manually at any time.

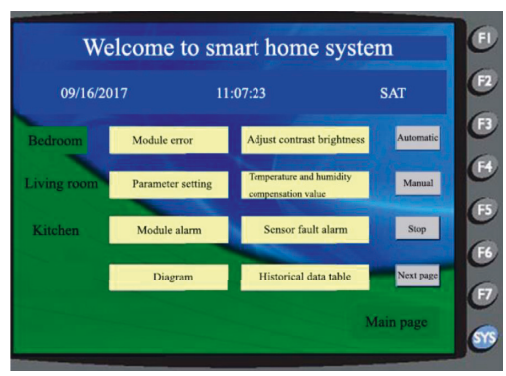

Figure 4: Main page.

4.4. System Program Import and Test. In view of the interference of the external data to the whole experimental measurement, this study adopts the PID control algorithm based on the BP neural network as the algorithm of the whole experiment, and reduces the external interference to the experimental measurement through the combination of PLC and algorithm, making the measurement data of the whole system more stable and accurate. In this study, five groups of temperature values are randomly selected from the report, and the temperature at the same time is measured and recorded. Through the comparative analysis of these two

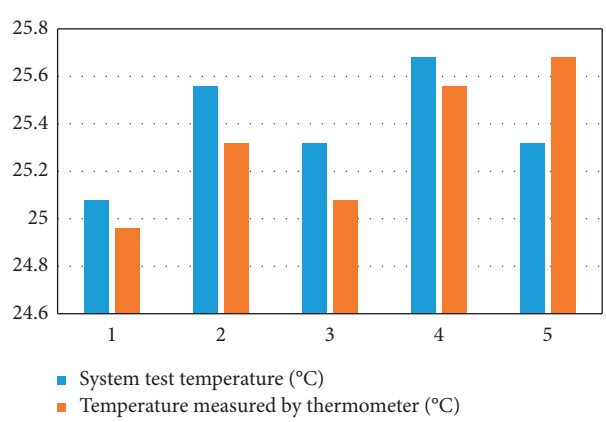

Figure 5: Temperature data table.

groups of data, the feasibility of the system is proved. The selected temperature is shown in Figure 5.

Through the comparative analysis of the temperature measured by the system and the temperature measured by the thermometer, it is proved that the system is accurate and feasible for the indoor temperature detection program, and has the advantages of small fluctuation and convenient operation.

5. Conclusions

The smart home is a new industry, which has been born gradually under the influence of the internet of things. It can not only improve the living efficiency of the contemporary people, but also improve the safety, stability, and convenience of the living environment, and improve the comfort of the residential environment. Based on the ZigBee wireless communication technology, PLC technology, and modern sensor technology, this study studies and designs a feasible smart home system.

The Android mobile terminal and human-computer interface are designed in this system, which can be operated directly by users, and can monitor data in real time, reflecting the convenience of the design; PLC is selected as the main controller, which can improve the stability of the system; and the ZigBee wireless communication technology is used to collect and send data, which improves the efficiency of the system and saves the design cost. According to the system requirements, the overall architecture of the whole home system is analyzed, and the selection of the required components and the design of the wiring circuit are determined. According to the requirements of the actual smart home, we collect indoor parameters, including temperature, humidity, smoke concentration, natural gas concentration, infrared detection, noise detection, and raindrop humidity detection.

In the human-machine interface, the user can set the upper and lower limit values of the parameters and the alarm parameter values according to the comfortable parameter values. There are manual and automatic operation modes for users to choose. Through the analysis and processing of the PLC program, the operation of each peripheral equipment switch state is carried out to adjust the comfort of the indoor environment. Android mobile terminal is mainly for users to directly control the status of output devices on mobile phones. The man-machine interface mainly completes the real-time monitoring of data information, parameter setting, overlimit alarm, historical trend curve, and fault alarm, and can switch the required monitoring interface at any time.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Design and Implementation of Enterprise Financial Risk Control Information Management System Based on Big Data of Internet of Things

Daowen Ren[1] and Haiyan Wu[2]

[1]*School of Accounting, Guangzhou College of Technology and Business, Guangzhou 510850, Guangdong, China*
[2]*School of Management, South China Business College Guangdong University of Foreign Studies, Guangzhou 510545, Guangdong, China*

Correspondence should be addressed to Haiyan Wu; 204004@gwng.edu.cn

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The Internet of Things is a huge network. It is a combination of massive sensing devices and the Internet. In the Internet of Things, a large number of sensing devices are continuously collecting data and sending it to the data center. Data present massive characteristics, forming the big data of the Internet of Things. With the rapid development of informatization and network technology, almost all domestic enterprises have paid more and more attention to the research of enterprise network, informatization, and interactive experience. Under the background of the rapid development of e-commerce, the enterprise financial risk control information management system is bound to become the trend of information development. In the process of system analysis, this paper considers the sustainable development needs of the actual business of the enterprise financial risk control information management system and makes an in-depth study on the management and technology of the system development in strict accordance with the business process optimization and principles of the enterprise financial risk control information management system. This paper proposes to introduce the technology of Internet of Things into the enterprise financial risk control information management system, build the application mode framework of Internet of Things for enterprise asset management, and focus on the in-depth study of key technologies such as data collection and information transmission. The experimental results show that the time cost of sensor clustering is 1% of hierarchical clustering. In the worst case, the time cost of sensor clustering only accounts for 1/14 of hierarchical clustering.

1. Introduction

In recent years, with the development of electronic technology, the operation mode of social production and public services is developing in the direction of intelligence, leading to the development of society. IoT big data is one of the hot spots in the current IoT industry development. The Internet of Things integrates intelligent perception and recognition technology with ubiquitous computing and ubiquitous networks. It is called the third wave of the Internet of Things in the development of the world's information industry after the computer and the Internet. It mainly uses intelligent sensing, identification, and other technologies and uses network communication transmission technology to communicate things. IoT technology is changing the way of life.

With the wide application of Internet of Things technology in enterprise financial risk control information management, higher requirements are put forward for data processing in enterprise financial risk control information management. The traditional enterprise information data processing technology cannot meet the technical requirements. It includes the integration and extraction of enterprise big data based on the Internet of Things, which requires the support of big data technology. After an in-depth investigation of enterprise acquisition systems, analysis systems, and storage systems using the Internet of Things.

Although big data processing technology has been applied to most enterprise processing analysis systems, there are still many problems to be solved. For example, how to quickly process and analyze massive redundant data with low data value density, how to quickly remove redundant data for real-time processing in the face of large-scale data flow, and how to optimize the large table equivalent connection in the existing big data computing environment, starting from the data scenarios and data characteristics of practical applications, this paper proposes some optimized processing methods.

The innovation of this article is as follows: (1) Through the research in this paper, it is expected to establish an enterprise quality information management system for IoT big data. It proposes innovative optimization designs for file systems, big data retrieval, and analysis, and solves the basic problems. (2) The research in this paper can reduce the storage and management pressure of IoT big data. It provides support for further verification, experiments, and applications of efficient storage and management of big data. It also provides new ideas for big data management theory and systematic methods. (3) It has very important theoretical significance and practical value.

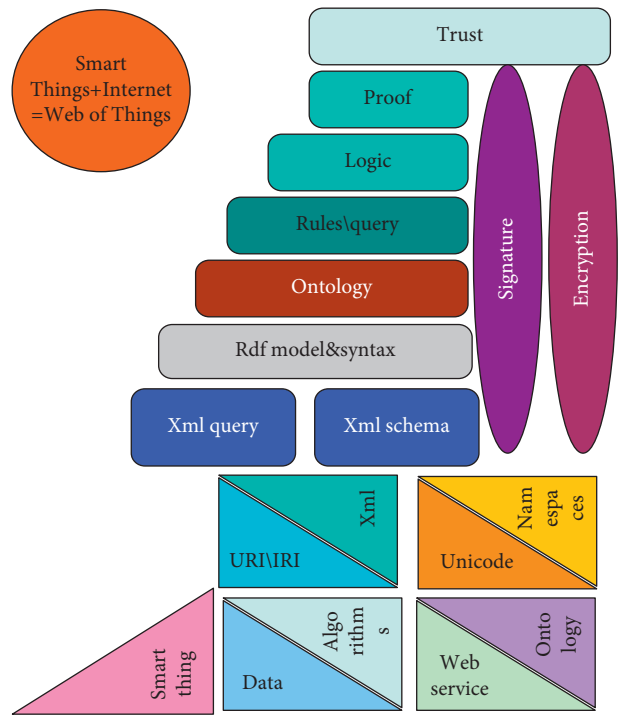

Figure 1: Big data and IoT integration.

2. Related Work

In recent years, big data research on the Internet of Things has become a hot spot for scholars, and more and more scholars are collecting data from factories, hospitals, and stores. When Nobre G C researched the circular economy, it found that cutting-edge technologies such as big data and the Internet of Things have the potential to capitalize on organizational and social adoption of the CE concept. It is becoming more and more common in daily life [1]. Ghallab et al. believes that the Internet of Things is the basic concept of a new technology, which has great development prospects and significance in various fields [2]. Ge et al. conducted a survey of big data technologies in different IoT fields, hoping to facilitate knowledge sharing in the IoT field. He discussed the similarities and differences of big data technologies used in different IoT domains. He suggested that certain big data technologies used in one IoT domain could be reused in another IoT domain. He also developed a conceptual framework outlining the key big data technologies in all the reviewed IoT domains [3]. Babar and Arif believe that the recent growth and expansion in the IoT space offers great business prospects for the direction of the new era of smart cities. The real-time processing of data and intelligent decision-making capabilities pose extensive challenges to the continuous enhancement of multi-faceted urban facilities [4]. Pouryazdan et al. improved the value of crowd-perceived big data by properly motivating users in a mobile crowd-aware system. He found that since data collection is participatory, crowd-aware systems face challenges in data credibility and authenticity assurance. The motivation may be to manipulate perceived data to maximize revenue [5]. Shadroo and Rahmani found that IoT has emerged as a new opportunity in recent years. All the electronic devices around us contribute to daily life. Approaches such as big data and data mining can be used to improve the efficiency of IoT and the storage challenges of large data volumes, as well as the transmission, analysis, and processing of data volumes on IoT. The purpose of his research is to investigate research on the Internet of Things using big data and data mining methods to identify topics that must be more emphasized in current and future research paths [6]. Tong and Sun built a real-time image detection and processing platform using the IoT-based Adaboost framework. This enables real-time image transmission and processing based on different databases. His research found that RT-IDPP proposed for IoT enables image detection and tracking. This method can not only run effectively on different cloud platforms but also meet the real-time requirements in the process of image detection and tracking, ensuring that the image detection rate is higher than 97% [7]. However, the shortcoming of these studies is the uncertainty of data quality, and the calculation and analysis of massive data are very complicated. Therefore, these research data still need to be improved.

3. Methods of IoT Big Data

Big data is used to describe any large amount of structured, semistructured, and unstructured data that have the potential to be extracted into information. Big data extracts large amounts of useful data and information from applications. This is very beneficial and can save costs, improve the efficiency of information collection, and improve the ability to innovate [8]. Figure 1 shows the application of big data integrated with IoT.

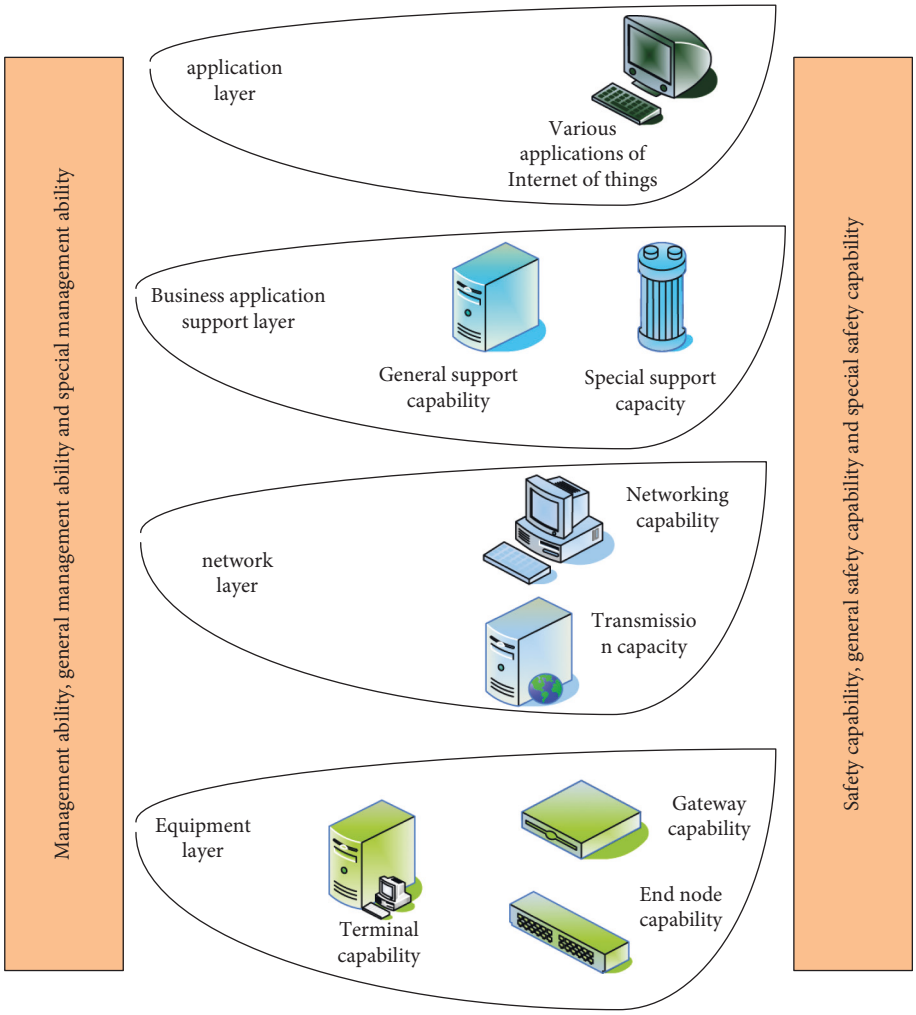

Figure 2: Reference model for IoT.

3.1. Internet of Things. IoT needs to leverage a range of existing or evolving advanced technologies, such as machine to machine communication (M2M), data mining and decision-making, self-organizing networking, security and privacy protection, cloud computing, and sensing and triggering technologies. In order to connect physical objects and virtual objects with each other to provide better services. Therefore, the reference model of the Internet of Things is briefly summarized [9]. It is shown in Figure 2.

The main part of the IoT reference model can be divided into four layers: application layer, business/application support layer, network layer, and device layer. In addition, it also includes cross-layer management capabilities and security capabilities [10]. Among them, the application layer refers to the various Internet of Things applications that users can finally see. The business/application support layer includes general support capabilities and special support capabilities. The general support capability corresponds to the public network support capability, while the special support capability corresponds to the industry private network support capability. The network layer includes networking capability and transmission capability. Networking capabilities can provide control functions related to network connectivity. The transmission capability provides links for IOT services/applications, as well as control and management information for data transmission. Equipment layer capabilities can be logically divided into terminal capabilities, gateway capabilities, and end node capabilities. The terminal refers to the entity directly communicating with the information communication network. The end node refers to the entity that communicates with the information communication network through the gateway.

The Internet of Things is a new mode of communication where objects in the virtual extended world and the physical world are interconnected. It runs a plethora of applications and services and then develops it while having to overcome enormous challenges to make IoT a reality. IoT involves different knowledge domains such as ubiquitous computing, network communication, object recognition, and special data processing [11]. In this context, outliers detected by big data processing are used to select and implement the IOT architecture.

3.2. Big Data Algorithms

3.2.1. Clustering Algorithm. The ability of classical clustering algorithms to deal with big data is limited. In the face of large-scale and high-complexity datasets, using them directly is inefficient or even ineffective. At present, in the era of big data, the problem of clustering large-scale data needs to be solved urgently. At present, in order to improve the scalability and practicability of clustering algorithms, people have proposed several novel clustering ideas to solve the problem of big data clustering based on the reasons for the failure of traditional clustering algorithms [12]. The first is parallel processing, the second is data compression, and the third is data sampling. These three clustering ideas alleviate the clustering problem of large datasets to a great extent. Table 1 summarizes the time and space complexity of classical traditional clustering algorithms.

It can be seen from Table 1 that although the time complexity of the K-means algorithm is linearly related to the dataset size N, the algorithm complexity can be applied to big data. However, in practical application, the algorithm is very sensitive to the selection of initial clustering centers. It also contains NP-hard problems and is not suitable when dealing with large-scale data. The time complexity of the remaining algorithms is nonlinear with N. With the increase of data size, the time complexity will increase more obviously. This not only reduces the quality of the clustering algorithm but also far exceeds the running time of traditional clustering algorithms. Therefore, none of them can directly handle large-scale datasets [13]. Figure 3 is a common big data clustering algorithm. Representative algorithms include cure algorithm, clara/clarans algorithm, and birch algorithm.

3.2.2. Neighbor Propagation Clustering Algorithm. The nearest neighbor propagation algorithm is referred to as the AP algorithm, and clustering is carried out by iteratively updating the representative matrix $R(n, s)$ and the fitness $a(n, s)$, where $R(n, s)$ points from point X_i to point X_k, indicating the representativeness of X_k as the class representative point of X_i, and $A(n, s)$ points from point X_k to X_i, indicating the suitability of X_i selecting X_k as the class representative point. It is based on the moment of similarity of data. The core step of the AP algorithm is the iterative update of representativeness and fitness.

(1) Algorithm analysis. Its formula is as follows:

$$\begin{aligned} &R(n,s) \leftarrow k(n,s) - \max_{s',k.t.s' \neq s} \{A(n,s') + k(n,s')\} \\ &IFn \neq s, A(n,s) \leftarrow \min\left\{0, R(s,s) + \sum_{n' \notin \{n,s\}} \max\{0, R(n',s)\}\right\} \\ &A(s,s) \leftarrow \sum_{n' \neq s} \max(0, R(n',s)). \end{aligned} \tag{1}$$

Then, for any point X_i, its class representative point is X_k, where

$$s = \arg\max_{s}(A(n,s) + R(n,s)). \tag{2}$$

Table 1: Time and space complexity of traditional clustering algorithms.

Clustering algorithm	Complexity	
	Time	Space
K-means	$O(nKt)$	$O(K)$
K-median	$O(n^2t)$	$O(n)$
PAM	$O(K(n-K)^2)$	$O(K)$
Single completelink	$O(n^3)$	$O(n^2)$
DBSCAN	$O(n\log(n))$	$O(n)$

N: total number of objects, K: number of representative objects, and T: number of iterations

The AP algorithm is initialized to $A(n, s) = 0$, that is, each point is equally likely to be represented by other points and to represent other points.

(2) Comparative Experiment of CBAP and AP Algorithms. For the dataset Data Sets A whose size does not exceed 4500, the CBAP algorithm and the AP algorithm are used for clustering, respectively. Figure 4 shows a comparison of the corresponding time curves and the r index.

It can be seen from the comparison between CBAP and AP1 that the CBAP algorithm greatly shortens the natural logarithm of the clustering time represented by the ordinate in the clustering time. When the size of the dataset reaches more than 3000, the time of the AP algorithm is dozens of times that of the CBAP algorithm. According to AP2, the clustering results of CBAP and AP are basically the same (the r index is about 0.97). Therefore, it does not reduce the clustering quality of the original AP algorithm [14].

Based on the good clustering results for artificial datasets, we will continue to apply the CBAP algorithm to cluster some real datasets. Table 2 lists the corresponding A index, B value, R index, and clustering time of the two methods under different real datasets (300 core points are taken in the experiment [15].

As can be seen from Table 2, compared with the AP algorithm, the CBAP algorithm not only greatly reduces the clustering time but also the A index and B value are significantly better than the original algorithm. This is because the selection of core points reduces the proportion of noise points or abnormal data, thereby improving the clustering performance of the AP algorithm on the core set. Therefore, after the clustering results of the core set are mapped to the large dataset, the clustering quality of the large dataset is also improved. This further proves the effectiveness of the CBAP algorithm for clustering big data. If the data points are within the upper and lower limits of the control chart and the arrangement and distribution do not show chain, tendency, periodic characteristics, etc., it can be determined that the process quality is under control. On the contrary, it is necessary to explore the causes and propose solutions.

3.3. Control Chart Method. The control chart method is the main method used in the statistical process control subsystem module. It can determine that the process quality is at a normal level and plays a role in preventing defective products. The process quality is affected by various factors

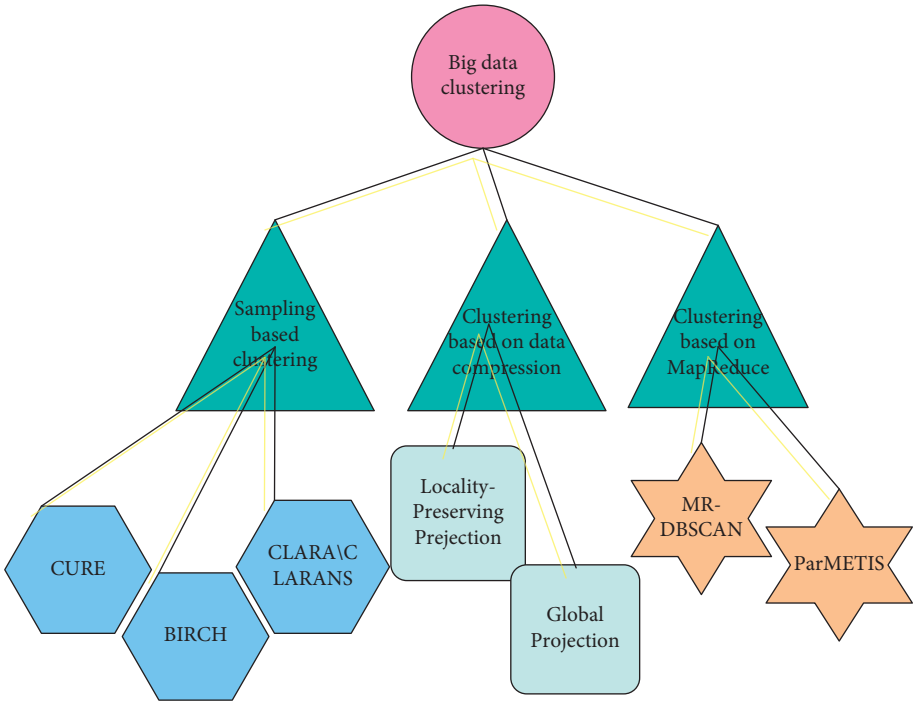

Figure 3: Common big data clustering algorithms.

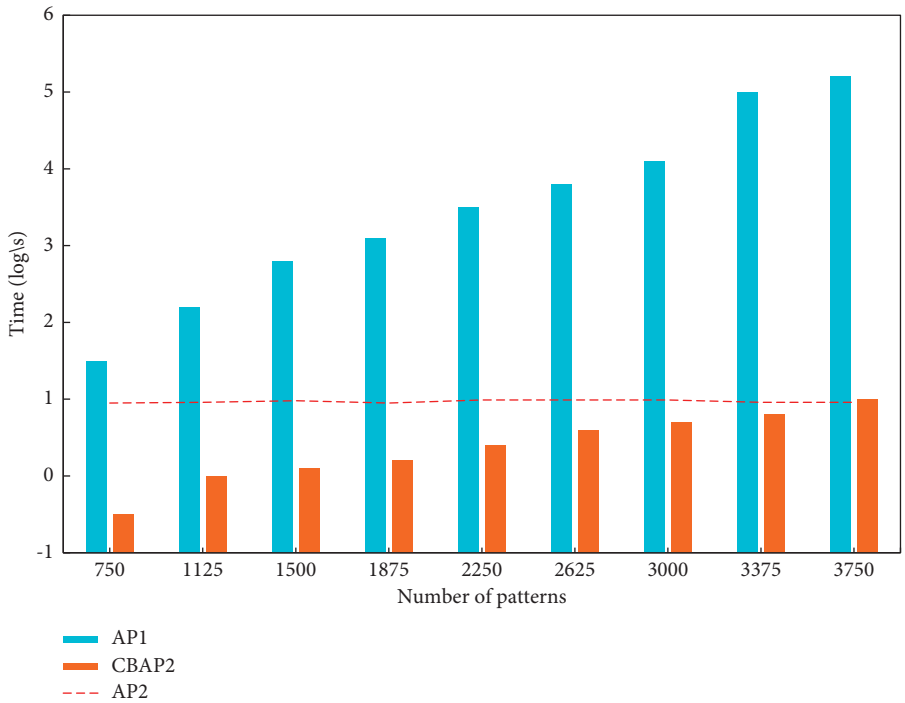

Figure 4: Comparison of clustering time between CBAP and AP and the corresponding R metrics.

Table 2: Comparison of the performance of CBAP and AP on real datasets.

Dataset	A-index		B-value		Time		R-index
	AP	CBAP	AP	CBAP	AP	CABAP	
Letter $\{f, i, g\}$	0.721	0.813	0.843	0.909	39.48	2.41	0.922
Letter $\{r, s, t\}$	0.472	0.666	0.618	0.941	39.78	2.73	0.521
Usps {0, 6, 9}	0.711	0.722	0.828	0.986	73.06	17.32	0.842
Usps {3, 4, 5}	0.655	0.725	0.877	0.956	34.52	10.78	0.836

and exhibits random fluctuations and abnormal fluctuations. The smaller the fluctuation range, the more stable the process quality, and vice versa [16].

The calculation principle of the three control lines of the control chart (taking the mean value control chart as an example) is as follows:

$$\begin{aligned} cl_{\overline{X}} &= \overline{\overline{X}}, \\ ucl_{\overline{X}} &= \overline{\overline{X}} + 3\sigma_{\overline{X}}, \\ lcl_{\overline{X}} &= \overline{\overline{X}} - 3\sigma_{\overline{X}}, \end{aligned} \tag{3}$$

where $cl_{\overline{x}}$ is the center line of the control chart, $ucl_{\overline{x}}$ is the upper control line of the control chart, and $lcl_{\overline{x}}$ is the lower control line of the control chart. Among them, the expected value of x is

$$e(\overline{X}) = \mu. \tag{4}$$

The expected value of standard deviation is

$$d(\overline{X}) = \frac{\sigma}{\sqrt{N}}. \tag{5}$$

μ and σ are calculated from the sample data size to get $\mu = \overline{\overline{x}}, \sigma = \overline{r}/D_2$, so

$$\begin{aligned} cl_{\overline{X}} &= \overline{\overline{X}} \\ ucl_{\overline{X}} &= \mu + 3\frac{\sigma}{\sqrt{N}} = \overline{\overline{X}} + \frac{\overline{r}}{D_2\sqrt{N}} = \overline{\overline{X}} + B_2\overline{r} \\ lcl_{\overline{X}} &= \mu - 3\frac{\sigma}{\sqrt{N}} = \overline{\overline{X}} - 3\frac{\overline{r}}{D_2\sqrt{N}} = \overline{\overline{X}} - B_2\overline{r}. \end{aligned} \tag{6}$$

In the formula, $B_2 = 3/D_2\sqrt{N}$ and $\overline{r}$ are the mean values of the sample ranges, and D_2 is obtained from the standard ["Conventional Control Chart" (GB/T4091-2001)] query.

3.4. Dependency-Based Sensor Clustering

3.4.1. Definition of Dependencies. Sensor similarity (SensorSimilarity): Let D and K be two sensor sets, and T_A and T_B be two object sets detected by A and B, respectively; then the sensor similarity of A and B is defined as the intersection of T_A and T_B [17].

$$\text{Sensor} - \text{Similarity}(D, K) = |T_D \cap T_K|. \tag{7}$$

The calculation method of sensor similarity can facilitate 1 and 2, but this is a time-consuming process. Therefore, a more efficient calculation method of sensor similarity is proposed, which can greatly reduce the computational time overhead of sensor similarity. The calculation formula of sensor similarity is expressed as follows:

$$\begin{aligned} &\text{Sensor} - \text{Similarity}(D, K) \\ &= \frac{Jaccard(T_D, T_K)}{1 + Jaccard(T_D, T_K)} \bullet (|T_D| + |T_K|), \end{aligned} \tag{8}$$

where $Jaccard(T_A, T_B)$ represents the Jaccard coefficient between T_A and T_B, that is,

$$Jaccard(T_D, T_K) = \frac{|T_D \cap T_K|}{|T_D \cap T_K|}. \tag{9}$$

In physical object retrieval, if the access to one sensor D data file will inevitably lead to another sensor K data file access, then we say that sensor A depends on sensor B [18].

It assumes that there are sensor dependencies of $D \longrightarrow K$ and $K \longrightarrow L$ in the sensor set, and according to the transitive relationship of the dependencies, $D \longrightarrow L$ can be inferred. The most important operation in the dependency graph is the initialization of the dependency graph. According to the above formula, S6 and S1 have higher sensor similarity than S8. Therefore, in the clustering process, node S6 will always cluster before S8 and S1. Therefore, as shown in Figure 5(b), we do not need to maintain the dependency between S6 and S8. The initialization algorithm of the dependency graph is shown in Figure 5.

3.4.2. Sensor Clustering. Assuming that the sensor similarity between D and K is not 0, and the sensor similarity between A and C is 0, then

$$\text{Sensor} - \text{Similarity}(\text{D}, \text{K}) = \text{Sensor} - \text{Similarity}(\text{D}, (\text{K}, \text{L})). \tag{10}$$

Proving

$$|D \cap (K \cap L)| = |D \cap K| + |D \cap L| + |D \cap K \cap L|. \tag{11}$$

Consider

$$|D \cap L| = 0. \tag{12}$$

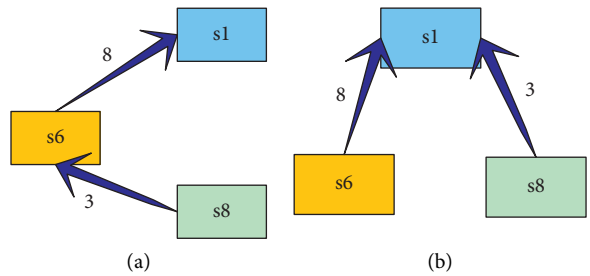

Figure 5: Schematic diagram of the dependency graph simplification process.

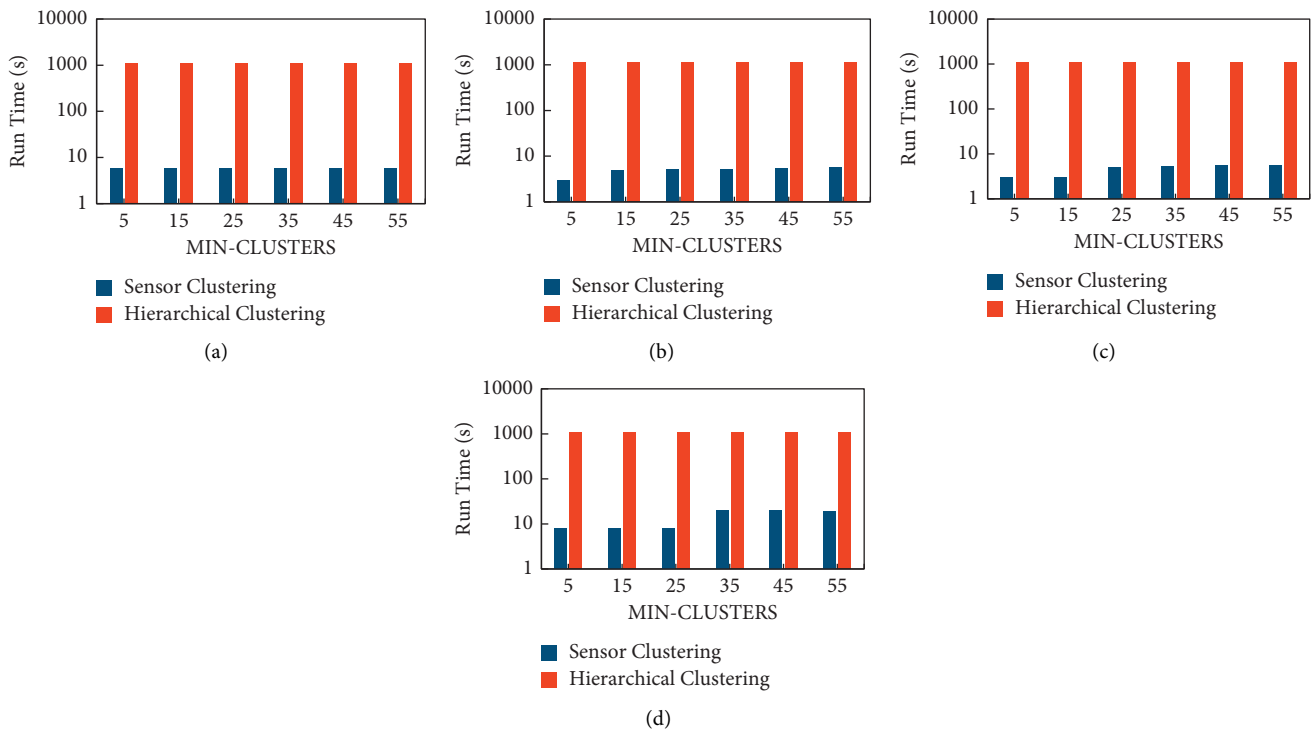

Figure 6: Time cost comparison of clustering algorithms. (a) Trace1. (b) Trace2. (c) Trace3. (d) Trace4.

Hence,

$$|D \cap K \cap L| \leq |D \cap L| = 0. \tag{13}$$

Therefore,

$$|D \cap (K \cap L)| = |D \cap K|. \tag{14}$$

If the root node is merged with a leaf node, the sensor similarity between the root node and other nodes will not be changed. Therefore, the dependent edge connected to the leaf node can be deleted directly. It loops the above steps until the number of clusters reaches the lower limit of the number of clusters. The remaining nodes in the dependency graph represent clusters after clustering, and the merged point set in each node is the sensor set represented by the cluster [19].

The time cost comparison between sensor clustering and hierarchical clustering is shown in Figure 6. The time cost of the clustering process here is obtained by calculating the average time statistics. In the best case, the time overhead of sensor clustering is 1% of that of hierarchical clustering. In the worst case, the time cost of sensor clustering is only 1/14 of that of hierarchical clustering. The experimental results show that the spatial cost of sensor clustering is reduced by 14 times, 20 times, 40 times, 50 times, and 23 times, respectively, compared with hierarchical clustering. Sensor clustering has obvious time overhead and memory overhead advantages [20].

4. Experiment and Analysis of Enterprise Financial Risk Control Information Management System

The main functions of the financial information management system, budget, financial management, cost, planning, fund management, sales, and others, are the main functions of the financial information management system. The main

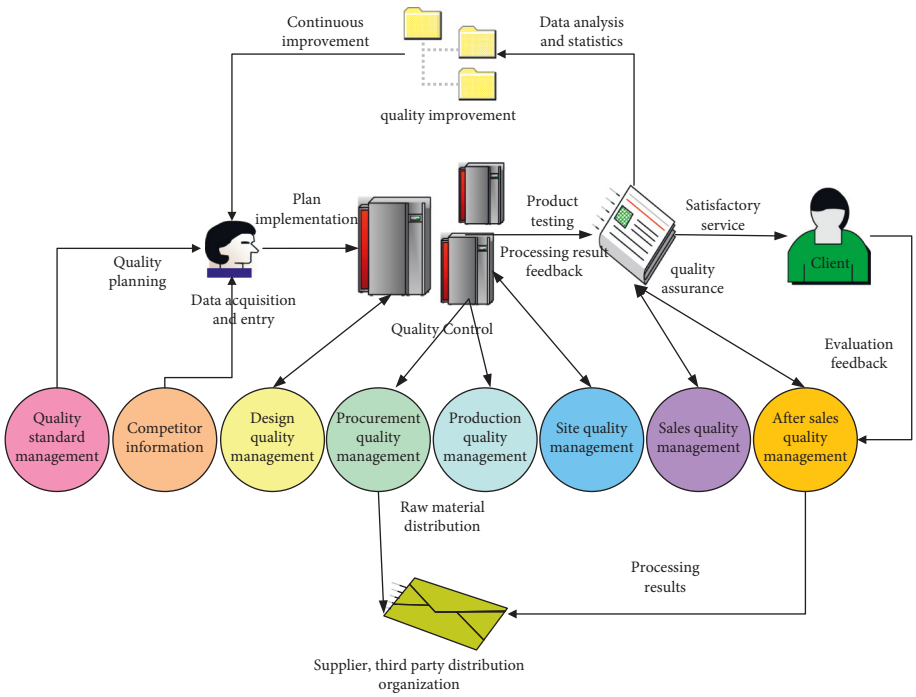

Figure 7: Quality management business model.

functions of the design of enterprise financial management information system are as follows: First, the system can clearly show the flow direction of cash flow; second, the system needs to be able to display the information of financial assets and fixed assets of the enterprise and can analyze and compare them; third, by using this system, the enterprise financial management personnel and accounting personnel can realize the analysis and calculation of various data in the financial system; fourth, the enterprise financial management information system can provide the decision-makers with the basis they need; fifth, with this system, the operation efficiency and financial management efficiency of the enterprise can be greatly improved.

Software to achieve quality management business must implement the whole process of quality management functions and coordinate the relationship between them. It realizes the product quality planning, organization, and coordination of the whole life cycle. Therefore, a software business model is established by the business logic of quality management, quality responsibility, and modern quality management means, as shown in Figure 7.

The software business model consists of eight main business modules. It covers the whole process of product quality and is closely related to the five elements of personnel, equipment, materials, methods, and environment. It involves the entire product life cycle, including product design and development, process confirmation, manufacturing, storage, transportation, and delivery, as well as subsequent customer experience, feedback, and evaluation services. In order to improve the market competitiveness of enterprises and explore their own and product improvement goals, competitor benchmarking information management is added to the model. The software model shows that the whole system is an open system closely related to the external environment [21]. In addition, the four-stage quality management tasks of quality planning, quality control, quality assurance, and quality improvement in the model form a closed-loop loop with the business process. This clearly demonstrates the quality improvement idea of PDCA cycle.

4.1. The Overall Goals and Tasks of the System. The enterprise quality information system is a modular and componentized system platform constructed by integrating contemporary advanced quality management concepts, technologies, and tools. It can make full use of computer network resources and optimize the configuration and utilization of internal resources of the enterprise according to the unique application environment and business process of the enterprise. It enables suppliers, various departments of the enterprise, distribution agencies, and customers to form a coordinated operation as a whole. The top-level data diagram of the quality management information system is shown in Figure 8.

4.2. Creation of Database Tables. The creation of the data table must strictly follow the three normal form (3NF) of the data, and the relationship between the entities should be optimized according to a unified standard. This lays the foundation for building a high-quality database. In the first normal form of the database, the data table requires a primary key, no duplicate records can appear in the database, and each field is atomic and cannot be further divided. The second normal form of the database, and the second normal form is established on the basis of the first normal

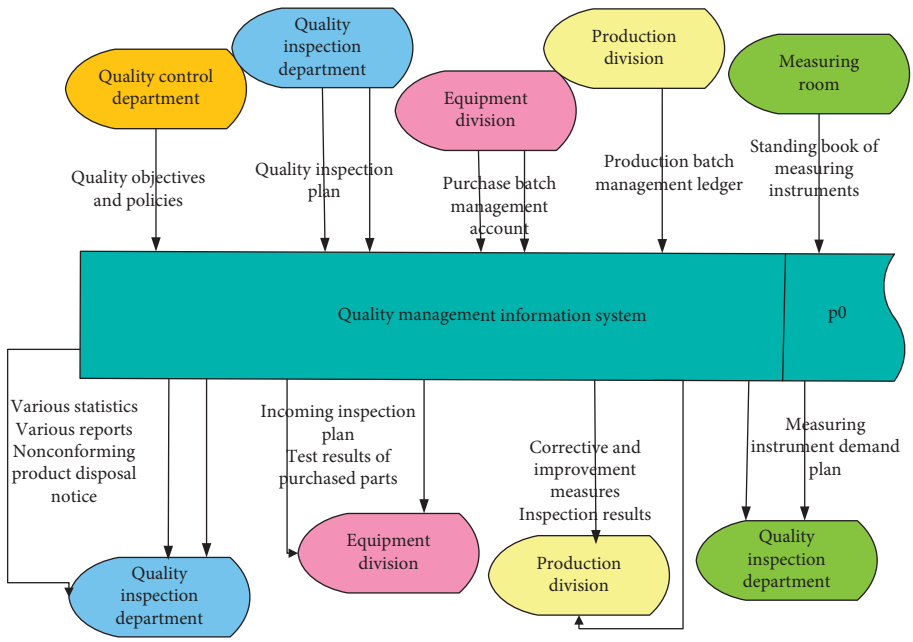

Figure 8: Top-level data diagram of the quality management information system.

form. It requires that all non-primary key fields in the database completely depend on the primary key and cannot generate partial dependencies, and it requires that union queries be used as little as possible. The third normal form of the database is based on the second normal form. It requires that non-primary key fields cannot generate transitive dependencies on primary key fields [22]. According to the entity attribute relationship diagram in the previous section, the design of the system data table is obtained. Tables 3 and 4 show some of the data tables.

4.3. Integration Testing. System testing emphasizes interaction, so this paper tests the combination of interrelated modules. It repairs the defects obtained by testing in the software and continues to perform regression testing until the specification is met. To illustrate this point, three associated modules of the system are selected for integration testing. The test report is shown in Table 5.

It can be seen from Table 5 that the integration tests are carried out on the software's basic management, production quality management, design quality management, and sales quality management. It is found that the interfaces between the modules can interact normally, and the behavior log of the addition, deletion, and modification of the database can be recorded, so the assembly system basically meets the design requirements.

5. Discussion

The modern era is an information age, and big data is the key word of this era. Through the integration of big data and the Internet of Things, human society has reached an unprecedented level of intelligence. This brings unprecedented convenience to people's production and life. This is the trend of the times and has broad prospects. Massive IoT sensors generate a large amount of sensory data every day, so IoT is considered to be one of the most important big data sources in the future.

With the improvement of modern enterprise financial management requirements, computer technology has also been more applied to enterprise financial management and has had a great impact on all aspects of the enterprise, such as accounting methods and processes, job division in the financial department, storage forms of accounting information and data, etc. It has changed the traditional financial management mode from manual service and paper bookkeeping to unified software management, greatly improving the efficiency and accuracy of financial work, saving labor time and costs, and creating more benefits for enterprises. In view of this, this paper makes a detailed analysis and research on the enterprise financial risk control information management system. Based on the theory of enterprise financial risk, this paper analyzes the business process, related technology, and system architecture of the enterprise quality management information system. It can be predicted that with the passage of time, the application of the Internet of Things will promote the further development of the data space and form a huge Internet of Things big data. Therefore, the big data of the Internet of Things is of great significance to the design and implementation of the enterprise financial risk control information management system.

This paper mainly introduces the concepts of big data and the Internet of Things, as well as big data clustering algorithms. Collecting data of enterprise quality information through this method, this paper briefly introduces the integration, management, and technical framework, etc., in data processing. When big data is integrated into the Internet of Things, it is bound to improve the

Table 3: Process quality statistics table.

Listing	Data type	Length	Is it empty	Primary key	Interpretation
Id	Char	12	Not null	Y	Product number
Sno	Varchar	6	Not null	N	Station number
Pname	Varchar	20	Not null	N	Product name
Property	Varchar	20	Not null	N	Quality characteristics
Worker	Varchar	8	Null	N	Operator
opperationDate	Date	8	Not null	N	Processing date
Situation	Char	2	Not null	N	State
Mno	Varchar	12	Null	N	Set number
Measurement1	Double	(8, 2)	Null	N	Measured characteristic value 1
Measurement2	Double	(8, 2)	Null	N	Measured characteristic value 2
Measurement3	Double	(8, 2)	Null	N	Measured characteristic value 3
Measurement4	Double	(8, 2)	Null	N	Measured characteristic value 4

Table 4: Quality act data sheet.

Listing	Data type	Length	Is it empty	Primary key	Interpretation
Dno	Char	12	Not null	Y	Document number
Date	Date	8	Not null	N	Upload date
Dname	Varchar	20	Not null	N	Document name
Content	Varchar	50	Null	N	Content description
Url	Varchar	40	Not null	N	Access path
Quantity	Char	4	Null	N	Quantity
Introduction	Varchar	8	Null	N	Brief introduction

Table 5: Software integration test report.

Number	Module name	Module interface description	Pedagogical operation	State	Result
1	Module and login interface	Authorized authentication	Registration, authorization, password modification, and record viewing	Complete	Pass the test
2	Design quality and production quality management module	Standard information can be seen on the control interface	Modify structural parameters	Complete	Pass the test
3	Sales and after sales quality management	After sales receiving information prompt	Submit sales quality issues	Complete	Pass the test
4	Site quality management and homepage	Questions and data can be displayed on the home page	Add problem description	Complete	Pass the test
Test conclusion	The assembly system basically meets the design requirements				

intelligence of human production and life. Its application can involve almost all aspects, such as the medical and health industry, network enterprises, advertising and marketing industry, financial services industry, and so on. Therefore, a good grasp of the big data of the Internet of Things is indispensable for the future realization of the enterprise financial risk control information management system.

6. Conclusions

The financial department of an enterprise is a comprehensive economic information management department. An important component of the big data design enterprise financial risk control information management system is the financial information management system, which is not only a centralized reflection of the enterprise's business status but also the most direct means to supervise the implementation of the national financial system. With the rapid development of the Internet of Things, it has driven the rapid attack of the information industry. The amount of data is growing explosively, and the data structure is becoming more and more complex. Financial informatization means that financial personnel improve the business process of enterprise management through modern technical means and build a supporting enterprise financial management mechanism to fully tap the information potential of the enterprise's financial resources, so as to ensure that the enterprise's information resources can be fully utilized, promote the overall financial management level and efficiency of the enterprise, and ensure the efficient and low-cost development of various business activities of the enterprise. It will help enterprises better achieve their financial goals and even the overall strategic goals. Based on the characteristics of

manufacturing quality management and the laws of product formation, this paper applies Internet of Things big data to research and develop the enterprise financial risk control information management system, realizes the networked management of product quality, standardizes the business process of enterprise quality management, and enables enterprises to establish a perfect quality system. By understanding the concepts of the Internet of Things and big data, the enterprise quality management system model is established by using the clustering algorithm, control chart method, and sensor clustering of dependency. The business process of enterprise quality management is sorted out, and the system applies integration testing on the business logic structure. Due to the increasingly complex production mode of manufacturing enterprises, the number of quality related parties is gradually increasing. Therefore, the research content of this paper needs to continue to think and explore, and the enterprise financial risk control information management system should be further refined and improved. If an enterprise wants to be in an invincible position in such a competitive environment, it must grasp the financial information timely and accurately, correctly analyze the development prospect of the enterprise, and make reasonable scheme decisions in time. In today's information age, only with modern management methods can we reflect the business status and operation of an enterprise faster, better, more truly and effectively. In today's complex and rapidly changing market, only computers can quickly, objectively, comprehensively, and accurately make detailed data analysis.

Data Availability

This article does not cover data research. 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

The Current Situation and Trend of Blockchain Technology in the Financial Field

Weixuan Zhang

College of Arts and Science, Vanderbilt University, Nashville 003535, Tennessee, USA

Correspondence should be addressed to Weixuan Zhang; weixuan.zhang@vanderbilt.edu

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In the Internet era, with the development and application of information technology, the financial environment is becoming more and more complex, and traditional financial business products and service models are gradually unable to meet people's daily needs. In response to this problem, it is important to iteratively upgrade the traditional business products by rationally applying the existing information technology in the entire financial market and realize the adjustment of the organizational structure of financial institutions and the optimization of products and services. With the development of network technology, the research on the application of blockchain technology in the financial field is gradually carried out, and its advantages and characteristics are of great significance to the optimization and upgrading of the traditional financial system. The purpose of this paper is to analyze the research status and trends of blockchain technology in the financial field. Through CiteSpace to analyze all relevant researches on blockchain technology in the financial field, we can grasp the research status and trends of blockchain technology in the financial field as a whole, coping with financial issues in the new environment. This article explains the basic theory of blockchain technology and conducts an overall visual analysis of related research on blockchain technology in the financial field based on CiteSpace. The results showed that the research keywords of blockchain technology in the financial field at home and abroad are concentrated in "supply chain finance," and China's research on this keyword accounts for 59.5%. Foreign research on this keyword accounts for 26.5%. The difference is 33%, and the overall popularity is on the rise.

1. Introduction

With the continuous progress of the times, the rapid development of the national economy and the process of urbanization have promoted the rapid development of Internet technology. At the same time, the Internet finance industry continues to mature. In order to solve the current business pain points of serious centralization, opaque transaction information, and difficulty in establishing customer credit in the financial industry, scholars have actively explored the Internet transformation in the traditional financial field. Blockchain technology is a brand-new distributed infrastructure and computing paradigm. Blockchain technology has successfully solved a series of problems such as serious centralization and information opacity in the financial field and achieved good optimization results.

At a time when traditional finance is being impacted by the new model of emerging Internet financial applications characterized by lightweight and online services, in the entire financial market, how to reasonably apply existing information and new technologies, fully grasp the role of blockchain technology in finance, study the status quo and trends in this field, realize the structural adjustment of financial institutions, and optimize products and services for the financial industry has far-reaching significance for the development and growth of the financial industry. However, CiteSpace has few restrictions on the problem to be solved, so its application range is wide. In recent years, scholars have used CiteSpace to solve problems in the financial field, but there is little overall research on blockchain technology in the financial field. Therefore, this paper uses CiteSpace to analyze the research status and trends of blockchain

technology in the financial field to solve problems in the financial field, which has both theoretical and practical significance.

The innovations of this paper: (1) the theoretical knowledge of blockchain technology is introduced, and how blockchain technology plays a role in the financial field is analyzed using blockchain technology and CiteSpace. (2) The overall grasp of the research status and development trend of blockchain technology in the financial field is carried out. Through CiteSpace analysis, it is found that the research on blockchain technology in the financial field at home and abroad is on the rise in recent years. The research keywords mainly focus on "supply chain finance."

2. Related Work

With the continuous development of network technology, more and more people have studied the blockchain. Sikorski et al. explored the application of blockchain technology in relation to the Fourth Industrial Revolution (Industry 4.0); they showed an example of using blockchain to facilitate machine-to-machine (M2M) interaction and established an M2M electricity market in China. While this technology has significant understudied potential to support and enhance the efficiency gains of the revolution and to identify areas for future research, no research has been done on cryptocurrencies [1]. With this, Ittay explored how blockchain research beyond Bitcoin could bridge the gap from transaction throughput to security primitives and privacy and some of the challenges that remained. Although it provided a reference for the development of cryptocurrencies, there was insufficient research on the regulatory field of blockchain [2]. Based on this, Yeoh examined the key regulatory challenges affecting blockchain of the European Union (EU) and the United States, and innovative distributed technologies. Although this research expands financial inclusion in the financial field, research on privacy aspects of user information has not been carried out [3]. Therefore, Engelhardt described specific examples of the application of blockchain technology in the health sector and expanded the application of blockchain technology in this field but did not solve the problem of blockchain application in digital asset transfer [4]. Eze P identified the problems of existing attempts to implement an all-inclusive smart contract platform and proposed a new framework. Although this framework answered some of the ongoing questions about the current implementation of smart contracts involving blockchain, there was no in-depth study on the philosophy of blockchain technology and the issue of blockchain ontology [5]. With scholars' in-depth research, blockchain technology continues to develop, but new problems also appear.

CiteSpace can be used to analyze the research status and trend of blockchain technology in the financial field because of its advantages in data analysis. Yi et al. quantitatively studied the knowledge structure, development, and evolution of social commerce using CiteSpace to systematically review the current state of the social commerce literature [6]. Ming uses the Scientometric software CiteSpace to visually analyze the English test in China from 1995 to 2020 by drawing a map of keyword co-occurrence, time zone, author cooperation network, and scientific research institution cooperation network [7]. Chen et al. used the information visualization analysis software CiteSpace to analyze institutions, authors, cited references, and keywords [8]. However, although these studies have applied CiteSpace to different degrees and angles, the disadvantage is that there is no overall grasp of the research on the application of blockchain technology in the financial field, and there is no application of blockchain technology in the financial field.

3. Current Situation and Trend Method of Blockchain Technology in the Financial Field

3.1. Blockchain-Related Technical Methods

3.1.1. Blockchain Structure. A blockchain is a chain consisting of one block after another. Each block stores a certain amount of information, and they are connected into a chain according to the time sequence of their generation. This chain is kept in all servers, and as long as one server in the entire system can work, the entire block chain is secure.

The top-level block structure of the blockchain is a structure designed to be tamper proof, and its structure is shown in the following formula:

$$(H(C_{n-1}), H(C_n), X_d). \tag{1}$$

H $(Ci-1)$ is the hash value of the previous block, H (Ci) is the hash value of the block, and X_d is the information in the block. Each block has a hash value pointing to the previous block, so if the block information on the blockchain changes, the hash value of the new block is modified, and all subsequent blocks are modified. This structurally guarantees the immutability of the blockchain. In various interlocking systems, the information recorded can be called a general ledger. The Merkle trusted tree is generated to solve the authentication problem in multiple one-time signatures. The Merkle trusted tree structure has the advantage of a large number of authentications for one signature and has significant advantages in authentication. The bottom layer of the blockchain uses Merkle tree to store transaction data for fast calculation, fast rollback, lightweight nodes, and other operations. When performing P2P transmission, RLP is used to serialize, encode, and decode the block data [9]. In terms of data structure, the blockchain is a chain structure that is linked by hashes to protect the recorded content. The blockchain can be regarded as a state transition system in general, and its state change form can be formally described by the formula as follows:

$$\begin{cases} \delta_{t+1} = \eta(\delta_t, X_t), \\ C = (X_0, X_1, \ldots, X_n), \\ \delta_{t+1} = \eta(\ldots\eta(\eta(\delta_0, X_0), X_1)\ldots). \end{cases} \tag{2}$$

Among them, blockchain B is the sum of the confirmed records of T_i within a period of time, and δ_{t+1} represents all

the information of the confirmed records in the blockchain network. After adding a new block C, it needs to perform a state transition with the previous δ_t to finally confirm δ_{t+1}. η is called the state transition function, which converts δ_t to δ_{t+1}. The consensus mechanism on the blockchain can ensure the consistency of data information between servers. Common consensus mechanisms include Pow, PBFT, Raft, and so on. The so-called "consensus mechanism" is to complete the verification and confirmation of transactions in a short period of time through the voting of special nodes. For a transaction, if several nodes with unrelated interests can reach a consensus, it can be considered that the entire network can also reach a consensus on this. Smart contracts ensure the operation logic on the blockchain. Smart contracts are not a concept unique to blockchain [10]. The essence of a smart contract is a set of distributed computer programs that perform a series of operations according to predetermined events. Once the smart contract is deployed on the blockchain, it is difficult to change the smart contract, but it is generally possible to "change in disguise" by upgrading or terminating the smart contract [11]. A smart contract is a computer protocol designed to inform, verify, or execute a contract. Smart contracts allow for trusted transactions without third parties that are traceable and irreversible. Generally speaking, smart contract development is carried out after the blockchain development is basically perfected. Using smart contracts allows nodes on the blockchain to do things in a unified way. The nodes on the blockchain only need to determine the content of the agreement with each other, and the smart contract can run effectively. With the further improvement of blockchain and smart contracts, smart contracts can gradually handle complex system logic such as transaction settlement, resource allocation, and privacy protection. Some key processes that required human and material costs in the past can rely on smart contracts to reduce the investment of human and material resources, improve efficiency, and reduce costs [12].

According to the application scenarios and the historical development of the blockchain, there are about three types of blockchains as shown in Table 1.

3.1.2. Blockchain Architecture. The starting point of the blockchain is to maintain trust between participants that do not trust each other through the blockchain to establish virtual currency. There are three stages in the development of blockchain. In the blockchain 1.0 virtual currency stage, a large number of virtual currencies represented by Bitcoin entered the capital market. In the stage of blockchain 2.0 intelligent architecture, intelligent architecture appears on the blockchain, and many decentralized applications are applied to the market. A sign of maturity is building a distributed platform. With the continuous deepening of future blockchain technology and applications, blockchain is the trust stage of blockchain 3.0, such as the Internet of Things, big data, cloud computing, and so on. Each blockchain development stage has its architecture changed [13]. For example, in the blockchain 1.0 virtual currency stage, there are basically no concepts such as smart contracts and DAPPs. It also means that general virtual currencies do not have a Turing-complete language. In the blockchain trust stage of blockchain 3.0, the general technical architecture of blockchain has not been fully formed. The technical architecture of the current blockchain is basically in the blockchain 2.0 smart contract period, and specific types of blockchains will also have a partial impact on the technical architecture of the blockchain, which can be generally represented by Figure 1.

3.1.3. Supply Chain Finance Relying on Blockchain. Supply chain finance based on block chain is developing rapidly. The following steps are generally carried out to complete the accounts receivable mode: small- and medium-sized enterprises generate accounts receivable after trade with core enterprises. Small- and medium-sized enterprises apply for financing to the blockchain supply chain finance platform by means of documents and upload the transaction history information to the chain. Core enterprises will trade information, credit upstream and downstream small- and medium-sized enterprises supplier list chain. After the bank makes a loan, the loan information will be on the chain. Small- and medium-sized enterprises will send goods to core enterprises, i.e., goods information chain. After the core enterprise pays the payment information, the payment information will be linked. Small- and medium-sized enterprises repay to financial institutions and link up the repayment information [14]. Supply chain finance relying on blockchain is shown in Figure 2.

As shown in Figure 2, an enterprise user indirectly interacts with blockchain nodes through the integration of supply chain financial platform logic, financing application, financing credential confirmation, and other operations. The essence is that each enterprise integrates information on the blockchain. After relying on the blockchain, it can be seen that many things have become transparent in the whole process. In blockchain supply chain finance, members of various institutions jointly maintain the transaction information of data books on multiple chains. It not only greatly helps financial institutions to strengthen the review of the specific flow and use of funds but also core enterprises to improve corporate security and reduce corporate financial risks. More importantly, due to the decentralization of the blockchain, it can balance the disparity between SMEs and core enterprises in the supply chain and reduce the financing cost of SMEs [15].

3.1.4. Coinjoin. Blockchain privacy protection is to solve the problem of account privacy leakage caused by public transaction information. Currently, it is mainly achieved by directly or indirectly hiding key user information. Typical privacy protection technologies include CoinJoin, Stealth Address, Ring Signature, and zkSNARKs. Coinjoin is a widely used privacy-preserving technology on the blockchain. The completely public transaction information on the blockchain will leak the privacy of transaction information. More precisely, even if the attacker intercepts the company's

Table 1: Three mainstream types of blockchain.

	Public chain	Alliance chain	Private chain
Degree of centralization	Decentralization	Weak centralization	Strong centralization
Participant	Everyone can enter	Members of the alliance	Chain owner
Consensus mechanism	Pow et al.	PBFT etc.	Raft et al.
Openness	Public	Semipublic	Private
Typical scene	Cryptocurrency	Supply chain finance, banking	Database management, auditing.
Representative project	Bitcoin	Hyperledger fabric	No

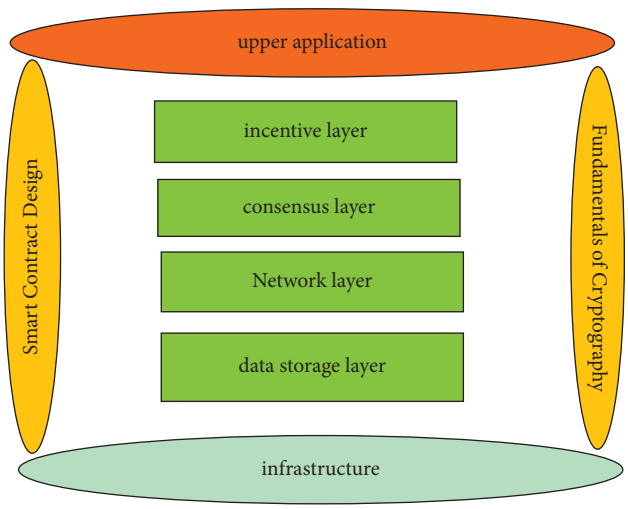

Figure 1: Blockchain technology architecture.

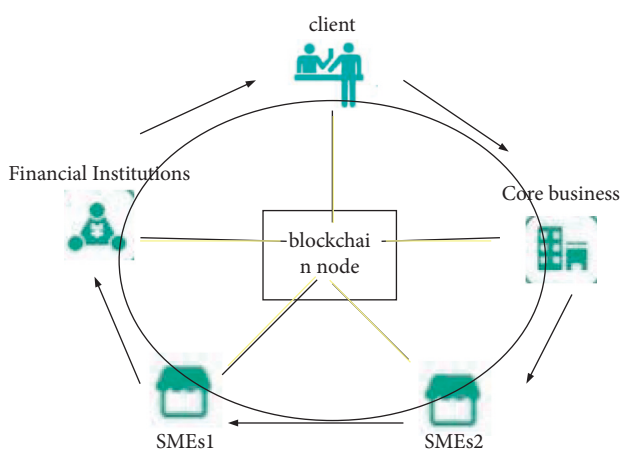

Figure 2: Supply chain finance relying on blockchain.

private information, the attacker cannot determine who sent it and to whom it is sent. This technique makes it impossible for the attacker to obtain the complete information of the transaction, thus protecting the privacy of the transaction [16]. Its main idea can be expressed by the formula:

$$G_N(\mathrm{t}_1, G_A(\mathrm{T}_0, n), A) \longrightarrow G_A(\mathrm{T}_0, n), A. \quad (3)$$

Among them, X_0 and n are the messages that the sender wants to send to the receiver. G_A (x) represents the encryption using the public key of the receiver. A represents the address of the receiver, t_1 represents the verification message generated after using the signature, and $G_N(x)$ is the process in which the so-called intermediary uses its public key N to encrypt.

If it is a message sent from the sender to the middleman, the sender encrypts X_0 and n with the recipient's public key, and after wrapping t_1, G_A (X_0, n) together, $G_N(x)$ processes the wrapped data packet to encrypt. After receiving the information, the intermediary uses the secret key to decrypt the information to obtain t_1, G_A (X_0, n), A. The intermediary cannot decrypt G_A (X_0, n) without the recipient's private key, so the signature information will be sent to the recipient after t_1 verification. The recipient decrypts with his own private key to complete the Coinjoin process. The relationship between the receiver, the middleman, the sender, and the attacker can be intuitively explained with Figure 3.

3.2. Cryptography-Related Methods. Blockchain is a new technology based on cryptography.

3.2.1. Hash Function. Hash function is also called hashing function. A hash function refers to a function that maps the key value of an element in the hash table to the storage location of the element. Its definition is shown in the following formula:

$$H\colon \{0,1\}^* \longrightarrow Q|h = H(w). \quad (4)$$

When the hash function is used for signature, its properties are shown in Table 2:

When the hash function is used for signature, its characteristic points are mainly compressed mappability, many-to-one mapping, irreversible in calculation, avalanche effect, weak anticollision ability, strong impact resistance, and evenly distributed mapping. There are many implementation methods in the general implementation of hash functions, but many hash functions have the following basic structure. The basic structure of the hash function is shown in Figure 4.

In Figure 4, R is the input string, $\mathrm{SC_i}$ is the output string, f is the compression algorithm, y_m is the intermediate input grouping variable, and SC is the intermediate output string. After entering the hash function, the input string is divided into $y_1, y_2, \ldots, y_n$ input grouping variables. When the length of the input string is not enough, random padding is performed. One is the input grouping variable, and the other is the value of SC_{i-1} after the last f-function. Initially, $\mathrm{SC_o} = R$ will be set. Its basic structure expression is shown in the following formulas:

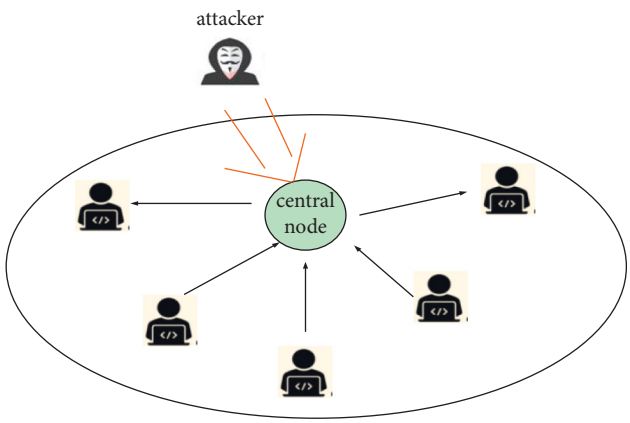

Figure 3: Process diagram of coinjoin.

Table 2: Hash function properties.

Serial number	Feature
1	Compression mappability
2	Many-to-one mapping
3	Computationally irreversible
4	Avalanche effect
5	Weak collision resistance
6	Strong impact resistance
7	Mapping is evenly distributed

$$SC_x = f\left(SC_{x-1}, y_{x-1}\right); \quad 1 \le x \le i, \tag{5}$$

$$h(w) = SC_i. \tag{6}$$

Now commonly used password hash functions are as follows: MD5, SHA, RIPEMD, and so on. Hash function has become an essential tool for digital signature, file verification, password management, and many other information security aspects [17].

3.2.2. Symmetric Cryptography and Public-Private Key System. The encryption and decryption stages of the symmetric cryptosystem are shown in the following formulas:

$$M' = E(z, f), \tag{7}$$

$$M = D\left(z', f\right). \tag{8}$$

The encryption process is a process in which the message z performs a certain encryption operation E through the encryption function f to generate M'. The decryption process is a process in which the encrypted ciphertext z' performs a certain decryption operation D through the encryption function f to generate M. Commonly used symmetric encryption algorithms include DES (insecure), AES, ChaCha20, and so on. Public–private key cryptosystems are also called asymmetric cryptosystems. Compared with the symmetric key system, the public–private key system is more difficult to understand. In a public key encryption system, the encryption key is different from the decryption key, and the public key refers to the public key that anyone can obtain and use. The top secret key is not disclosed to the public, and only the encryptor can know it. The private key cannot be inferred from the public key [18]. Under the public–private key cryptosystem, Jk_g (M) is generally used to represent the process of encrypting J with the public key g; $Jk_s(M)$ is used to represent the process of decrypting M with the private key s.

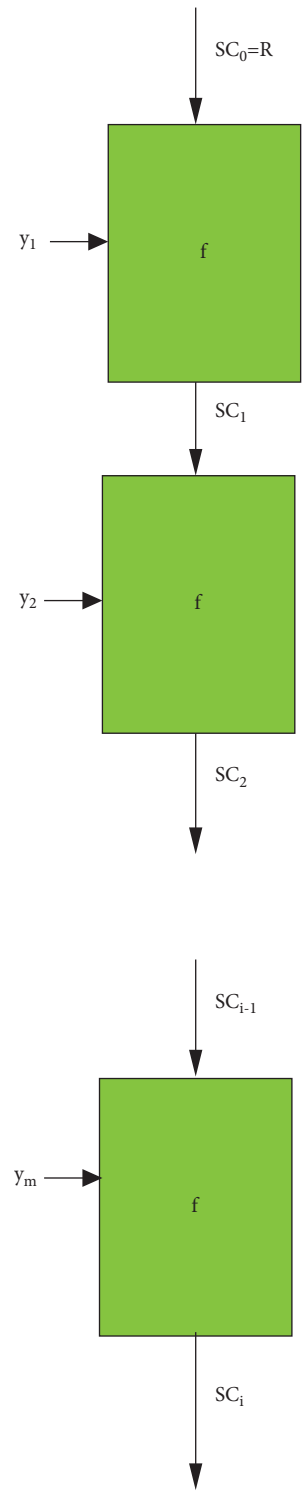

Figure 4: Hash function basic structure.

Taking the widely used RSA public and private key cryptographic mechanism as an example, the security of RSA is based on a basic difficult problem in number theory: the product of two large prime numbers is easy to obtain, but the factorization of the product of two large prime numbers is extremely difficult. The specific description of RSA key generation is as follows:

Y and U are the two prime numbers selected, and the product $c = Y * U$ and $\text{ø}(c) = (Y-1) * (U-1)$ is calculated. Any integer z is chosen so that it satisfies $\gcd(z, \text{ø}(c)) = 1$. t is determined so that it satisfies $(tz) \bmod \text{ø}(c) = 1$, that is, $tz = k\text{ø}(c) + 1$, $k \geq 1$ is an arbitrary integer. Public integers c and z are used as public keys, and t will be secretly stored as the private key.

The RSA encryption algorithm is shown in the following formula:

$$\begin{aligned} S &= E(z) \\ &= z^z \bmod c. \end{aligned} \tag{9}$$

The RSA decryption algorithm is shown in formula:

$$\begin{aligned} M &= D(S) \\ &= S^t \bmod c. \end{aligned} \tag{10}$$

For RSA, the strength of the secret increases with the length of the key. Generally used RSA keys require at least 1024 bits. However, the longer the key, the more time the encryption and decryption algorithms need. The main comparison between the symmetric key system and the public–private key system is shown in Table 3.

Symmetric cryptosystem and public–private key cryptosystem are the basic concepts in cryptography. Symmetric ciphers are relative to public–private key ciphers. In today's cryptographic techniques or schemes, symmetric cryptography and public–private key cryptosystems have their own advantages and disadvantages, so often in the same cryptographic technique or scheme, symmetric cryptography, and public–private key will appear in the same cryptographic technique or scheme at the same time [19].

3.2.3. ECC Elliptic Curve Cryptography Mechanism. Elliptic curve cryptography (ECC) is a public key cryptography technique based on elliptic curve theory that allows for faster, smaller, and more efficient key creation. ECC uses the properties of elliptic curve equations to generate keys rather than use the traditional method of using the product of large prime numbers to generate keys. In some difficult problems, the discrete logarithm problem on elliptic curves is often used. Compared to RSA, ECC requires only a shorter key length and takes less time for encryption and decryption operations [20]. Overall, ECC can be an order of magnitude faster than RSA.

According to the Riemman-Roch theorem, any curve in the plane can be represented by the Weierstrass equation (a cubic equation). On the finite field Yt modulo T, the elliptic curve is the plane determined by the equation $i^2 + a_1io + a_3o = i^3 + a^2i^2 + a_4i + a_6$, and the commonly used simplified Weierstrass equation such as formula (11) can be obtained by coordinate simplification:

$$\left\{a, b \in Y_t\colon o^2 \equiv i^3 + ai + b \,(\bmod t)\ \&\ 4a^3 + 27b^2 \neq 0 \,(\bmod t)\right\} \cup \{W\}, \tag{11}$$

where W represents the point at infinity, and a and b are two elements on the finite field Y_t. The operation rules of the group can be further constructed at the time of concrete construction. Generally, the following definition method is used to define the addition operation on the elliptic curve. For any $k = (i_1, o_1) \in Y_t$, $j = (i_2, o_2) \in Y_t$, k and j are connected as a straight line $ki + jo + R \equiv 0 \pmod{\mathrm{T}}$. The definition of the algorithm is shown in the following formula:

$$k + j = \begin{cases} W, & i_1 = i_2\ \&\ o_1 = -o_2, \\ -R = (i_3, o_3), & \text{other}. \end{cases} \tag{12}$$

The slope λ of the straight line is shown in the following formula:

$$\eta = \begin{cases} \dfrac{o_2 - o_1}{i_2 - i_1} \,(\bmod t), t \neq j, \\[2ex] \dfrac{3i_1^2 + a}{2o_1} \,(\bmod t), t \neq j. \end{cases} \tag{13}$$

Therefore, when $i_1 \neq i_2$ and $o_1 \neq -o_2$, as shown in the following formula:

$$\begin{aligned} -R &= (i_3, o_3) \\ &= \left(\left(\eta^2 - i_1 - i_2 \,(\bmod t)\right), \eta\left(i_1 - i_3\right) - o_1\right) (\bmod t)\Big). \end{aligned} \tag{14}$$

Further, the following construction rules are given below to construct the elliptic curve additive exchange group A (Y_t): (1) Closure: from the definition of addition, A (Y_t) satisfies the closure. (2) Unit element: $k + W = W + k = k$, the point at infinity is its additive unit element. (3) Inverse element: $\forall k \epsilon A$ (Y_t), $\exists j \epsilon A$ (Y_t) makes $k + j = W$. It can be easily verified that A (Y_t) satisfies the commutative law and the associative law, thus an Abelian group is constructed.

If the order of $k \epsilon Y_t$, k will satisfy the operation of dot product as shown in the following formula:

$$nk = \underbrace{\{k + k + \cdots + k\}}_{n * k} = W, \tag{15}$$

where nk is called a multiple of k. When B is a point on A (Y_t) and the order of B is prime n, then {0B, B, 2B, 3B, . . ., $(n-1)$

Table 3: The main comparison between symmetric key system and public–private key system.

	Symmetric key system	Public–private key system
Principle	Use the same key	Use a different key
Speed	Generally faster	Generally slower
Key management	Difficulty in key management	Simple key management
Key distribution	The key distribution is complex and requires a dedicated or complex communication protocols	Simple key distribution, no dedicated Channels or complex communication protocols
Applicable environment	Encrypted data	Encryption key, digital signature

$B\}$ is obviously a cyclic subgroup, and the base point B is considered as a group generator. is denoted as the order of element k in the group. The definition of the elliptic curve cofactor $\forall k \epsilon A\ (Y_t)$, ord (k) is shown in formula :

$$v = \frac{\#A(Y_t)}{\mathrm{ord}(k)}. \tag{16}$$

$\#A\ (Y_t)$ is the number of elliptic curve points. The cofactor v can be used to judge the pros and cons of elliptic curve cryptography. Generally speaking, the smaller the v is, the larger the order of the base point in the group and the key space are. The problem of computing the magnitude of k in $Q = \mathrm{kG}$ given Q and G is known as the discrete logarithm problem on elliptic curves, which is now generally regarded as a "hard" problem. For security reasons, in general, ECC requires a large p value, and the p value is generally 256 bits or more. Based on this intractable problem, many cryptographic public–private key cryptosystems have made good technical solutions for encryption, decryption, signature, and so on. The SM2 algorithm used in this paper is one of them.

3.3. Use CiteSpace to Visually Analyze the Research Status and Trends of Blockchain Technology in the Financial Field

(1) Literature search strategy

This article uses CiteSpace to visually analyze the research status and trends of blockchain technology in the financial field and search for research on blockchain technology in the financial field until January 1, 2022. The language of the literature is limited to Chinese and English.

(2) Search terms

Searches are carried out using the following keywords in combination with their synonyms: "blockchain technology," "financial field," "supply chain finance," "risk factors," etc.

(3) Literature selection

Read the titles and abstracts of the retrieved articles, read the full text of studies that may meet the selection criteria, cross-check the screening results of the articles, and resolve inconsistencies through group discussions.

(4) Inclusion standard as shown in Table 4.

(5) Exclusion standard as shown in Table 5.

The screening process is as follows: first, total the number of searched items, then delete duplicates, then read the title and abstract of the remaining literature and delete irrelevant studies. Then, after reading the rest of the literature, irrelevant studies were excluded, and finally, the articles included in this study were obtained. The flow chart of literature search and screening is shown in Figure 5.

(6) Coword cluster analysis

Coword cluster analysis is a commonly used literature research method [21]. Coword analysis takes the keywords or subject headings of related documents as the research object, by counting and summarizing the frequency of the co-occurrence of any two keywords in the same document and then constructing keyword cowords based on the frequency between these keywords. Then, clustering or coordinate visualization analysis is carried out according to the coword matrix, and the relationship between keywords is analyzed quantitatively, so as to discuss the hot topic or research structure or hotspot of a certain research field. Coword analysis focuses on the calculation of word frequency and coword frequency. The formulas are as follows:

$$\begin{aligned} Q_w(e_r) &= \sum_{y=1}^{T} U_y(e_r), \\ U_y(e_r) &= \begin{cases} 0, e_r \notin U_y, \\ 1, e_r \notin U_y, \end{cases} \end{aligned} \tag{17}$$

$$\begin{aligned} Q_w(e_i\colon e_o) &= \sum_{y=1}^{T} U_y(e_i\colon e_o), \\ U_y(e_i\colon e_o) &= \begin{cases} 0(e_i\colon e_o) \notin U_y, \\ 1(e_i\colon e_o) \notin U_y. \end{cases} \end{aligned} \tag{18}$$

Among them, $Q_w\ (e_r)$ represents the statistical accumulation degree of the keyword er of the related topic document data, and w represents the number of documents included in the sample document. When the keyword er belongs to the document U_y, the value of $U_y\ (e_r)$ is 1. Otherwise, the value is 0. Q_w $(e_\mathrm{i}\colon e_\mathrm{o})$ represents the relative reference cumulative frequency of a two-dimensional common word pair $(e_\mathrm{i}\colon e_\mathrm{o})$. If the keywords kq and kr both belong to the

Table 4: Literature inclusion standard.

Serial number	Standard
1	The research object is a system based on blockchain technology
2	Using blockchain technology to upgrade and optimize the traditional financial field
3	Report at least one of the following results: Degree of decentralization, security performance, accuracy, and information transparency
4	The study design type is a performance study or a system comparison study.

Table 5: Literature exclusion standard.

Serial number	Standard
1	Nonfinancial research
2	Studies with duplicate publications or overlapping data
3	Test reports, meeting summaries, letters and comments
4	Studies not available in full text

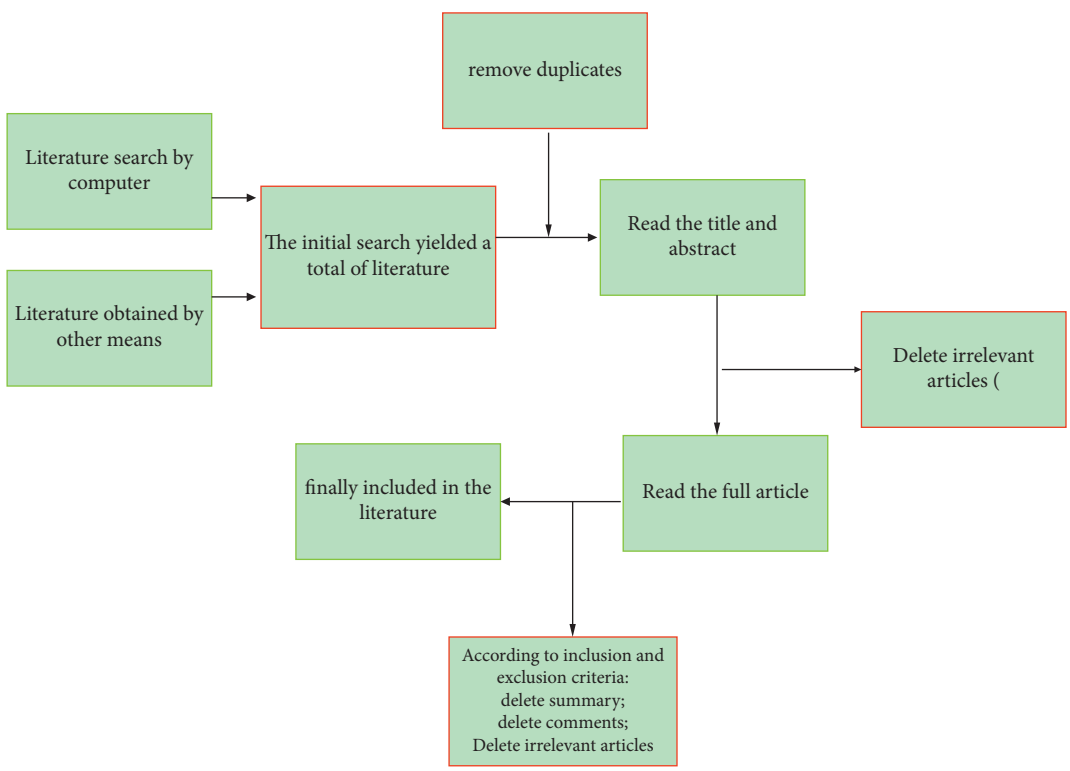

Figure 5: Flowchart of literature search and screening.

document PJ, the binary word pair takes the value 1, otherwise it is 0.

(7) Multidimensional scaling analysis

Two-dimensional Euclidean space distance calculation is to use vector coordinates to represent points. The coordinates of the keyword G_1 are represented by $G_1 = (a_1, a_2)$, the coordinates of the keyword G_2 are represented by $G_2 = (b_1, b_2)$, and the Euclidean distance between G_1 and G_2 is represented by the following formula:

$$S = \mathrm{sqrt}\left((a_{1\_} b_1)^2 + (a_2 - b_2)^2 \right). \quad (19)$$

The formula for calculating the three-dimensional Euclidean space distance is shown in the following formula:

$$S = \mathrm{sqrt}\left((a_1 - a_2)^2 + (b_1 - b_2)^2 (c_1 - c_2)^2 \right). \quad (20)$$

Extended to the x-dimensional space, the Euclidean distance calculation formula is as follows:

$$S = \mathrm{sqrt}\left(\sum (a_{i1} - a_{i2})^2 \right), \quad i = 1, 2, \ldots, x. \quad (21)$$

S is the Euclidean distance in the x-dimensional space.

4. Experiments and Analysis of the Research Status and Trends of Blockchain Technology in the Financial Field Based on CiteSpace Knowledge Graph Visualization

4.1. Results of Literature Screening on Blockchain Technology in the Financial Field. A total of 864 Chinese documents were obtained in this search, 733 English documents were obtained, and all of which were between 2010 and 2020. The sources of the documents were journals, and the search theme was "blockchain finance," which were retrieved in CNKI and web of science, respectively. According to the statistics of CNKI and Web of Science, the annual changes of literature related to blockchain financing from 2010 to 2020 are shown in Figure 6.

As can be seen from Figure 6, during the past 10 years from 2010 to 2020, the number of blockchain finance research literature at home and abroad generally showed an upward trend, and the trend was obvious, indicating that the research heat of blockchain finance was increasing year by year both at home and abroad. In terms of quantity, since 2012, the number of domestic literature on blockchain finance has been higher than the number of foreign literature in the same year. The difference between the two is 32, and in 2020, it reached a maximum of 68, which further shows that domestic scholars have gradually strengthened their efforts in recent years. Research in this field also shows that compared with foreign scholars, domestic scholars have paid more attention to blockchain finance in recent years [22].

The industry research situation can be better understood through statistical results, and the top 10 journals with the most frequent occurrences are presented in pie chart as shown in Figure 7 for details.

It can be seen from Figure 7 that the distribution of journals of literature included in blockchain finance. It is calculated that the share of the above-mentioned journals in CNKI and Web of Science reaches 33.4% and 19.8%, respectively. It can be seen that the main source journals of CNKI sample documents are logistics technology, accounting for 15%. The main source of foreign sample literature is International journal of production economics, accounting for 30%. From the distribution of journals, the journals published by blockchain finance at home and abroad are all distributed in the fields of finance, economic production, and logistics. Both at home and abroad, the influence of published journals is at the upper middle level, which further indicates that blockchain finance is increasingly becoming an important research direction in the field of finance or blockchain [23].

4.2. Data Processing. Through the use of Mysql statistical screening, there are 2018 English keywords and 2024 Chinese keywords.

In the process of statistics, it was found that the word frequency statistics table of Chinese and English keywords is finally obtained. The word frequency of "supply chain" with the highest foreign word frequency is 78, while the word frequency of "supply chain finance" with the highest Chinese word frequency is 419. There is a certain gap between them. Therefore, in this paper, the frequency of word frequency statistics is normalized, and the zero-average normalization method is adopted, that is, the Z-score normalization method. Z-values are calculated, and normalized Z-values follow a standard normal distribution. The mean is 0 and the standard deviation is 1. Therefore, the larger the Z value, the higher the hotspot of the keyword. After calculation, the standardized Chinese and English keyword word frequency map is obtained, and the top five keywords of each selected word frequency are summarized into a high-frequency keyword map, as shown in Figure 8:

As can be seen from Figure 8, the Chinese keyword high-frequency word supply chain finance has the highest Z value, reaching 28.5; the English keyword high-frequency word supply chain finance has the highest Z value, reaching 21.5. It can be seen that the research hotspot focuses on the research on supply chain finance.

This article collects statistics from the number of domestic and foreign blockchain finance annual literature publications and the number of keywords from 2010 to 2020, and the summary is shown in Figure 9.

From the comparison of the two figures, it can be seen that China's research on blockchain finance shows a steady upward trend both in terms of literature quantity and word frequency quantity, and the trend is obvious, indicating that the publication of blockchain finance literature is stable, and the research in this field is gradually deepening. Foreign research on blockchain finance has fluctuated in terms of the number of publications and the frequency of keywords, but since 2010, the research attention has increased, which also shows that the research topic of blockchain finance has increasingly entered the international academic research field.

4.3. High-Frequency Keyword. This paper makes statistics on the annual frequency of high-frequency keywords in Chinese and English and then understands the annual hot words and development trends as shown in Figure 10:

As can be seen from Figure 10, the annual trend of high-frequency keywords supply chain finance of CNKI is on the rise. The number of articles has risen from 10 articles in 2010 to the highest point of 63 articles in 2018, while the annual trend of high-frequency keywords of web of science has some changes. This year, the research focus has turned to Supply chain, reaching a peak of 13 in 2020. The growth trend of Web of Science high-frequency keywords can be divided into stable, growing, and fluctuating. The stable type includes risk management, risk, financing, and so on. The annual trend of these keywords is stable, which also shows that these keywords are mature and have a certain degree of research attention. Growing types include inventory strategies, financing constraints, and so on. These keywords are emerging topics, and the trend of popularity is rising, which further shows that the subtopics of supply chain finance research are constantly enriched and developed. The volatility type includes supply chain management, supply chain finance, and so on. These keywords have common

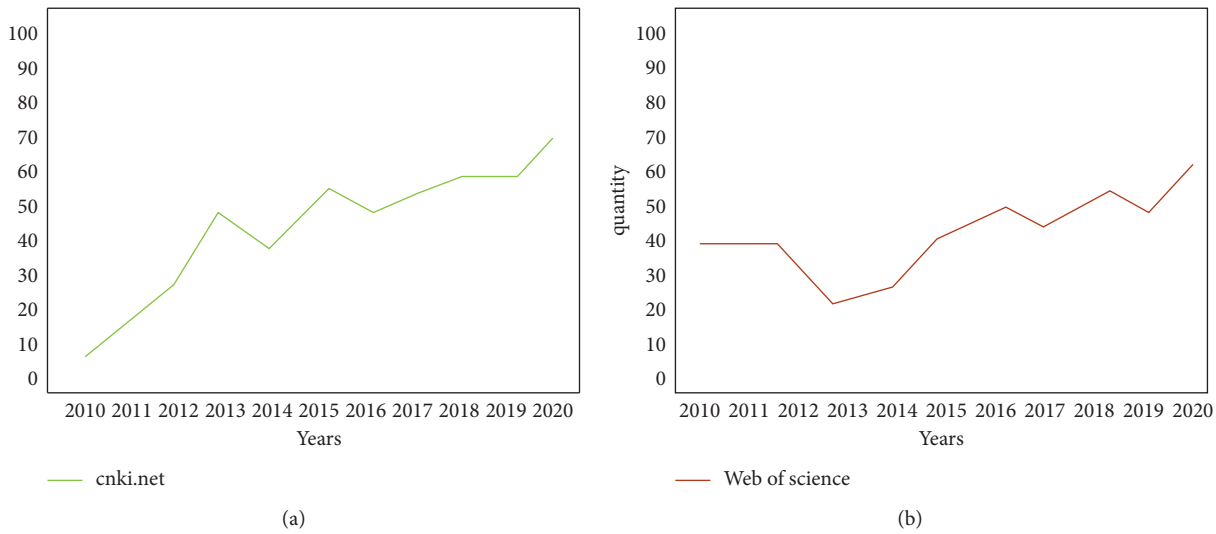

Figure 6: Annual changes in blockchain finance-related literature. (a) Annual changes of relevant documents on CNKI. (b) Annual changes in Web of Science-related literature.

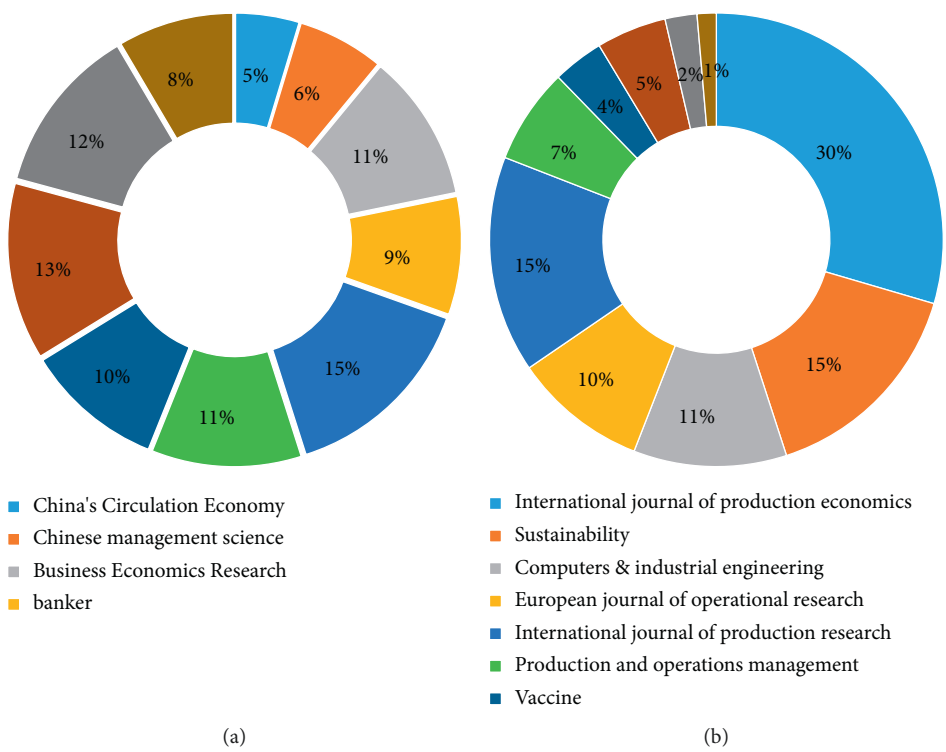

Figure 7: Top source journals for blockchain finance literature. (a) Major source journals of CNKI sample literature. (b) The main source of Web of Science sample literature.

characteristics and all belong to the main disciplines. In the past 10 years, the trend of keywords has a certain volatility, but on the whole, it belongs to the rising trend of volatility.

Through a comprehensive comparative analysis, it can be seen that in the research of blockchain in the financial field at home and abroad, the research in the financial field of blockchain technology at home and abroad is on the rise as a whole, mainly focusing on the keyword "supply chain finance." China's research on this keyword accounted for 59.5%, and foreign research on this keyword accounted for 26.5%, with a difference of 33%. This kind of research that focuses on combining national conditions and starting from the general environment is in line with the needs of relevant problems in the reality of the national economy. There may be some uncertain factors, such as the instability of the retrieval environment and the difference of operators, so that

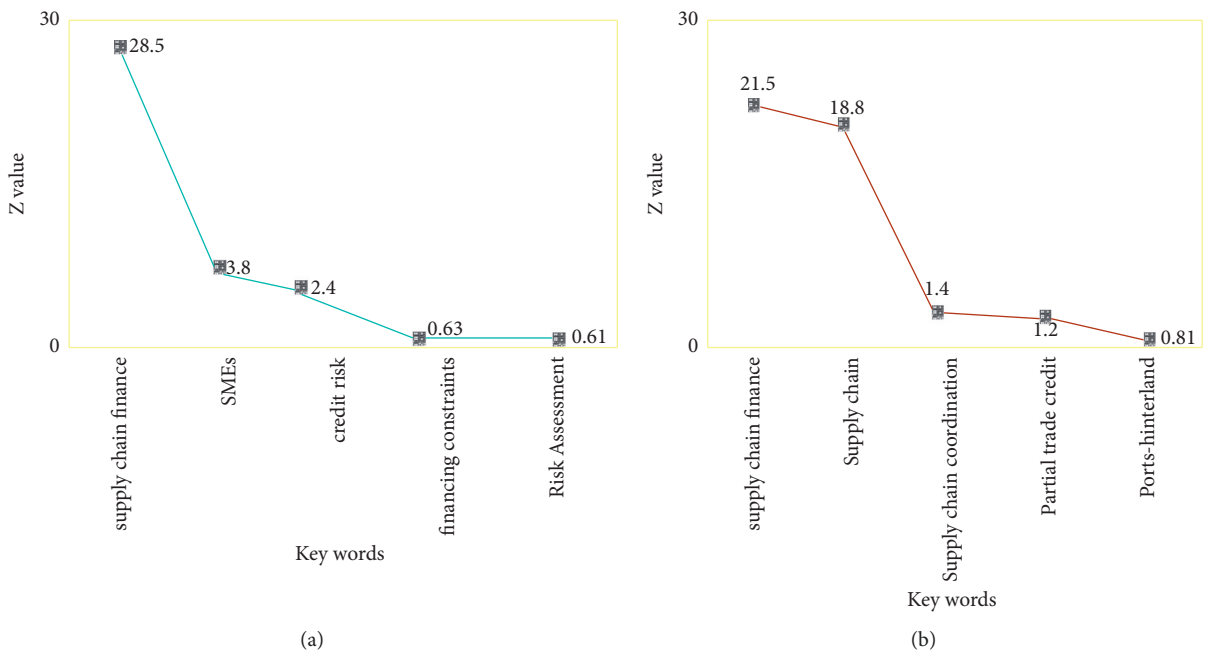

Figure 8: Keyword high-frequency word Z value. (a) Z-value of high-frequency words of Chinese keywords. (b) Z-value of high-frequency words of English keywords.

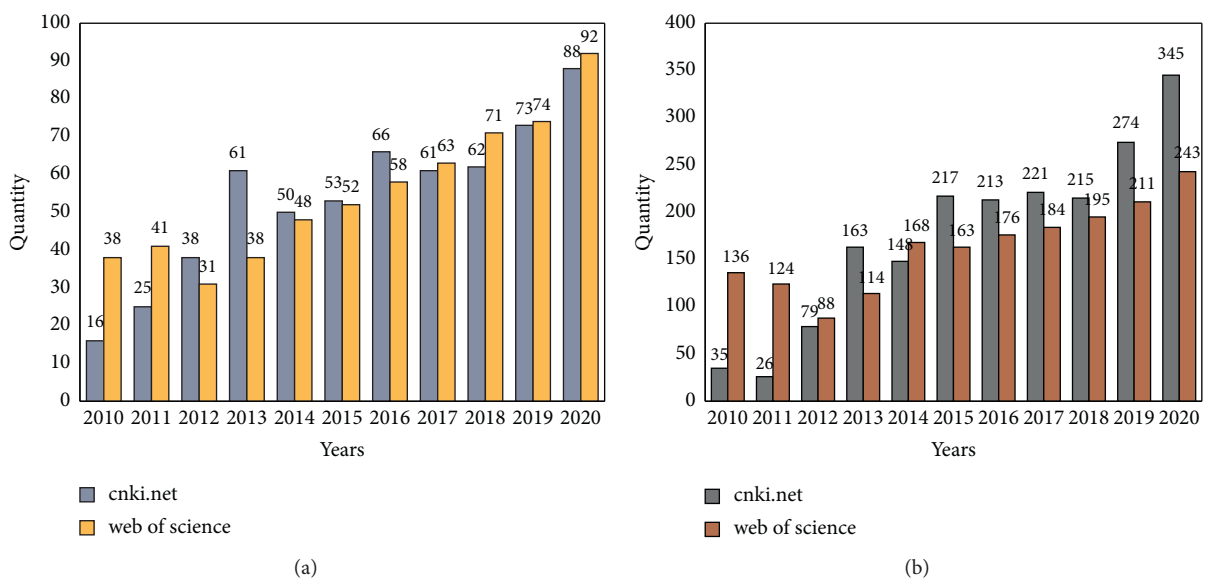

Figure 9: Annual statistics of blockchain finance at home and abroad. (a) Annual statistics on the number of blockchain financial literature at home and abroad. (b)Annual statistics of blockchain financial keywords at home and abroad.

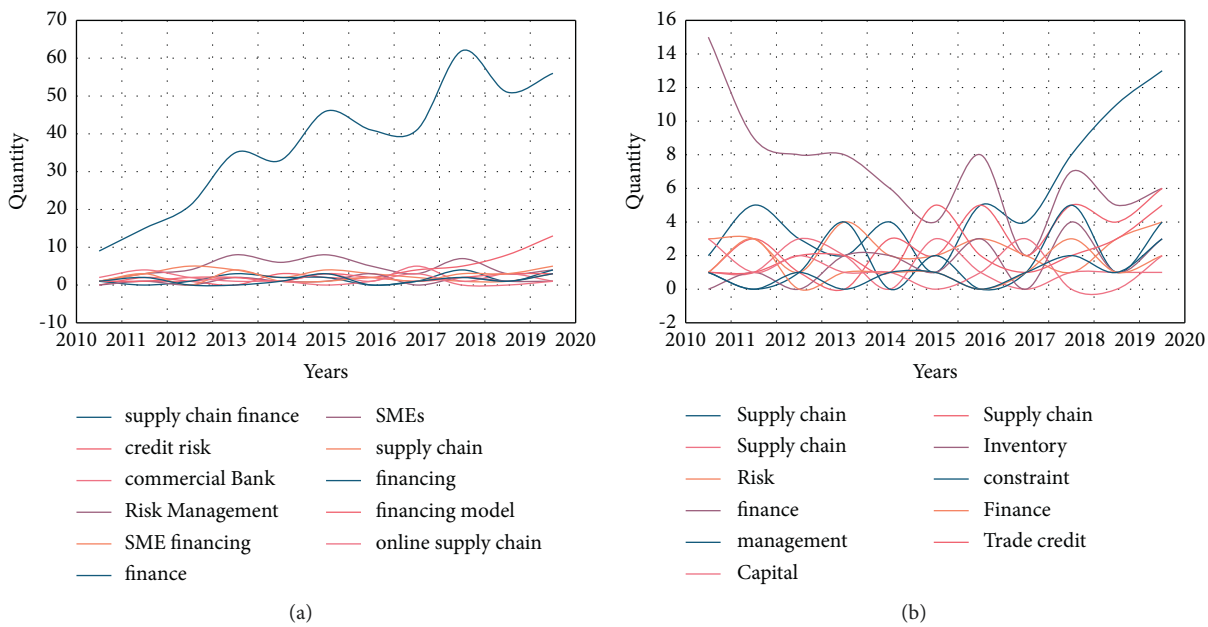

Figure 10: Annual trend of high-frequency keywords. (a) Annual trend of high-frequency keywords in CNKI. (b) Annual trend graph of high-frequency keywords in Web of Science.

the results of this experiment are not completely accurate and reliable, and there are certain differences.

5. Conclusions

With the rise of Internet finance, people have higher and higher requirements for financial services. The development of the financial field cannot be separated from the contribution of the Internet. Due to its technical advantages, blockchain technology has been widely applied in many fields. This article first gives a general introduction to blockchain technology, so that people can understand its functions and principles and then use relevant principle formulas to analyze its function. In the experimental part, this article used CiteSpace to analyze the current research status of blockchain in the financial field, conducted a search and analysis on the development of blockchain technology, and concluded that in the research on blockchain technology at home and abroad in the financial field, the research in the field of blockchain finance at home and abroad is extensive, but the main focus is on the keyword "supply chain finance" showing an overall upward trend. This provided ideas for the development and research of blockchain technology in the financial field in the future, so it is necessary to study the status quo and trend of blockchain technology in the financial field.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this article.

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Research Article

E-Commerce Network Security Based on Big Data in Cloud Computing Environment

Yifu Zeng,[1,2] Shuosi Ouyang,[3] Tuanfei Zhu,[1,2] and Chuang Li[4]

[1]*College of Computer Engineering and Applied Mathematics, Changsha University, Changsha 410022, Hunan, China*
[2]*Hunan Province Key Laboratory of Industrial Internet Technology and Security, Changsha University, Changsha 410022, Hunan, China*
[3]*School of Accounting, Hunan Vocational College of Commerce, Changsha 410205, Hunan, China*
[4]*School of Computer Science, Hunan University of Technology and Business, Changsha 410205, Hunan, China*

Correspondence should be addressed to Shuosi Ouyang; z20190823@ccsu.edu.cn

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The popularization and development of big data and cloud computing in e-commerce still face a series of problems, among which the most prominent one is security. How to establish an effective risk assessment system in the cloud computing environment is the primary concern of e-commerce enterprises. This article mainly discusses the network security of e-commerce based on big data in cloud computing environment. Because the servers of the cloud computing platform are deployed on a global scale, all the above nine processes can be carried out in real time, thereby improving the operational efficiency of the enterprise. Moreover, in large-scale e-commerce applications, according to probability statistics, the distribution of all these process steps must be uniformly distributed. Cloud computing is the commercial realization of computing resources, which is essentially a producer-consumer model. Cloud computing can balance the load to the greatest extent and solve various inconsistencies that may exist in the process of data processing. Balanced conflict greatly improved the solution. The speed, at which the case process runs, maximizes the potential of cloud computing on a commercial level. This article makes an effective investigation of information assets in various aspects. In this article, the comprehensive risk value of the system was calculated as 4.4. According to the risk level, this article sets up the electronic commerce system's physical security and access and data backup control vulnerability to resolve problems; another big data reflect is also not allowed to ignore. In view of these problems, this article proposes corresponding improvement strategies responsibility allocation.

1. Introduction

Cloud computing platform, also known as cloud platform, refers to services based on hardware resources and software resources, providing computing, network, and storage capabilities. In the implementation platform of cloud computing, two are currently more popular. One is Google's own MapReduce, Bigtable, and GFS; the other is a Hadoop system, implemented by borrowing Google's technology, including the corresponding MapReduce, Hbase, and HDFS.

The realization of cloud computing relies on software and hardware platforms that can realize virtualization, automatic load balancing, and on-demand. The providers in this field are mainly traditional leading software and hardware manufacturers, such as EMC's VMware, RedHat, Oracle, IBM, HP, and Intel. The main features of these companies' products are flexible and stable cluster solutions and standardized, inexpensive hardware products. Therefore, e-commerce security is not only a network security issue, but also a commercial security issue [1, 2]. E-commerce security is a multidisciplinary discipline that includes not only technologies related to cybersecurity, but also technologies related to commercial security [3]. With big data and cloud computing becoming the mainstream of information technology [4, 5], researching e-commerce security in big data and cloud computing environments has

become an urgent academic task [6, 7]. The main concern of commercial transaction security is the various security issues arising [8, 9], which are virtually inseparable and complementary. Without the foundation of cybersecurity, the security of commercial transactions is like a castle in the air; there is nothing to talk about [10, 11]. Commercial transactions are not secure, and even if the network itself is more secure, it cannot meet the special security requirements of e-commerce [12]. This article mainly discusses the network security of e-commerce based on big data in the cloud computing environment and aims to make certain contributions to the network security of e-commerce.

Liu et al. built an economic model that considered the trade-off between system availability and client security constraints. When a brand-building company is a pioneer, both companies have higher security restrictions on their clients. In the mixed market, each company's manager n checks the user's emphasis on security and availability. He believes that with restrictions, users begin to pay more attention to security; managers of companies with lower levels of security restrictions should increase client security restrictions [13, 14]. Bing is increasingly important for activities related to reputation and integrity. Therefore, he proposed an electronic identity (eID)-based cloud service platform architecture [15, 16]. Pop believes that managing large amounts of data processed in distributed systems consisted of data centers that have a significant impact on end users. Therefore, he can effectively implement the management process of such a system by using a unified overlay network interconnected by a secure and efficient routing protocol [17, 18]. Chen et al. believe that providing a highly secured critical infrastructure system should develop scalable [19, 20].

The innovations of this article are as follows: (1) The indicator system, on which the evaluation is based, is analyzed. (2) Corresponding new security policies are formulated for more serious risk locations. (3) A security risk assessment model including asset analysis module, security knowledge base module, and risk assessment calculation module is constructed.

2. Proposed Method

2.1. E-Commerce Theory. The basic characteristics of e-commerce are universality, convenience, integrity, security, and coordination. In general, therefore, e-commerce security is not only a network security issue but also a business security issue; e-commerce security is an interdisciplinary discipline that includes not only technologies related to network security but also technologies related to business security. E-commerce business model refers to how electronic enterprises use information technology and the Internet to operate their enterprises, applications on the Internet, and on the basis of network security, how to ensure the smooth progress of e-commerce [21]. The value of e-commerce is that consumers shop and pay online through the Internet, which saves time and space for customers and enterprises and greatly improves transaction efficiency. Especially for busy office workers, it also saves a lot of precious time. That is to achieve the confidentiality, integrity, authentication, and forgery of e-commerce. Without the security of the network as the basis, the security of commercial transactions is like a castle in the air. Commercial transactions are not secure, and even if the network itself is no longer secure, it cannot meet the special security requirements or sort out security issues, including related technologies, protocols, architecture, software, and solutions, especially the latest research results of e-commerce security issues. On this basis, the e-commerce security issues in big data and cloud computing environments are analyzed. Among them, the type of e-commerce refers to the classification of e-commerce, and there are five kinds in total; business-to-consumer (B2C), business-to-business (B2B), business process, consumer-to-consumer (C2C), business-to-government (B2G), and consumer-to-government (C2G).

Security issues are an important factor that constrains them. Since e-commerce, security issues have disappeared like ghosts. Broadly speaking, e-commerce security should include information. In order security, there must be a corresponding technology to meet specific security needs. The security issues of e-commerce are mainly manifested in three aspects: information security, transaction security, and property security. Its source code has four levels: hardware level, software level, application level, and environment level. Various measures should be taken to address security challenges and promote the further development of e-commerce in China [22]. Traditional network security consists of three elements: confidentiality, integrity (ensuring that content is not compromised or tampered with, and only authorized individuals identify it), and availability; with the development of services such as online e-commerce, a new element has been added: antirefusal mechanism, that is, documents or transactions signed by individuals on the network cannot be rejected to ensure the normal development of online business. As shown in Figure 1, it is a more complete e-commerce transactional information security application. Among them, there are four elements of e-commerce: shopping malls, consumers, products, and logistics.

2.2. Big Data. Big data refers to the collection of data whose content cannot be captured, managed, and processed by conventional software tools within a certain period of time. The most notable feature of big data is the large scale of data. Internet of Things are rapidly emerging, and cloud computing has arrived. Whether it is instant messaging tools, cloud platforms, or social networks, you can generate large amounts of data anywhere, making the security situation more complex than traditional security. Data integrity challenges and the ability to prevent data loss, theft, and destruction have some technical problems, and traditional security tools are no longer effective. On the other hand, collecting and centrally storing large amounts of corporate data, user data, personal privacy, and user behavior records increases the risk of data breaches. If these data are abused, it will threaten the information security of the enterprise and even personal safety. Analysis of massive data helps

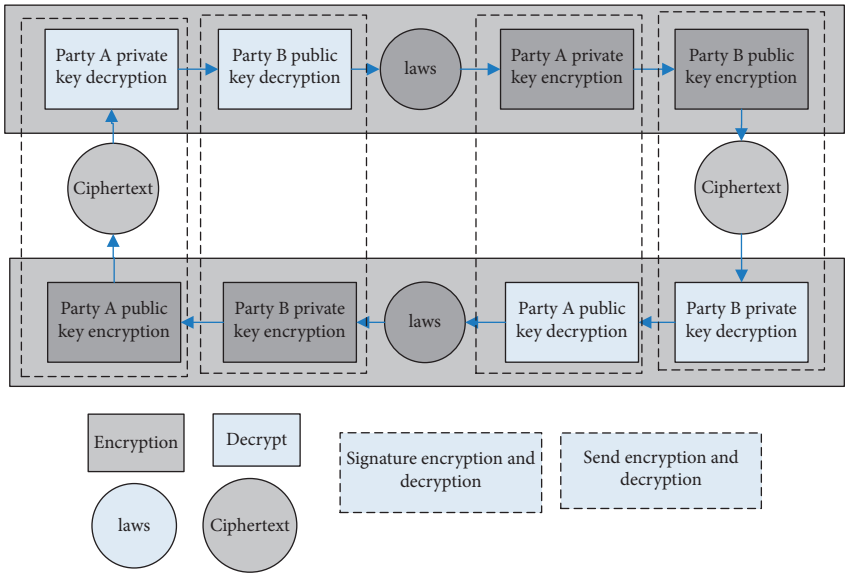

Figure 1: A more complete e-commerce transaction information security application diagram.

information security service providers better describe anomalous behavior on the network to identify risk points in the data [23]. Combine real-time security defenses to analyze business data, identify phishing attacks, prevent fraud, and prevent hackers. Traces left by cyber-attacks are often the attack.

2.3. Cloud Computing. Cloud computing is a type of distributed computing. It refers to decomposing the huge data computing processing program into countless small programs through the network "cloud and then processing and analyzing these small programs through a system composed of multiple servers to obtain the results and return them to the user. Cloud computing is the commercial implementation of computing resources. It is essentially a producer-consumer model. Cloud services are considered to be a valuable commodity economy, and cloud users can provide products to consumers according to their own needs. Suppliers and points are purchased from suppliers worldwide based on certain payment methods. In the short term, the impact of cloud computing on individuals is relatively small. Perhaps many of the previous technologies introduced cloud computing to enterprises first, especially, which are the most direct changes: they will be worrying. Whether it will eventually expand individuals remains to be seen [24].

The characteristics of cloud computing are ultralarge scale, high reliability, versatility, and high odd scalability. With the rise of an environment, a new trend in the application of cloud computing services the economic, business, management, and e-commerce fields. It is an electronic outsourcing based on cloud computing technology. Enterprises only need to access the e-commerce cloud service provider, established by the software library, to obtain the required management procedures and business database information. There is no investment to establish a complete set of internal software and procedures. The cost is relatively low, and only a certain rent is required. When the enterprise's existing IT resources can meet the business needs, uninterrupted business and the enterprise do not need to invest in new equipment or pay high cloud. Any idle IT resources in IT can help with this task. In fact, the business operation mode of the enterprise is to use the cloud computing platform to virtually establish various resources distributed throughout the country and realize resource sharing at the application layer. Businesses do not need sharing. Cloud computing has a wide range of applications, including cloud IoT, cloud security, cloud storage, private cloud, cloud gaming, and cloud education.

2.4. Risk Assessment Model. After asset analysis, it is necessary to separately examine the threats and vulnerabilities faced by individual assets, so that the risk of integrating all assets can be obtained from them. The theoretical model of risk assessment is shown in Figure 2.

Regardless of the size of the enterprise, when operating an e-commerce system, a series of security controls are preconfigured to prevent potential security risks or to improve control measures against security attacks that have occurred. Existing control measures improve the results of systemic risk assessments by reducing the likelihood of threats occurring and reducing the destructive effects of threat impacts. In the risk assessment process, the actual existing security measures need to be included in the risk calculation, so as to obtain the risk value that is most consistent with the information assets in the current tense. The risk assessment result information of a single information asset is stored in a unified database, and the comprehensive risk assessment module in the evaluation model performs effective reasoning according to certain inference rules, and combines the object. Get the overall risk profile of the system and explain the results accordingly. The following is a breakdown of the identification of threats and

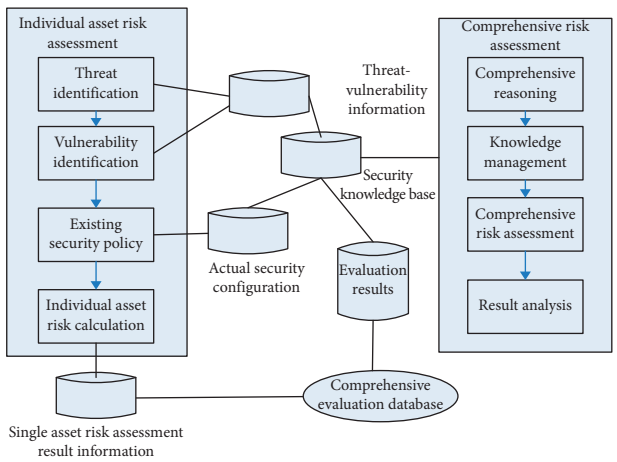

Figure 2: Risk assessment model diagram.

vulnerabilities in a single asset risk, the impact of existing security strategies, and the classification of risk levels, combined with qualitative and quantitative methods.

2.4.1. Estimation of the Events. Under the influence of existing security measures, the probability of a threat event is affected by four factors: whether the asset is attractive, whether the asset is easier to convert into compensation, the technical size of the threat, and whether the vulnerable points are easy to be used and threatened. The probability of defining the occurrence of threat T is $P(T)$. From the above four factors, we can define four factors as $P(A)$, $P(B)$, $P(C)$, and $P(V)$. The threat event $P(T)$ and is as follows:

$$P(T) = P(A) * P(B) * P(C) * P(V). \tag{1}$$

Since $P(A)$ and $P(B)$ are directly related to asset attributes, $P(C)$ and $P(V)$ are directly related to the attributes of the vulnerable points. We can combine these four items, respectively.

$$P(T) = P(A) * P(V), \tag{2}$$

where $P(A)$ is the correction factor associated with the asset and $P(V)$ is the probability that the vulnerable point is utilized. Therefore, the probability of estimating the probability of a threat event is to determine the correction factor associated with the asset and the probability that the vulnerability is exploited. The set of vulnerable points corresponding to a threat Ti ($i = 1, 2, \ldots, n$) is defined as $Vi = \{Vi1, Vi2, \ldots, Vim\}$, and the probability of any vulnerable point being utilized is an independent probability event, that is, the probability that at least one event that can be utilized in a set of vulnerable points corresponding to a threat at a certain moment occurs

$$P(V_i) = 1 - \prod_{j=1}^{m} \left(1 - P\left(V_{ij}\right)\right). \tag{3}$$

Taking into account the information asset factor, the probability formula for a threat event can be written as

$$P(T_i) = P(A_i)\left(1 - \prod_{j=1}^{m}\left(1 - P\left(V_{ij}\right)\right)\right). \tag{4}$$

2.4.2. Estimation of the Extent of the Threat. In the risk assessment, the quantification of the degree of impact on the system after the threat event has been a difficult problem. A threat may have different levels of impact on e-commerce systems. Common threats such as "cannot perform critical operations," "system outages," "transaction information disclosure," "loss of revenue," "damage to corporate image," and "harm the public safety" are shown. The size of a single impact attribute generated by a particular threat is not consistent, and different system platforms take different levels of attention when encountering these hazards. In order to make a better quantitative measurement of the degree of influence on Weibula, this article refers to the existing risk assessment method research and introduces the concept of multiattribute and influence degree, that is, a certain specific rib and influence on different levels of the system. It is called a certain rib and consequence attribute. Each different rib and consequence attribute is given a corresponding weight value. The weight value depends on the importance of the threat and the system's ability to withstand. Therefore, it is necessary to confirm the threats that will cause security damage to the e-commerce system based on the actual situation of the system being evaluated. When assessing the degree of influence, it weighs different consequence attributes in order to obtain the level of risk that is consistent with the actual situation.

The consequence attribute set that threatens T_i can be defined as X: $\{t = 1, 2, \ldots, s\}$, and the corresponding consequence attribute value set is D: $\{d_n | i = 1, 2, \ldots, n; t = 1, 2, \ldots, s\}$, where x_1 and d_n, respectively, represent the t-th consequence attribute of threat T_i and the possible influence value on the consequence attribute, s is the number of types of consequence attributes; the weight set corresponding to the threat consequence attribute is defined as $W\{w_1 | t = 1, 2, \ldots, s\}$, which weighs consequence attribute.

Since the impact of threats on e-commerce systems is multifaceted, different consequence attributes have different dimensions and cannot be measured directly with uniform standards. Value attribute values of each consequence are dimensionless, and the relative consequence attribute value D^*: $\{d_{it}^* | i = 1, 2, \ldots, n; t = 1, 2, \ldots, s\}$ is obtained, where d_{it}^* is the dimensionless value, indicating the relative influence value of threat T_{iw} on the consequence attribute x_t.

$$d_{it}^* = \frac{d_{it}}{\max\{d_{it}\}_{k=1}^{n}}. \tag{5}$$

According to previous section, combined with the value of the multidimensional threat consequence attribute and its weight, the formula for the degree of influence of the threat can be

$$E(T_i) = P(T_i) * \sum_{t=1}^{s}\left(w_t d_{it}^*\right). \tag{6}$$

Combine formula (4) to get

$$E(T_i) = P(A_i)\left(1 - \prod_{j=1}^{m}\left(1 - P\left(V_{ij}\right)\right)\right)\sum_{t=1}^{s}\left(w_t d_{it}^*\right). \quad (7)$$

2.4.3. Impact of Existing Security Policies. Regardless of the size of the enterprise, when operating an e-commerce system, a series of security controls are preconfigured to prevent potential security risks or to improve control measures against security attacks that have occurred. Existing control measures improve the results of systemic risk assessment by reducing the threat, the likelihood of occurrence, and reducing the destructive effects of the ribs and impacts. For complexity, in order to simplify the evaluation work, we consider the impact of existing security measures from each dimension. Assume that a security measure $S = \{S_1, S_2, \ldots, S_1\}$ is implemented for an asset A_{iw} enterprise, and the impact of reducing the possibility of T_i occurrence is $Sa_{ik}(k = 0, 1, 2, \ldots, 1)$, which reduces the damaging and destructive impact of $Sb_{ik}(k = 0, 1, 2, \ldots, 1)$. We define the range of Sa_{ik} and Sb_{ik} to be 0-1, 0 for complete influence and 1 for no effect.

Influence of events and events are expressed as

$$\begin{aligned} P(T_i) &= P(A_i)\left(1 - \prod_{j=1}^{m}\left(1 - P\left(V_{ij}\right)\right)\right)\prod_{k=1}^{l} Sa_{ik}, \\ E(T_i) &= P(A_i)\left(1 - \prod_{j=1}^{m}\left(1 - P\left(V_{ij}\right)\right)\right) \\ &\quad \prod_{k=1}^{l} Sa_{ik}\sum_{t=1}^{l}\left(w_t d_{it}^*\right)\prod_{k=1}^{l} Sb_{ik}, \end{aligned} \quad (8)$$

$R(A_i)$ that the asset A_i faces

$$\begin{aligned} R(A_l) = A\sum_{i=1}^{n} E(T_i) = A_l\sum_{i=1}^{n}\Bigg[P(A_l)\left(1 - \prod_{j=1}^{m}\left(1 - P\left(V_{ij}\right)\right)\right) \\ \prod_{k=1}^{l} Sa_{ik}\sum_{t=1}^{s}\left(w_t d_{it}^*\right)\prod_{k=1}^{l} S_{b_{ik}}\Bigg]. \end{aligned} \quad (9)$$

2.4.4. Risk Level Division. After obtaining the risk profile of a single asset, it is necessary to synthesize the risk values of all assets risk faced by. Assuming that there are N items in the asset, the risk value of each asset is dimensionlessly processed, and the risk ranking of each asset is obtained. The asset pricing strategy is based on the asset's confidentiality, integrity, and usability value of the entire system. Therefore, the weight of the assets A_i on the system can be obtained according to the value of the asset, and the value of all assets is normalized to obtain the weight of the importance of the entire system δ

$$\delta_i = \frac{V(A_i)}{\sum_{i=1}^{N} V(A_i)}. \quad (10)$$

The overall risk of the entire e-commerce system is

$$R = \sum_{i=1}^{N}\delta_i R(A_i). \quad (11)$$

3. Experiments

3.1. Experimental Design. Combined with the risk assessment framework of this article, the design of the questionnaire content for the actual investigation of enterprises needs to start from the basic security status of the system. Basic information of the enterprise includes the basic situation of the enterprise, the information assets and the overview of the e-commerce system. The information assets include hardware and software asset content, service asset content, cloud asset status, personnel assets, and document assets. The e-commerce system overview includes system network topology map, system bearer service status, system network structure, outbound lines, and network boundary conditions. Business data, data backup, and security incidents occur within one year. Security status surveys are conducted from security management organizations, security management systems, system construction and operation maintenance management, physical security, network security, equipment and host security, application and data security, emergency response and disaster recovery technologies, and personnel security management.

Using the results of the questionnaire to conduct risk assessment, experts also need to conduct statistical analysis on the collected data to determine the basic situation of the system and the main risks. These risk generation risk sets can be entered into the security knowledge base for storage to provide a reference for real-time risk monitoring. The factual data collected through the questionnaire needs to be formalized before the risk calculation, in order to make the obtained raw data meet the needs of the evaluation model. There are three types of factual data that need to be formalized: subjective indicator data, objectiveness indicator data, and objective nonindicator data.

Subjective indicator data is the subjective evaluation of some indicators by the respondents, such as the subjective cognition of the employees in the questionnaire on the overall security status of the e-commerce platform. This type of data can be evaluated by adding credibility. The degree of deviation between the score of each evaluator and the last evaluation result is the credibility of the index value, and the credibility range is between 0 and 1.

The objective indicator data is the value of an indicator that can be read directly from the system, such as the time the terminal server has been used or whether a firewall is configured (which is indicated as true). The "fuzzification" of this type of data does not need to refer to other samples, and can be directly set to a reliability of 1.

This article establishes a model-based risk assessment tool by analyzing the composition and security elements of the system. The models of information system risk factors established by these tools are usually quantified or semi-quantitatified, and the results are based on the information

collected. For example, @RISK, CORA, Buddy System, etc., are risk assessment tools that combine qualitative and quantitative assessments.

3.2. Data Collection. This article analyzes the data of a part of the enterprise that deploys e-commerce in an application. Management framework and indicator system are also based on this article, the e-commerce system is investigated, and the system-related information assets and threats are identified. Risk factor such as data vulnerability is avoided. For the convenience of recording and calculation, it is used to classify the asset data under investigation. Based on the space, only some assets in the system and some threats and vulnerabilities identified are analyzed.

4. Discussion

4.1. Analysis of Security Risks of Network E-Commerce

4.1.1. Analysis of Hidden Dangers of Property Security. According to the assets, threats, and vulnerability information collected in this article, the questionnaire results are combined with the expert scores to assign corresponding risk factors, and the asset value table shown in Table 1 is obtained.

The system has set some security measures in advance when deploying the cloud-based e-commerce platform. Combined with the impact of existing security measures, the risk analysis is first performed on individual information assets. As shown in Table 2, the threats to assets are listed: the degree of vulnerability, the consequences of the threat attribute value, and the degree of impact of security measures.

As shown in Figure 3, it is a data graph of the influencing factors. According to formula (11), the comprehensive risk value of the system is $R = \sum_{i=1}^{N} \delta_i R(A_i) = 4.4$. And 9-10 is the extra high risk. According to this, the risk faced by the system is at a risk corresponding to the hardware and is most serious, indicating that the physical security of the e-commerce system, system permissions, and data backup control have urgent problems to be solved. The risks reflected by cloud data security and the configuration of security managers cannot be ignored.

4.1.2. Analysis of Hidden Dangers of Transaction Security. Transaction security refers to various insecurities in the e-commerce transaction process, including being enlarged. As shown in Figure 4, for the proportion of cases reported in the network case, it can be seen from the figure that the proportion of online shopping cases accounts for 38%. As we all know, the security risks of online e-commerce transactions cannot be underestimated. There are many transaction security issues in reality, for example, the seller uses the advantage of information to fake the buyer with inferior information; the identity of the of the to enter, and does not comply when providing the service, the fee charged is not the service or not enough services. Of course, the opposite is true.

Table 1: Asset value table.

Assets	Ava (A)	Inte (A)	Conf (A)	Reli (A)
1	3	4	5	
2	4	3	2	
3	2	4	4	
4	3	3	2	
5	4	2	1	
6	5	4	2	
7	3	3	2	
8	4	2	4	
9	2	3	5	3
10	2	6	2	5

Table 2: Single asset risk information.

Asset number	Asset value	Asset weight	Risk value
1	3.1	0.08	7.55
2	3.6	0.13	5.14
3	2.8	0.09	2.21
4	3.2	0.09	6.21
5	3.7	0.11	3.22
6	4.2	0.13	5.11
7	2.3	0.08	2.34
8	3.5	0.09	4.37
9	2.1	0.08	3.28

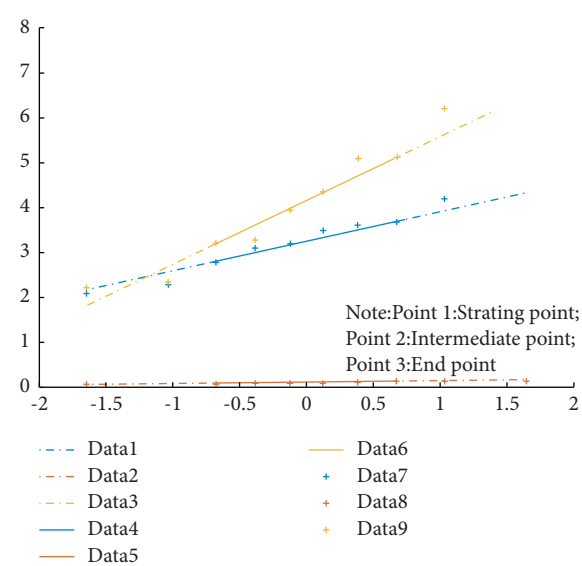

Figure 3: Single asset risk information.

4.1.3. Analysis of Hidden Dangers of Information Security. As shown in Figures 5 and 6, the network information is stolen and the ratio chart is taken. Illegal deletion of transaction information and the loss of transaction information may cause economic disputes and economic losses to one or more parties to the transaction. The most common information risk is the illegal theft and disclosure of information. It often causes a chain reaction and creates a follow-up risk. This is also the biggest concern for businesses and individuals. The typical manifestation of information

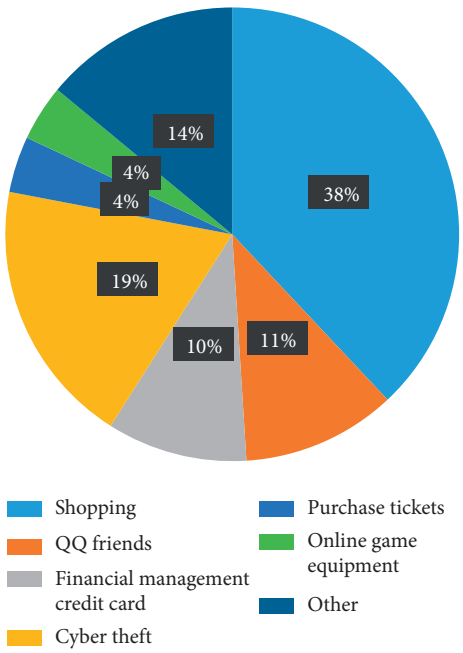

Figure 4: Proportion of network security incidents.

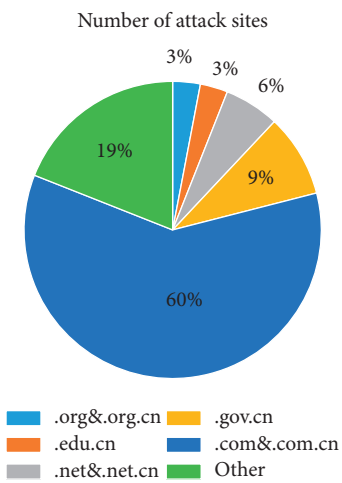

Figure 5: Statistics of website attacks.

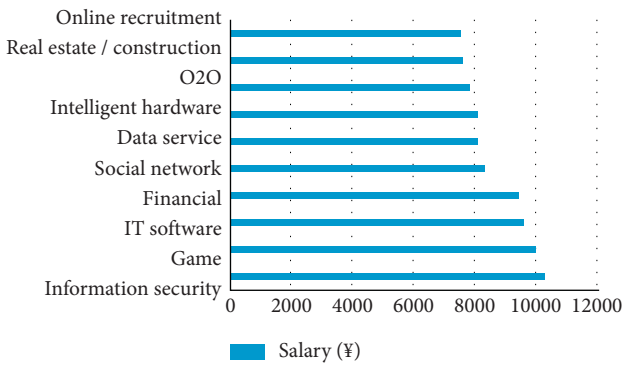

Figure 6: Industry salary treatment data map.

risk is cyber fraud. Cyber fraud brings huge economic losses to manufacturers and consumers.

4.1.4. Analysis of Hidden Dangers of Network Security. Cyber security is the measure taken to prevent the theft of such information and commercial competition.

5. Conclusions

Cloud computing is a computing method based on the Internet. In this way, shared hardware and software resources and information can be provided to computers and other devices on demand. Users no longer need to know the details of the infrastructure in the "cloud," nor do they have the corresponding expertise, nor do they need direct control. Whether it is e-commerce, in era economic networking information, it has a pivotal position. The combination of the three is the mainstream in the future. In the process of combining the three, how to avoid various risks and create a safe and stable network environment is a new topic facing enterprises and scholars. It is also based on this purpose, the author of the "risk assessment as a service" idea integrate big data security, cloud computing security, e-commerce security, risk assessment four major content, and research in the enterprise to deploy e-commerce system in cloud computing in the environment; in order to solve various security problems faced, a security risk assessment model needs to be established.

The article analyzes the patterns of e-commerce in big data and cloud environments and the specific practical problems such as the reliability of supplier services, storage risks, service continuity, and the concealment of viruses and hacker attacks, establishing a cyclical risk. In the cycle of risk assessment, information such as information assets, threats, risks, and security policies are continuously enriched to form a security knowledge base. By migrating the security knowledge base to the cloud, a risk management cloud can be generated. When the e-commerce enterprise operates the system platform, the risk management cloud can dynamically monitor and manage the system security in real time, and realize the idea of "security as a service." The framework theoretically realizes the dynamic in systems under and cloud environments.

The product of the fusion of traditional computer and network technology development such as load balancing, by distributing computing on a large number of distributed computers, rather than wooden computers or remote servers, the operation of enterprise data centers will be more similar to the Internet. This enables businesses to switch resources to the applications they need, accessing computers and storage systems on demand. Typical cloud computing providers often provide general network business applications, allowing us to access software and data stored on servers through software such as browsers or other Web services. In this article, the risk assessment model established for realizing the dynamic management of e-commerce system security risk under big data and cloud environment has not been tested by the actual network environment. The validity and practicability of the model need to be tested by

practice and continuously improved and strengthened. At the same time, the model established in this article needs to be further strengthened in the quantification of the system after the threat event occurs and the improvement of the security knowledge base. Solving the security risks faced by e-commerce under big data and cloud environment to promoting the even national economy. It is hoped that there will be an effective model with dynamics under big data and cloud environment. The risk assessment problem promotes the consistent and steady development of big data, cloud computing, and e-commerce. However, due to the limitations of time and technology, we have not conducted in-depth research on e-commerce network security under the combination of cloud computing and big data.

Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Conflicts of Interest

The author states that this article have no conflicts of interest.

Acknowledgments

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Research Article

The Default Risk of Bank Customers Based on Embedded Microprocessor Wireless Communication under the Internet Finance Background

Xie Wangsong

Business School, Wuxi Taihu University, Wuxi 214064, Jiangsu, China

Correspondence should be addressed to Xie Wangsong; xiews@wxu.edu.cn

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Internet finance refers to a new financial business model in which traditional financial institutions and Internet enterprises use Internet technology and information and communication technology to achieve capital financing, payment, investment, and information intermediary services. Embedded microprocessors have more than 32-bit processors with high performance. And it is small in size, light in weight, and low in cost. This article aims to explore the default risk of bank customers based on embedded microprocessor wireless communication under the background of Internet finance and how to control the credit risk of bank customers and help to clarify the development direction of Internet finance. Based on multimedia technology and orderly logistics model, this article designs a customer default credit risk management system. In order to test the performance of the bank customer credit risk management system, a small customer credit evaluation system was created. The experiment proves that the customer credit evaluation system can well realize risk evaluation and risk early warning and promote the sustainable development of the bank. At the same time, the system can be applied to most scenarios in the financial industry.

1. Introduction

With the reform of interest rate marketization, the traditional model relying on spreads and scale expansion to achieve high-profit growth faces serious challenges. Internet technology and the traditional financial industry began to integrate. The rapid development of Internet finance and the concept of continuous innovation have been driving traditional financial institutions to change their business models and service models. The issue of customer credit risk management is imminent. The development and use of embedded systems have enabled people to find a way to solve the problem. The characteristics of high portability and strong stability of embedded systems have made more and more people begin to invest in research. The pace of financial innovation has accelerated, and Internet finance represented by Internet payment, online loans, and crowdfunding has developed rapidly. As a representative of the traditional banking industry, commercial banks actively carry out Internet business and services, and adopting a more distinctive and differentiated marketing strategy is an inevitable choice for the development of the times [1–3].

With the continuous integration of Internet technology and commercial banking, the risks faced by commercial banks are also increasing. In the context of Internet finance, commercial banks face this. Commercial banks use Internet technology to optimize the business functions, product functions, and service functions of online banking. For example, when using the Internet for intermediary business, you can use the Alibaba microfinance model to expand personal, small, and micro enterprise loans; banks should actively cooperate with relevant industries and market departments and realize foreign exchange products, gold products, capital products, and financial derivatives. For online sales, banks should also develop e-banking services, establish e-commerce platforms, promote online banking to external users, and integrate multiple functions to increase revenue from intermediary businesses.

In the 2015 government work report, it is clearly stated that it is necessary to promote the development of Internet finance, which means the development of Internet finance in China.

The risks include customer information security risk, payment system security risk, cash laundering risk, liquidity risk, market risk, interest rate risk, and credit risk of customer default [4, 5]. This article mainly studies the bank's Internet financial credit business—medium customer default credit risk.

Credit risk refers to the possibility that the debtor will not perform the contract or fail to fully perform the contract, resulting in the loss of the creditor. In the bank credit business, the credit risk refers to the possibility that the lender cannot return the loan on time according to the agreement reached with the bank or the loan amount is lower than the agreed amount, resulting in a certain loss of the bank. Compared with traditional commercial banks, the Internet faces a wider range of participants, including borrowers, Internet service providers, and network equipment vendors. In the absence of effective credit risk management, its default rate will be far greater than the commercial bank credit risk default rate [6]

The traditional commercial bank's credit risk management process for customers is divided into five steps: credit investigation, credit initial evaluation, credit review, credit recognition, and credit tracking adjustment. In the process of risk management, the mutual trust between the bank and the customer is not high, the customer risk management mechanism is not perfect, and the customer profile information is not updated in time, and continuous dynamic monitoring cannot be formed. With the advancement of the Internet, the bank's control over customer credit risk still has the following problems: first, the credit risk organization structure is not perfect, second, the credit risk information management system needs to be strengthened, and third, it fails to effectively prevent the infection of credit risks [7, 8]. In this context, this article proposes to use multimedia technology to build a customer credit risk management system to solve the current shortcomings of credit risk management.

As an important development direction of computer technology, multimedia has changed the insufficiency of traditional computers to deal with digital and text information alone, enabling computers to comprehensively process sound, text, and graphic information and with image, rich and convenient interactivity. The improved man-machine interface has changed how computers are used, opening the door for computers to enter the realm of human life and production and opening up a very broad market for the computer industry. In the long run, the bright future of multimedia technology has been widely accepted.

Multimedia technology has three distinct features: integration, interactivity, and comprehensiveness. Integrated multimedia technology can simultaneously process three media: sound, graphics, and text. Generally speaking, the interactivity of multimedia technology means that both users and computers can exchange information under the interaction. Each user is both a consumer of information and a provider of information. Comprehensive multimedia technology integrates various media into an organic whole and cooperates with each other to express various actual information and changes in real time.

The application of multimedia technology is more and more extensive. For the current application, multimedia applications mainly appear in the following aspects: CAI teaching, games and entertainment, electronic publications, multimedia display, and information inquiry system. Far more than this, this article will study the application of multimedia technology in the bank customer credit risk information management system [9, 10].

The contribution of this article is to use multimedia technology to design and implement the bank customer default risk management system under the background of Internet finance and strictly control the default risk of customers in the process of developing commercial banking Internet financial services: in the early stage of financial business, through the prediction of customer default risk, customer screening, through information cross-matching to prevent fraud risks; in the business development process, through customer credit to prevent credit risk; in the final link, through risk monitoring to provide users with security, convenient and efficient Internet financial credit service. The design of the system is based on the ordered logistic model, designing relevant functions according to the needs of commercial banks, using the logistic model [11] structure, and using Apache Shiro [12], jQuery, and MyEclipse web development technology implementation system [13, 14].

1.1. The Theoretical Basis of Bank Customer Default Risk Management. Most credit risk management models summarize the characteristics of default customers and quality customers from historical data, summarize the influencing factors of credit risk, and then construct a model to quantitatively characterize customer credit risk. Specifically, the most widely used models include discriminant analysis [15], neural network model [16], and logistic regression model [11]. In this article, by comparing the above models, the advantages and disadvantages of each model are analyzed, and the applicability of the ordered logistic model is proposed.

1.2. Construction of Ordered Logistic Model. The most significant difference between the ordered logistic regression model and the traditional binary logistic model is that the number of dependent variables is increased from two to more, and the values of multiple dependent variable probabilities are hierarchical. The previous data processing steps are consistent with the binary logistic regression. The credit variable is unified into the WOE transformation of the original data, and the WOE (weight of evidence) value is generated from the original data for logistic regression. This method is most commonly used in the industry. Prior to this, factor analysis was performed on various types of amount variables that may have collinearity, and the common factors were extracted. The different classifications of each variable were transformed into a specific value and incorporated into a logistic regression, as shown in Figure 1.

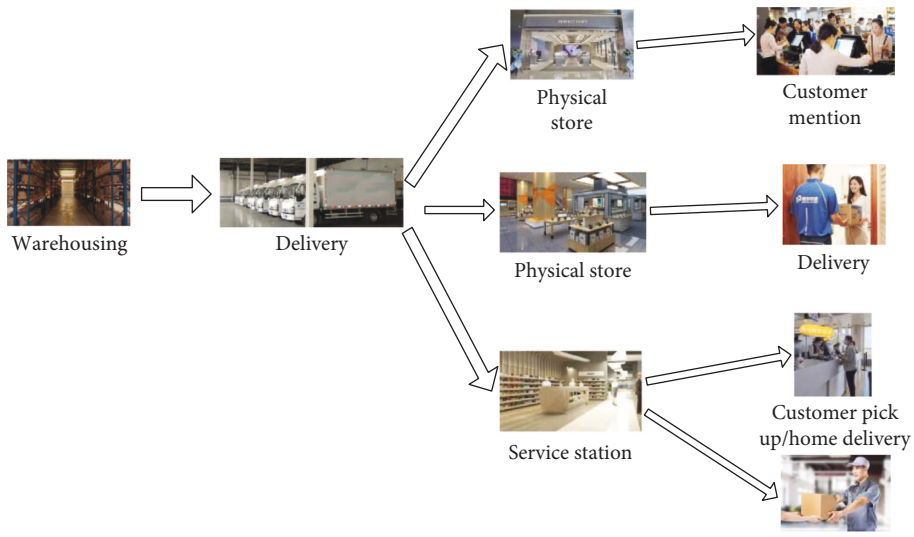

Figure 1: Orderly logistics distribution.

For category i of a nominal variable, or a segment of a continuous variable, WOE can be defined as follows:

$$WOE_{\mathrm{i}} = LN\,(B \div G). \tag{1}$$

Logistic regression is performed by replacing the original variable with the value of WOE. The larger the WOE value, the higher the ratio of the dependent variable to 1 in the data interval. The traditional binary regression equation after fitting is as follows:

$$\log(\text{odds}) = a + \sum_{i=1}^{n} \beta_i \times \text{woe}_i. \tag{2}$$

An ordered multiclassification model can be used as an appropriate estimation model when the explanatory variables are more than only the two states of default and nondefault, and the classification is as follows:

$$\ln\left\{\frac{p(y \le i|x)}{[1 - p(y \le i|x)]}\right\} = u_i - \left(a + \sum_{j=1}^{j} \beta_j X_j\right). \tag{3}$$

The ordered logistic model, also known as the "cumulative classification" regression model, can predict the cumulative formula:

$$p(y \le i|x) = p(y \le u_i|x) = \frac{e^{u_i - \left(a + \sum_{j=1}^{j} \beta_j X_j\right.}}{e^{u_i - \left(a + \sum_{j=1}^{j} \beta_j X_j\right.} + 1}. \tag{4}$$

Once the cumulative probability is calculated, the probability of belonging to a particular category can be calculated:

$$\begin{aligned} &p(y = 1) = p(y \le 1),\\ &p(y = 2) = p(y \le 2) - p(y \le 1),\\ &p(y = i) = 1 - p(y \le i - 1),\\ &p(y = 1) + p(y = 2) + \ldots + p(y = i) = 1. \end{aligned} \tag{5}$$

There are order relationships in different categories of default probabilities (that is, the probability of default is increased in turn). It is suitable to use the ordered multiclass logistic model for regression analysis of data. The model contains three ordered classification functions:

$$\begin{aligned} \ln\left(\frac{p_1}{p_2 + p_3 + p_4}\right) &= \beta_1 - \sum_{j=1}^{j} \beta_j X_j,\\ \ln\left(\frac{p_1 + p_2}{p_3 + p_4}\right) &= \beta_2 - \sum_{j=1}^{j} \beta_j X_j,\\ \ln\left(\frac{p_1 + p_2 + p_3}{p_4}\right) &= \beta_3 - \sum_{j=1}^{j} \beta_j X_j. \end{aligned} \tag{6}$$

In formula (6), p_1, p_2, p_3, p_4 indicates the may settle in advance, normal, suspicious, and loss. When there are K categories of dependent variables recorded as $N_1, N_2 \ldots N_4$, the ordered multiclass regression results will have K-1 thresholds, denoted as $U_1, U_2 \ldots U_{k-1}$. If $U_{i-1} < Y' \le U$, then $Y = N_i$.

1.3. The Architecture and Verification Method of Wireless Communication for High-Confidence Embedded System. In the functioning of society, trust is often the overall expectation that the words, promises, and statements of others can be trusted. The belief that one dares to trust because one believes sustains the shared values and stability of society. This thinking also applies in the computer world, where failure to function properly can occur if trust is broken. A trusted computing base (TCB) is the sum of hardware, firmware, and software required to perform key functions or security protection mechanisms in a computer system. Once any component in the trusted computing base fails or has a security breach, it may cause harm to the safe operation of the entire system. In traditional embedded systems, because application tasks, kernels, and system software run in the

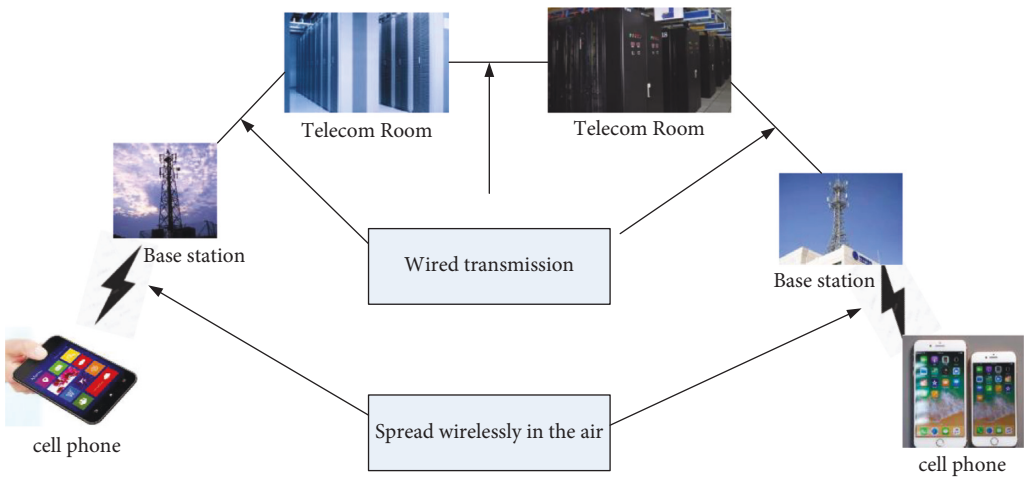

Figure 2: Common wireless propagation process.

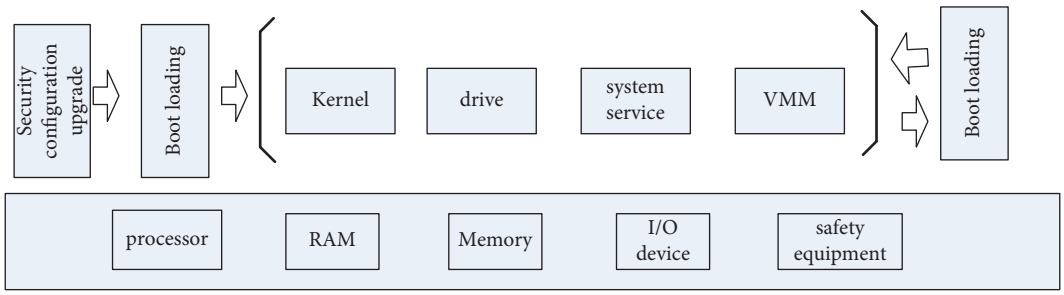

Figure 3: Schematic diagram of safety requirements for embedded systems.

same address space, tasks can access any function and data in the system. Therefore, the entire software and hardware platform is regarded as a trusted computing base for the secure and reliable execution of embedded systems. Although the greater the coverage of the trusted computing base, the higher the possibility of system security problems, this is acceptable for traditional embedded platforms because relatively fixed functions and closed execution environments make all application tasks and systems. Modules can be treated or verified as trusted components. The process of wireless communication is shown in Figure 2.

1.3.1. Safety Requirements. The core of high-confidence embedded software security requirements is to protect the correct execution of critical tasks without the leakage of security-critical information. In a system where there may be untrusted components (as shown in Figure 3), the security requirements can be decomposed into the following aspects.

Ensure the isolation between applications and between applications and systems. Component isolation is the basis for achieving higher-level system security strategies, and it is also an effective way to reduce damage caused by application failures. If there is no isolation between the application and the system, malicious or invalid application tasks can damage the kernel or prevent the implementation of security services in the kernel. If there is no isolation between applications, the code or data that performs critical tasks may be modified or stolen by out-of-control tasks. The realization of the isolation method requires the help of hardware facilities and corresponding software technology.

1.3.2. Software Verification Method Based on Abstraction Layer. The verification research in this article is based on the verification framework of the abstraction layer because based on the above verification system, it adds the following features: it models the registers, memory, and corresponding assembly instructions that need to be used in the x86 hardware platform and has the ability to express system software verification.

The framework can abstract the data and prove the data refinement relationship between the protocols. In Figure 4, it is proved that in the forward simulation process of the program and the protocol, the initial/end state types corresponding to the program and the protocol are the same, and if the modeled system is more complex, the protocol often needs to describe the data more abstract than the data manipulated by the implementation code.

On the other hand, when verifying the attributes that the module satisfies, it can be directly deduced on its protocol without the need to expand the implementation of the module, as shown in Figure 5 for its functional correctness proof diagram. Since the module's protocol has covered all its behaviors, when proving security attributes such as isolation and confidentiality, it can be done directly on the

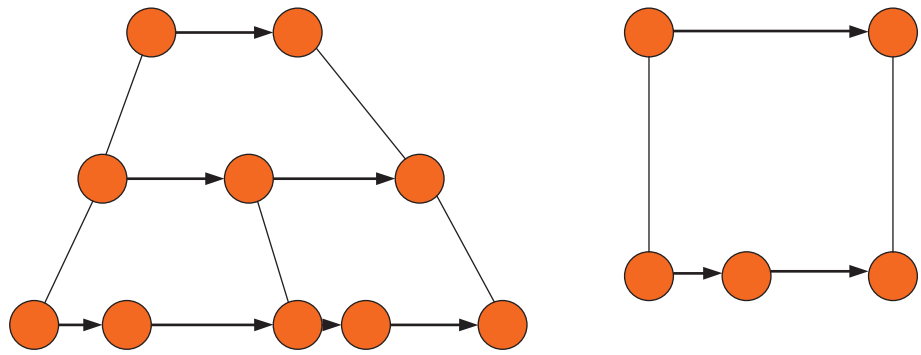

Figure 4: Proof of equivalence and proof of data refinement.

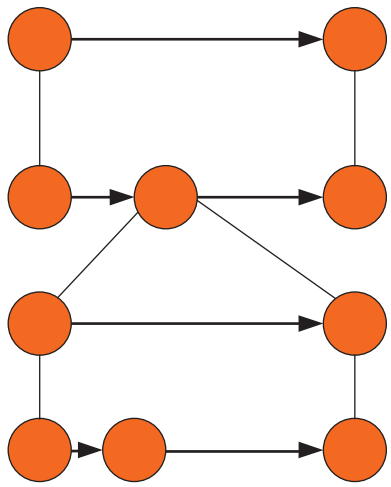

Figure 5: Context-dependent functional correctness proof.

abstract protocol, which reduces the workload of attribute proof.

1.3.3. Abstraction Layer Interface. The abstract layer interface L is a staged abstract machine model formed by the program verification process. The formal definition is as follows:

$$L = \varphi|i\mapsto\sigma|i\mapsto s|L_1\oplus L_2. \tag{7}$$

In addition to primitives and abstract states, the abstraction layer interface also maintains a set of invariants INV to ensure that all primitives at the abstraction layer meet the constraints of INV.

$$\forall s, s'.INV(s)\wedge\sigma(s, s') \longrightarrow INV(s'). \tag{8}$$

Access the required abstract state by calling the primitives provided by L. Its formal definition is as follows:

$$\begin{aligned} M = \varphi|i\mapsto k|i\mapsto v|M_1 \oplus M_2, \\ L_1\mapsto i\mapsto k\colon i\mapsto\sigma. \end{aligned} \tag{9}$$

It is defined as a tuple containing an abstract list, namely,

$$d\colon := (\text{cons\_buf}\colon \text{list } Z). \tag{10}$$

The formal specifications of the three are shown in formulas (11) to (15):

$$\frac{d' = d[\text{cons\_buf}\longleftarrow\text{nil}]}{cb\_\text{init}(d) = d'}. \tag{11}$$

Not empty:

$$\frac{c :: tl = d.\text{cons\_buf}\_d' = d[\text{cons\_buf}\longleftarrow tl]}{cb\_\text{read}(d) = (d', c)}. \tag{12}$$

Empty:

$$\frac{\text{nil} = d.\text{cons\_buf}}{cb\_\text{read}(d) = (d', CB\_\text{EMPTY})}. \tag{13}$$

Normal write:

$$\frac{\text{length} < CB\_\text{SIZE}}{cb\_\text{write}(d, c) = d'}. \tag{14}$$

Overflow coverage:

$$x :: l = d.\text{cons\_buf}, \tag{15}$$

$$\text{length} = CB\_\text{SIZE}, \tag{16}$$

$$\frac{d' = d[\text{cons\_buf}\longleftarrow l + +[c]]}{cb\_\text{write}(d, c) = d'}. \tag{17}$$

The status and migration relationship of the command list is shown in Figure 6.

Correspondingly, the abstraction layer primitive is defined as the operation of the module function in the abstract state, as shown in equations 18 to 22.

Buf is not empty:

$$i = d.\text{rpos}\, i \neq d.wpos\, c = d.\text{cons\_buf\_conxrete}[i], \tag{18}$$

$$\frac{d' = d[\text{rpos}\longleftarrow (i + 1)\text{mod}CB\_\text{SIZE}]}{cb\_\text{read}(d) = (d', c)}. \tag{19}$$

It is empty:

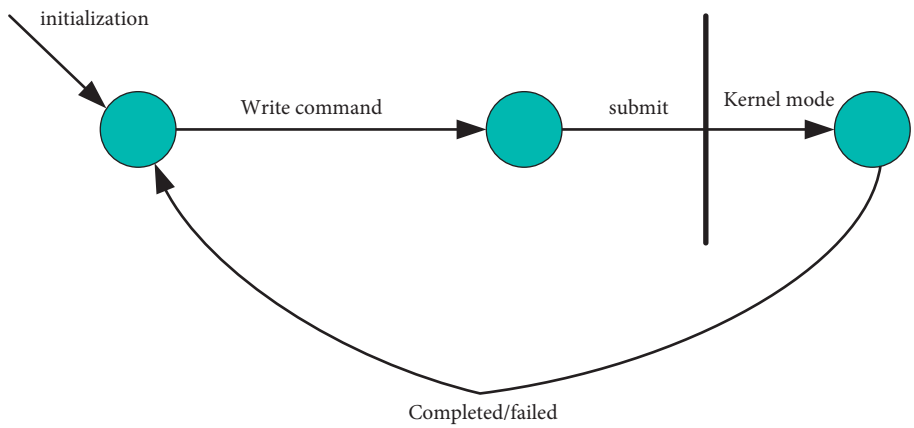

Figure 6: Command list status and migration relationship.

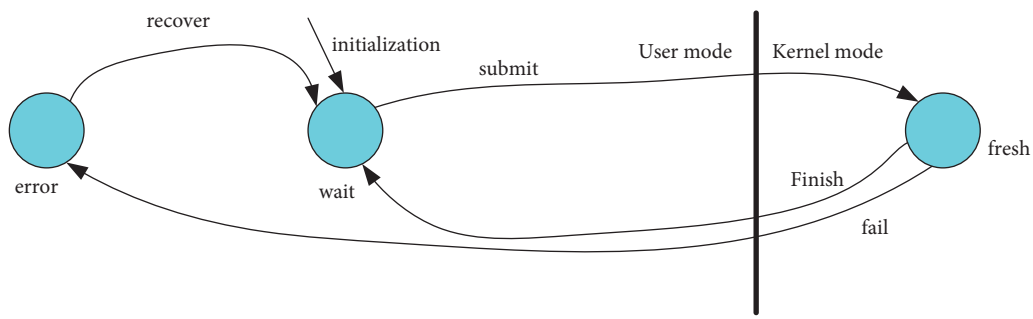

Figure 7: Status and its migration relationship in the status list.

$$\frac{d.\text{wpos} = d.\text{rpos}}{cb\_\text{read}(d) = (d', CB\_\text{EMPTY})}. \quad (20)$$

$$i = d.\text{wpos}\, i' = (i+1)\text{mod}CB\_\text{SIZE}\, d.\text{rpos} \neq i'. \quad (21)$$

$$\frac{\begin{gathered} b = d.\text{cons\_buf\_concrete}[i \mapsto c], \\ d' = d[\text{cons\_buf\_concrete} \longleftarrow b][\text{wpos} \longleftarrow i'] \end{gathered}}{cb\_\text{write}(d, c) = d'}. \quad (22)$$

Among them, for the mapping m, $m[i]$ is used to represent the reference to the i element as the key. The state in the state list and its migration relationship are shown in Figure 7.

Table 1: Customer credit evaluation indicators.

Primary indicator	Secondary indicator
Basic information	Age Gender Area Marital status Education
Occupational situation	Career status
Economic situation	Monthly income Real estate
Credit status	Historical credit history

1.4. Indicator Design. The bank customer default risk evaluation system based on multimedia technology is mainly to evaluate the credit risk of bank customers. According to China's current index system related to personal credit, customer information can be summarized into four aspects, namely, basic information, occupational status, economic status, and credit status [17]. Each aspect can be further subdivided into a total of four first-level indicators and nine second-level indicators. The specific evaluation indicators are shown in Table 1.

(1) Basic Information

Through the application form submitted by the customer, after verification, the customer's personal basic information is confirmed, and the bank provides indirect information for understanding the customer's repayment ability and willingness to repay. The basic information reflects the most basic personal situation of the customer and is characterized by easy access and easy verification, including age, gender, region, marital status, and education.

Age: it is segmented according to age group, including 23 years old, 24–30 years old, 31–40 years old, 41–50 years old, and 50 years old and above.

Gender: there are two types of men and women.

Region: according to economic conditions and regional characteristics, Hangzhou, Jiaxing, Jinhua, Shaoxing, and Huzhou in Zhejiang Province are in the first category, Wenzhou, Taizhou, and Yiwu are in the second category, and Cuisine, Lishui, and Zhoushan are in the third category.

Table 2: Virtual credit evaluation indicators.

Serial number	Virtual evaluation index	Meaning and remarks
1	Age	Whether age ≤23 (1: Yes; 0: No)
2		Whether age is 24~30 (1: Yes; 0: No)
3		Whether age 31~40 (1: Yes; 0: No)
4		Whether age 41~50 (1: Yes; 0: No)
5		Whether age ≥51 (1: Yes; 0: No)
6	Gender	Gender(1: Male; 0: Female)
7	Area	Whether it belongs to the first category (1: Yes; 0: No)
8		Whether it belongs to the second category (1: Yes; 0: No)
9	Marital status	Whether you are married and have children (1: Yes; 0: No)
10		Whether married or without children (1: Yes; 0: No)
11		Whether it is unmarried (1: Yes; 0: No)

Marital status: there are four types of children: married, children, married, unmarried, and others.

Education status: it is divided into graduate students and above, universities, junior colleges, technical secondary schools, and high schools, and other five categories.

(2) Occupational situation: personal occupational indicators can directly show the customer's income level and the industry and occupational stability of the work they are doing. It is an important indicator to examine the credit level of customers, including the nature of the unit, position, title, and working years.

(3) Economic situation: the personal income status of the customer, the housing situation, the assets, and the debt situation and the personal economic status indicators are the most direct indicators reflecting the customer's repayment ability, including monthly income, whether there is real estate, and personal total assets.

At present, there is no channel for measuring the total assets of individuals in China. This article only considers the monthly income and whether there are two indicators of real estate.

Monthly income: it includes less than 2,000 yuan, 2000–5000 yuan, 5000–10000 yuan, and more than 10,000 yuan, a total of four files.

(4) Credit status: the customer's personal credit loan records in the bank and the customer's loan record indicators reflect the customer's credit ethics in past credit loans. The credit status is mainly reflected in the historical credit record, which can be channeled by the People's Bank of China.

Historical credit records can be divided into two categories: good historical credit records and bad historical credit records.

Since a large number of evaluation indicators are qualitative indicators, this article adopts a large number of virtual evaluation indicators when setting evaluation indicators, and a total of 26 interpretation evaluation indicators are set for 9 secondary evaluation indicators [18]. See Tables 2 and 3 for details.

2. Design of Bank Customer Default Risk Management System under the Background of Internet Finance

2.1. Functional Requirements Analysis. The bank credit risk management system constructed in this article measures credit risk by guiding the customer's basic information, occupational status, economic status, and credit status and guiding the mode of credit risk management, starting from its own actual and business management needs, and in commercial bank credit. On the basis of the management system, the customer has been resegmented and improved. The risk management system needs to have the following three functions:

(1) *Risk Measurement Function.* The risk management system divides customers into different categories based on different customer conditions. According to different customer categories, the risk indicators of financial business are calculated. The specific risk indicators include default probability, default loss rate, and expected loss rate. By comparing the calculated values of risk indicators in different dimensions, the managers are instructed in different organizations and customers. The product or industry conducts scientific and reasonable loan placement, reduces loan risk indicators, and optimizes loan quality.

(2) *Query Function.* After the bank manager maintains the credit information through the electronic banking financial service maintenance page, the system can realize customer information, loan information, personal relationship, default record, bad record, loan recovery details, interest rates, and bank acceptance bills. The information of "ten small pieces," such as discount information and customer contribution, has wide coverage and a large amount of information.

(3) *Risk Warning Function.* The key to risk management is to detect and identify the source of risk, risk range, risk level and risk trend early, and issue corresponding risk warning signals. The purpose is to take precautionary measures against potential risks in

Table 3: Basic information of virtual credit individuals.

Serial number	Virtual evaluation index	Meaning and remarks
1	Education	Whether graduate or above (1: Yes; 0: No)
2		Whether university (1: Yes; 0: No)
3		Whether junior college (1: Yes; 0: No)
4		Whether secondary or high school (1: Yes; 0: No)
5		Whether junior high school and below (1: Yes; 0: No)
6	Income	Whether the monthly income is less than 2,000 yuan (1: Yes; 0: No)
7		Whether the monthly income is 2~5 thousand yuan (1: Yes; 0: No)
8		Whether the monthly income is 0.5~10,000 (1: Yes; 0: No)
9		Whether the monthly income is 10,000 yuan or more (1: Yes; 0: No)
10	Real estate	Whether the house has its own property rights (1: Yes; 0: No)
11		Is there a housing mortgage (1: Yes; 0: No)
12		Whether living with parents (1: Yes; 0: No)
13		Whether to rent a house (1: Yes; 0: No)
14		Whether the unit is allocated (1: Yes; 0: No)
15	Credit status	Credit bureau records (1: Bad; 0: No)

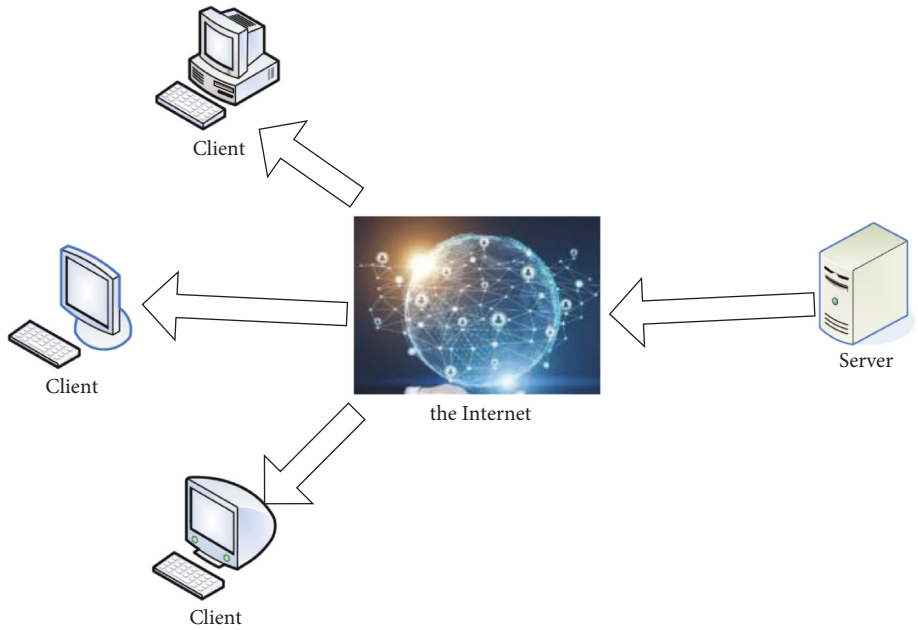

Figure 8: Schematic diagram of B/S structure.

advance according to the risk warning signals provided by the risk warning system so as to eliminate them in the bud. The system has set up three major early warning rules: large loan monitoring, macro early warning, and micro early warning. When the customer or loan information reaches the early warning condition, the system will give the loan manager an early warning prompt. The micro-warning needs to be managed by the administrator to select the "early warning disposal" method. After the early warning is processed, the early warning information is no longer displayed. This function moves the risk threshold forward and gives early warning of the loan-related risks, which is beneficial to the loan manager to take measures in advance, resolve risks, and ensure the safety of loans.

2.2. System Features

(1) The system adopts B/S mode, the interface is clear, the information query is accurate, flexible, convenient, and fast, and the data storage is safe and reliable. The structure of the B/S mode is shown in Figure 8.

(2) manages system user roles.

(3) ability to maintain a database and statistics of data through the network.

(4) Set different permission levels and open the corresponding permissions for the permission level.

(5) The system maximizes ease of installation, ease of maintenance, and ease of operation.

(6) The system is stable and reliable.

(7) System compatibility is good, and it will not affect the display effect when used under different browsers.

3. Realization of Bank Customer Default Risk Management System under the Background of Internet Finance

3.1. System Architecture Design. The full name of the B/S architecture is browser/server, which is the browser/server architecture. Its characteristics only realize a very small number of transaction logic in the front end, and the main transaction logic is implemented on the server side. The browser client, the network application server, and the database end constitute a three-tier architecture of view, control, and data access. MVC exists in the desktop program at the beginning, *M* refers to the business model, *V* refers to the user interface, and *C* refers to the controller. The purpose of using MVC is to separate the implementation code of *M* and *V* so that the same program can use different representations. The B/S architecture does not require an additional installation package, just a web browser.

In the B/S architecture, the web browser is only responsible for the display logic, and the transaction logic is placed on the web application server side, thus avoiding the huge fat client and reducing the pressure on the client. Because the client contains very little logic, it is also known as the thin client [19, 20].

Advantages of B/S mode software are as follows:

(1) It can be operated in any place where there is a computer with Internet access without installing special software.

(2) The B/S architecture can be directly placed on the local area network or the Internet, and the purpose of multiclient access is achieved through certain permission control, and the interaction is strong.

(3) B/S architecture does not need to upgrade multiple clients or upgrade the server

Combined with the many advantages and practical needs of the B/S structure design, the bank credit risk management system is designed to adapt to the B/S mode. B/S model includes a user presentation layer, business logic layer, and data access layer. The three-tier architecture is described in detail as follows:

The user presentation layer: the program interface that the user sees runs on the client computer and completes the information released through the browser. The user sends a service request to the server by operating the service menu and displays the return result of the server, and the user presentation layer does not perform actual data processing and communicates only the user's instructions to the business logic layer.

Business logic layer: after receiving the processing instruction of the presentation layer, the business logic layer transfers the program file to complete the business processing, generates a data processing request to the data access layer, generates a user interface for the data returned by the database, and feeds the data back to the user computer browser.

Data access layer: the database management system and the database file are deployed on the database server. The data access layer responds to the data processing request sent by the program file, completes the operation of writing, reading, and deleting data to the database, and feeds back the data processing result. Give the business logic layer.

3.2. Related Technology Introduction

3.2.1. Apache Shiro Technology. Apache Shiro is a powerful and easy-to-use Java security framework that provides authentication, authorization, encryption, and session management [21]. In addition to the above features, Shiro also offers a lot of extensions:

(1) Web Support: it provides some common functions for web applications.

(2) Caching: cache can make the application run more efficiently.

(3) Concurrency: it includes multithread-related functions.

(4) Testing: it helps us to test related functions.

(5) Run As: it allows the user to assume another user identity (if allowed), sometimes useful in managing scripts.

3.2.2. jQuery Technology. jQuery, as its name suggests, is JavaScript and Query, which is a library for assisting JavaScript development. It is a lightweight JS library that is compatible with CSS3 and is compatible with a variety of browsers (IE6.0+, FF1.5+, Safari2.0+, Opera 9.0+). jQuery makes it easier for users to work with HTML (an application under the standard universal markup language), implement animation effects, and provide AJAX interaction for websites. The jQuery documentation is also very comprehensive, and it is very detailed for various applications, and there are many mature plug-ins to choose from. jQuery can keep the user's HTML content and HTML page code separated, thus greatly improving the user experience.

jQuery is a free, open source and uses the MIT license. Developers can use jQuery's syntax design to make it easier to create animation effects, manipulate document objects, use AJAX, and more. jQuery also provides an API for developers to write plug-ins. Developers use modular methods to easily develop powerful static or dynamic web pages [22, 23].

3.2.3. MyEclipse Technology. MyEclipse is a software development platform that is currently used more. It is a powerful enterprise-level integrated development environment developed on the basis of Eclipse and its own plug-in.

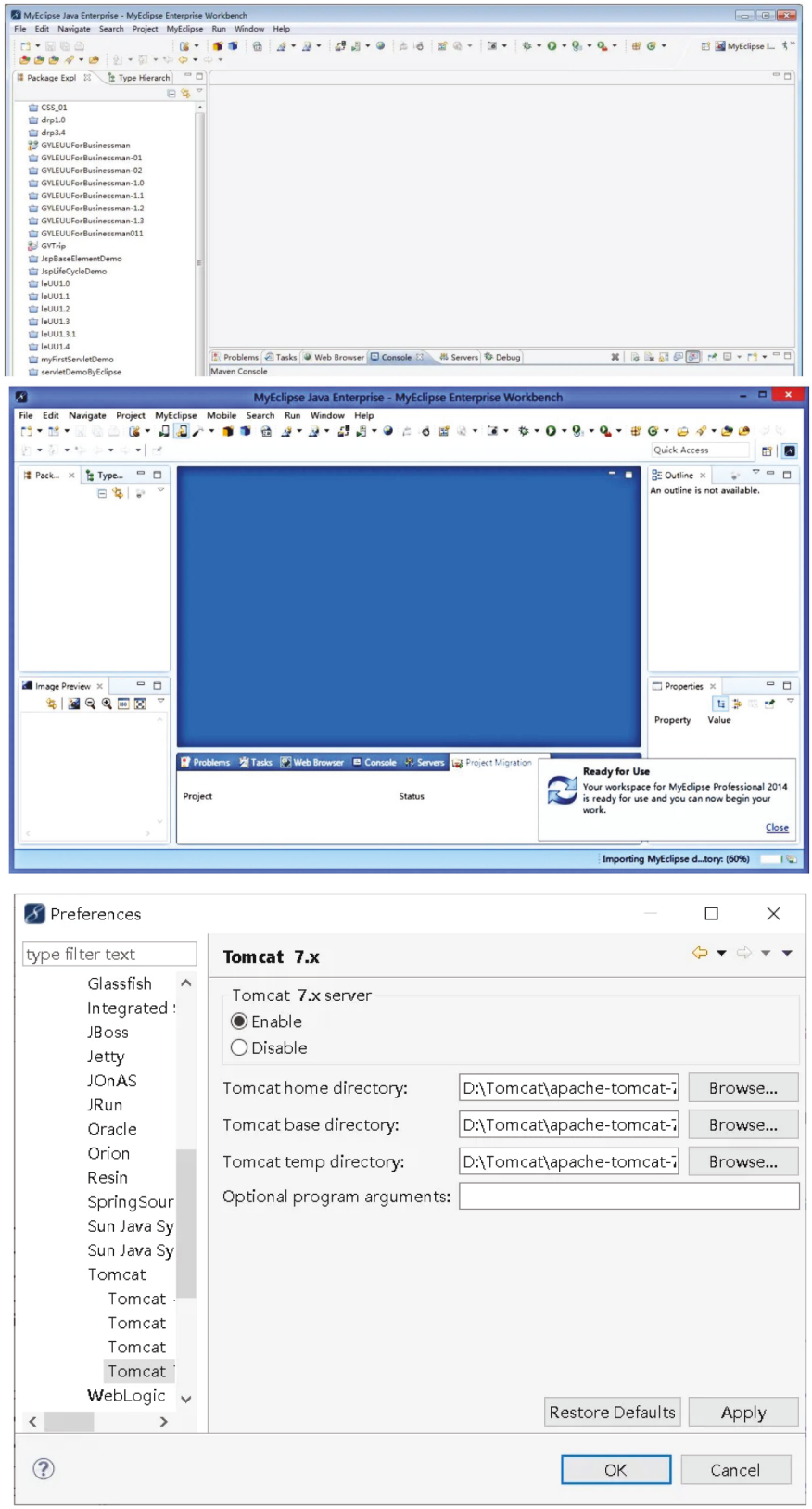

Figure 9: Several operation interfaces of MyEclipse (http://alturl.com/juviv and http://alturl.com/4ktif,http://alturl.com/o9kjh).

Table 4: Customer basic information table.

Name	Primary key	Field name	Data type	Length
Name	Yes	Customer name	VARCHAR	8
Gender	No	Gender	VARCHAR	8
Age	No	Age	InB	50
Education	No	Education	VARCHAR	50
Employer	No	Company	VARCHAR	20
Level	No	Customer level	VARCHAR	10

Table 5: Transaction information table.

Name	Primary key	Field name	Data type	Length
Transaction flow number	Yes	Exchanged	VARCHAR	50
Account number	No	Account number	VARCHAR	50
Transaction content	No	Exchange content	VARCHAR	50
Transaction hour	No	Exchange time	Date time	8
The transaction amount	No	Exchange amount	Float	8
Trading status	No	Exchange status	VARCHAR	50

Table 6: Customer credit record form.

Name	Primary key	Field name	Data type	Length
Customer number	Yes	CUSTID	VARCHAR2	20
Bad record subject	No	SUBJECT	VARCHAR2	2
Bad record date	No	RECORDDATE	VARCHAR2	10
Bad record description	No	BADDESCRIPTION	VARCHAR2	400
City code	No	INSTCITYCODE	VARCHAR2	6
Business number	No	BMNO	VARCHAR2	20
Reason for breach of contract	No	REASON	VARCHAR2	3
Default start date	No	STR_DATE	VARCHAR2	8
Default end date	No	END_DATE	VARCHAR2	8

It is mainly used for the development of Java, JavaEE, and mobile applications. Several common MyEclipse operation interfaces are shown in Figure 9.

MyEclipse includes complete code writing, code debugging, and other functions, which can perfectly support many programming languages, supported for language and framework development, such as PHP, Python, Vue, Angular, React, Java, and JavaEE. It is a widely used development platform.

3.3. Database Design. The system uses a database to integrate customer information and can strongly support customer credit in commercial banking.

Risk management is the customer credit risk management system through the database to correlate and screen the various data, thereby forming a measure of the customer's basic profile, customer credit records, and credit risk. The database is the foundation of the customer's credit risk management system.

Through the analysis and design of the customer credit risk management system, the data in Tables 4–6 in the system is obtained:

The customer risk management system monitors the customer information by querying and setting parameters according to the collected basic information of the customer, business information, and credit records and compares the calculated values of the risk indicators of different dimensions and forms risk warning information to guide the banking network business. The account manager conducts scientific and rational financial operations for different clients, reduces network credit risk indicators, and optimizes credit quality.

3.4. Management System Implementation Renderings. Style consistency should be maintained in the interface design. Consistency includes the use of standard controls, as well as the consistency of the color and font of the visual elements in the interface, and the consistency of the informational content.

After entering the bank customer credit management system website, the login interface is displayed first. The login interface designed in this article is shown in Figure 10. If the customer enters the system for the first time, they need to complete the registration before they can log in. When logging in, the customer needs to fill in the username and password to enter the system.

After logging in to the system, you will be taken to the home page interface. The homepage interface is shown in Figure 11. As can be seen from the figure, the credit management system of this article includes the workbench subsystem, credit evaluation subsystem, customer data query subsystem, and risk early warning subsystem. The

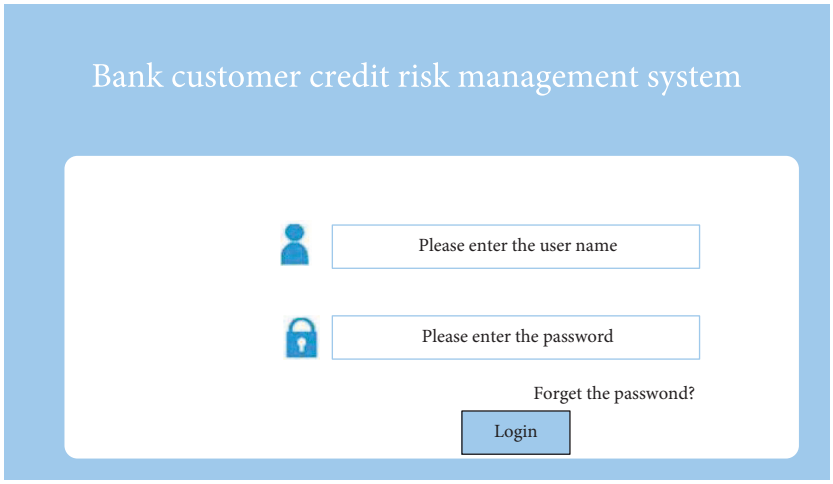

Figure 10: User login interface.

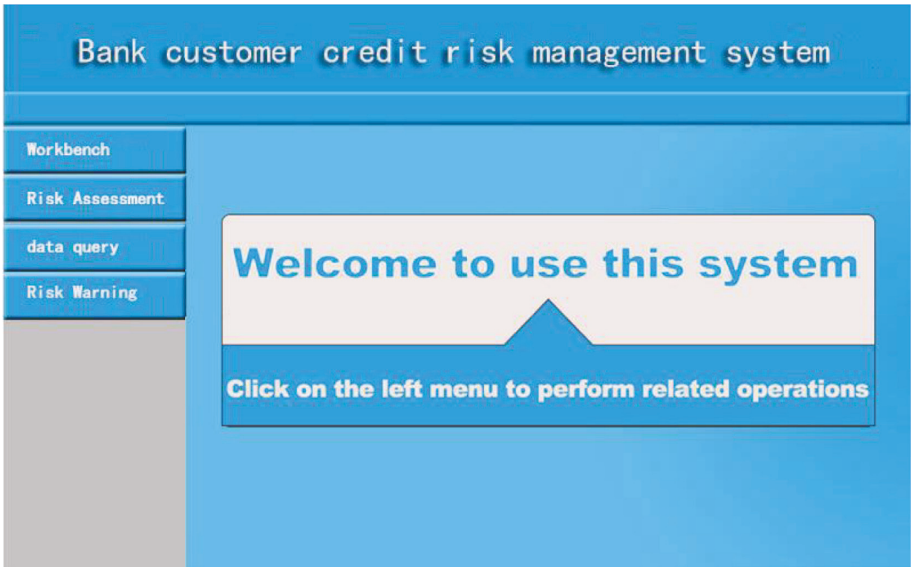

Figure 11: Home page interface.

First level index	Second level index	Standard score	Score
Basic information	age	7	
	Gender	10	
	Area	7	
	Education	10	
Economic situation	monthly income	6	
	Real estate	9	
credit status	Bad record	10	
	Default record	10	

Figure 12: Credit risk assessment subsystem interface.

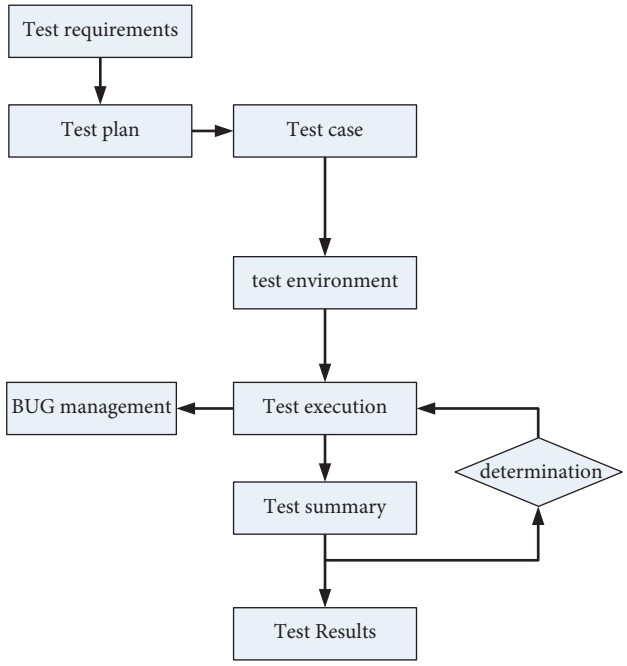

Figure 13: Test process diagram.

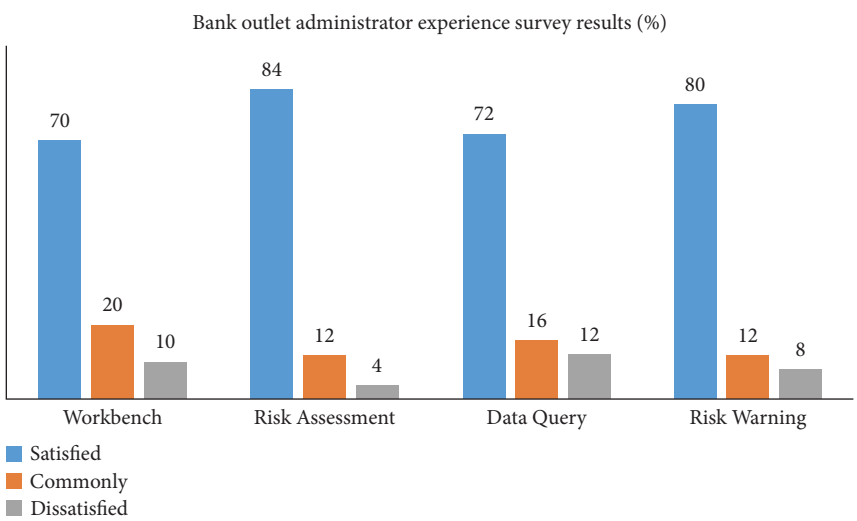

Figure 14: Bank outlet administrator experience survey results.

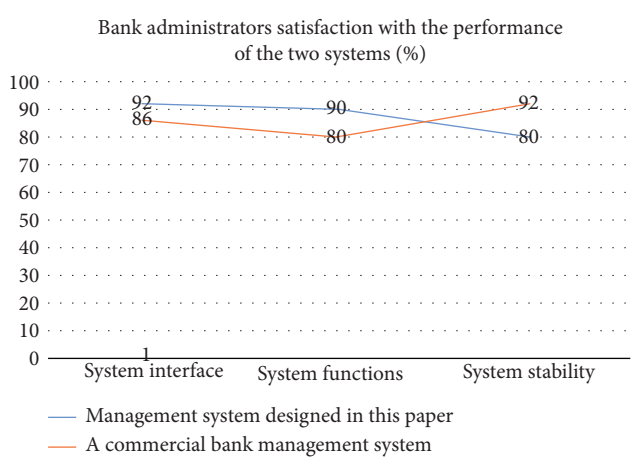

Figure 15: Bank administrators' satisfaction with the performance of the two systems.

workbench subsystem covers customer basic information and customer financial business information; the credit evaluation subsystem can conduct customer default risk evaluation according to customer evaluation indicators; the customer data query subsystem facilitates account managers to query customer bad records and default records—risk warning. The system performs a warning of poor default according to the risk evaluation parameters.

This article introduces the credit risk assessment subsystem. In the evaluation subsystem, the customer default risk can be evaluated. As shown in Figure 12, the figure shows the first-level indicator and the second-level indicator. The bank administrator can score the indicator. After the completion, the system can calculate the risk evaluation results and save the evaluation results.

4. System Testing and Analysis

In order to test the function of the designed bank customer credit risk management system, this article builds a small test system. The purpose is to verify whether the risk assessment index design is reasonable, whether the designated function is implemented, whether it can automatically list the customers beyond the warning risk threshold, and whether it can get the correct results for various query conditions. Through testing to find out whether the expected function is achieved, the advantages of this articke credit management system are analyzed. The test process is shown in Figure 13.

In the process of system experience survey for bank administrators, 50 bank administrators compare their satisfaction with the performance of the two management systems. The test indicators are the interface, function, and stability of the management system. The comparison results are shown in Figures 14 and 15. According to the analysis of the comparison results, the test version of the credit management system designed in this article is more satisfactory than the credit management system of a commercial bank in terms of system interface and system function, but the satisfaction of the stability of the system is slightly lower. Because the system is a test version, the system stability module should be strengthened in the subsequent debugging.

5. Conclusions

With the rapid development of Internet technology, commercial banks have rapidly integrated with Internet technology, forming Internet finance represented by new products and services such as e-banking, mobile banking, and e-commerce. Internet finance has certain risks. The purpose of this article is to explore the risk of bank customer default based on embedded microprocessor wireless communication in the context of Internet finance. We expect to solve the problem of data management in the development of the embedded module, which is more convenient for customer credit management. Although the bank customer default risk under Internet finance is explored in this article, there are still shortcomings: the distribution of objects in the experiment of the article is narrower and still does not represent a broad scope despite the classification.

Data Availability

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

Conflicts of Interest

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Research Article

Application and Development of Computer-Aided Design Methods in Clothing Design under the Environment of Internet of Things

Yuan Li

College of Architecture and Art Design, Xi'an Peihua University, Xi'an 710125, Shaanxi, China

Correspondence should be addressed to Yuan Li; 150185@peihua.edu.cn

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With the rapid development of Internet technology, its computer-assisted functions are also rapidly improving and the changes in computer functions have brought great convenience to all the aspects of life. In the clothing industry, the application of computer-aided technology and the production of sample clothing and the rendering of clothing have been introduced. This method greatly shortens the cycle of making and designing clothes and also greatly reduces the workload of the staff. The main content of this article is to explore the influence of the application of CAD on clothing design. Starting from the actual needs of digitally designed clothing, the formation model of clothing and the basis of digital application are derived. In this article, computer-aided technique is used as a modeling development tool and its related functions are introduced through methods such as multideformation modeling and NURBS surface modeling. According to the functional characteristics of the computer-aided dye applicator, it is concluded that the dyeing effect of the model is also diverse, and then the virtual display effect of the digital three-dimensional model of the clothing is obtained. Through the digital design, the clothing design can not only meet the functional requirements but its performance also meets the reliability, stability, and safety. The experimental results show that with the increase of W, the area of the two-dimensional unfolding film gradually increases and the amplitude becomes smaller and finally stabilizes at 0.1263.

1. Introduction

In recent years, with the rise and development of computer technology, especially the Internet technology, the clothing industry has gradually brought computers into the clothing production and other links because of the actual needs, such as the pursuit of efficiency and the need for the realization of new technology. China is the world's largest textile producer and exporter, and the textile and garment industry is the pillar industry of China's export earnings [1–3]. After China's accession to the WTO, the biggest challenge faced by the textile and garment industry is innovation, ability, and brand competition. According to the existing research, the value of innovation and brand is increasing in world trade. The profit space of the world is shrinking year by year only relying on labor resources. Only by improving the quality and innovation ability, enhancing the development and research ability, and speeding up the information construction can the competitiveness of Chinese textile and garment enterprises be comprehensively improved [4–6]. Therefore, in the information age, clothing, like other industries, is undergoing profound reform, from traditional paper and pen drawing to computer-aided design with various software packages, which requires not only the combination of abstract art and practical technology but also the interaction of rational technical conditions and emotional sensibility, which is the future trend of clothing [7]. The characteristic of CAD is to realize the development and innovation of fashion design based on science and technology and to extend its design concept widely, so as to drive its development process [8–10]. This is the development value of CAD for fashion design and is also an important embodiment of the continuous progress of design concepts driven by the development of science and technology

[11, 12]. In this way, we can break through the shackles of traditional fashion design and achieve the ultimate goal of innovative development of fashion design [13–15]. The continuous development and progress of the times put forward new requirements for the application of science and technology, and the position of computer-aided design in fashion design and development is also crucial, which is the key to promote the scientific development of fashion design thinking and concept formation [16]. This is also the main embodiment of the concept of scientificity and integration and one of the advantages of its application [17, 18].

Taking the typical Tibetan clothing as an example, Guo Chen proposed a virtual reality interactive teaching mode for clothing design education. These processes include the use of 2D clothing CAD software to display traditional clothing structures, the use of virtual reality technology to make clothing models, and the use of a unity game development platform for interaction. This virtual reality interactive teaching method expands the traditional clothing design teaching method and traditional clothing design development research [19]. Webster and Ed discussed how computer-aided drawing and computer-aided engineering programs can be used to simplify the design of television systems and facilities. The hardware design, basic system composition, typical CAD workstation software, and system design application of the system are discussed. This paper summarizes the design of facility building and TV system, including whether to use CAD/CAE software or not. Finally, taking the overall design of the mobile remote production vehicle as an example, the application of CAD/CAE is mainly introduced [20]. It can be found that their research pays more attention to the scale of garment production and the improvement of efficiency, but there is no improvement in design. Therefore, it is meaningful to audit fashion design based on computer-aided design.

This paper follows the development trend of the industry and applies modern information technology to the digital forming technology of garment three-dimensional modeling earlier in China, so as to make the research level of this direction keep pace with the advanced level of foreign countries. Based on the theory of garment engineering and modern information technology, the three-dimensional digital stereo forming technology and the concept of computer graphics are effectively combined, which embodies the innovation of this paper: (1) pay attention to the technical innovation of digital design relying on the theory of technology; (2) innovation of garment production method: pay attention to the transformation of traditional garment design method by modern digital technology.

2. Proposed Method

2.1. Application of CAD Technology in Garment Design

2.1.1. Application of Clothing Style. Fashion designers can use the rich and colorful brush library in the computer painting function, such as Photoshop to create an image of the human body model and appropriate clothing styles, and after designing the latest styles, they can directly select the best models and actions from the previous human body model database or design more appropriate styles based on the body shape of models. When designing clothing styles, designers can use "undo, restore, eraser" and other function keys to make style modification more flexible. In addition, the designer can make full use of the layer function to modify some patterns of the clothing and all the design schemes can be stored in the computer, without the need for manual redrawing. Scanners, hand-painted boards, and other professional tools can also put the hand-painted lines highlighting the designer's unique personal style into the computer, so the use of computer-aided design means can perfectly integrate art and technology. For the texture of clothing, it can be polished on editing software such as PS to achieve elegant, comfortable, and other effects.

2.1.2. Application of Color and Fabric Filling. Painting in a certain area of clothing is a very time-consuming and labor-consuming work, but the use of computer-aided design technology can easily solve this problem. It can not only transform between color block and color but also complete the problem of "traditional hand painting rework" with a click of the mouse. This efficient way of work is incomparable to hand painting. Generally speaking, when designers draw clothes by hand, they often need to use a variety of tools, such as watercolor pen, brush, marker pen, color lead, and drawing board. These tools are not only very expensive but also consume surprisingly fast. But for Photoshop and Auto-CAD, it is just a problem of a scanner or a sketchpad. It can change the color, flow, shape, transparency, and so on of the brush anytime and anywhere. If the designer wants to borrow a pattern on a shaped garment, the hand painter needs to do manual drawing work, but the scanner in the computer drawing software can copy it to the computer with one key. In the later modification process, the designer can adjust the saturation, color temperature, contrast, etc. according to the actual situation, so that the color of the garment becomes more gorgeous and dazzling. Due to the development of modern science and technology, there is almost no color difference between the color of electronic equipment and the color in real design, so there is no need to worry too much about the color difference.

2.1.3. The Application of Computer-Aided Clothing Design. The intelligent drawing tools and new dynamic guides provided by CORELDRAW software can fully reduce the difficulty of user manipulation, allow users to create the size and position of objects more easily and accurately, reduce click steps, and save design time. Take a casual women's top as an example. In terms of style design, designers can use CORELDRAW software to open the pattern library of women's wear and select the most appropriate pattern to match, so as to complete the basic design drawings. After that, the designer can import more styles of collar, cuffs, and other combinations, until the selection of excellent style drawings, and complete the details of the design. Then, in the process of clothing fabric design, the designer can import the best pattern in the fabric library with the pattern filling tool

provided by the software and determine the appropriate proportion of fabric size, inclination, and tiling. The last part is the material simulation, which uses the filter and layer functions of the drawing software to show the performance effect of the two-dimensional fabric image on the clothing style and then simulate a variety of fine textures.

2.2. Computer-Aided Digital Clothing Modeling Method

2.2.1. Computer-Aided Technique. 3D modeling, one of the computer-aided technologies, is a modeling software package based on Win NT or Win 98 platform. It is one of the most widely used 3D modeling software on personal PCs. With the continuous introduction of new versions, the versions after 3.0 have significantly improved in terms of workflow mode, custom interface, renderer, and modeling technology, consolidating the position of 3 ds Max on personal PCs. 3D modeling in fashion design can clearly and stereoscopically display the details of clothing, and the regulation of details is very delicate, which is conducive to the style innovation in fashion design.

There are two main methods for 3 ds Max modeling, a geometric model-based method and an image-based rendering method. Clothing modeling mainly adopts methods based on geometric models. When carrying out clothing digital modeling, we must follow a principle, under the premise of ensuring the visual effect of the clothing three-dimensional modeling, we try to use a simpler model and try to use a parametric construction method to draw. At the same time, in the process of creating a clothing model, the model must first be segmented, which is conducive to operation or observation in the virtual reality system.

The establishment of the clothing model will directly affect the quality of the entire virtual reality system. Compared with two-dimensional modeling systems, three-dimensional digital modeling can more completely represent the geometric three-dimensional modeling of objects in the computer, which provides a certain foundation for the expression of virtual clothing. 3D digital modeling technology is the core technology of 3D digitilization. There are many 3D modeling methods, including surface modeling, solid modeling, parameter modeling, feature modeling, and component modeling, mainly polygon modeling, sliced NURBS surface modeling, and patch modeling.

2.2.2. Three-Dimensional Modeling of Clothing. Generally speaking, building a model can be done by several methods, but there are advantages and disadvantages. The modeling of clothing belongs to complex hybrid modeling, which designs the developable surface of clothing from the perspective of set. According to different parts of the human body, the clothing worn on the human body will change according to the dynamic changes of the human body. Among them, the different effects on human body parts are divided into dynamic parts and static parts. For the dynamic part of human body, the NURBS surface modeling method based on a slice is used; in this way, the model can take into account the stretching of the human body and the deformation of the human body, thus dynamically adjusting the model size; for the static part, polygon modeling and patch modeling method can be used to describe the qualitative part more quickly. Therefore, aiming at the digital modeling mode of human body clothing, this section proposes to use traditional CAD software, use the VR system and 3 ds Max to develop interactive object model, and use a hybrid modeling mode based on polygon modeling, patch modeling, and NURBS surface modeling to realize the visualization of mixed modeling of clothing.

The clothing model is obtained by the method of three-dimensional modeling, and the means of three-dimensional modeling will inevitably affect the operability of 3D printing clothing. The modeling visualization effects of polygon modeling are shown in Figure 1, patch modeling are shown in Figure 2, and NURBS modeling are shown in Figure 3.

The basic idea of garment 3D modeling is to form the garment basic body with polygon modeling and perform local processing with patch modeling and NURBS modeling. Comprehensive modeling can reduce working time and improve modeling efficiency. 3D printing is a kind of rapid prototyping technology, also known as additive manufacturing. It is a technology based on digital model files, using adhesive materials such as powdered metal or plastic to construct objects by printing layer by layer. 3D modeling can provide 3D printing models.

3. Experiments

In this paper, 3D modeling software is used to design clothing, the hardware platform is Windows, and the data processing is analyzed by SPSS. The details are as follows.

3.1. Database Design

3.1.1. Database Entity E-R Diagram

(1) User Information. It is mainly used to store user's characteristic information, such as age, occupation, and education background. The user information attribute diagram is shown in Figure 4.

(2) Human Characteristics Information Data. It is mainly used to store human body feature information, including human height, skin, gender, head, body part, leg, and other human body feature information. The attribute map of human body's characteristic information is shown in Figure 5.

(3) Clothing Category Information. It mainly includes clothing category information, such as coat, vest, and other information. The Category attribute diagram of clothing is shown in Figure 6.

(4) Style Information. Style information table is mainly used to store the detailed information of clothing style, such as style, collar type, pocket, and board type. Its structure is shown in Table 1.

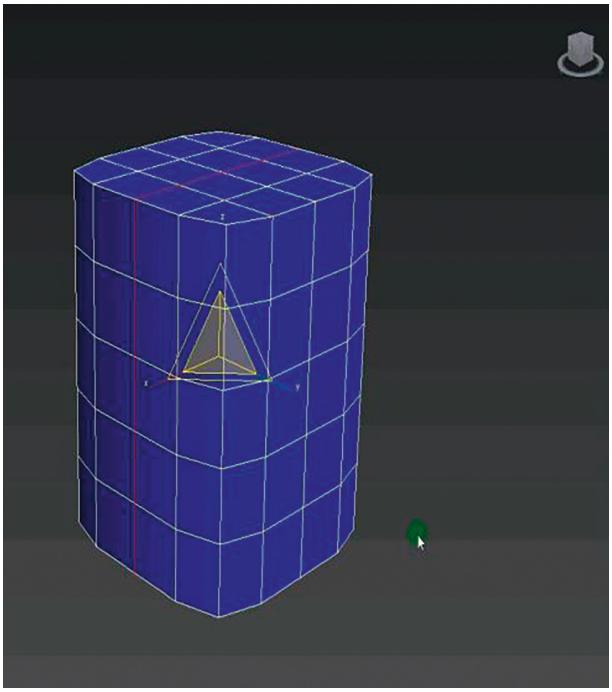

Figure 1: Polygon modeling.

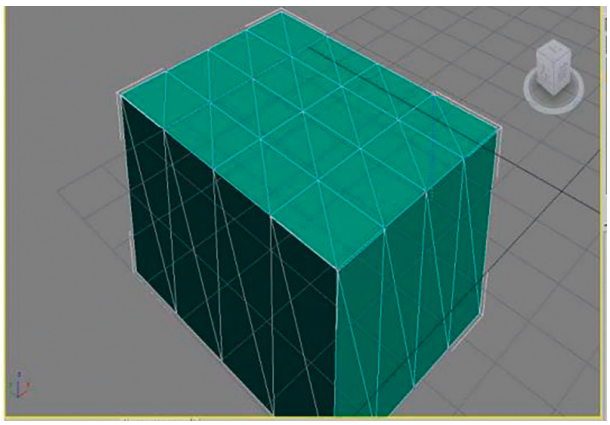

Figure 2: Patch modeling.

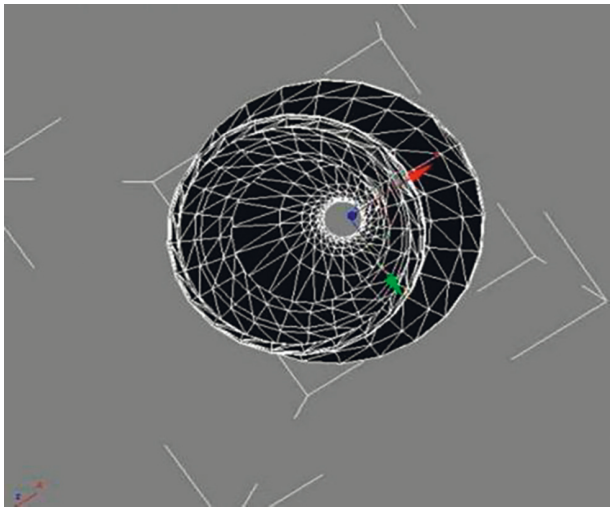

Figure 3: NURBS modeling.

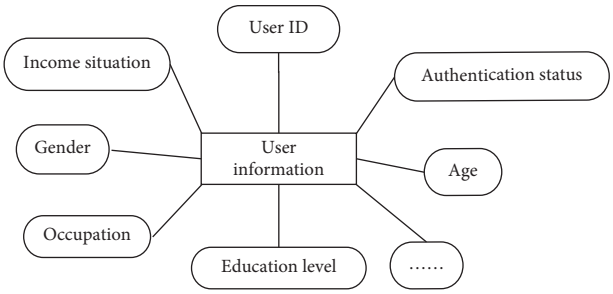

Figure 4: User information attribute.

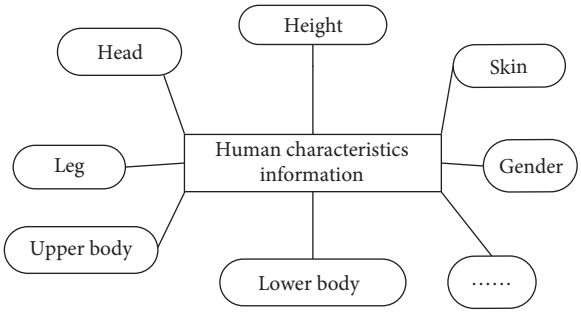

Figure 5: User-related data.

3.2. Software Testing

3.2.1. Test Method. Black-box testing focuses on the external structure of the program, regardless of the internal logical structure, and mainly tests the software interface and software functions. For each subfunction of the black-box test system, we input the corresponding test case on the website page to test each function, select the principle of test case, and design the test case according to the parameters that the user needs to input on the page.

3.2.2. Test Items

(1) Performance Test. Its purpose is to test the overall performance of the integrated system.

Test content: after integrating each module into the framework, we run the system and test the overall operation performance of the system.

(2) Function Test. Its purpose is to confirm the correct execution of each functional module of the system.

Test content: character modeling test and clothing design test are performed.

4. Discussion

4.1. Character Modeling. Enter software and create a new interface named "women's upper body modeling" file, with suffix .Max, to carry out women's upper body polygon

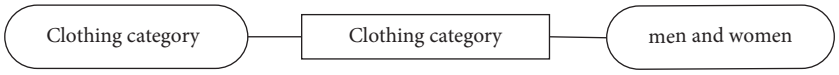

Figure 6: Clothing category attribute.

Table 1: Style information.

Field name	Data type and length	Allow space
StyleID	Int	No
StyleNO	Varchar (20)	No
CategoryID	Int	No
StyleType	Varchar (20)	No
Collar	Varchar (20)	No
Sleeve	Varchar (20)	No
Pocket	Varchar (20)	No
Button	Varchar (20)	No
Slit	Varchar (20)	No
Plate	Varchar (20)	No
StyleNote	Nvarchar (200)	Yes

modeling. Open a simulation scene of the object's female body, create a plane object, and display its front view as shown in Figure 7.

Select the white part of the plane in the figure, and right-click and select the "Edit polygon" option to turn it into an editable poly object. In the geometry classification menu, select the composite object, pick up the related ontology, and adjust and edit the polygon point to draw in the side view and front view. First, divide the plane object into 6 pieces vertically and 5 pieces horizontally, and move the poly point and the connected plane to move in three dimensions. In the drawing process, switch the front view and side view to ensure that the contour line cannot cross the body; finally, the ideal body shape of the female body wrapped in left anterior film is obtained. Considering the elasticity of the human body in motion, a certain degree of elasticity on the positive and negative sides is added to the built model, so that the model fits the human body better.

The function test of the character modeling part is shown in Table 2.

4.2. Clothing Modeling

4.2.1. Upper Garment Modeling. In the process of clothing modeling, we first use polygon patch modeling method to define the boundary of clothing, construct a model similar to the shape of the object clothing, and then use the NURBS surface modeling method to process the deformation as shown in Figure 8.

Finally, according to the characteristics of the object female body and the requirements of the object fashion design, taking the above principles into account, the basic model of the upper body object female clothing frame editing view is shown in Figure 9.

4.2.2. Change of the Garment Area. The line chart of the change of the two-dimensional garment area with the increase of W is shown in Figure 10.

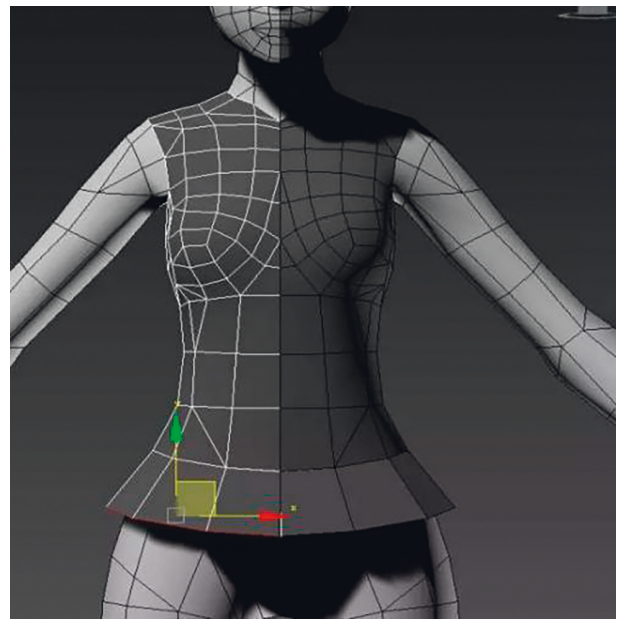

Figure 7: Plane object based on polygon modeling.

With the increase of W, the area of two-dimensional unfolded garment increased gradually and the range became smaller and smaller and finally tended to stabilize at 0.1263. As for the area of three-dimensional clothing, because the area of three-dimensional clothing is the sum of small triangular patches, the number and size of small triangular patches have been determined when generating three-dimensional clothing, so its value is unchanged.

4.3. Virtual Display Renderings. The upper body and the lower body of the object women's clothing are modeled separately. The upper body modeling mainly uses the polygon modeling method of the function module covering the object. The method of polygon patch modeling and NURBS surface modeling is mainly used to draw wire frame for the lower skirt. The upper and lower modeling clothing pieces are sewn to get the virtual display effect of the object women's clothing. By means of conduction, the existing pattern of clothing fabric is attached to the modeled clothing block and the design scheme of the object women's clothing is shown in Figure 11. Although there are some errors in the transmission process, it is also an inevitable error in the design. It can be adjusted by hand painting later.

In the process of stitching the front and back pieces, there will be the situation that the combination position of the front and back pieces does not match, which shows that there will be position error in the drawing process. Because the subject is manual drawing, the error of the geometric

Table 2: Test table of character modeling part.

Test title	Character modeling function test	
Test purpose	Test whether the character modeling function can operate normally	
Test object	General user	
Test name	Test steps	Test results
Character creation	Input parameters for persona modeling, view operation results, and generate persona model	The results are correct
Head portrait selection	Select the person's head image, select the hair style, and view the operation results	The results are correct
Face adjustment	Adjust the face of the character model slightly	Testing the facial function of the character model can accurately adjust to the target value
Persona save	Test to save the generated character model	The generated persona model is saved without exception
Conclusion	After the test, the expected effect is achieved and the operation is normal	

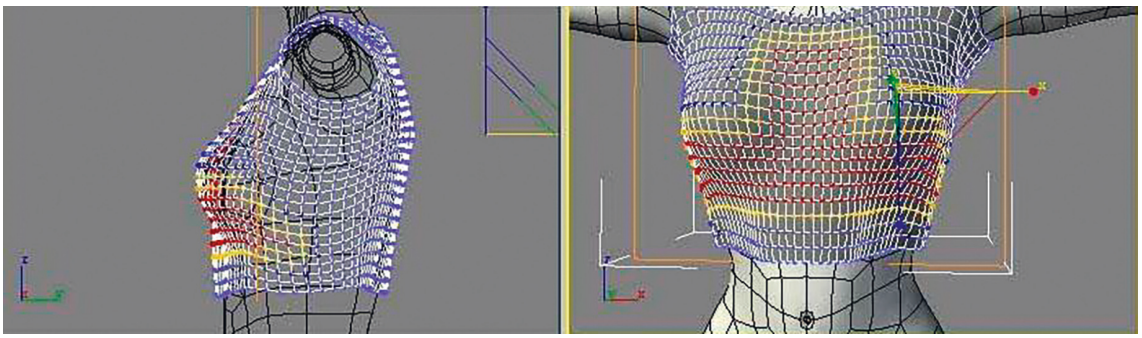

Figure 8: Converting object clothing to editable poly.

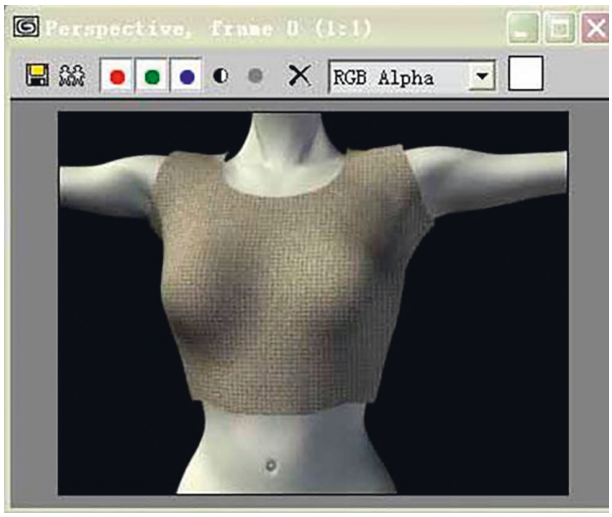

Figure 9: Object dress model in wire frame edit view.

model caused by manual is inevitable, which affects the accuracy of the clothing model. Due to the lack of molding materials and equipment and other subjective reasons, the subject did not transform the virtual display effect map into the final solid model but only realized the parametric modification and innovative design of the model. However, with the progress of science and technology, after the model parameters are set, the production of entities will be simpler. And, the parameters can be optimized for the existing model.

In order to properly increase the reality of the object's three-dimensional clothing, based on the functional characteristics of the 3 ds Max dye applicator, the dye effect of the model is varied, including the lighting, clothing material, and pattern forming effect. For the beauty of the clothing model,

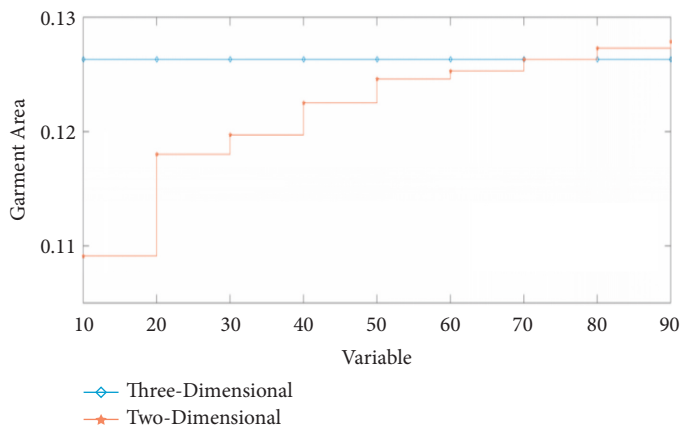

Figure 10: 3-D and 2-D unfolded area line chart.

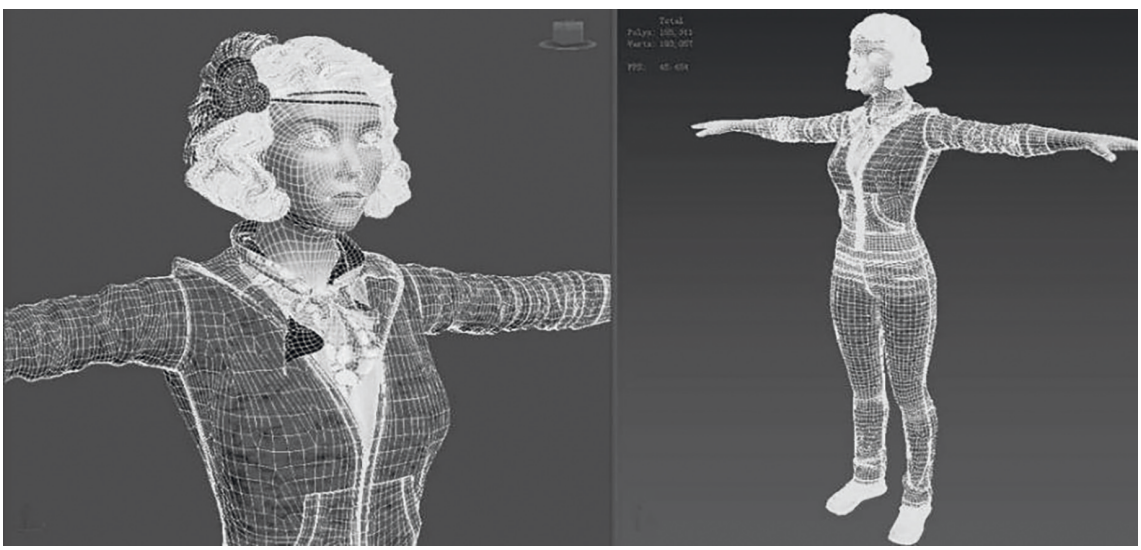

Figure 11: Design scheme of object women's clothing.

the virtual display effect of the digital three-dimensional clothing model of women's clothing is shown in Figure 12.

The test table of some functions of clothing design is shown in Table 3.

Through the test of the above system, it shows that the virtual system of clothing design meets the functional requirements, with reliability, stability, and safety, and meets the design requirements.

Figure 12: Virtual display effect of the female digital clothing model.

Table 3: Relevant function test table of clothing design part.

Test title	System test of clothing design	
Test purpose	Test whether the relevant functions of clothing design can operate normally	
Test object	General user, administrator	
Test name	Test steps	Test results
Garment cutting	In the clothing cutting part, key points can be set correctly, clothing pieces can be cut correctly, and operation results can be viewed	All operations can be completed normally and the results are correct
Garment splicing	The garment splicing part can move the garment piece correctly, arrange the garment piece, and check the operation results	All operations can be completed normally and the results are correct
Clothing preservation	Users can save, modify, delete, and share the finished garment items and view the operation results	All operations can be completed normally and the results are correct
Conclusion	The test results meet the expected results, and the module functions normally	

5. Conclusions

Relying on digital 3D design is an important difficulty in the field of manufacturing research. Using this technology to turn designers' related inspirations into reality is a technological innovation based on the combination of digital model design and computer graphics. The combination of digital technology and clothing design is based on the research of a number of key core technologies, including digital human body modeling and computer-aided body measurement, as well as clothing design research. As for the auxiliary system of fashion design, this paper makes use of 3D modeling, which not only strengthens the innovation but also strengthens the artistic sense of fashion design, making it more fashionable and more in line with the needs of the public.

This article first introduces the relevant computer-assisted human body technology theory, and then, based on modern digital technology, it expounds the basic concepts and content methods of the technology theory. This method uses digital clothing design that relies on mathematical foundations and ergonomics. On the basis of theoretical knowledge, combined with the editing of 3D digital model technology and computer graphics, we prepare for the abovementioned practical steps.

This article mainly describes the digital practice process of computer-aided clothing design, using digital design tools

to introduce computer-aided digital technology processing into clothing design, including body measurement, design modeling, three-dimensional modeling, and physical modeling. The overall process of proportion design and so on, correspondingly produced corresponding three-dimensional clothing effects and physical models.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Design of Intelligent Fire Alarm System Based on Multisensor Data Fusion

Mengjie Li [1,2] and Chao Liu [1]

[1] *School of Safety Science and Engineering, Xi'an University of Science and Technology, Xi'an 710000, Shaanxi, China*
[2] *Fire and Rescue Brigade of Chang'an District, Xi'an Fire and Rescue Detachment, Xi'an 710000, Shaanxi, China*

Correspondence should be addressed to Mengjie Li; 19120089002@stu.xust.edu.cn

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With the rapid development of today's alarm system, the market demand for an intelligent alarm system is increasing. The traditional alarm system needs technological progress/advancement to meet the needs of the society, and the alarm system needs to develop in the direction of integration, both digitally and professionally. The intelligent fire warning systems using integrated multisensor digital data integration techniques can obtain the data information of the measured object more accurately and comprehensively from multiple dimensions, to improve the system alarm accuracy. This article aims to study the application of multisensor data fusion technology in intelligent fire alarm systems. For the issue of multivalued bias of the ID3 algorithm, this paper proposes the CAC_ID3 algorithm. Through the C4.5, the CART and the ID3 algorithm are compared and analyzed on the $F1$ value and the correct rate of the multisensor intelligent fire alarm data is set, and experiments show that the correct rate and $F1$ value of the CAC_ID3 algorithm are 1, which are higher than the other three algorithms. This shows that the CAC_ID3 algorithm has good classification effect and superior performance.

1. Introduction

With the growth of the community, all walks of life have generally entered the stage of informatization. However, with the diversification and complexity of information, it has become extremely difficult to collect information. In the actual large industrial field, the data collected by a single sensor are relatively simple, which is not conducive to analyzing the data and making decisions. Therefore, the fusion of multiple sensors is required by the market and is one of the prerequisites for leading various fields to a higher/advanced level. The integrated multiple sensor solutions were mainly used in the military at first, and its main work was to collect the military information of the blue party or locate the blue party's position. In a fire alarm system, the occurrence of fire is a comprehensive phenomenon which is accompanied by changes in light, smoke, temperature rise, radiation and gas concentration, and in order to detect and capture these information, various fire sensors need to be used. The multisensor data fusion solution can enhance decision-making precision and productivity. This technology has been applied extensively in all walks of life and has achieved good results by greatly improving decision-making capabilities.

The development of social science and technology has brought earth-shaking changes to people's lives. In people's daily life, multisensor data fusion algorithms are found in every corner of their life. The alarm system based on a multisensor can combine the information of each sensor through the network to form a tight alarm system. In the multisensor alarm system, each sensor can monitor any abnormal information in real-time [1, 2]. As long as there is an abnormal situation, the sensor will send an alarm indication, so that the alarm system can be analyzed through the multisensor fusion algorithm in time. When the analysis result gives an alarm command, the system will immediately send the alarm information to the relevant staff, so that the staff can immediately take corresponding protective

measures. Therefore, the development of an intelligent fire alarm system based on the multisensor data fusion not only makes the corresponding security work accurate and efficient but also makes the alarm system intelligent, so that the relevant security personnel do not need to do a lot of repetitive patrol work. At the same time, the management efficiency of the alarm system is improved. Through the multisensor data fusion technology, the temperature and humidity of the environment can be effectively monitored, and the dangers such as floods and fires can be well prevented. Therefore, exploring the alarm system of the data fusion technology not only promotes the intelligent development of an alarm system but also provides a reference for the use and management of various alarm systems of the same type and provides a reference for future academic research in the field of multiple sensors digital integration method.

Recently, a number of professionals and scholars focused primarily on the study of the multisensor data fusion. However, it does not pay enough attention to the fire alarm system. If we only talk about the advantages of data fusion in the development of fire alarm systems, security systems, and other systems, there will be a lack of research and exploration of specific concepts. Thus, in this article, a smart fire alarm is designed based on a multisensor digital integration approach to promote the development of multisensor digital integration approach and offer future information for the relevant studies on fire alarm systems.

2. Related Work

The multiple sensors message integration method is also known as the multiple sensors digital integration method. Although the growth of the multiple sensors message integration method started relatively late, it has developed rapidly. Hwang K H considered a multisensor data fusion system using load cells and vision sensors when developing a flounder classifier for fish management in aquaculture systems. In a single-sensor measurement approach, each sensor has its own shortcomings. The load cell showed high performance in adult fish measurements, but fry measurements were significantly affected by the water weight. The vision sensors show high performance in fry measurements, but the fish movement can affect the accurate measurements in adults. Therefore, the effects of water weight disturbance and motion disturbance are addressed using a data fusion algorithm, and its performance is evaluated by comparing the single-sensor measurement results and the multisensor data fusion results [3]. To protect the seniors against falling, a live falling forecast system is fitted to the wrist known as the wearable intelligent device, which can promptly trigger an alert to minimize unintentional damage resulting from falls. Currently, most algorithms built on individual sensor dates do not provide an exact representation of fall states, while fall recognition methods integrated with multiple sensor data can increase the flexibility and precision of forecasts. Pan D devised a fell recognition system based on multiple sensors digital integration. The three characteristic parameters representing the human acceleration and posture changes were extracted using a digital integration method, and the efficiency of the multisensor digital integration algorithm was verified [4]. In the purpose of improving the practical value of multimedia browser web, it is essential to integrate space data and antimedia messages in antimedia browser web. Therefore, the method of spatial data and information fusion in multisensor networks cannot express the local change of the local dynamics in great detail, which causes the error of large fusion of data and multisensor messages. Zhang J presents a way to fuse the space data and multisensor networks in the multisensor systems using the superfluous data. The test outcomes indicate that this approach can decrease the power expenditure of converging space data and multimedia messages in multimedia sensor webs, and the integration precision is also good [5]. Yao W focused on how to optimize the energy consumption of LEDs. Firstly, based on the energy optimization algorithm (EOA), combined with the characteristics of the algorithm's collective operation and information integration, an LED energy consumption optimization algorithm control based on the multisensor data fusion is proposed. In order to ensure that the energy consumption optimization at this time does not lead to an increase in computational complexity, the proposed algorithm is improved in real-time. The optimal processing angle (OPA) is introduced to realize the efficient transformation of the energy consumption problem of multisensor coordination behavior, and the equivalent linear programming problem is obtained. Finally, a multisensor LED energy consumption optimization control is realized [6]. At the same time, policy discussions in Europe have resulted in the introduction of green economics principles to strike a favorable break between the sustainability of farming and profits by making it more efficient. This attitude poses small businesses with legal issues in terms of technical and financial difficulties. Decision support systems (DSSs) can be an efficacious answer to surmount these constraints; therefore, Aiello G proposes a multisensor solution for decision fusion. This approach is an easily used and low-cost solution to reducing the use of agricultural fertilizers and fertilizers on covered crops [7]. The use of simultaneous phasor measures in wide-area surveillance applications allows real-time grid access to system operations. Intentional injection of the wrong synchrophasor measured values, nevertheless, can lead to unsuitable control actions that impair the safety and stability of the power transmission network. To solve this problem, Khalid H M presents a model prediction based on multisensor track-level fusion. The results indicate that the TFMP proposed by him can precisely extract swing variables from pollution measures in the existence of multiple system disruptions and stochastic data infusion [8]. In summary, multisensor data fusion technology has been applied to various fields, including real-time prediction systems and industrial internet of things while countries around the world are working on upgrading security measures; however, in the development of intelligent fire alarm systems, there are not many research studies on the use of the multisensor data integration method, so more in-depth exploration is needed.

3. Theories Related to the Design of Intelligent Fire Alarm System Based on Multisensor Data Fusion

3.1. Theory of Multisensor Data Fusion. The multiple sensor digital integration technology is a technology about the comprehensive processing of the multiple resource information [9]. It intelligently synthesizes the multisource information from the system to generate more accurate and complete estimates and judgments than a single source of information, thereby improving the reliability of the early fire warning system and effectively reducing the false alarm rate [10, 11]. The advantages of the multiple sensor message integration method over the information obtained by a single sensor are summarized as follows: firstly, the accuracy of the system is greatly improved. The information collected by each sensor can be confirmed more accurately, reducing the probability of false positives and false negatives. Secondly, it improves the judgment of the system and reduces the alarm time. The fusion analysis of the information collected by the sensor greatly reduces the data processing time. Thirdly, the robustness and reliability of the system are enhanced. When the signal has a transmission delay, distortion, and so on, the multisensor shows good robustness. Moreover, the information between the multiple sensors can be exchanged and transmitted, thus increasing the fault tolerance rate of the system. Fourthly, it enhances the accuracy of the system. Through the proper fusion of multisource information, the ambiguity and uncertainty of the system are greatly reduced. Fifthly, it reduces the overall cost of the system. With the advancement of technology, the cost of building a multisensor system is often much lower than that of building a single-sensor system [12].

Data fusion is a fundamental function that exists in both humans and other biological systems [13]. Humans can use the information detected by the various organs of the body and prior knowledge to synthesize instinctively. The multiple sensors digital integration refers to the fusion of the data collected by the multiple homogeneous or heterogeneous sensors at different locations on the same detection target, thereby weakening some redundant data information that may exist between the sensors. The complementarity of the information between each sensor in time or space is used to reduce the ambiguity caused by a single sensor in the acquisition process and to increase the accuracy of system decision-making. Based on different types of measured objects and according to the actual needs of the measured objects, the level of data fusion is also different [14, 15]. In actual implementation, the level of multisensor digital integration can be categorized into 3 levels as follows: decision-level integration, feature-level integration, and data-level integration.

Decision-level fusion first needs to complete a preliminary decision result of the local decision on the measured object and then proceed to the next step of digital integration processing. The next step is to monitor whether the data collected by each sensor involved in the digital integration come from the same measured object, that is, to associate the preliminary decision results of each sensor [16, 17]. Finally, the decision results of all sensors on the same measured object are fused to obtain the final result. Decision-level fusion belongs to the upper-layer fusion method, and the schematic diagram of the decision-level fusion is shown in Figure 1.

The information extracted by feature-level integration is the complete message of the object under test which is to extract the features from the bottom-level data collected by each sensor in the system and then classify and fuse the extracted multisensor feature information [18, 19]; it belongs to the fusion of the middle level. Figure 2 displays a diagram of feature-level fusion.

In the data-level integration, each individual sensor needs to perform data fusion on the data messages gathered from the identical target and then process the fused data, such as classification and recognition, data estimation, and feature extraction. Finally, the final data of the tested target are obtained [20, 21]. Data-level fusion is to directly fuse and analyze the raw signal data captured by the transducers without preprocessing, which is the lowest-level data fusion method. Figure 3 shows a schematic diagram of data-level fusion.

3.2. Multisensor Data Fusion Algorithm. The multiple sensors digital integration intelligent algorithm is applied in most multisensor systems, and the intelligent fire alarm system of this paper mainly uses the multisensor data fusion intelligent algorithm for fusion decision-making. The following is an introduction to the commonly used fuzzy logic and artificial intelligence-related algorithms.

In the multiple sensors digital integration system, the fuzzy logic inference method is actually equivalent to a kind of multivalued logic. It assigns a real value from 0 to 1 to each logical proposition and inference operator to indicate its credibility in the fusion process, which is also called a certainty factor in some places. Then, the multivalued logical reasoning method is used, and various operators are used to combine the data and information collected by each sensor, so as to achieve the purpose of multiple sensors digital integration. Figure 4 shows the principle diagram of fuzzy logic reasoning [22, 23].

Artificial intelligence algorithms are a method of data fusion handling techniques method produced by simulating the human head. It uses a large number of simple processing units that interact and connect with each other in a certain way to process data information. The core of AI deals with computer science and engineering. Using machine learning, machines can perform the same kind of learned events as humankind. They can not only constantly obtain fresh learning but also enhance that knowing and refine that knowledge progressively and methodically. A number of generalized approaches to inductive training are available in machines for machine learning, and decision trees are one of them, which can be used for data classification and system construction [24, 25]. Based on the advantages and disadvantages of the two, it is found that in general, the fire alarm system can achieve the expected effect only through the

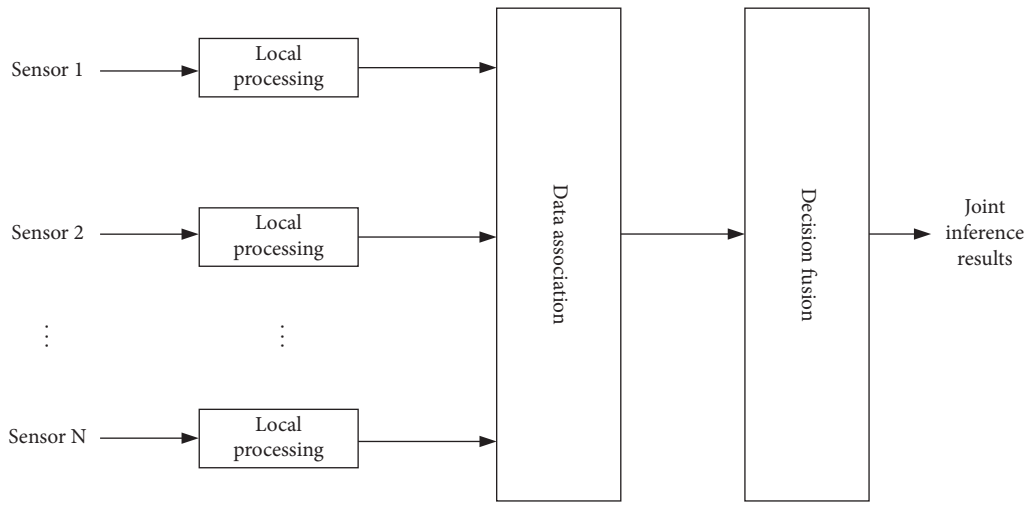

Figure 1: Schematic diagram of the decision-level fusion.

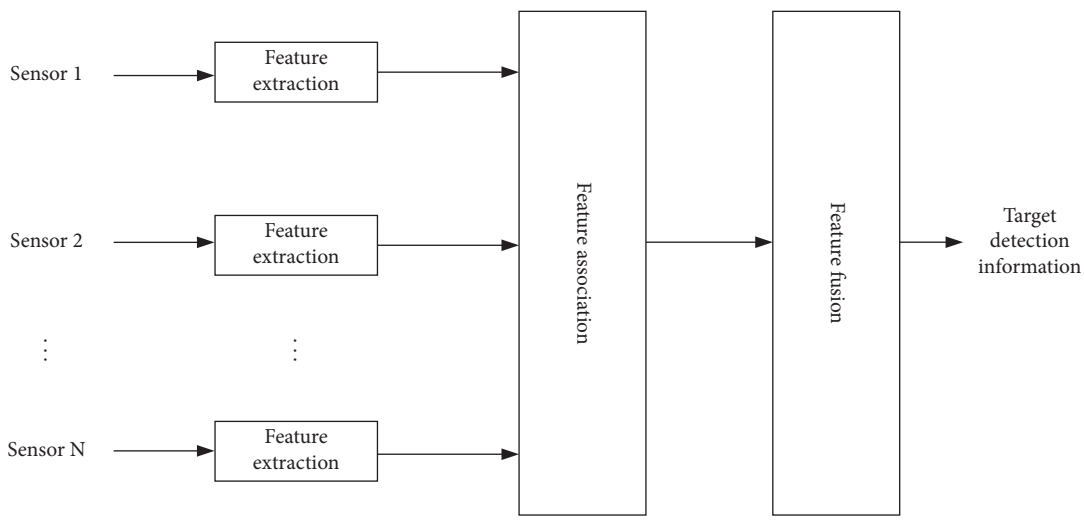

Figure 2: Schematic diagram of the feature-level fusion.

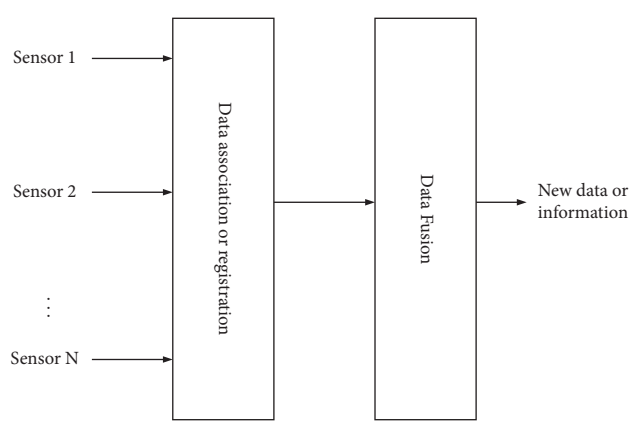

Figure 3: A schematic diagram of the data-level fusion.

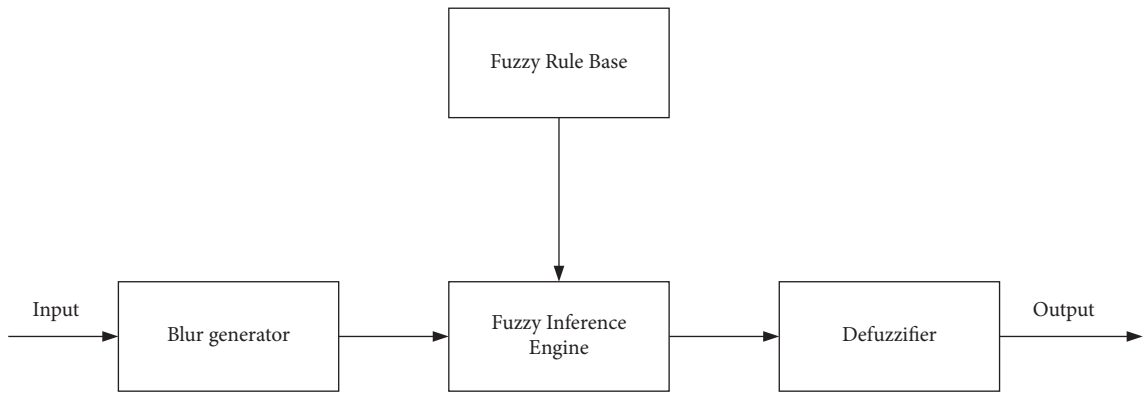

Figure 4: A schematic diagram of the fuzzy logic system.

decision tree algorithm, so the policy-making tree algorithm in machine learning is selected to control the fire alarm system.

3.3. Different Decision Tree Algorithms

3.3.1. ID3 Algorithm. For the issue that the ID3 method tends to have more attributes, this paper proposes the CAC_ID3 algorithm, which is an extended algorithm built on the ID3 method. And the algorithm is applied to the multisensor intelligent fire alarm system. The algorithm adjusts the information gain by introducing the attribute confidence and correlation function ratio and improves the classification accuracy.

The ID3 algorithm takes the properties with message benefits as knots and builds various branching for the goal of decision-making tree formation. The idea of the ID3 algorithm is to first consider all instances as the rooting knots of the decision-making tree, calculate the message degree of all properties based on their entropy using information-theoretic methods, and then select the properties based on the message degree. The tree is further split through the attribute value to establish branch nodes. Then, each branch node is regarded as the root node, and this process is repeated until the last branch node belongs to the same category, thus constructing a decision tree. The calculation formula of the ID3 algorithm is shown in the following formula:

$$I(F,B) = -\frac{F}{F+B}\log\frac{F}{F+B} - \frac{B}{F+B}\log\frac{B}{F+B},$$
$$I(A) = \sum_{i=0}^{v}\frac{f_i+b_i}{F+B}I(f_I,b_i), \tag{1}$$
$$I(f_i,b_i) = -\frac{f_i}{f_i+b_i}\log\frac{f_i}{f_i+b_i} - \frac{b_i}{f_i+b_i}\log\frac{b_i}{f_i+b_i},$$

where R means a vector space; F represents the large positive and negative sample level in vector space R; B represents a small positive and negative example level in the vector space R; f_i stands for the amount of positive examples included in the subset R_i; and b_i stands for the amount of counterexamples included in the subset R_i.

The information gain rooted at attribute A is as follows:

$$\text{Gain}(A) = I(F,B) - I(A). \tag{2}$$

The CAC_ID3 algorithm introduces attribute correlation and confidence and uses a new method to calculate the information gain, which effectively weakens the multivalue bias in the ID3 algorithm so that the classifying precision of the decision-making trees becomes higher. The formulation is shown in equations (3) and (4).

The confidence of the attribute A is expressed as follows:

$$0\angle\lambda(A)\angle 1,$$
$$I'(A) = (1-\lambda(A))\sum_{i=0}^{v}\left(\frac{f_i+b_i}{F+B}I(f_i,b_i)\right), \tag{3}$$

$$\text{CAC}(A) = \frac{\sum_{i=1}^{n} x_{i1}/x_{i1}+x_{i2}}{n}, \tag{4}$$

where $x_{ij}(j=1,2)$ means that the dataset S takes the i-th value in the attribute A; the decision attribute C takes the j-th value of the sample total; and n represents the number of value types of the attribute A.

Among them, the usage of formula (4) is as follows:

$$\text{CAC}(\text{RFID}_d) = \frac{x_{11}/x_{11}+x_{12}+x_{21}/x_{21}+x_{22}}{n}, \tag{5}$$

where x_{11} indicates the total number of samples whose intrusion value is "Yes" when the attribute " *RFI D* detection" is "Yes" and x_{12} represents the total number of samples whose intrusion value is "No" when the attribute " *RFI D* detection" is "Yes."

Among them, n is the number of value types detected by the attribute *RFI D*; here, $n = 2$.

$$W(A) = \frac{CAC(A)}{\sum_{k=1}^{i} CAC(k)},$$
$$\text{Gain}' = (I(F,B) - I'(A))W(A), \tag{6}$$

where i represents the quantity of attributes in the database; W stands for the weight of every attribute association; and Gain' represents the new information gain.

3.3.2. CAC_ID3 Algorithm. The algorithm CAC_ID3 obtains the recalculated information gain Gain′, and Gain′ is employed to build new decision-making trees. In this writing, decision-making trees construction test is carried out through Table 1 (softball decision table), and the attribute confidence of each attribute of the dataset in Table 1 is set as $\lambda(\text{outlook}) = 0.1$, $\lambda(\text{temperature}) = 0.3$, $\lambda(\text{humidity}) = 0.5$, and $\lambda(\text{wind}) = 0.3$.

By calculating the informational benefit of every property from Table 1, the final decision tree can be obtained. Figures 5 and 6 are the decision trees constructed by the ID3 and the CAC_ID3 algorithm, respectively. From Figures 5 and 6, the CAC_ID3 algorithm can well solve the shortcomings of the multivalue bias of the ID3 algorithm.

3.3.3. C4.5 Algorithm. C4.5 algorithm is an enhanced version of the decision tree algorithm based on the ID3 algorithm. The algorithm uses the information gain rate instead of the information gain degree to select attributes, which can complete the discrete processing of the continuous attributes and can increase the processing ability of the continuous data. And before the decision tree is established, the tree is prepruned, and if there are problems with the data, they can be dealt within time. There is no need to wait for the tree to be pruned after it is built, which greatly improves the efficiency of the algorithm. The calculation formula of this algorithm is shown in the formula.

$$P(C_j) = \frac{|C_j|}{|T|} = \text{freq}(C_j, T),$$
$$P(v_i) = \frac{|T_i|}{|T|}, V = v_i, \tag{7}$$
$$P(C_j|v_j) = \frac{|C_{jv}|}{|T_i|},$$

where T represents the dataset and $\{C_1, C_2, \ldots C_k\}$ represents the set of categories in the dataset T.

The category information entropy is calculated as follows:

$$\text{Info}(C) = -\sum_j P(C_j)\lg P(C_j),$$
$$\text{Info}(C) = -\sum_{j=1}^{k} \frac{\text{freq}(C_j, T)}{|T|}\lg\frac{\text{freq}(C_j, T)}{|T|} = \text{Info}(T). \tag{8}$$

The class conditional entropy is calculated as follows:

$$\text{Info}\left(\frac{C}{V}\right) = -\sum_j P(v_j)\sum_i P\left(\frac{C_j}{v_j}\right)\lg P\left(\frac{C_j}{v_i}\right),$$
$$\text{Info}\left(\frac{C}{V}\right) = -\sum_{i=1}^{n}\frac{|T_i|}{|v_i|}\text{Info}(T_i) = \text{Info}(T), \tag{9}$$

Table 1: Softball decision table.

Numbering	Outlook	Humidity	Wind	Temperature	Activity
1	Sunny	High	Strong	Hot	No
2	Overcast	High	Weak	Hot	Yes
3	Rain	Normal	Strong	Cool	No
4	Overcast	High	Strong	Mild	Yes
5	Sunny	Normal	Strong	Mild	Yes
6	Rain	Normal	Weak	Mild	Yes

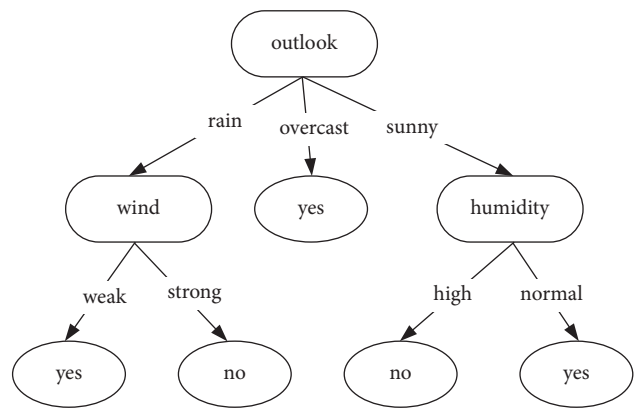

Figure 5: Decision tree constructed by the ID3 algorithm.

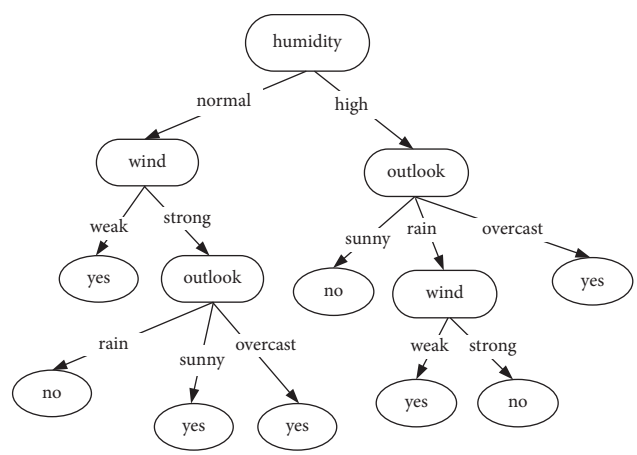

Figure 6: Decision tree constructed by the CAC_ID3 algorithm.

where V represents an attribute in the dataset T and $\{v_1, v_2, \ldots v_n\}$ means that the attribute V has n values that do not overlap with each other.

The informational benefit is as follows:

$$I(C, V) = H(C) - H\left(\frac{C}{V}\right)$$
$$= \text{Info}(T) - \text{Info}_v(T) = \text{gain}(v). \tag{10}$$

Informative entropy of attributes v is as follows:

Table 2: Dataset description.

Serial number	Dataset name	Totality of instances	Amount of attributes	Amount of class labels	With or without missing values
1	Car	1473	5	13	N/A
2	Krkopt	20020	10	2	No
3	Nursery	28056	6	17	No
4	Tic-tac-toe	210300	24	3	N/A

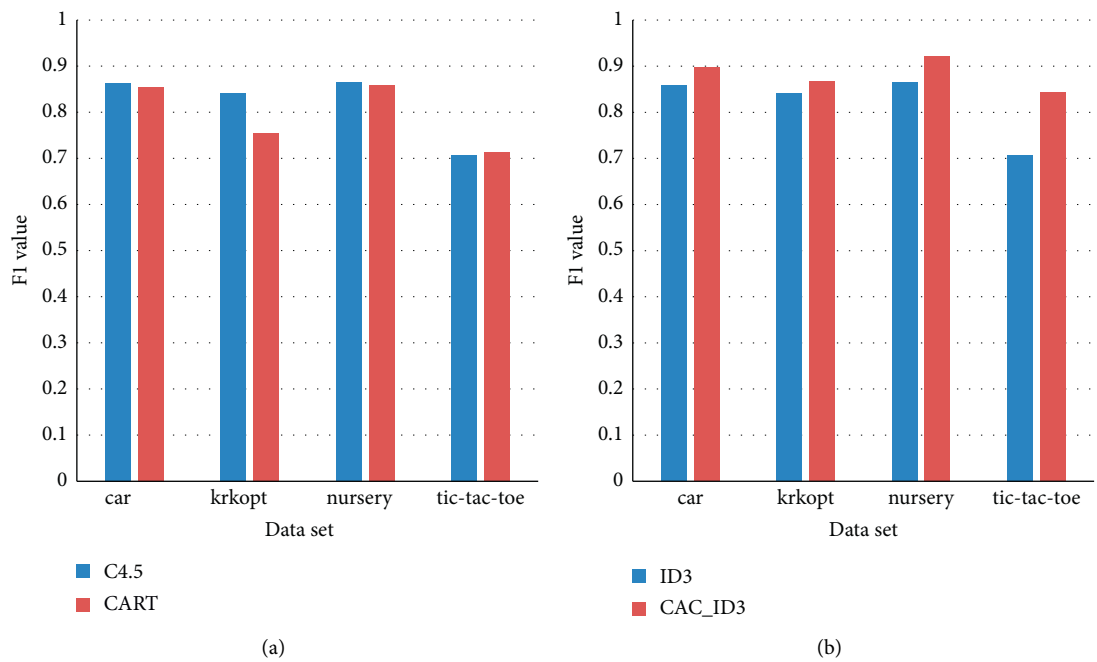

Figure 7: $F1$ values of the four algorithms in the four datasets. (a) $F1$ values of the C4.5 algorithm and the CART algorithm in the four datasets. (b) $F1$ values of the ID3 algorithm and the CAC_ID3 algorithm in the four datasets.

$$\begin{aligned}\text{Info}(V) &= -\sum_{i} P(v_i)\lg P(v_i)\\ &= -\sum_{i=1}^{n}\frac{|T_i|}{|T|}\lg\frac{|T_i|}{|T|} = \text{split\_Info}(v).\end{aligned} \tag{11}$$

The information gain rate is as follows:

$$\text{gain\_ration}(v) = \frac{I(C,V)}{H(V)} = \frac{\text{gain}(v)}{\text{split\_Info}(v)}, \tag{12}$$

where $\{T_1, T_2, \ldots T\}$ represents the n subsets into which the dataset T is divided; v_i represents the value of all instances in the subset T_i; $|T_i|$ represents the number of examples in the dataset T; and $|C_j| = \text{freq}(C_j, T)$ represents the number of instances of C_j.

3.3.4. CART Algorithm. The full name of the algorithm CART is classification and regression tree. It employs a binary reciprocal partitioning technique to split the present example set into two subset samples so that each non-leaf node generated has two branches. The decision-making tree produced by the CART algorithm is a binary tree with a straightforward construction. There are two basic ideas for the classification tree method of the algorithm CART: the first method is to construct a tree by recursively dividing the training samples into the independent variable spaces and the second is to prune the classification tree with a subset of the validation data, that is, the decision tree.

The article further verifies the capability of the algorithm by a comparative study of the four algorithms: *CAC_I D3* algorithm, *I D3* algorithm, *C4.5* algorithm, and CART algorithm. The first is $F-$measure, and the second is the correct rate. The calculation formulas of the two performance evaluation indicators are shown in the formulas. The empirical dataset is the one in UCI, which is shown in Table 2.where P means accuracy; R means recall rate; and β indicates parameters.

$$\begin{aligned}F_\beta &= -\frac{(\beta^2+1)PR}{\beta^2 P + R},\\ \text{accuracy} &= \frac{(\text{TP}+\text{TN})}{(\text{P}+\text{N})}.\end{aligned} \tag{13}$$

As can be observed in Figure 7, in the four sets of datasets, the $F1$ result of the CAC_ID3 algorithm is the best. In the tic-tac-toe dataset, the C4.5, the CART, and the ID3 algorithms are similar. The $F1$ values of the three algorithms are all around 0.71, while the $F1$ value of the CAC_ID3

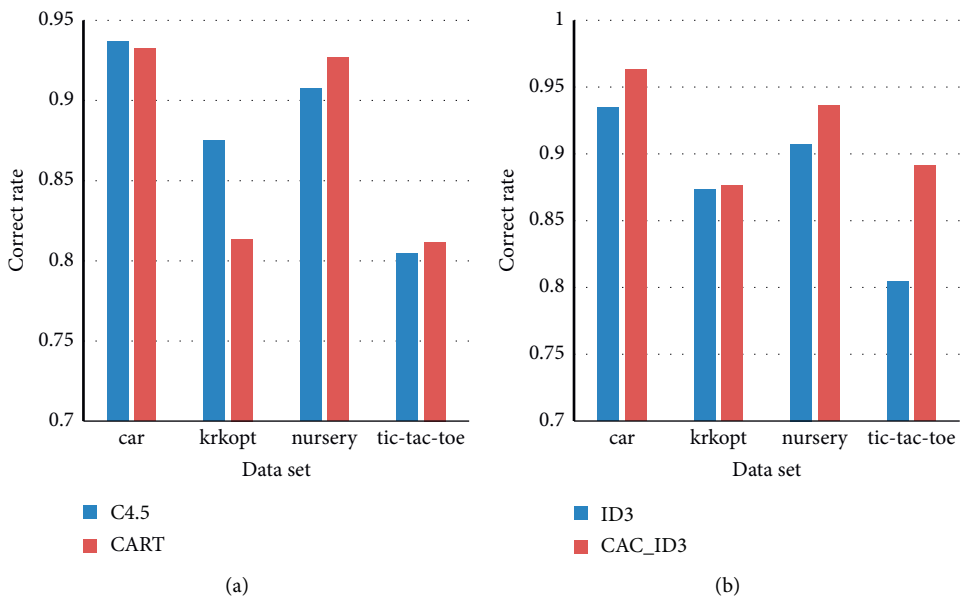

Figure 8: The accuracy of the four algorithms in the four datasets. (a) The correct rate of the C4.5 algorithm and the CART algorithm in four datasets. (b) The correct rate of the ID3 algorithm and the CAC_ID3 algorithm in four datasets.

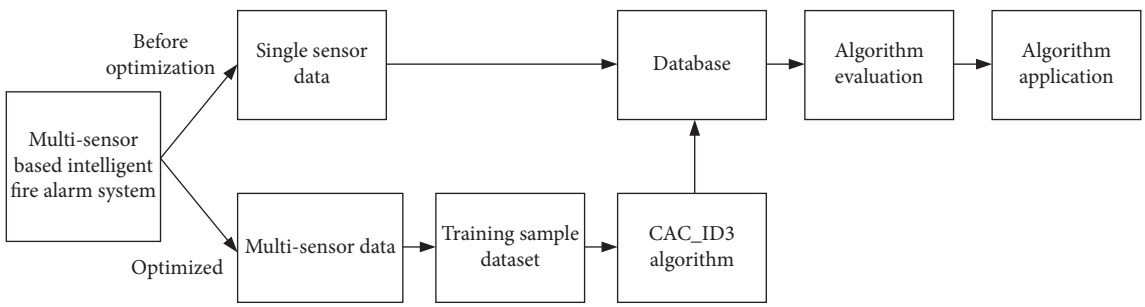

Figure 9: The experimental schematic diagram of the decision tree algorithm to predict the multisensor intelligent fire alarm system.

Table 3: Fragments of datasets based on the multisensor intelligent fire alarm system.

Numbering	RFID	Infrared	Human face	Surroundings	Video	Whether to invade
1	0	1	0	2	0	Yes
2	1	0	1	0	0	Yes
3	0	1	1	0	1	Yes
4	0	0	0	0	0	No
5	0	1	1	0	0	No
6	1	1	0	2	1	Yes
7	1	1	1	0	1	Yes
8	1	1	0	2	1	Yes
9	0	0	0	1	0	No
...	...	...	...	...	...	...

algorithm reaches 0.8431. This shows that the CAC_ID3 algorithm has superior performance.

As shown in Figure 8, in general, the CAC_ID3 algorithm performs well on the four datasets. On the dataset car, the accuracy rates of the C4.5, the CART, and the ID3 algorithm are basically the same. The CAC_ID3 algorithm is at least 0.0263 higher than the other three algorithms. This shows that the execution efficiency of the CAC_ID3 algorithm is high.

4. Experiment Analysis of CAC_ID3 Algorithm

Data analysis plays an important role in the intelligent fire alarm system. The quality of the data analysis is directly related to the accuracy of the information. When a large amount of data is collected, it first needs to be classified. So, this paper proposes the CAC_ID3 algorithm. Through the comparative analysis of the CAC_ID3 algorithm and other decision tree algorithms, it can be seen that the CAC_ID3

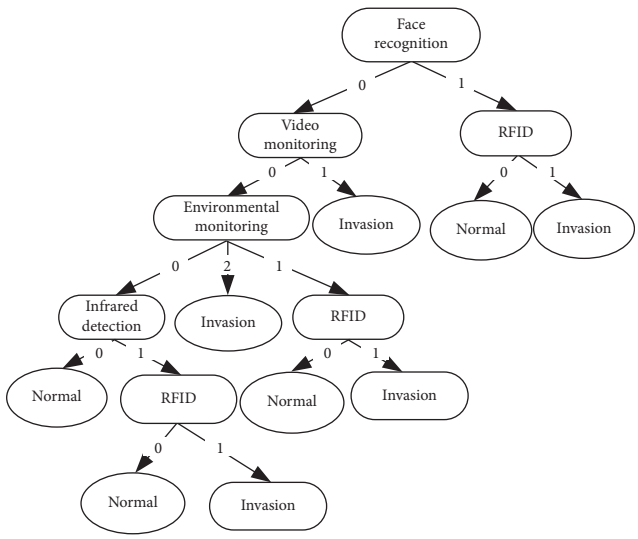

Figure 10: The decision tree generated based on the CAC_ID3 algorithm.

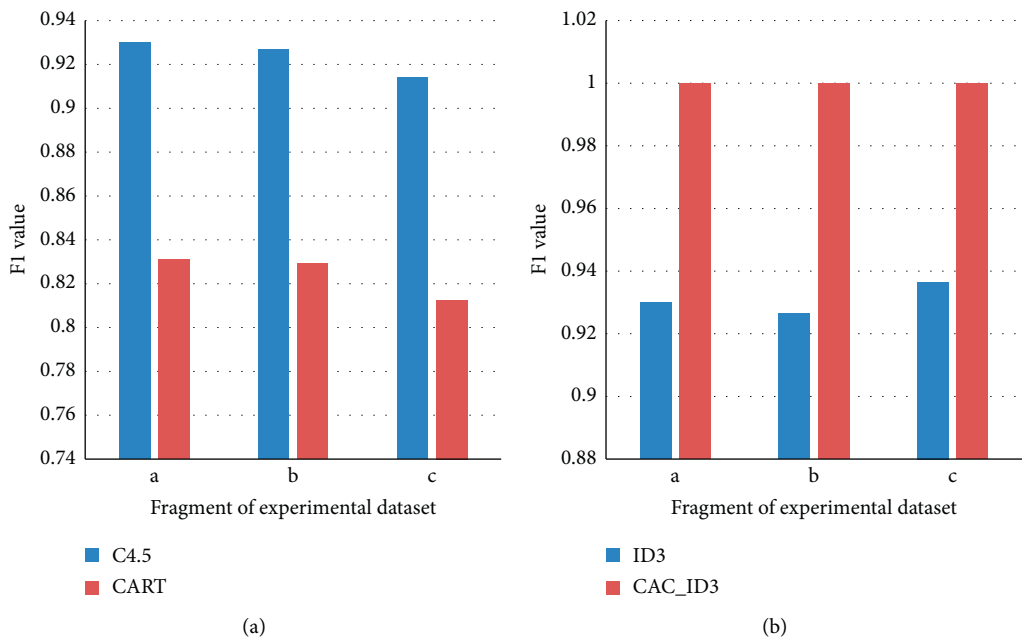

Figure 11: $F1$ value of the four algorithms in the system experimental dataset. (a) The $F1$ value of the C4.5 and the CART algorithm in the system experimental dataset. (b) $F1$ values of the ID3 algorithm and the CAC_ID3 algorithm in the system experimental dataset.

algorithm can realize the data classification well. Therefore, this article classifies the intelligent fire alarm data based on the multisensors through the CAC_ID3 algorithm. Figure 9 is the experimental schematic diagram of the decision tree algorithm to predict the multisensor intelligent fire alarm system.

This system applies the C4.5 algorithm, CART algorithm, ID3 algorithm, and CAC_ID3 algorithm to the multisensor intelligent fire alarm system by using the developing environment and developing language and then conducting experimental comparisons. The performance of the algorithm is judged by the correct rate and F1 value. The data segment set of the multisensor intelligent fire alarm system is shown in Table 3. Table 3 divides the dataset into two parts, from which 80% are arbitrarily picked as the trainer set and 20% as the validation set.

In Table 3, 1 in RFID attribute, infrared attribute, face attribute, and video attribute means alarm and 0 means normal; 0 in the environment attribute is normal, 1 is a warning, and 2 is an alarm. The attribute of the class label is whether to invade or not, and it contains two values of "Yes" and "No."

The confidence and information gain of each attribute are calculated by the CAC_ID3 algorithm. It is calculated

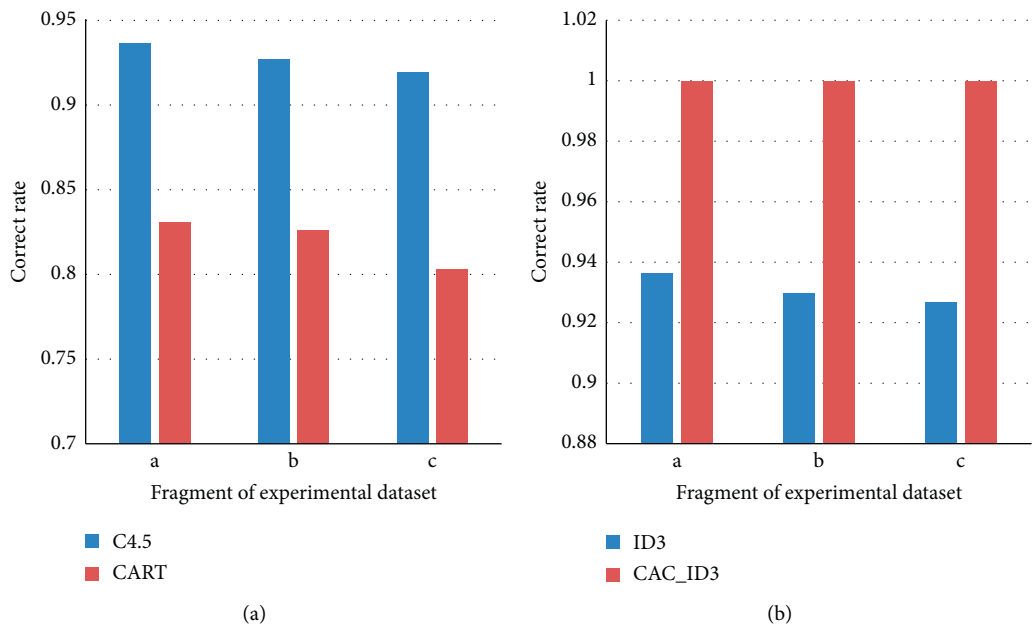

Figure 12: The accuracy of the four algorithms in the system experimental dataset. (a) The correct rate of the C4.5 and the CART algorithm in the system experimental dataset. (b) The correct rate of the ID3 algorithm and the CAC_ID3 algorithm in the system experimental dataset.

that the information gain of the face attribute is the largest; that is, the face attribute is selected as the division attribute. Figure 10 shows the decision tree based on the CAC_ID3 algorithm.

The decision-making trees generated based on the CAC_ID3 method are evaluated through Table 3, which shows that the accuracy ratio of the validation set is 100%. This article compares and analyzes the accuracy rate and the F1 value of the different algorithms to judge the performance of the algorithm.

According to the experimental results in Figures 11 and 12, it is observed that the accuracy and F1 value of the CAC_ID3 algorithm in the system experimental dataset are both 1, which are higher than those of the other three algorithms.

5. Discussion

According to the fast growth of the domestic market and the progress of the society, the construction industry is developing rapidly and many large buildings are rising. At the same time, the diversity of building styles and uses changes, and the probability of fire occurrence also increases to a certain extent. It may be due to a variety of fire sources, or it may be caused by human factors. Not only fires caused by buildings but also car fires, forest fires, and so on are also included. Different fires have different fire sources, but when a fire occurs, there will be different physical and chemical reactions, and there will be characteristics such as smoke, temperature, and gas concentration, and the characteristics will be different in different places. Therefore, the accuracy of the fire alarm system is particularly important. Based on the multisensor data fusion technology, it can dramatically decrease the false alarm rate of the fire and can increase the accuracy of fire judgment. Through the comparative analysis of the F1 value and the correct rate of the C4.5, the CART, and the ID3 algorithm on the four datasets, it is concluded that the F1 value and the correct rate of the CAC_ID3 algorithm are higher than those of the other three algorithms. It shows that the CAC_ID3 algorithm has an ideal classification effect.

Finally, through the comparative analysis of the F1 value and the correct rate of the four algorithms in the system experimental dataset, it is concluded that the classification correct rate and F1 value of the CAC_ID3 algorithm are slightly higher than those of other algorithms. Therefore, the CAC_ID3 algorithm has a certain practical significance in the application of a multisensor intelligent fire alarm system.

The entire comparison measurement figures indicate that the CAC_ID3 algorithm outperforms alternative algorithms in terms of performance comparison of algorithms, with datasets based on multisensor intelligent fire alarm systems. The feasibility and superiority of the CAC_ID3 algorithm in data classification are verified.

6. Conclusion

The multiple sensors message integration method is developed by imitating the sensory organs of humans and animals. The paper first expounds on the theoretical basis of multisensor data fusion and then determines the machine learning technology in artificial intelligence as an intelligent algorithm for fire signal processing. Aiming at the problem of multivalue bias in the ID3 algorithm, this article presents an improved approach. The first aspect is to introduce confidence into the expected entropy. The second aspect is to

introduce attribute correlation information. Its purpose is to weaken the information gain of the attributes with small attribute value and category relationship. To further validate the capability of the CAC_ID3 method, the article compares the C4.5, the CART, the ID3, and the CAC_ID3 algorithm through experiments, showing that the execution performance of the CAC_ID3 method is more efficient than that of the other three algorithms. Then, this article uses the CAC_ID3 algorithm to classify the data of the multisensor intelligent fire alarm system and compares it with the other three algorithms. The testing outcome indicates that the classification precision of the CAC_ID3 algorithm is better than that of other algorithms. The accuracy and classification speed of the CAC_ID3 algorithm are more suitable for the real conditions of an intelligent fire alarm system based on multiple sensors digital integration. Therefore, it facilitates the advancement of work related to intelligent fire alarm systems and has a good application value. The multisensor intelligent fire alarm system is highly sophisticated and involved. Because of the authors' limitation of time and efforts as of resources, there are some deficiencies in this paper, such as the elaboration and scaling of the multisensor smart fire alarm system; other interferences that impact the decision tree algorithm classification precision are not considered such as the compatibility of the multisensor data fusion technology to intelligent fire alarm system.

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: The Impact of Artificial Intelligence and Blockchain Technology on the Development of Modern Educational Technology

Mobile Information Systems

Received 13 September 2023; Accepted 13 September 2023; Published 14 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.

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] Y. Chen, "The Impact of Artificial Intelligence and Blockchain Technology on the Development of Modern Educational Technology," *Mobile Information Systems*, vol. 2022, Article ID 3231698, 12 pages, 2022.

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Volume 2022, Article ID 3231698, 12 pages
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Research Article

The Impact of Artificial Intelligence and Blockchain Technology on the Development of Modern Educational Technology

Yan Chen

Nantong Vocational University, Nantong 226007, Jiangsu, China

Correspondence should be addressed to Yan Chen; chenyan@mail.ntvu.edu.cn

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In order to solve the problem of adding artificial intelligence and blockchain technology to education, the purpose of meeting the needs of combining artificial intelligence and blockchain technology with modern education is to make up for the lack of artificial intelligence in modern education, improve students' interest in learning, and cultivate high-quality students. Through practice and analysis in a chemistry class in an experimental school, samples were taken from 821 students in the third grade parallel class, and 39 teachers taught students in accordance with their aptitude; finally, from the average score statistics of the first and second inspections, it can be seen that the intelligent classroom teaching of chemistry has a certain effect on improving the average score of students in parallel classes in grade three.

1. Introduction

Blockchain is a new type of computer application, such as point-to-point transmission, data storage, authentication mechanism, and encryption algorithm [1]. During the 18th study of the Security Council of the People's Republic of China, Xi Jinping further proposed that the blockchain should be regarded as the most important factor in technological new democracy, and the development of blockchain technology and innovation is required quickly. In China, blockchain research was still in a blank period from 2008 to 2012. Since 2015, it has begun to show explosive growth, and the growth rate has continued to accelerate. In 2015, Chinese scholars' research on blockchain mainly focused on the concept and principle of blockchain. The first exploration of blockchain applications began in 2016, but the application areas are mainly concentrated in financial applications such as digital welfare and Internet finance; as of 2017 and 2018, the application of blockchain has not been expanded to a certain extent [2]. At present, the application of blockchain technology in China has expanded to many fields such as finance and medical care. At present, it mainly studies and discusses the application status and development of blockchain technology in China's education field.

Melanie Swan defines three levels of blockchain technology development: Blockchain 1.0 (currency interconnection), mainly Bitcoin and other virtual currencies; Blockchain 2.0 (Asset Interconnection), which takes smart contracts as the basic feature and can develop decentralized applications DAPP as needed; Blockchain 3.0 (Internet of Everything) which is still in its infancy. In addition to currency, economy, and transaction fields, in the fields of government management, health services, culture, art, education, etc., blockchain technology has been effectively applied [3]. Decentralized self-organizing DAO, decentralized autonomous company DAC, decentralized autonomous society DAS, and fully automated market will affect the development of the world in the future. The development path of blockchain technology is shown in Figure 1.

With the continuous development of Chinese culture and technology, China has also adopted the important idea that technology is the first manufacturing power, various strategies to strengthen the country with science and technology have also been continuously proposed, in this

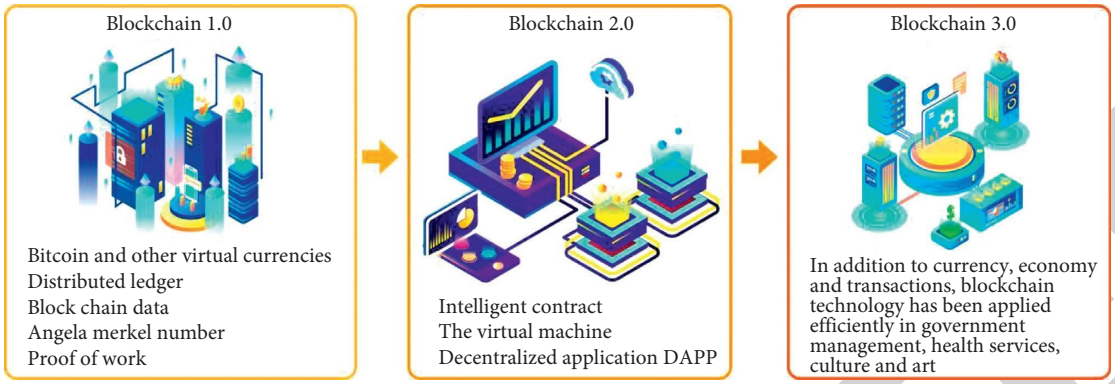

Figure 1: The development road map of blockchain technology.

situation, the effectiveness of education and teaching has gradually been paid attention to, at the same time, China also proposed to integrate science and technology into modern education, for example, artificial intelligence technology born with the development of science and technology, and with the emergence of related technologies such as blockchain technology, it can be well used in modern education, improve the level of education and teaching through science and technology, and stimulate students' interest in learning. At the end of the nineteenth century, technologies such as photography and slide projectors contributed to visual education, while phonographs and tapes contributed to audio-visual education; in the current era, the invention of computers and networks has contributed to modern education; it is not difficult to see that, with the development of science and technology, education is slowly undergoing innovation and optimization (see Figure 2) [4].

Blockchain technology can prevent many criminals from stealing teaching data by other means, avoid the information insecurity problems highlighted by the centralized data market, and greatly improve the security of personal privacy information in the extensive data market and make a reasonable calculation [5]. It can also help teachers identify the teaching focus through microlectures and cooperate with network experts to conduct teaching, do a good job of data integration and preservation of small courseware data, protect the security of teachers' courseware or related intellectual property rights through virtual transaction systems, improve the privacy in the payment process, and promote teachers' innovation in teaching work.

Modern society pays more attention to efficiency and convenience, and all walks of life should put efficiency first, and especially in today's technological development, education should also pay attention to its own high-efficiency research, make full use of various new technological means, and strengthen the effectiveness and convenience of education [6]. In the twenty-first century, schools and colleges should recognize the advantages that intelligent equipment provides for life and education, and the positive significance of introducing new technologies to the development and innovation of education, but in the current modern education, there are still many problems that need to be improved, as shown in Figure 3.

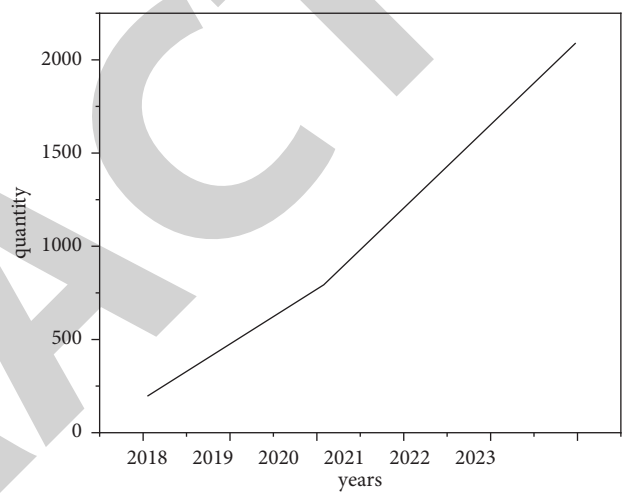

Figure 2: Market size of China's artificial intelligence technology.

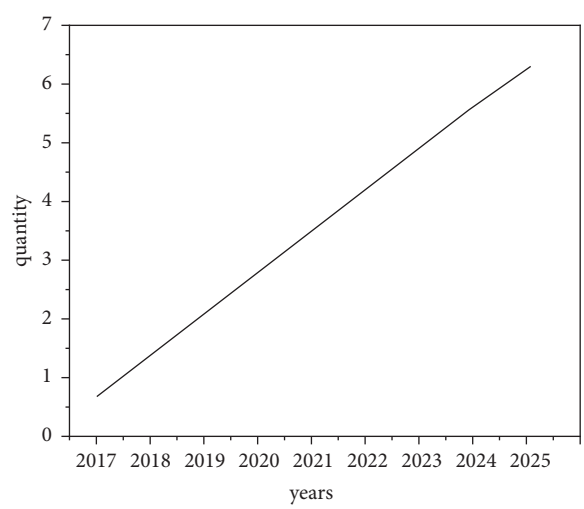

Figure 3: The economic investment of the United States in intelligent education.

Blockchain technology is a distributed database system supported by a new type of decentralized protocol, various technologies come into play to keep data securely stored in it, it has a very high protection effect on the data information

stored on the blockchain, data stored in this way can only be modified by updating the block, and the risk of being tampered with is greatly reduced [7, 8]. This technical feature effectively avoids the traditional centralized management mode and adopts distributed storage technology, which greatly reduces economic and social costs. By applying the blockchain to the management of digital educational resources, it will further explore the research of blockchain in the field of education and provide new ideas and methods for the management of digital educational resources.

2. Literature Review

In the new educational environment, Krylova N. P. [9] and others conducted a heated discussion on the strategies adopted by the new teaching model. Tian W. [10] believed that, in the new era, the various technologies and means used in education should meet the changes brought about by the development of the times and pursue the exchange activities and learning activities between people. Mohammad M. [11] is also actively exploring the significant impact of new technologies on education. Through the reading comprehension of foreign literature, it is found that foreign research on smart classrooms is earlier; the research mainly includes four aspects: theoretical research, design research, applied research, and evaluation research, among which design research and applied research are more. Lee J. [12] and Chettaoui N. [13] believe that the application of artificial intelligence in education is gradually maturing; it participates in student learning in a new way and helps teachers improve teaching efficiency. They believe that, in the next 25 years, educational cobots will assist teachers to appear in the classroom of the future and provide corresponding cases. At the same time, imagine smart classroom learning with the blessing of smart technology. Taub M. [14] conducted research and analysis on the teaching effectiveness of smarter classrooms, with the purpose of investigating primary school students' cognition of smarter classroom teaching. The researchers analyzed learners' cognitive scores by randomly selecting a sample of 100 students from two schools in India. The results of the study found that traditional teaching strategies, teachers' knowledge, presentation skills, use of blackboards, explanation of examples, questioning, consolidation, and feedback were much better than smarter classroom teaching. Saxena A. [15] et al. believe that, with the improvement of human-computer interaction, which can be interacted with a computer or smartphone through body movements, the integration of somatosensory-based applications and classrooms makes learning more enjoyable and enjoyable for students. Kularajasingam J. [16] envisaged that the evaluation system in the smart classroom environment takes teachers and students as the object, makes technological improvements in the current era, and provides a large amount of introduction of science and technology for education, but with it comes more investment in funding, coupled with all aspects of the school's work, Padmanegara O. H. [17] and others believe that many schools are not well prepared to introduce advanced technology, and many schools are still relatively blind in technology and capital investment; it has contributed to the comparison atmosphere of many schools, which is not conducive to the improvement of the school's educational level. For example, many schools still have major deficiencies in the electronic books, the electronic construction of student information, the coverage of online teaching, and the construction of communication and exchanges; at the same time, the school does not know which subject should put a lot of technology and investment, resulting in a waste of technology. For example, in the process of distance education, although it has many advantages, it is difficult to adapt to all schools and disciplines, especially in terms of cultivating emotion and focusing on practice, it is even more difficult to play a role, and the intelligence level, cognitive level, and cultural foundation of different students should also be considered; therefore, schools should clearly recognize the disciplines suitable for each technology and should also be based on their own conditions and development conditions, to appropriately control the introduction of new technologies to contribute and help to improve their own education level. Therefore, a research idea map was designed, as shown in Figure 4.

3. Methods

3.1. Requirements for Modern Intelligent Education. In the modern intelligent education, each school should do a good job of transferring the educational environment from teachers to the network; it also includes the transfer of textbooks to multimedia education; schools should strengthen network construction under the current situation, recognizing that network awareness is the most basic awareness [18, 19]. Since the network has spread all over the world, China's information network is still far behind other developed countries in terms of hardware facilities and basic awareness; therefore, it is necessary to strengthen the construction, invest heavily, strengthen the awareness of the whole people's network, focus on the development of the students' association and the establishment of the network, and adapt to the arrival of the network environment. At the same time, in the network environment, the information education of teachers and students should also be strengthened, and the transformation of teachers' identities and roles should be strengthened [20]. Actively change students' learning methods, improve the information quality of teachers and students, and vigorously teach teachers and students that they should start from basic network use common sense; at the same time, the development and production of teachers' courseware should be strengthened, and the teaching process should be the center of courseware, and the production level of courseware should be vigorously improved, develop the ability to use software classrooms, microclassrooms, etc., and improve communication and construction quality around the world.

3.2. The Importance of Artificial Intelligence to Education. With the continuous progress of science and technology, the rapid progress of science and technology has brought many

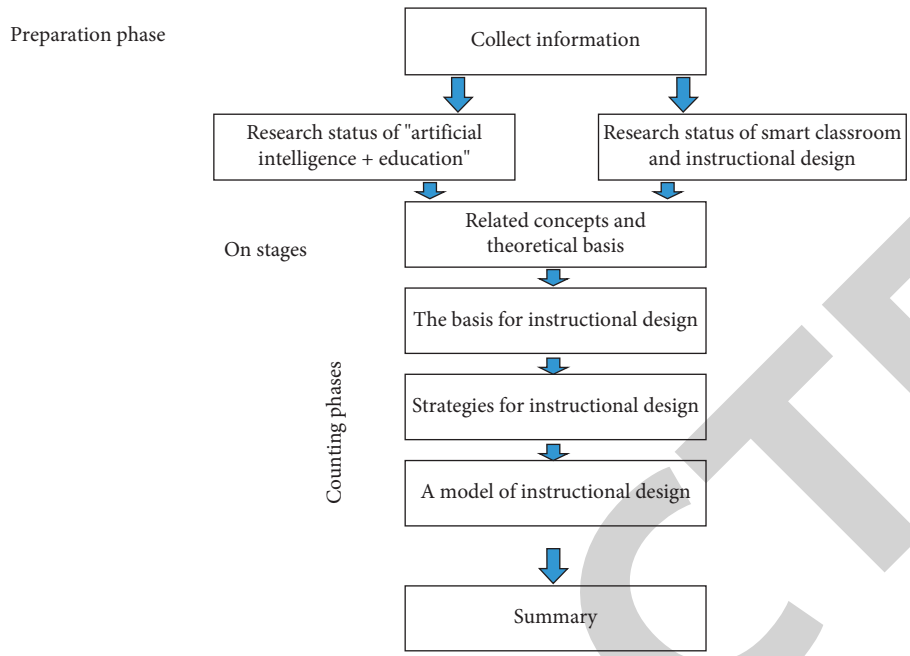

Figure 4: Research idea map.

changes to human life [21]. Whether it is education, parents, teachers, or students, they should recognize the transformation of the environment with the arrival of artificial intelligence; therefore, in the twenty-first century, education informatization is also an irreversible trend, and schools should actively establish new ideas and new models for teaching and strengthen the cooperation between labor and education [22]. For education itself, artificial intelligence is of great significance, artificial intelligence has a strong ability to adapt to all aspects of work, and facing different types of students, artificial intelligence can also analyze the individual differences of students from multiple aspects, formulate different teaching goals for students, and also promote individual development from a deep level; diversifying education from multiple perspectives is conducive to the inheritance of culture. Artificial intelligence goes deep into the field of teaching; it can also promote the reform of education informatization, through its own informatization characteristics; it can also provide teachers with more superior teaching resources. Promoting the birth of personalized teaching, it is easier for teachers to discover the deficiencies of education and hidden dangers in the teaching process through artificial intelligence technology and respond to them (see Figure 5) [23].

For students, artificial intelligence education can also find out the problems of students in the learning process in time and provide answers and corrections for students; it can also formulate learning goals for students that are suitable for their own development; artificial intelligence technology can rely on its own high-intensity computing ability; it can formulate reasonable learning methods and learning plans for students, mobilize all educational resources and information in an instant, and also optimize the teaching process for teachers. In order to prevent teachers from using

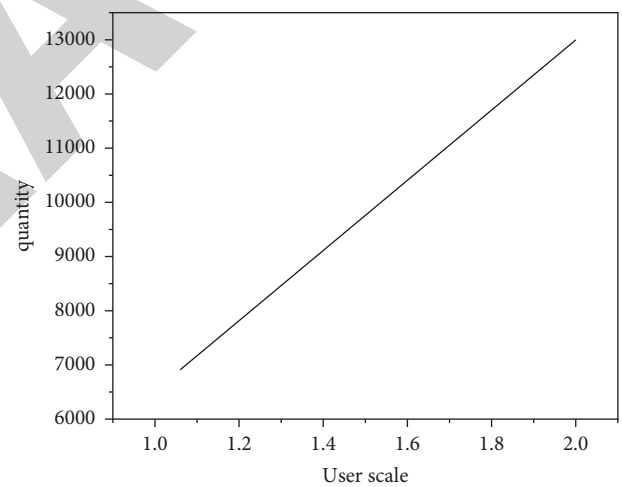

Figure 5: Scale of school education users in China.

traditional teaching concepts when formulating courseware, being bound by tradition makes teaching more rational and targeted. In addition, the addition of artificial intelligence can also create a good learning environment for students, integrate classroom education with entertainment, and find more small games suitable for students on the Internet.

AI + education is the product of deep intelligence and learning. To improve teaching, people use smart devices in education, improve learning and teaching, create a new teaching environment, provide schools with self-paced learning resources, and ultimately achieve the purpose of educating people [24]. "Artificial intelligence + education" mainly relies on intelligent technology, evolved on the basis of the previous Internet, and at the same time has the characteristics of technological update and intelligent

promotion. Intelligent education can also help teachers reduce the burden of teaching, and students can facilitate independent learning and individual review; the school education system is easy to manage, and the core of the device is artificial intelligence, which is also more convenient for schools and other educational institutions. "Artificial intelligence + education" should not only focus on the improvement of students' academic performance, but also pay more attention to your own growth and development. The research believes that artificial intelligence + learning is a deep learning tool in intelligence, and its intelligent test can track comments in real time, and various online and offline tests can rely on intelligence. Technology and smart tools are used to measure all abilities of students, complete most teachers, and ultimately measure results.

Learn from the smart classroom teaching model constructed by Chen Weidong, Liu Bangqi, and others and the strategies proposed by the author, and then go deep into the actual characteristics of the teaching environment of smart cloud chemistry classrooms in practice schools, promote the needs of learners' development, and focus on starting from the perspective of psychology. The design of smart classroom teaching activities is determined, including assignment of tasks, situational introduction of lessons, cooperative sharing, timely feedback, and individual review. The teaching activity design model is shown in Figure 6.

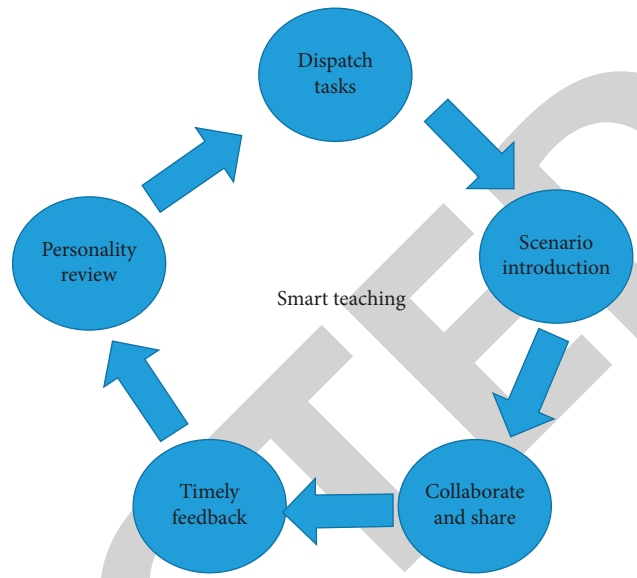

Figure 6: Teaching activity design model.

3.3. The Role of Blockchain Technology in Education. With the continuous transformation of society, technologies such as big data, cloud storage, and the Internet of Things continue to emerge; as a disruptive technology, blockchain can be integrated into education and realize the functions of transferring, recording, exchanging, and analyzing the effect of big data on learning and education, and from the technical level and the level of education it needs to carry out in-depth strengthening, intensify the process of education informatization and intelligence, let each school rebuild the education ecology, change the wool of the school, innovate the means of education, and improve the level of education [25]. The concept of blockchain is also constantly updated in development; as a multiparty joint maintenance, the security and privacy of transmission and access are guaranteed by passwords and can make data difficult to be tampered with and denied in the storage process; it has a strong security principle and has a strong diversity in functions and expressions; there are different operation and maintenance methods and management modules for basic components, accounts, contracts, interfaces, and applications. Blockchain technology is the integrated embodiment of technology, including consensus mechanism, cryptography principle, and distributed storage mechanism, which can complete the common benchmark of each node, reach an agreement on various data, emphasizing the use of asymmetric encryption technology to ensure information security, and also make all participating nodes independent, so that the data can be better preserved (see Table 1).

In the teaching process, the use of blockchain technology can fully change the connotation, goal, form, and structure of education, making modern education more intelligent and diversified; it has the advantages of being transparent and trustworthy, safe and intelligent, difficult to tamper with, and traceable, allowing students to inquire and access educational results such as learning certificates, evaluation results, award status, and practical experience at different educational stages; it can also manage various information in a unified way, strengthen its standardization, and ensure that students' information is true and effective; in addition, it is more difficult to cover up the records of disciplinary violations to enhance social fairness; when students transfer schools, they can also transfer relevant materials collectively; in the face of employment, education, and other stages, you can also transfer records without pressure, reducing the impact of system loopholes and human interference, realize an effective record of the whole process of students' learning, and form a distributed and permanent learning record that is difficult to be tampered with; it saves the time and cost of reviewing and verifying materials by education departments and human resources departments and can also maximize the authenticity and effectiveness of students' learning materials and improve the level of education certification and promote the rational allocation of global educational resources and the overall development of educational undertakings (see Figure 7).

The application of blockchain technology can also ensure the reasonable combination of Internet, big data, and other technologies, build a perfect educational environment, realize the popularization and promotion of intelligent education, promote the reform of the education system, reconstruct the value of education, and better meet the needs of society [26]. Blockchain technology also emphasizes the safety and reliability of education, which can integrate a large number of online and offline teaching, academic or non-academic certification, etc., and according to the students' personality, hobbies, and potential quality differences it can make reasonable deployment, make any way of learning be

Table 1: Differences between blockchain and traditional technology.

Taxonomy	Traditional technical features	Traditional technical description	Blockchain features	Blockchain description
Recording method	Single center control	Single node full authority record and maintenance	Multicenter control	Multicenter consensus confirmation record, common maintenance
Transfer method	Single center control	Single central node full supervision and operation	Multicenter control	Multicenter collective supervision, mutual supervision and checks and balances
Data consistency	External presentation of a single data channel	Single data inventory, no consistency risk	Data consistency through multicenter consensus	Will face certain systemic attacks
Data security	Single center is solely responsible, single point of risk	A single center is responsible for the security endorsement of the entire system; as long as a single node is breached, there will be systemic risks	Multicenter coordination, multiparty secure computing	Multiple centers back up their data, verify data with each other, and check and balance each other, so there is no need to worry about data loss caused by a single center

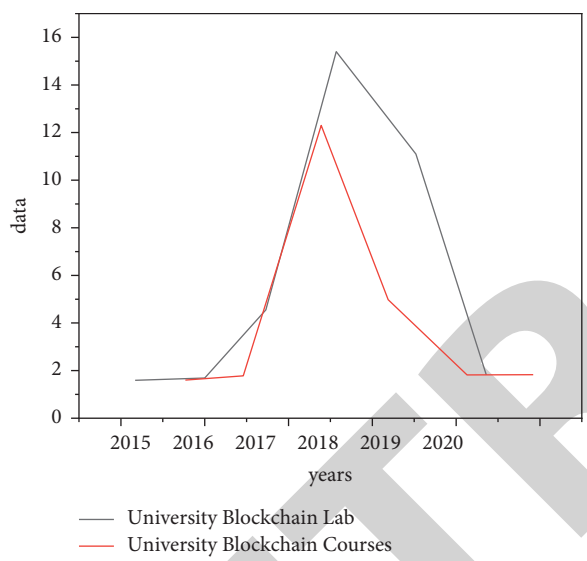

Figure 7: China's blockchain education structure.

recognized, and promote the integration and collaboration of social practice, vocational education, and higher education, realize the record of students from internship employment to entrepreneurial innovation, and promote the fairness and principle of education certification records [27].

3.4. Adaptive Learning in Intelligent Education. In the design of the intelligent education system, we should focus on the educational adaptive learning technology and focus on personalized learning, such as intelligent tutoring systems, through intelligent methods to achieve personalized learning of students, detecting students' gaps and deficiencies in knowledge and cognition, diagnosing qualified steps for students, and fully analyzing data which can be designed through artificial intelligence Bayesian formulas (1) and (2).

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}, \tag{1}$$

$$OP(B) = P(B|A)P(A) + P(B|A)P(A), \tag{2}$$

where $P(A|B)$ is the probability of taking a for the case of b, and $P(B|A)$ is the probability of taking b for the case of a, $P(A)$ is the probability of a, and similarly $P(B)$ is the probability of b; according to probability theory and mathematical statistics, the posterior probability is the product of the prior probability and the adjustment factor. Therefore, in the design, the difference a of the learner and the behavior b of the curriculum education can be formulated and designed; for example, students' physical responses such as heart rate, pulse, and skin temperature can detect students' learning behavior, or students' attention distribution can be detected through mouse and keyboard input, eye movements, etc., judging students' learning and interaction data based on eye tracking such as blinking and pupil dilation; after the data of the learner is collected, the state of the learner can be diagnosed and the future development can be predicted, which can be imported through the following formulas:

$$L = \frac{1}{2}\sum_{i=1}^{mk}\left(Y^{(K)} - T_I\right)2, \tag{3}$$

$$\left(Y^{(K)} - TI\right)^2 = \frac{1}{2}\sum_{i=1}^{MK}(\partial i)^2, \tag{4}$$

where $\partial i = Y^{(K)} - T_I$ represents the difference between the i th element in any vector and the i th element of the vector, the one-half is to make the subsequent derivation calculation more convenient, and in the design process, the students' responses can be incorporated into the regression equation to solve the various loss functions. In addition, in the design, the weights W and W of the network can also be incorporated into it, so that the reciprocal of L and W is 0, as shown in equations (5) and (6).

$$\frac{\partial L}{\partial W} = 0, \tag{5}$$

$$W - \partial\frac{\partial \mathrm{l}}{\partial \mathrm{w}} = 1. \tag{6}$$

∂ is the student learning rate and the step size of the weight, $(\partial \mathrm{l}/\partial \mathrm{w})$ is the gradient; when expressing in it, you can also

use functions to express abstractly, it should be noted that, in many cases, the physical characteristics of students need to be estimated, and it is difficult to accurately collect them, so the estimate can be compared with the likelihood and brought into the regression equation; for example, it can analyze the pronunciation of letters during reading and support personalized learning. For students with writing difficulties, students' writing skills can also be measured through a tablet, allowing students to translate into more appropriate learning activities. Artificial intelligence can distinguish learning steps and methods that are more suitable for students and classify tasks through feedback, pay more attention to the individual needs of students, and analyze students' learning trends, so that students' talents can be strengthened, and a corresponding feedback mechanism can be obtained, raising the level of personalization in education.

3.5. Build an Analysis Model of Digital Education Resource Sharing. The construction of an analysis model for sharing digital educational resources requires the collection of data related to digital resource information; to analyze the basic factors of resource allocation information, the specific calculation steps are as follows.

3.5.1. Collect Shared Resource Information. In the digital education resource sharing system, there are many users who provide shared information; in order to ensure the reasonable distribution of shared digital resource information, first, it is necessary to collect and classify shared information resources according to different providers; the information resource sharing process that defines the information provider is shown in formulas (7) and (8).

$$\frac{dnA}{dt} = vAnA\left(1 - \frac{nA}{Na} - \frac{aAB - bAB}{NB}nB\right), \tag{7}$$

$$\frac{dnB}{dt} = vBnB\left(1 - \frac{nB}{Nb} - \frac{aBA - bBA}{NB}nA\right). \tag{8}$$

Among them, vA and vB represent the sharing speed of the information uploaded by the provider, aAB and aBA, respectively, represent the inhibitory effect coefficients between different information providers due to information resource sharing, and ba and bs represent the facilitation coefficients between information providers, respectively. Due to the different overlapping methods of digital resource information, the overlapping situation of digital resource information is shown in Figure 8; among them, A and B, respectively, represent the digital resource information uploaded by the provider to the sharing platform. As can be seen from Figure 8, there are three situations in the information resources shared by different providers: (1) The information provided by different providers does not overlap, as shown in Figure 8 (1). (2) Different providers provide some of the same or overlapping information, as shown in Figure 8 (2) (3) (4). (3) Different providers provide the same or similar information, as shown in Figure 8(5).

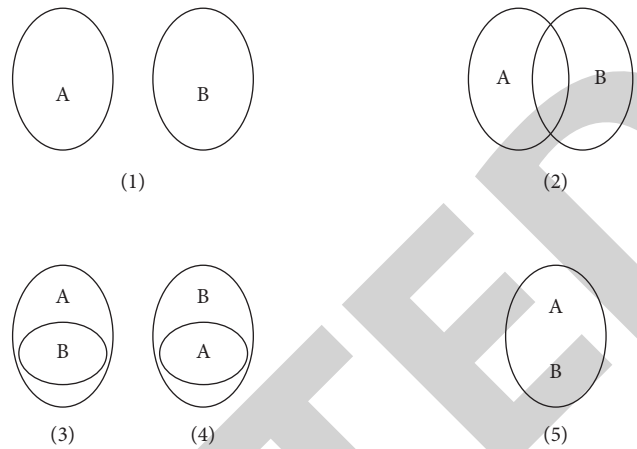

Figure 8: Schematic diagram of the overlapping situation of shared information resources.

According to the representation of Figure 8, SAB is defined as the information overlap degree of the provided information A and B; therefore, if the value of SAB is 0, the configuration factor can be defined directly; if the value of SAB is not 0, weight reduction processing needs to be performed on the collected shared digital resource information, and duplicate digital resource information is eliminated.

3.5.2. Evolutionary Configuration of Shared Information Resources. When the information overlapping degree of the shared information uploaded by different information providers is 0, it means that the sharing of information resources has reached a balance; when the information demanders tend to be saturated with information resources, the equilibrium conditions shown in equations (9) and (10) are established.

$$\frac{nA}{Na} = vAB\frac{nB}{NB} + 1, \tag{9}$$

$$\frac{nB}{NB} = vBA\frac{nA}{NA} + 1. \tag{10}$$

Therefore, the equilibrium condition of information resource sharing is converted into a variable representation, as shown in equations (11) and (12).

$$\mathrm{p}(\mathrm{nA}, \mathrm{nB}) = 1 + \mathrm{vAB}\frac{\mathrm{nB}}{\mathrm{NB}} - \frac{\mathrm{nA}}{\mathrm{NA}}, \tag{11}$$

$$\mathrm{q}(\mathrm{nA}, \mathrm{nB}) = 1 + \mathrm{vBA}\frac{\mathrm{nA}}{\mathrm{NA}} - \frac{\mathrm{nB}}{\mathrm{NB}}. \tag{12}$$

3.5.3. Analyze the Allocation Factor of Shared Digital Resources. Assume that the number of samples of shared digital resource information completed by the equilibrium evolution configuration is m, and the configured factor index is n; at the same time, define the j th configuration factor of the i th sample in the configuration information as siy, the

value range of i is [1, m], and the value range of j is [1, n]; then the initial matrix composed of all sample values of shared digital resource information can be expressed as formula (13).

$$S = |Sij|mxn. \tag{13}$$

Before calculating the initial matrix of samples, the data in the matrix needs to be standardized, and the average value of the data in the j th column is calculated by formula (14).

$$\overline{sj} = \frac{sij}{\overline{si}}. \tag{14}$$

The construction matrix obtained after a series of processing can be expressed as shown in

$$W - |Wij|mxn. \tag{15}$$

Substitute the collected relevant data of the shared digital resource information into the matrix, and calculate the relevant matrix and the eigenvalues and eigenvectors of the matrix; thereby, a unitized eigenvector corresponding to the eigenvalues of the matrix configuration is obtained, and the eigen polynomials that make up the eigenvector are marked as Aj. Finally, the number of configuration factors can be further determined by the cumulative contribution rate of the configuration factors of the shared digital resource information, and the cumulative factor contribution rate of the first k factors can be expressed by formula (16).

$$qk = \sum_{i=1}^{k} \left(\frac{\gamma j}{\sum_{i=1}^{n} \gamma j} \right). \tag{16}$$

When the eigenvalue of the eigenvector is not less than 1, the number of configuration factors can be determined [28].

3.6. Automatic Digital Measurement. In the process of learning, the degree of participation of students can often greatly affect the effect of learning. Students should have a high degree of enthusiasm and initiative, only then can we ensure knowledge absorption in the learning process, and in intelligent education, through artificial intelligence and digital technology, students can be measured in various ways to help students establish a high degree of enthusiasm and participation [29]. With the development of smart devices and the Internet, a lot of learning requires the development of digital media, so in the process of students' learning, usually, digital interaction is isolated and difficult to participate in; for example, although traditional MOOC videos have many advantages, it is difficult to ensure students' participation and completion; there is also a lot of uncertainties in its ratings. In this case, it is necessary to motivate and improve the avoidance of boredom when in trouble and focus on people-oriented participation through analytical automation, pay attention to the temporary emotional and cognitive states of students in the learning process, such as boredom and love, and analyze the reasons why students appear in a state in a specific step and analyze it and then reduce the situation that causes the student's related state, improve students' participation, or analyze the number of mouse clicks of students and analyze students' psychological state; this automated method can be used on a large scale, promote the consistency of intelligent learning, reduce the influence of other factors, and ensure the participation of students (Figure 9).

3.7. Specific Development of CAI Courseware. The specific development of CAI courseware should meet the following basic requirements: (1) courseware development should fully reflect the characteristics of distance education, which can improve learners' interest and consciousness in learning; (2) courseware must meet the basic conditions for running on the Internet and should also have the characteristics of safety, stability, and small capacity; (3) courseware should have complete text and production scripts; (4) the relevant nouns, concepts, symbols, names, theorems, laws, and important knowledge points in the text description of the courseware should be linked with the relevant background information; (5) for important parts of the courseware, pictures, dubbing, or animations can be appropriately used to strengthen the learning effect, but pure expressive pictures or animations unrelated to the teaching content should be avoided [30]. The basic process of CAI courseware development is shown in Figure 10.

4. Results and Analysis

Under the planning of intelligent education, technologies such as artificial intelligence and blockchain under the digital background have brought new development and growth space for education [31]. For the application of artificial intelligence and blockchain technology, it is one of the directions of extensive discussion and research in various countries in the world; artificial intelligence will show the advantages that traditional technology cannot reach, and it has strong capabilities in data collection, information processing, analysis, etc.; if artificial intelligence is applied to modern education, it can also simulate the teaching work of teachers, collect students' learning situation in an all-round way, and list various methods suitable for students' learning according to their individual differences, pay attention to students' overall learning life, quickly improve students' ability to build knowledge, and automatically generate courseware, and the courseware is processed according to the materials collected in the teacher's work; it can also collect new knowledge independently, automatically make scientific discoveries, and even replace the teacher's teaching work (as shown in Figure 11).

Since the beginning of 2020, the outbreak of the epidemic has brought shocks and changes to all sectors of society; on the one hand, it has had a large impact on traditional education; on the other hand, it has also accelerated the generation of digital learning, and the whole year of 2021 will make digital education almost everywhere in the society; under the influence of this trend, people have seen the advantages of digital teaching, and all sectors of society have turned their attention to various new technologies; in an attempt to integrate new technologies into

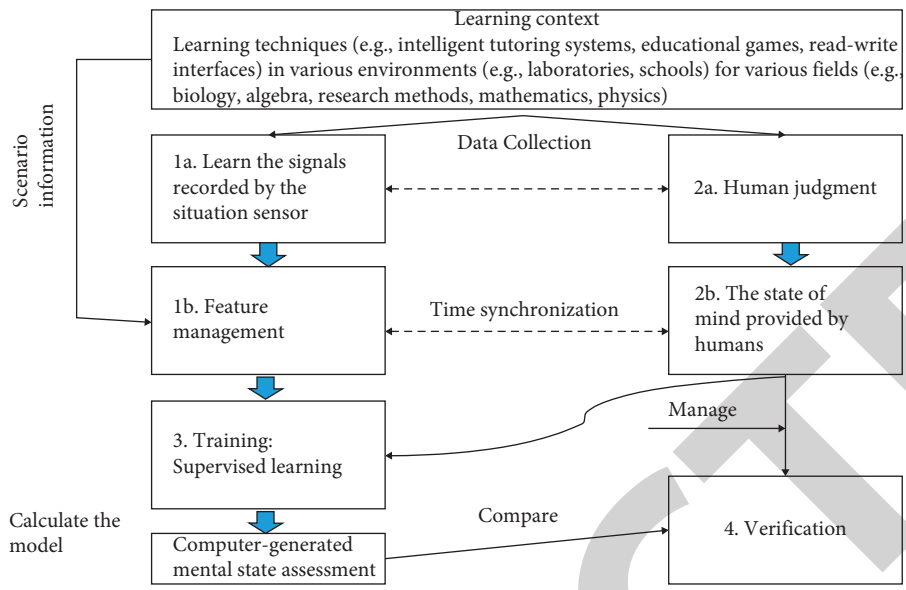

Figure 9: Digital measurement method.

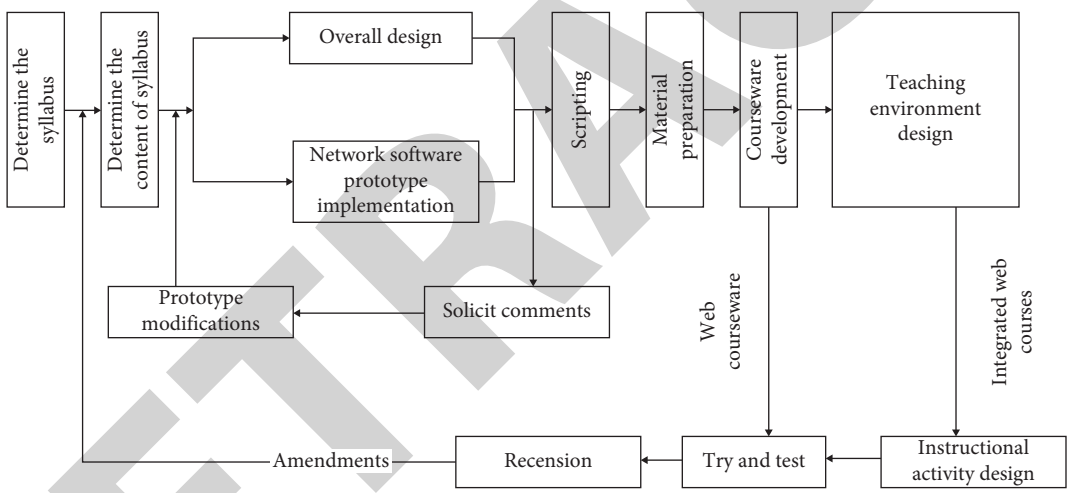

Figure 10: The basic process of CAI courseware development.

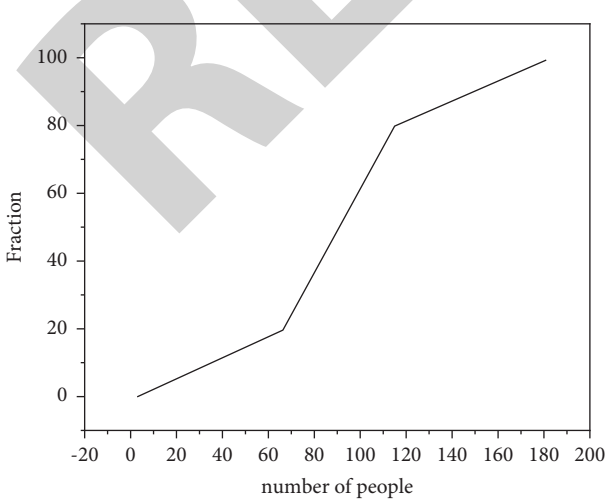

Figure 11: The score growth curve of the students who received the intelligent education test.

teaching, the OECD also released the integration methods for artificial intelligence, blockchain technology, etc.; the application of intelligent technologies and the construction of personalized learning are explored [32].

In the process of this combination, schools should clearly recognize what can be taught through multimedia network; in the information system constructed by multimedia network teaching, schools should teach students in the right way, make changes for the development of society, and reset teaching goals for students, cultivate students' ability to acquire, process, learn, and create, and pay attention to the diversity and sharing of teaching, through the advantages of the massive resources of the network, to allow students to access and learn various resources through various programs, software, data, etc., strengthen the shortcomings of traditional multimedia teaching in some aspects, and, through the guidance of experts, allow students to obtain better education, no longer limited by the level of teachers and teaching materials.

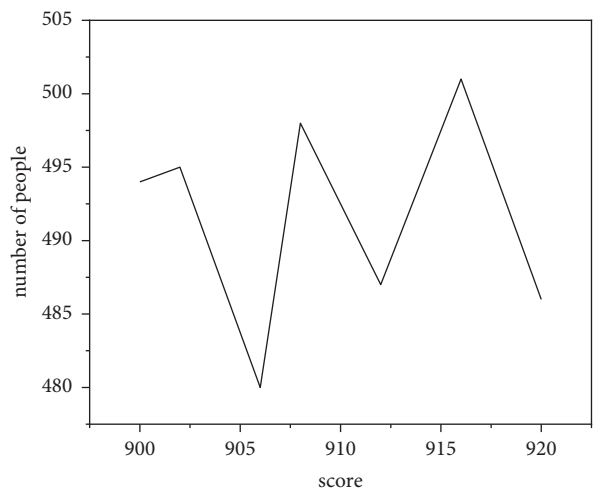

Figure 12: Statistics of the average grades of the first inspection in parallel classes in the third year of junior high school.

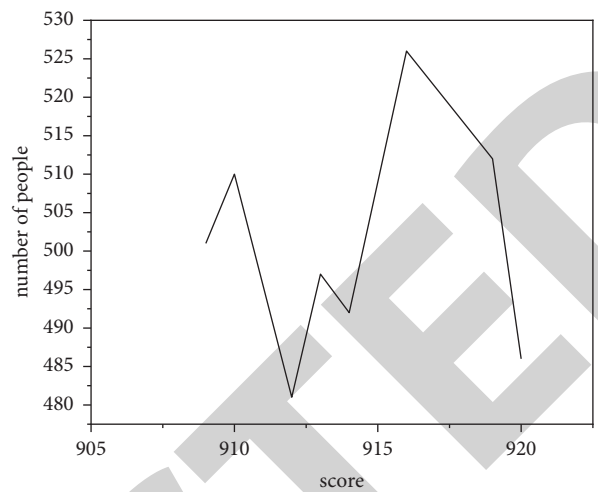

Figure 13: Statistics of average grades in the second inspection of the third grade parallel classes.

Through a one-semester experiment in an experimental school, the students of the school started classroom teaching in the smart classroom VR room from the first day of junior high; for students who have just entered the third year of junior high school, it is the first systematic study of chemistry, and it is also the first time to enter the smart chemistry laboratory for classroom learning; in response to this feature, the Smart Cloud Lab, a smart classroom, was specially selected for public classroom presentation; through a semester-long experiment, from the analysis of the students' first and second chemistry grades, as well as the results of questionnaires and interviews before and after the teaching implementation, the teaching activity design model designed in this study has achieved good results.

Classes 909 to 919 are classes at the same level; statistical analysis is made on the average scores of the first and second tests of these 11 classes, as shown in Figures 12 and 13; it can be found that, during the first inspection, the average grades of the total grades of each class were different; the highest average grade was class 917; the average grades of the experimental classes 915 and 916 belong to the middle level among the 11 parallel classes; the average grades of each class in the second inspection were higher than those in the first inspection; it can be seen from the score statistics chart that 915, 916, 918, and 919 are the classes that have improved a lot compared to the first examination, especially the 916 class that has made the greatest progress; from the statistics of the average scores of the first and second inspections, it can be seen that the implementation of smart classroom teaching of chemistry in the third grade of an experimental school has a certain teaching effect on the average grades of students in the third grade parallel classes.

By analyzing the average scores of the secondary tests in parallel classes, it can be seen that it is proved that, under the implementation of teaching, the problem of students' academic performance can be effectively solved and students' interest in learning can be improved, but there are certain limitations in comparing secondary average scores; it also lacks a certain degree of scientificity; it is possible to further analyze the effect of the implementation of smart classroom teaching of chemistry in junior high schools.

5. Conclusion

By strengthening the focus of intelligence and blockchain technology in education, it is proved that adding intelligence and blockchain technology to education can make learning better; it meets the learning needs of the new era and makes learning less desirable. Good students improve the academic satisfaction of most students. And in the continuous research, intelligent education will also analyze the learning methods suitable for different students by observing students' different psychological characteristics, emotional changes, attention, etc., build personalized learning goals for students, increase student engagement through automated digital measurements, and more; it can also promote the fairness and credibility of education, reduce the probability of various adverse problems, and provide maximum guarantee for the development of the education industry.

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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Research Article

Infrastructure Smart Service System Based on Microservice Architecture from the Perspective of Informatization

Yanyan Lv[1] and Wenken Tan[2]

[1]*School of Digital Construction, Shanghai Urban Construction Vocational College, Shanghai 201499, China*
[2]*College of Architecture and Urban Planning, Tongji University, Shanghai 200092, China*

Correspondence should be addressed to Wenken Tan; twk@tongji.edu.cn

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With the rapid development of engineering information technologies such as building Information Model (BIM), geographic information system (GIS), Internet of Things, big data, and cloud computing, and the intelligent management of infrastructure will become an inevitable development trend. Microservice architecture, because of the service component and other related characteristics, using this architecture can build a high availability and low coupling application system, which effectively improves the service quality of the system, and therefore the microservice architecture has gradually become the flow software development architecture. Based on the research of infrastructure digitization and integration of construction and maintenance, this paper proposes the concept of infrastructure intelligent service system (is3) from the perspective of information flow, so as to realize the intelligent management of infrastructure. This paper is based on the system requirements analysis. The intelligent service system of infrastructure with microservice architecture is designed, and its performance is tested through experiment. The test results show that in the brain high development test, the designed service reached no error, and the average response day was stable below 27 ms; in the continuous high concurrent test, the average response time of the designed service side remained within 100 ms when the concurrency is 12000, and no request occurred during the test.

1. Introduction

In the process of the continuous and in-depth development of the national smart city construction, the use of information technology can manage the entire life cycle of the project construction from beginning to end, running through all stages of the project construction process, which is conducive to promoting the construction of smart cities. With the advancement of Internet technology, human society has entered the cloud information era in which the Internet of Things technology, big data, and cloud computing technology are integrated and developed. In underground engineering activities, the development and progress of these information technologies is conducive to the information and intelligent management of underground engineering. Digital management methods have been widely used in infrastructure. With the explosive growth of data and the rapid development of information technology, "digitization" is gradually developing towards "intelligence."

This paper presents an understanding of Infrastructure Smart Services (iS3). iS3 mainly includes the functions of data collection, data processing, data visualization, and a series of analysis of infrastructure data for the whole life cycle of underground space engineering buildings. The whole life cycle of underground engineering refers to the survey stage, design stage, construction stage, and monitoring stage of the project, as well as the maintenance stage of the engineering structure during the operation period after the project is successfully completed. Due to the abundant underground engineering data, the iS3 system has many business functions. In order to realize the service of easy maintenance and modification of the system, as well as the analysis and decision-making of underground engineering

data, this paper develops an infrastructure intelligent service system based on the microservice architecture. In recent years, the microservice architecture development model has been widely used in the Internet. Unlike the monolithic architecture system, the microservice is a system composed of a group of tiny services. Compared with the traditional monolithic application, the business modules in the microservice system that need to expand their functions or need to remodify their functions can be offline alone, and the entire system does not need to be offline, which makes the system easier to redeploy, and the system operation and maintenance management will be more convenient. The infrastructure intelligent service system is developed based on the idea of microservice architecture, and the data exchange is also completed between the microservices through the communication between the interfaces, which can promote the rapid transmission of 3D model files in the network and between services.

2. Related Work

In terms of theoretical research, experts and scholars from various countries have discussed the application and development prospects of intelligent infrastructure construction, and have done relevant research in the technical and application aspects of digital management. To achieve more accurate structural health monitoring, Spencer et al. designed a wireless smart sensor platform for civil infrastructure. The platform uses a 24-bit high-precision analog-to-digital converter with 8 analog input differential channels and programmable antialiasing filters to meet critical structural health monitoring needs, enabling tightly synchronized sensing. It addressed the data loss problem and efficiently implements the demanding numerical algorithms required for system identification and damage detection on resource-limited sensor nodes [1]. Al-Humairi and Kamal proposed a real-time Covid-19 system to track and identify suspected cases using an IoT platform to capture user symptoms and notify relevant agencies. Taking into account the effect of scanning distance compared to contact wearable sensors, she conducted a monitoring experiment that tested different age groups. The results showed that the system achieves 99.9% accuracy in the range of (500 ± 5) cm [2]. Imoize et al. researched sustainable social intelligence infrastructure supporting 6G, introduced the evolution background of different wireless communication standards and emerging 6G applications such as multisensory extended reality and digital replication. In addition, he discussed the technology-driven challenges facing the implementation of 6G and proposes possible solutions to these challenges [3]. To enable secure communication between smart meters and infrastructure, Khalid et al. proposed an anonymous key agreement protocol for smart grid infrastructure that enables smart meters to connect anonymously to public infrastructure. He verified the validity of the protocol through random Oracle models and automated ProVerif tools [4]. Kaluarachchi explored the potential advantages of smart and green infrastructure in cities to help cities achieve considerable environmental and socioeconomic benefits; he introduced the concepts of grey, green, and smart infrastructure and discussed the advantages of using nature-based integrated smart, green solutions [5]. Selim and Elgohary discussed the public-private partnership (PPP) in smart infrastructure projects from the perspective of stakeholders, and studied and analyze the role of stakeholders in smart infrastructure projects through the concept of PPP. The study aimed to establish a successful PPP model for the smart infrastructure project phase, clearly demonstrating the roles of stakeholders. Especially in the case of high project cost, it can help improve work efficiency and work quality while reducing costs [6]. Smith developed a real-time adaptive traffic signal control system to divert urban road traffic flow. The system combined principles of automatic planning and scheduling, multiagent systems, and traffic theory to treat traffic signal control as a decentralized online planning process. In operation, signal timing plans are repeatedly generated and executed at each intersection to optimize the number of vehicles currently sensed passing through the intersection [7].

3. Infrastructure Service System and Microservice Development Framework

3.1. Infrastructure Service System. The infrastructure service system is based on the same data standard to collect, process, visualize, and analyze the data of underground engineering from the preliminary geological survey data, topographic data, environmental data, design data, construction data, monitoring data, until the later operation and maintenance of data collection, processing, visualization and analysis, and decision-making functions, so as to serve the infrastructure management system of the entire life cycle of underground engineering [8], which is shown in Figure 1. The system also solves the problems of data information loss and poor interaction in the whole life cycle of the project. Data visualization refers to the visual expression in the form of combining engineering BIM three-dimensional model data and GIS two-dimensional graphics data with engineering data. From the perspective of information flow, the infrastructure smart service system can be understood as an integrated decision-making service system that collects, processes, expresses, and analyzes the life-cycle data of the infrastructure. It mainly serves infrastructure objects such as roads, bridges, tunnels, integrated pipe corridors, and foundation pits, covering the whole life cycle of different information flow nodes in various stages from planning, survey, design, and construction to operation and maintenance.

3.1.1. Data Collection. Data collection refers to monitoring and sensing infrastructure status and acquiring infrastructure data through various types of sensors, and converting the acquired infrastructure data according to certain rules to facilitate data transmission, processing, storage, display, recording, and control [9].

3.1.2. Data Processing. Because the environment where the sensor is placed may collect some information irrelevant to

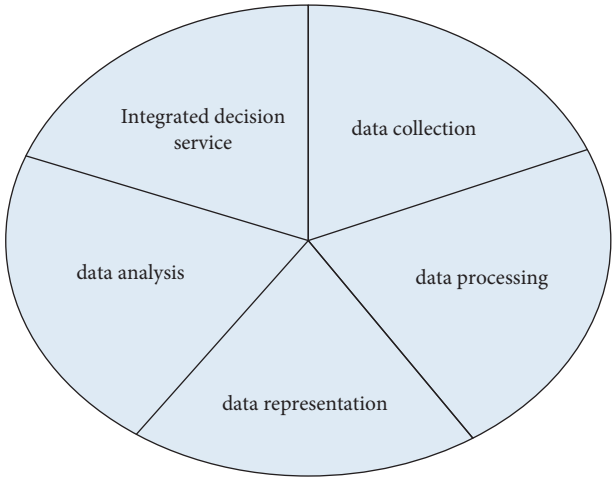

Figure 1: Conceptual diagram of infrastructure service system.

the state of the infrastructure, it is necessary to use some techniques to process the collected data [10]. The data at different stages of the infrastructure is denoised, classified, correlated, and fused by technical means. At the same time, infrastructure data should be standardized, including the standardization of data encoding and exchange.

3.1.3. Data Expression. Data representation is to display a large amount of abstract data generated by infrastructure in the process of engineering construction in a visual way [11]. Infrastructure data is included in planning, survey, design, construction, operation and maintenance. It detects and controls projects through 3D models and 2D GIS graphics.

3.1.4. Data Analysis. Data analysis is to use physical and mathematical methods to carry out qualitative and quantitative analysis of engineering construction in different aspects of the project and the whole life cycle [12], such as statistical analysis, artificial intelligence analysis, cost analysis, and big data analysis.

3.2. Microservice Development Framework. Microservices are services composed of multiple individual applications that can be centrally managed after completion through different programming languages and databases [13]. Microservices are divided by business functions, and these independent microservices are combined through the same protocol to form a final system or application, and data exchange between microservices is completed through network communication. If you need to expand a specific business function, you only need to expand the service of the business function, and you do not need to expand the entire system or application, so that you can improve the business with more confidence and improve the development efficiency of the team. The iS3 system in this article is developed using SpringCloud, a popular microservice framework. It also uses the development component Eureka provided by the SpringCloud family to complete the service registration discovery function, GateWay to complete the microservice gateway function, and Feign to implement the communication between microservices. The following content introduces the technical principles of these three parts in detail.

3.2.1. Service Registration and Discovery Eureka. The Eureka component implements the registration and discovery functions of microservices through the Eureka server and the Eureka client. Figure 2 shows the relationship between the two parts.

Eureka server and Eureka client are essentially a service, but they are configured differently in the service configuration file [14]. After each service is started, it registers its own IP, port number, service name, and other information with the Eureka server and periodically sends a signal to the Eureka server to check whether the service is alive. If the services need to call each other, the service consumer first uses the service name to initiate an application to the registry, obtains information such as the ip and port number of the service provider, and then calls the service. And the detailed information of these providers is cached locally, so that it can be used directly when there is a need for invocation [15].

3.2.2. Service Gateway. Every service in the actual development process needs to be packaged and published, so each service needs to use a different ip, address, and port number. The user's one click function on the client may need to request multiple services on the client. Microservice gateway is often developed into a system, which can avoid directly connecting the client and the server by isolating the client. The user's operation in the client only needs to send the request to the gateway system and then forward it to the back end for multiple services through the gateway. In this way, the real business services can be hidden in the Intranet, reduce the complexity of the client code, improve the security of the system, and also verify the client requests in the gateway system, monitor, and analyze the data. In this way, the backend microservices only need to care about the realization of business logic, and the gateway system to do their own duties [16]. Figure 3 briefly shows the overall architecture diagram of the gateway in the microservice architecture.

The simple routing management mode designed by SpringCloud's microservice component Gateway can not only forward all requests from clients uniformly and efficiently, but also perform security, monitoring, and current limiting on the microservice system. Figure 4 provides the basic flow of Spring Cloud's gateway component Gateway when processing client requests.

In the microservice gateway, the request sent by the client first finds the route corresponding to the request in the Gateway Handler Mapping, and sends the result to the Filter Web processor to find the corresponding filter chain. After the request is processed, the actual backend service is called, and the result is finally returned. It is possible to pass through the filter chain before requesting the backend

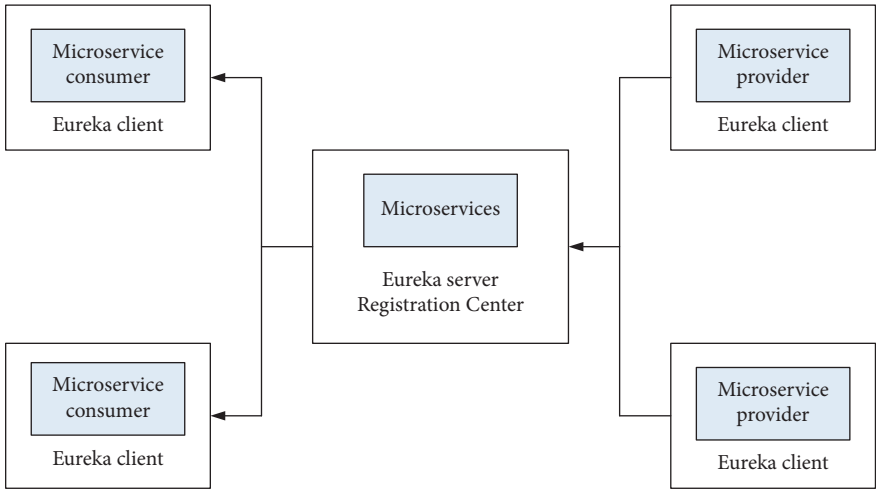

Figure 2: Eureka server and Eureka client.

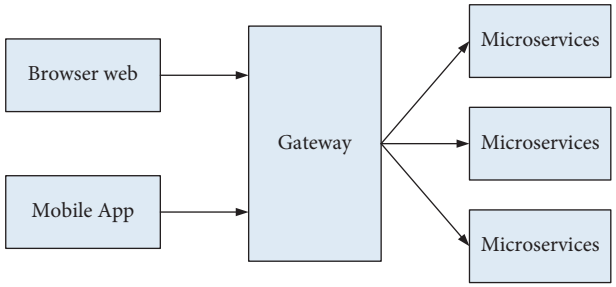

Figure 3: Schematic diagram of microservice gateway architecture.

business logic and after returning the result, so a dotted line should be added between the filter chains to separate [17].

3.2.3. Service Calls to Feign. In a system of microservice architecture, the services can obtain the required data through mutual visits, avoid the development of the same interface requirements for multiple services, and reduce the code repetition rate [18]. The communication between the service caller and the service provider in the Spring Cloud is HttpClient-based. Spring Cloud encapsulated httpClient, providing Rest Template and Feign communication, with the same Http call to the service as HttpClient. The Rest Template mode requires writing the service provider *s* url on the business code to call. However, if it is a more complex development situation, for system security considerations, you generally do not want to provide the details of the API. In this case, Feign components can be used for interservice calls. Feign encapsulates the Http calling process and is a declarative component. Noting the interface of the service provider in the actual development, the service name of the service provider is configured. Developers only need to call the interface of the paired service provider [19, 20]. This simplifies the writing of service requests and is more suitable for programming habits oriented to interface development. The Feign usage method is shown in Tables 1 and 2, Table 1 is the Feign process of the service provider, and Table 2 is the Feign process of the service caller.

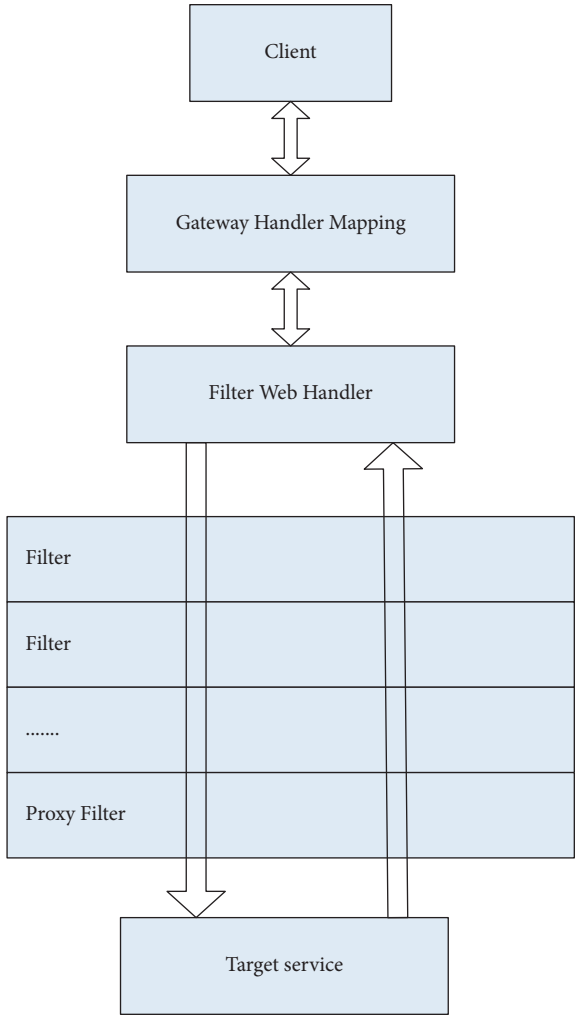

Figure 4: Flowchart of request processing by spring cloud gateway.

3.3. CHWBL Algorithm. The CHWBL algorithm is improved on the basis of the hash algorithm. The hash algorithm is currently a widely used load balancing algorithm in the field of load balancing. The main purpose is to ensure

Table 1: Feign process for service providers.

Begin	Define interface
1	@ FeignClient (name = "Product")
2	Public interface ProductClient
3	@GetMapping ("/getProduct")
4	Public string getProduct (String productId)
End	

Table 2: Feign process for service callers.

Begin	Inject at the place of the call
1	@ Autowired
2	Private ProductClient client;
3	@GetMapping(value = "getProduct")
4	Public string getProduct (string productId)
5	Return client.getProduct (productId)
End	

that the same request is sent to the same service node each time to achieve cache hits and cross-domain problems [21].

The first hash algorithm is to send the user request to a specific server by performing a hash operation on the user's IP and then modulo the number of servers, which can be expressed as formula (1) as follows:

$$h = \text{hash}(IP)\%n. \tag{1}$$

h is the corresponding server number obtained after the hash operation; hash is the hash algorithm used; IP is the IP address requested by the user; and n is the size of the service list.

Using this simple hashing algorithm to handle load balancing, when servers increase or decrease, all user requests need to relocate servers. Consistent hashing algorithm is optimized for this problem on the basis of simple hashing algorithm, abstracting the entire hash value space into a hash ring composed of nodes with a size of 232. The characteristic strings of the system nodes are hashed by the consistent hashing algorithm. The characteristic string is usually the IP address, name or port number of the service node, and a concatenated string, etc. The obtained hash calculation result is mapped to the hash ring, and the hash calculation formula (2) is as follows:

$$h = \text{hash}(IP)\%2^{32}, \tag{2}$$

where S is the characteristic string and 2^{32} is the size of the hash ring.

However, there is a problem with consistency hash algorithm. Conconsistency hash algorithm does not have a specific strategy of load balancing, and its load balancing effect mainly depends on whether hash algorithm is enough to randomly map requests and nodes to hash rings uniformly, if the randomness is insufficient. Uneven distribution can easily lead to a load tilt.

In view of the above problems, the significant improvement effect is CHWBL algorithm. In order to solve the problem of load tilt, CHWBL algorithm sets the upper limit of the load for each node. When the load of the node reaches the upper limit, the node will no longer accept the allocation of the request. This method can not only inherit the advantages of consistency hash algorithm, but also optimize the load tilt problem of consistency hash algorithm to prevent some nodes from overloading others but being relatively idle.

For example, when the system receives a request at time s, the load balancer of the system will calculate the total number of requests at the current time of the system, which can be expressed as formula (3) as follows:

$$L_{\text{sum}} = \sum_{i=1}^{n} L_{i(s)} + L_{\text{new}}. \tag{3}$$

Among them, L_{sum} is the total request load of the current system; $L_{i(s)}$ is the number of load requests being processed by the i-th node at time s; and L_{new} is a new request. At this time, the limit of node load is set as the average value of each node load, which can be expressed as formula (4) as follows:

$$\overline{L} = \frac{L_{\text{sum}}}{n}. \tag{4}$$

As shown above, $\overline{L}$ is expressed as the average load of all nodes; n is expressed as the total number of nodes. On this basis, the concept of a balance constant ε is introduced to dynamically control the upper limit of the load of the node. It can be set according to actual needs, and can be set separately or uniformly for different service nodes.

Through this method, the upper limit of the node load can be expressed as formula (5) as follows:

$$M_i = \overline{L} * (1 + \varepsilon). \tag{5}$$

As shown above, M_i is the upper limit of the load of the node, which is calculated by the average load of the system and the balance constant ε.

If the current system has m requests and n service nodes, the load number M of the nodes should satisfy the following formula:

$$M < \left\lceil (1 + \varepsilon) * \frac{m}{n} \right\rceil. \tag{6}$$

By limiting the upper limit of the load of service nodes in the consistent hashing algorithm, the CHWBL algorithm significantly improves the load balancing effect compared with the traditional consistent hashing algorithm, and retains the original excellent characteristics of the consistent hashing algorithm.

In a heterogeneous cluster with a distributed microservice architecture, there are differences in performance among the servers in the cluster. It cannot calculate the upper limit of the load of each node only based on the average load of the system like a homogeneous cluster. In order to adapt CHWBL to a heterogeneous cluster of microservices, it is necessary to set a weight for the nodes in the microservice architecture. The weight of each node can be expressed as formula (7) as follows:

$$W_i = \frac{P_{\text{cpu}} * W_{\text{cpu}}}{AVG_{\text{cpu}}} + \frac{P_{\text{ram}} * W_{\text{ram}}}{AVG_{\text{ram}}} + \frac{P_{\text{net}} * W_{\text{net}}}{AVG_{\text{net}}}. \tag{7}$$

Among them, W_i is the weight of the node; P_{cpu}, P_{ram}, and P_{net} represent the performance indicators of the current node's CPU MIPS, memory ram size, and network net bandwidth; W_{cpu}, W_{ram}, and W_{net} represent the weight of each indicator; and AVG_{cpu}, AVG_{ram}, and AVG_{net} represent the average performance indicator of all nodes in the system.

Combining the entropy weight method to calculate, the current three indicators can be expressed as X_1, X_2, and X_3. Among them, $X_j = \{x_1, x_2, \ldots x_n\}$ represents the parameter of each node of this indicator. Standardize each index to get Y_{ij} of each index, which can be expressed as formula (8) as follows:

$$Y_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)}. \tag{8}$$

Among them, Y_{ij} is the normalized value of the j-th indicator of the i-th node; X_{ij} is the specific value before standardization; $\min(X_j)$ represents the smallest value in a group of indicators; $\max(X_j)$ represents the largest value in the indicator. Calculate the proportion of the jth index of the ith node, which can be expressed as formula (9) as follows:

$$p_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}}. \tag{9}$$

p_{ij} is the proportion of the indicator. The information entropy of each index can be obtained by the proportion of the index, which can be expressed as formula (10) as follows:

$$E_j = -ln(n) \sum_{i=1}^{n} p_{ij} ln(p_{ij}), \tag{10}$$

where E_j represents the information entropy of the jth indicator; The weight of the indicator can be calculated through the information entropy of the indicator, which can be expressed as formula (11) as follows:

$$W_j = \frac{1 - E_j}{\sum_j 1 - E_j}. \tag{11}$$

W_j represents the weight of each indicator of W_{cpu}, W_{ram}, and W_{net}. These three weights need to be added together to be 1, which can be expressed as formula (12) as follows:

$$W_{cpu} + W_{ram} + W_{net} = 1. \tag{12}$$

At this time, the sum of the service node weights is equal to the number of nodes, which can be expressed as formula (13) as follows:

$$\sum_{i=1}^{n} W_i = n. \tag{13}$$

The above weight division method defines the weight according to the different performance of the nodes, so as to ensure that the nodes with good performance can be divided into higher weights, so as to allocate more load; on the contrary, nodes with poor performance have smaller weight division and less request load allocated. Then, according to the calculation formula of the CHWBL algorithm, the number of nodes is replaced by the sum of the weights of each node, T, because $T = n$, the average load of the node can be expressed as formula (14) as follows:

$$\overline{L} = \frac{L_{sum}}{T}. \tag{14}$$

After introducing the balance constant ε, the upper limit of the load of each node can be expressed as formula (15) as follows:

$$M_i = W_i * \overline{L} * (1 + \varepsilon). \tag{15}$$

At this time, the number of requests of each node in the system should not exceed the upper limit of its own load M_i.

4. Microservice Architecture Infrastructure Smart Service System Design

4.1. System Requirements. Infrastructure intelligent service system is based on the infrastructure data management of the whole life cycle of underground engineering with the same data standard, which mainly includes data collection, data processing, data visual expression of each link of the project, qualitative analysis of infrastructure data, and the corresponding decision-making function of the project. The data collected by various sensors and the data from different stages of underground engineering need to be imported into the corresponding engineering database of the system. Users can view the two-dimensional plan and 3D model map of the underground space infrastructure. Based on the various engineering data of the infrastructure collected in the database, a qualitative and quantitative analysis of the problems arising in the operation and maintenance process in the underground engineering can be conducted.

Because the environment where the sensor is placed may collect some information unrelated to the state of the infrastructure, some technologies are needed to process the collected data. Then through the same data standard processing, it was saved to the system engineering database. Users can also realize the management functions of data display, query, delete, and modify the engineering data information stored in the database. Develop strategies and qualitatively analyze underground engineering based on the data collected from the current infrastructure. In the design stage, underground space infrastructure will have a variety of two-dimensional plans, horizontal section, vertical profile, and two-dimensional and 3 D view models. In iS3 system, abstract data such as engineering data and model data in infrastructure can be used for visual expression and interactive sharing, so as to facilitate users' visual cognition of abstract data such as engineering and engineering data. In iS3 system, 2D graphics data and 3 D model data, including engineering data, can be uploaded and managed through files. The system also needs to design the function of user registration and login, grant the corresponding function permission to legal users, and the corresponding module function in the visit system. Table 3 shows the systematic divided functional categories and detailed functional descriptions.

Table 3: Statistics on functional requirements of iS3.

Function	Description
BIM model display	Build and render 3D models on the web 2D CAD graphics add component elements
2D graphics display	2D graphics as ArcGIS layers Browser 2D graphics with component elements, GIS data as basemap
Engineering data	Query, deletion, and modification of facility data The original engineering data provided by the cooperative unit
User management	User registration, login, permission verification, and other functions

4.2. System Design Ideas. The design of the infrastructure smart service system mainly includes two parts: the microservice technology stack and the business service. Among them, the SpringCloud technology is used to build the microservice architecture of the system. The business service refers to the service that truly realizes the business logic and provides results for the client's request. The infrastructure smart service system selects some components in SpringCloud when building the microservice architecture, and these components are indispensable in system development. It mainly includes the service registration and discovery component Eureka, the gateway component Gateway, and the mutual invocation component Feign between microservices.

The system is separated from frontend and backend: the frontend development framework is Vue.js, and the infrastructure data is stored in the MySQL data server; backend service development uses SpringBoot technology. SpringBoot improves and optimizes the traditional Spring development framework, reducing the lengthy and insignificant configuration file writing work. Using SpringBoot technology to develop will greatly improve the development efficiency of the application and greatly shorten the development cycle of the project. The development advantages of SpringBoot technology can be summarized as: ① Compared with the traditional framework structure, SpringBoot can quickly construct projects and the developed projects can run independently. ② SpringBoot does not need to rely on other servers externally due to the embedded Tomcat and other servers. ③ For the integrated use of many popular frameworks, you only need to install the dependency packages of the corresponding frameworks or configure them.

When part of the 2D graphics data designed in the system is loaded into the browser, the current geographic location needs to be displayed as the base map, and the 2D graphics can be imported into the ArcGIS server as a layer. The client loads the map resources and corresponding two-dimensional graphics to the frontend page for display by requesting the interface of the ArcGIS server. Table 4 shows the environment resource configuration requirements for system development to meet the needs of iS3 system development.

4.3. Overall System Architecture. The infrastructure intelligent service system designed in this paper uses the microservice architecture built by the Spring Cloud framework. The system as a whole includes a three-layer architecture of data layer, business service layer and display layer. Figure 5 shows the overall architecture of the infrastructure smart service system.

Table 4: iS3 system development environment.

Software type	Name and version
Operating system	Windows7 and above
Database	MySQL5.8
Backend development platform	IDEA2019.03
Frontend development platform	VSCode2017
Browser	Chrome
Java platform	Jdk1.8

4.3.1. Display Layer. The essence of the infrastructure smart service system is a web application, using the Vue framework and Three.js technology. The Vue framework is mainly used to design Web pages, and the Three.js technology is used to load JSON 3D model files, build, and render 3D models. When a user clicks a function on a web page, the browser sends a request to the backend. These requests first need to be forwarded through the microservice gateway system, after which OAuth2.0 authenticates and authorizes the current user, and then the backend-related microservice application responds. The microservice gateway undertakes services such as service aggregation and protocol conversion. By providing a coarse-grained API to the outside world, it reduces the http requests that need to be initiated when a page needs to access multiple microservices and decouples the front and back ends of the iS3 system.

4.3.2. Business Service Layer. The background business of the infrastructure smart service system mainly includes basic services and application services. The basic services include the Eureka microservice registry, the log service that monitors the running status of the system, and the cache service that uses Redis technology. The main application services of iS3 include data third-party interface service, engineering data management service, 2D data display service, file management service, BIM model display service, and user service.

4.3.3. Data Layer. The data layer includes infrastructure data, 3D model data, and 2D graphics data for different aspects of the project.

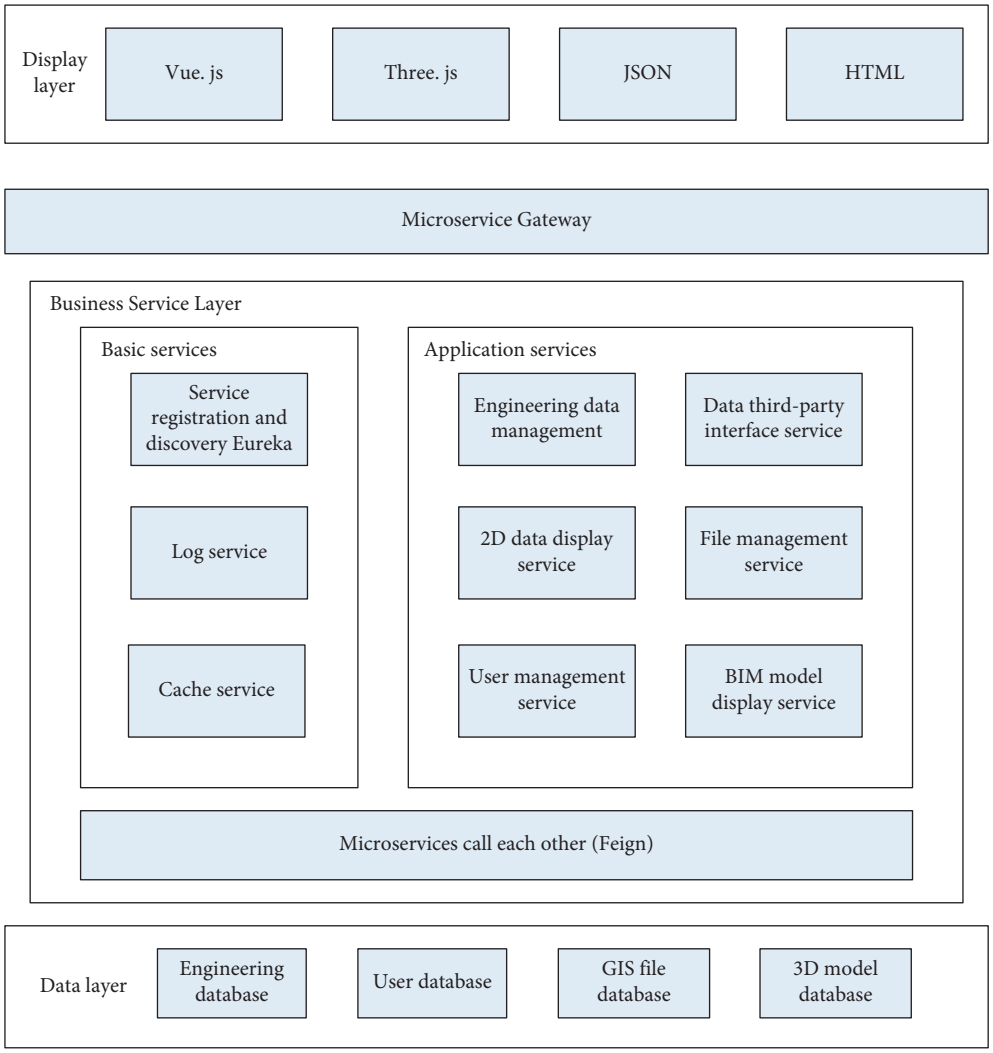

Figure 5: Overall architecture of iS3 system.

According to the requirements analysis and overall architecture design of the infrastructure intelligent service system, this section will divide the detailed functional modules of the business service layer of the system, and the system business service layer is mainly divided into the basic service module and the application service module. The basic service module mainly includes three parts: service registration and discovery module, log management, and cache management. The application service module is the main function module in the iS3 system, which needs to interact with the database and exchange data with the frontend page, which is related to the overall function of the system. The application service layer mainly includes six parts: data third-party interface service, engineering data management service, file management service, BIM model display service, 2-dimensional data display service, and user service to realize the mapping of requirements and functions. After dividing several modules of the application service layer, the specific business functions of each microservice need to be designed in more detail. Figure 6 shows the main functions of the design of the infrastructure intelligent service system.

The data third-party interface is responsible for automatically screening the collected infrastructure data according to the specified requirements, transforming it according to the unified standards, and finally storing the work in the engineering database. Engineering data management service realizes the management functions of infrastructure data query, increase, book division, and modification by operating the infrastructure data in the engineering database. The file management service can realize the unified upload and management of uploaded files (including engineering data files, 2-D graphics line data files, 3-D model data files,). The 2D model display service is responsible for loading the 2D graphics combined with ArcGIS into the frontend page for display and realizing the linkage of 2D data and infrastructure data. User service mainly designs the unified registration, login, modify personal information, and exit system functions, at the same time, the user service also provide permission setting and verification information function. The BIM Model Display service is responsible for uploading and displaying the BIM model, and can also view the

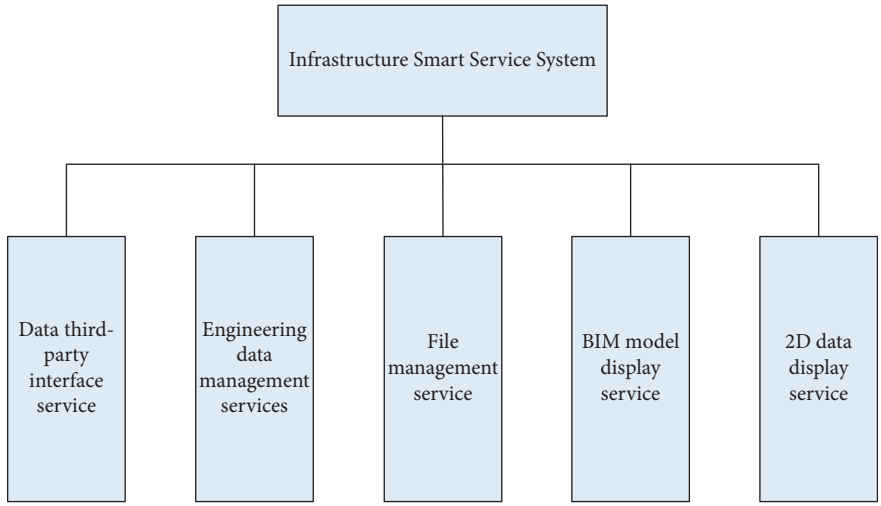

Figure 6: System function module design diagram.

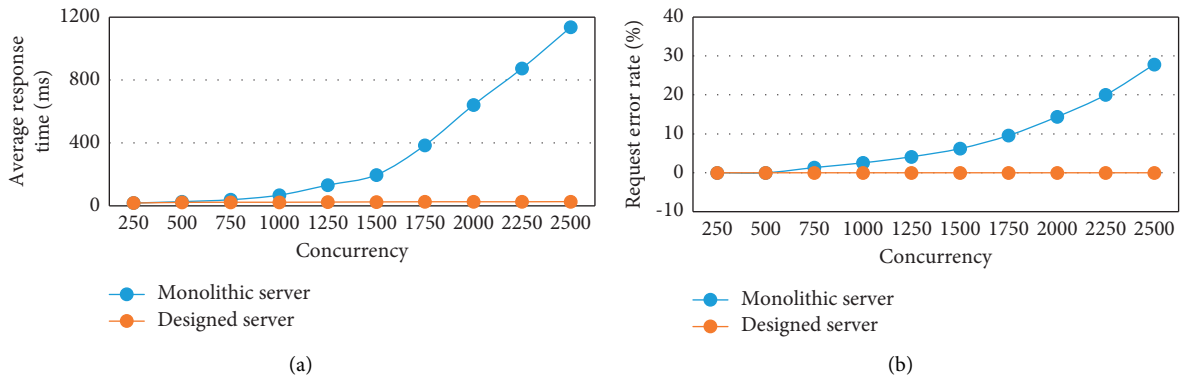

Figure 7: Instantaneous high-concurrency test results: (a) the average response time of the front and rear service end for instantaneous high concurrency and (b) the request error rate of the front and rear service under instantaneous high concurrency.

corresponding infrastructure data by clicking on the components in the model.

5. Microservice Architecture Infrastructure Smart Service System Functional Test

This section will stress test the server side of the infrastructure smart service system before and after the design, and compare it with the server side under the previous single architecture. To this end, Apache JMeter was selected as a stress testing tool to test the average response time and error rate of the server under high concurrency, simulate the concurrent access of a large number of users to the server through parameter settings, so as to verify the performance of the server.

5.1. Instantaneous High-Concurrency Test. In the transient high concurrency test, set the Ramp-UpPeriod parameter of the JMeter thread group to 1s. That is, start all threads within 1s, and then gradually increase the number of threads to increase the concurrency. The test results are shown in Figure 7:

As can be seen from Figure 7, under the instantaneous high-concurrency test, the server performance before and after the design is close when the concurrency number is within 500. As the concurrency number increases, the average response time between the two also increases, and when the concurrency number reaches 1500. The server error rate before the design was 6.21%. When the concurrent number reaches 2500, the average response time of the server before the design exceeds 1s and the error rate is 27.85%, while the designed server has no error and the average response time is relatively stable. The analysis of the test results can show that the designed server can significantly reduce the average response time and error rate under the instantaneous high-concurrency situation, and then improve the overall performance.

5.2. Continuous High-Concurrency Testing. In continuous high-concurrency testing, the Ramp-UpPeriod parameter of the JMeter thread group is set to 10s, which is changed to start all threads within 10s, and increase the number of threads successively directly from the concurrency number 2000. The results obtained from the test are shown in Figure 8:

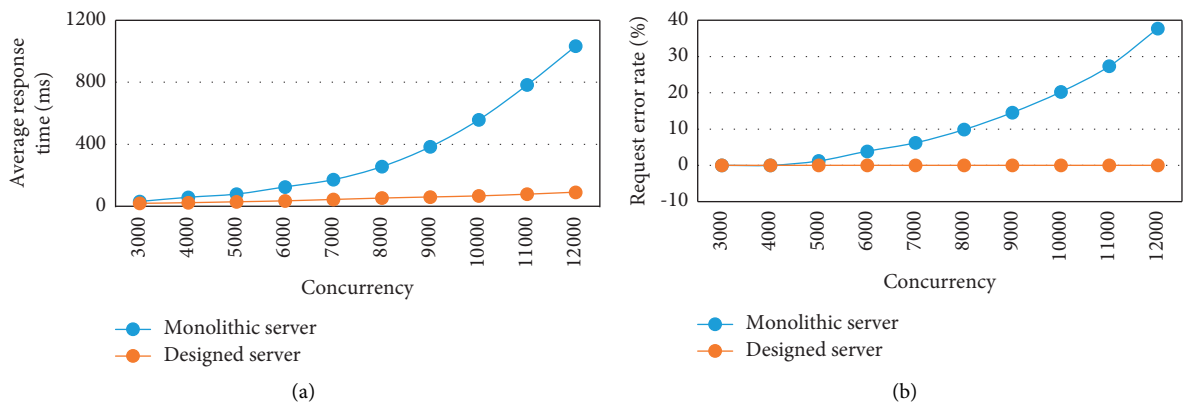

Figure 8: Continuous high-concurrency test results: (a) the average response time of the before and rear service for continuous high concurrency and (b) the request error rate of the front and rear service for continuous high concurrency.

As can be seen from Figure 8, under the continuous high-concurrency situation, the average response time and error rate growth trend of the before and after the design server are basically consistent with the test situation under the instantaneous high development. With the increase of the concurrency, the average response time and error rate also increase significantly, the average response time exceeds 1s at 12000 and the error rate reaches 37.73%, while the average response time is stable, maintained within 100 ms when the concurrency is 12000, and no request error occurs during the test.

Based on the above test results, it can be clearly concluded that the average response time and error rate of the service side are much lower than that of the design in the case of instantaneous high development or continuous high concurrency. Therefore, it can be concluded that the iS3 system server based on the microservice architecture can effectively improve its concurrent processing capacity and have excellent performance.

6. Conclusion

This paper makes a detailed analysis of the specific requirements and design of infrastructure intelligent service system. The innovative content is to combine microservice architecture to design iS3 system, study, and realize the data display of iS3 system and the display and interaction of 3D model in the Web in business service link. However, with the development of the Internet, big data, cloud computing, the Internet of Things, and the popularization of mobile technology, we need to pay attention to future research directions. The future research needs to be carried out from the following aspects: (1) The current iS3 system is running on a single server. Once the server collapses for some reason, the whole system will be offline and users cannot visit it. Considering this case, we can extend single points to clusters. (2) The current iS3 is only applicable to dry Web pages. For users who want to view the project progress and infrastructure status anytime and anywhere, they can design a simple version of the mobile iS3 system to facilitate the visual expression of iS3.

Data Availability

No data were used to support this study.

Conflicts of Interest

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

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Review Article

Comparative Analysis of Routing Schemes Based on Machine Learning

Shaoyu Yang,[1] Cong Tan,[2] Dag Øivind Madsen,[3] Haige Xiang,[4] Yun Li,[5] Imran Khan,[6] and Bong Jun Choi[7]

[1]*North China University of Water Resources and Electric Power, Zhengzhou 450046, China*
[2]*Henan University of Animal Husbandry and Economy, Zhengzhou 450046, China*
[3]*University of South-Eastern Norway, Bredalsveien 14, Hønefoss 3511, Norway*
[4]*Information Research Center, Beijing University, Beijing, China*
[5]*Department of Electronic Engineering, University of Illinois Urbana-Champaign, Champaign, USA*
[6]*Department of Electrical Engineering, University of Engineering and Technology, Peshawar 814, Pakistan*
[7]*School of Computer Science and Engineering, Soongsil University, Seoul, Republic of Korea*

Correspondence should be addressed to Shaoyu Yang; ysymagnet@126.com, Dag Øivind Madsen; dag.oivindmadsen@outlook.com, and Bong Jun Choi; davidchoi@soongsil.ac.kr

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Machine learning-based distributed routing algorithms, in contrast to traditional mathematical model-driven distributed routing algorithms, are typically data-driven, allowing them to adapt to dynamically changing network environments and various performance evaluation index optimization requirements. It is quite likely that it will become a key part of the next-generation Internet in the future. However, current intelligent routing research is still in its early stages. This article provides a comprehensive review of the state-of-the-art routing algorithms based on machine learning. First, important research on existing data-driven intelligent routing algorithms is presented with the key concepts and applications of these systems demonstrated. To enable intelligent routing algorithms to be deployed in real scenarios with cheap cost and high reliability, two appropriate training deployment frameworks and intelligent routing algorithm training and deployment strategies are given. Finally, the future development of machine learning-based intelligent routing systems is examined. The opportunities and problems that have been encountered, as well as prospective research directions, are discussed.

1. Introduction

In recent years, with the rapid development of the Internet, many emerging applications including industrial Internet, 4K + video and holographic communication, online games, and remote cloud services have emerged in large numbers. These emerging network applications bring highly differentiated service quality requirements. However, in the past, the method of improving network service quality by simply increasing the speed and capacity of equipment has gradually reached the ceiling and further improving the performance requires a high cost. Therefore, better optimization and utilization of existing network resources has become an important way to improve user service experience.

In a classical computer network design, the network layer uses best-effort packet forwarding, and the routing algorithm's focus is on the data packet's reachability, as well as the algorithm's performance and scalability. In recent years, with the rapid development of computer networks, the scale of the network has drastically increased, and the number of application service types on the upper layer of the network has also increased rapidly. As the number of service kinds grows, so do the goals for service performance improvement, which include latency, bandwidth, throughput, packet loss rate, and network stability. The traditional best-

effort routing algorithm makes the existing computer network architecture have certain limitations in optimizing these performance evaluation indicators. Figure 1 shows an example of the limitations of the traditional routing algorithm. In this example, the network flow load requires a bandwidth of 500 Mbps. The traditional shortest path-based routing algorithm directs all traffic to the bottleneck link, and the selected path has an available bandwidth (100 Mbps), which is much smaller than the service demand bandwidth. This not only will greatly reduce the user experience, but also may bring serious network congestion and cause a huge waste of network resources. Appropriate routing and offloading of the above traffic can well avoid the problem in this example. However, because the available bandwidth of the path changes dynamically with time in the real network environment, it is difficult for traditional routing algorithms to accurately perceive the current network status and perform appropriate actions accordingly.

In addition, the emergence of emerging network application scenarios such as data center networks has brought new challenges to the field of routing optimization and traffic engineering [1]. Compared with the traditional network, the network bandwidth of the data center is larger, and there are larger flows and long flows at the same time, and the demand and difficulty for traffic scheduling are also higher. Although there have been some routing and traffic engineering methods to try to solve the network optimization problem in various data center scenarios, in the data center network scenario, the existing routing and traffic scheduling optimization methods are still difficult to meet the requirements of efficient utilization of links and loads [2]. In order to meet complex network application scenarios and diverse service quality requirements, many network layer optimization schemes based on mathematical models have been proposed [3–6]. These routing optimization or traffic engineering schemes usually make some assumptions for the application scenario to simplify the problem, so that the optimization problem can be efficiently solved by using the existing mathematical methods. However, real network application scenarios are often difficult to fully meet these idealized assumptions, which makes routing optimization algorithms based on mathematical models unable to guarantee their deployment effects in real scenarios. In fact, many routing optimization problems can be solved even under hypothetically simplified scenarios.

It is still very complex, and there is no general model that can solve different types of routing optimization problems at the same time [7]. Since traditional routing optimization tasks need to be modeled separately for each specific scenario and specific optimization objectives, deploying these methods in a real network environment may have an impact on the scalability of network facilities. Therefore, traditional mathematical models have still difficulty to deploy large-scale routing optimization schemes in practical scenarios.

In recent years, artificial intelligence (AI) technology based on deep learning has developed rapidly and has been widely used in natural language processing [8], image recognition [9], game strategy calculation [10], and other fields. The research on deep learning models and the development of computer hardware such as central processing unit (CPU) and graphical processing unit (GPU) have made the strategies that can be learned by AI models more complex, and the training and execution efficiency is getting higher. The improvement of equipment computing power and model expression ability makes the AI model have strong learning ability and good generalization. It is gradually possible to use AI model to solve routing optimization problems and to endow the network layer with intelligence. Compared with the traditional model-driven routing optimization algorithm, the data-driven intelligent routing optimization algorithm has three advantages:

(1) *Accuracy*. Using real data to train machine learning algorithm models does not require complex assumptions and modeling of the network environment;

(2) *Efficiency*. In polynomial time, the optimized routing decision can be obtained by fast reasoning according to the input data;

(3) *Universality*. The same machine learning model can be used to solve different.

The above three advantages make the data-driven intelligent routing method better adapt to different network application scenarios and routing optimization goals than the traditional routing method and have better scalability in the process of deployment.

In addition to the rapid development of AI technology, the related research on software-defined networking (SDN) [11] and programmable routing devices [12, 13] that have emerged in recent years also provides the possibility of deploying intelligent routing algorithms. These works enable the routing layer to complete more complex tasks. The emergence of the SDN architecture enables the intelligent routing algorithm based on machine learning to run as an application in the SDN server with powerful computing power and effectively control the routing and traffic [14]. However, the existing research on the intelligent routing scheme based on machine learning is still in a relatively preliminary stage as it mainly focuses on the correctness and convergence of the intelligent routing algorithm. The training and deployment scheme of the intelligent routing algorithm in the real scenario is still not perfect. In addition, the computing power of current routing equipment is still far from the large-scale deployment of intelligent routing algorithms [15].

In order to provide a detailed evaluation of the relevant state-of-the-art machine learning-based routing methods, this article proposed a comparative study and has the following contributions:

(i) Introduces the related work of existing data-driven intelligent routing algorithms based on machine

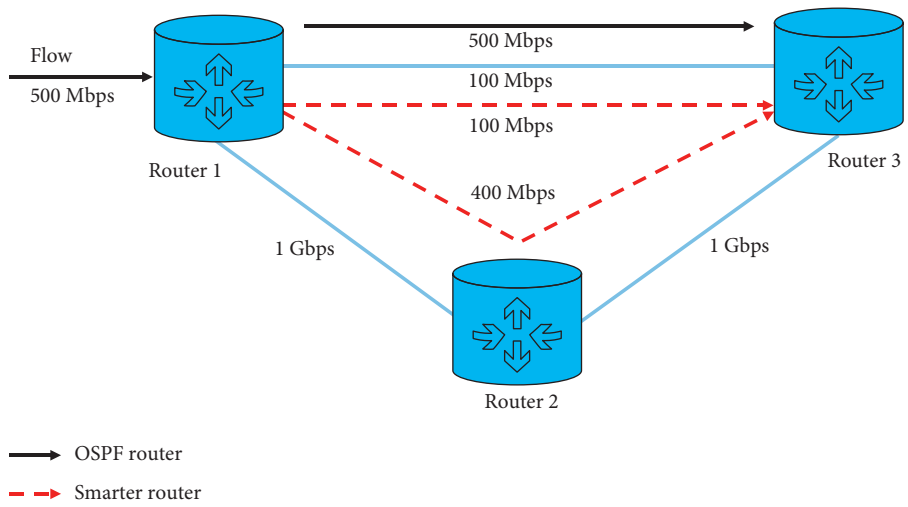

Figure 1: Illustration of flow decision in the open shortest path first algorithm.

learning from the perspectives of methods and application scenarios, and analyzes the advantages and disadvantages of different intelligent routing methods.

(ii) Further analyzes the training and deployment methods of existing intelligent routing algorithms.

(iii) Two intelligent routing algorithm training and deployment frameworks suitable for different application scenarios are proposed.

(iv) Analyzes the opportunities and challenges in the future development of intelligent routing algorithms based on machine learning, and gives the future research directions of intelligent routing algorithms.

2. Overview of Intelligent Routing Algorithms

The authors devised an intelligent routing algorithm Q-routing based on Q-learning and deployed in communication networks as early as 1994 [16]. The experiments demonstrated that the Q-routing strategy can efficiently avoid the network congestion and minimize the packet transmission time when compared to standard shortest path routing. However, although many subsequent works have perfected and optimized the method [17, 18], limited by the computing power of the router and the design of the network layer structure, the intelligent routing algorithm is difficult to be deployed in real network scenarios.

Reference [19] proposed the Q-learning-based energy-efficient and lifetime-aware routing (QELAR) method, which applied the idea of Q-Learning to wireless sensor networks (WSN) to optimize the energy consumption and lifetime of wireless sensor networks. Compared with the traditional network, the WSN is located in a complex and changeable environment and the demand for routing service quality is diverse. The traditional routing algorithm is often difficult to achieve satisfactory results in this application scenario. In addition, the structure of WSN is relatively independent compared with the traditional network, so the deployment of the intelligent routing method based on Q-learning is less difficult. Subsequent literature [20, 21] further applied the Q-learning method to the reliable transmission and accelerated forwarding of WSNs and achieved good results.

Deep learning has made great progress in the network area in recent years. It has been employed in transport layer congestion management [22], network vulnerability detection [23], video streaming optimization [24], and other domains. It has also gotten increased attention for solving routing optimization issues, and certain routing algorithms based on deep learning and deep reinforcement learning have been developed [25]. These intelligent routing algorithms not only use deep learning to improve the traditional routing algorithms [26], but also optimize the global performance for new network application scenarios such as data center network traffic scheduling and backbone network traffic engineering in recent years.

As more intelligent routing algorithms are proposed, how to deploy data-driven intelligent routing algorithms in real environments has also become a problem that has attracted much attention. The work of reference explored the prospect of deploying deep learning-based intelligent routing algorithms in real-world scenarios and proposed a way to deploy deep learning-based intelligent routing using a software-defined router (SDR) equipped with GPUs algorithm framework assumptions. However, according to our research, the existing research work still does not provide a feasible solution to deploy the intelligent routing algorithm in the existing computer network architecture.

According to the types of machine learning methods used, the data-driven intelligent routing algorithms are largely separated into intelligent routing algorithms based on supervised learning and reinforcement learning in recent years.

3. Supervised Learning-Based Routing Schemes

3.1. An Overview of Supervised Learning Methods Applied in Intelligent Routing. Supervised learning refers to the use of known input and output samples to train a model, so that the

model can accurately complete a class of machine learning tasks from input to output mapping [27, 28]. In recent years, intelligent routing systems based on supervised learning have mostly relied on deep learning models. Compared with traditional supervised learning methods, deep learning models can learn more complex strategies through labeled data, which provides the possibility to implement intelligent routing methods in complex network environments. In this section, we will briefly introduce the deep learning methods commonly used in existing intelligent routing methods.

The most common deep learning model is deep neural network (DNN), whose model design simulates the working principle of biological neurons, and the working process includes the feedforward process and the feedback process. Figure 2 shows its model structure and working process. In the feedforward process of DNN, the model passes the input vector forward layer by layer by combining linear weighting and activation function, and finally realizes the mapping from input to output. In the feedback process of DNN, the model transmits the deviation between the actual output result and the expected result in reverse layer by layer to complete the adjustment process of model parameters and achieve the effect of automatic learning. As an improvement to the DNN model, Ref. [29] proposed deep belief network (DBN). The DBN model combines the traditional DNN model with the restricted Boltzmann machine (RBM). The training process can be regarded as using the RBM to initialize the parameters of the DBN model and using the gradient reverse transfer process to fine-tune the parameters of the DBN model according to the task. As a basic deep learning model, the DBN model can be used in various tasks including routing optimization.

In the intelligent routing scheme, it is often necessary to process serialized information with variable dimensions, such as path information extraction [30] and traffic prediction at the next moment based on past traffic information [31]. In these tasks, it is difficult to achieve the desired effect only through the DNN model, and the recurrent neural network (RNN) is often used. The RNN can handle serialized input of indeterminate length well and has a good guarantee for the timing of network traffic information and the ordering of path features. Figure 3 shows the model structure of the RNN network. As an improvement of the RNN model, the long short-term memory unit (LSTM) [32] and the gated recurrent unit (GRU) [33] has better performance in existing works and is widely used.

In the intelligent routing scheme, the local or global topology information of the current network is an important basis for completing the intelligent routing decisions. However, due to the dynamic variability of the network topology, the traditional deep learning models are often difficult to handle this part of the information efficiently. The graph neural network (GNN) is a new type of neural network structure proposed in recent years, which is considered to be able to effectively deal with the problem of topological information extraction [34]. The GNN model vectorizes the characteristics of network nodes and edges, and performs several rounds of iterations. During each iteration, the vectorized representations of these nodes and edges are updated according to the topological dependencies using an update function based on the deep learning model. Finally, the vectorized representation of these nodes and edges will converge to a certain value, which means that the GNN model has transformed the topology information into vectorized representation information that can be used by the deep learning model. Studies have shown that the GNN model has good scalability and generalization, and has been widely used in network topology information extraction tasks [35].

3.2. Intelligent Routing Algorithm Based on Deep Learning. The most direct application of deep learning in routing optimization problem is to use deep learning model to replace the original routing algorithm based on a mathematical model. A general routing solution model is shown in Figure 4, which takes the network topology and network state information as input, and the deep learning model makes appropriate routing decisions according to the current network environment state according to the input information.

The authors in Ref. [15] proposed a routing decision scheme based on the DBN. Figure 5 shows the schematic diagram of the overall model of the scheme. The application scenario of this intelligent routing scheme is the backbone network. The scheme divides the routers into intradomain routers and border routers. When the data packets enter the backbone network through the border routers, the DBN model deployed on the border routers will calculate the data packets in the backbone network according to the current traffic status of each node in the network. The data packet is forwarded to the destination router through the intra-domain router and finally leaves the backbone network. In the above model, the interdomain routers are only responsible for route forwarding and network state information collection, thus avoiding the frequent exchange of network topology information in traditional distributed routing algorithms. The routing decision model of this scheme trains a DBN model separately for each routing node to each destination border router to output the appropriate next-hop node according to the network state information. The routing path calculation process adopts a hop-by-hop method to pass the corresponding DBN model generation. The work of Ref. [15] shows that the routing strategy based on the deep learning model can achieve 95% accuracy. At the same time, the deep learning model has the characteristics of making routing decisions based on part of the network state characteristics, which also makes the intelligent routing method based on deep learning. Compared with traditional routing methods, it has lower information exchange cost and faster routing convergence speed when the network environment changes. However, the deployment of the above scheme not only requires the backbone network routers to have strong model computing capabilities, but also needs to modify the existing routing protocols. Therefore, deploying the above scheme under the existing computer network architecture requires extremely high costs and will seriously affect the scalability of the network.

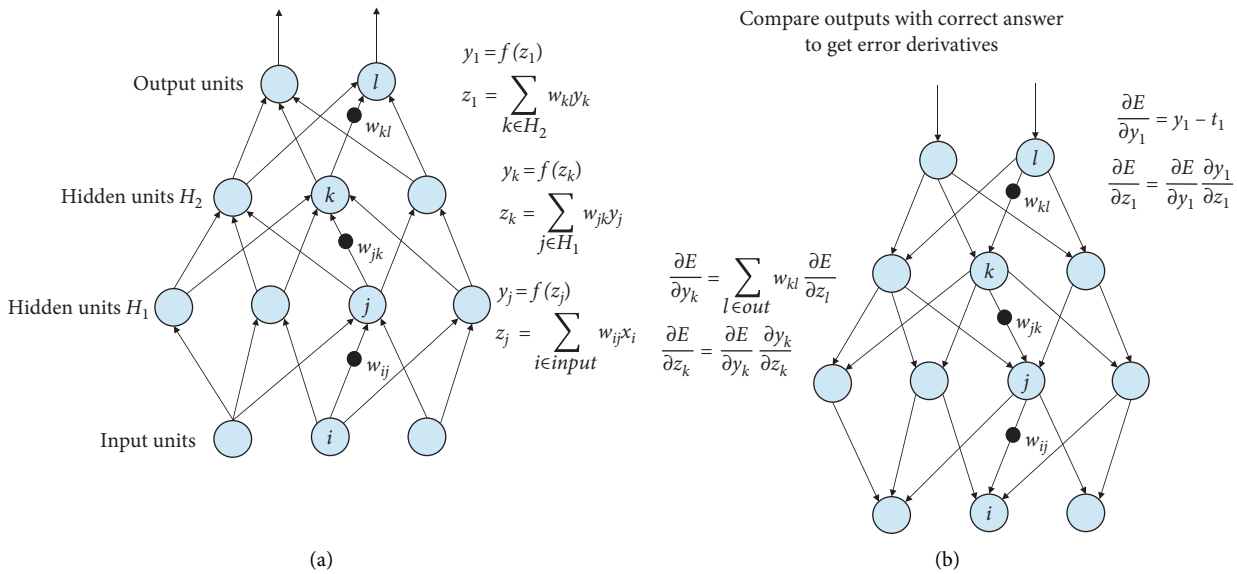

Figure 2: Illustration of DNN. (a) Feed forward, (b) Back propagation.

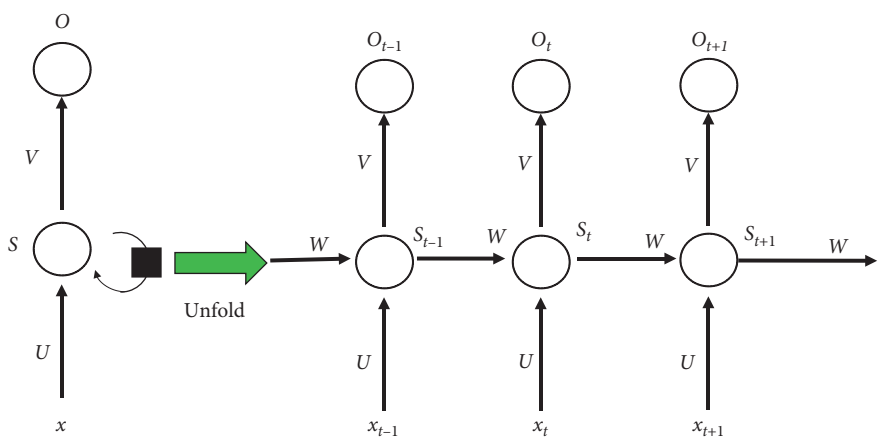

Figure 3: Process of RNN.

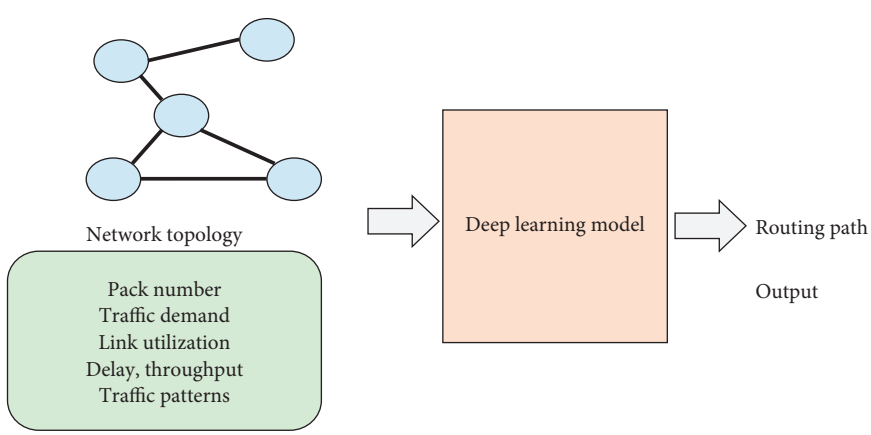

Figure 4: DL model for routing.

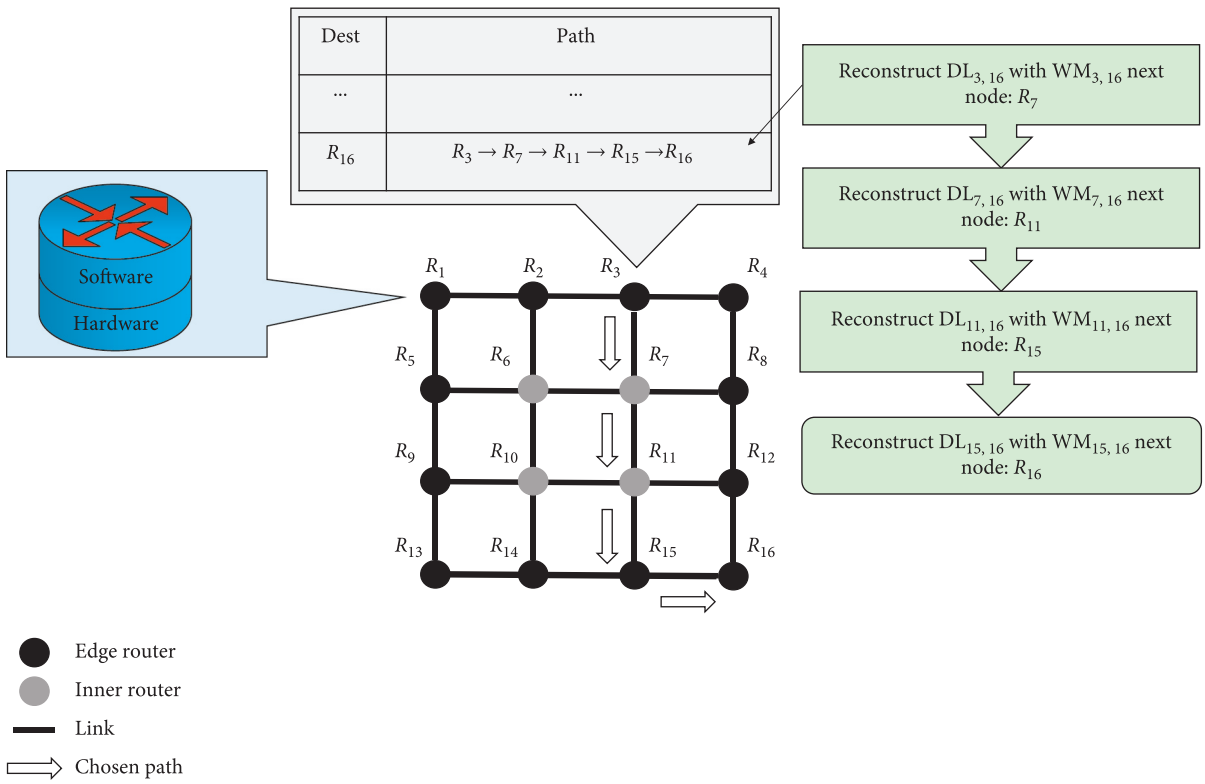

Figure 5: Protocol flow process of the deep belief network.

In addition to the DBN model, other deep learning models have also been tried to apply to intelligent routing tasks. The work of Ref. [36] compared the effect of applying different deep learning models to learn routing decisions. In this work, the hop-by-hop intelligent routing decision-making process is formally expressed as

$$\text{src}, \text{dst}_{n+1} = F(\text{src}, \text{dst}_n, \text{dst}, G). \quad (1)$$

Among them, src and dst represent the source and destination nodes, respectively, and src, dst_n are the nth routing node numbers in the route from src to dst; $F(\cdot)$ is the routing decision function; G stands for topology information. Through experiments, it is found that the combination of the topology-based feature extraction method and the graph-aware deep learning (GADL) model can effectively improve the model test accuracy and reduce the model training time compared with the existing deep learning models such as DBN and CNN.

To further utilize the topology information, Shin and Kim [26] designed a distributed intelligent routing algorithm based on GRU and GNN. In order to make the GNN model better represent the structural characteristics of the routing network and make the network feature information modeled by the GNN more convenient for the routing decision-making process, the router interface is added to the graph model as an additional node. Figure 6 shows the schematic diagram of the graph model after adding the router interface as an additional node. After GNN completes the topology modeling, the node information corresponding to each router interface is vectorized and represented by $\mathbf{h}_v$. It not only contains its own information, but also contains the entire network structure and state information required for routing decisions due to the information transfer characteristics of GNN. Using the routing interface information $\mathbf{h}_v$, each router can locally calculate the router interface that should pass through to the corresponding destination node. Due to the model characteristics of GNN, the iterative process of the above GNN topology modeling can be done in a distributed manner by deploying the GNN parameter update function on each router, so this method naturally has good scalability and distributed routing decisions. The simulation experiments of this work show that the distributed intelligent routing algorithm based on GNN performs well in terms of routing convergence speed, accuracy, robustness, and fault adaptability. The accuracy rate of 98% is achieved within 15 rounds of iterations for the max-min fair routing algorithm [37].

Combining with the content in Table 1, it can be found that the existing intelligent routing schemes based on deep learning models mainly generate routing paths in a hop-by-hop manner. Another routing mode corresponding to the hop-by-hop routing generation method is to calculate all possible paths in advance and select the appropriate path according to the network state through the deep learning model. This method based on path selection can avoid routing loops caused by the path generation model. However, the number of optional paths in the network will increase exponentially with the increase in the network size, and its huge output dimension makes the learning difficulty of the deep learning model based on path selection and the number of model parameters in an unbearable order of

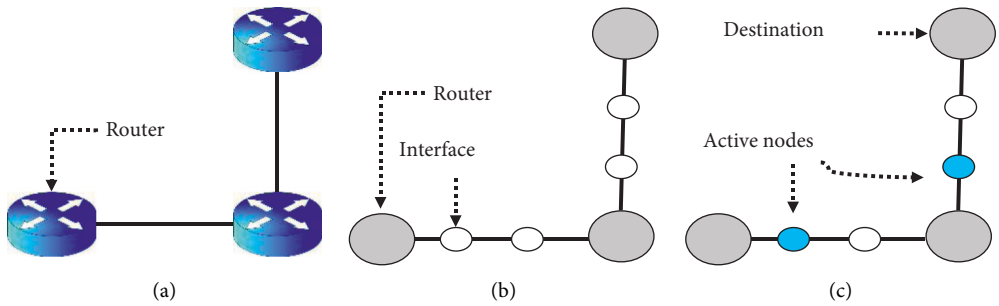

Figure 6: Inclusion of the router. (a) Example of network topology, (b) Associated graph model, (c) Example of output features.

Table 1: Comparison of various routing protocols based on machine learning.

Algorithm	Routing method	Controlling method	Learning method	Deployment	Training method
Ref. [15, 25, 39]	Path creation				
Ref. [26]	Path creation	Packet-based		Decentralized	
Ref. [40]	Predicting congestion		Offline		Offline
Ref. [30]	Predicting jitter and delay			Centralized	
Ref. [36]	Path creation	Flow-based		Centralized	
Ref. [16–21]	Path creation	Packet-based	Online	Decentralized	Online
Ref. [14]	Splitting ratio configuration	Epoch-based		Centralized	
Ref. [31] Ref. [38]	Link weights	Epoch-based	Offline	Centralized	Offline

magnitude [38]. In addition, due to the strong correlation between network path characteristics and topology, it is difficult for deep learning models based on path selection to have sufficient generality and generalization. Compared with the path selection method, the hop-by-hop path generation method can significantly reduce the output dimension and the difficulty of model decision-making, which can significantly improve the accuracy of routing decisions [39].

Existing work shows that the intelligent routing algorithm based on deep learning can quickly and accurately calculate the corresponding routing decision based on some network state information, and it shows certain advantages compared with traditional distributed routing in terms of information transmission cost and routing convergence speed. The distributed routing decision based on GNN has made some progress in the problems of topology information modeling, robustness, and fault adaptability that are difficult to be solved by intelligent routing solutions based on traditional deep learning models. However, the existing intelligent routing algorithm based on the deep learning model mainly learns the routing algorithm based on the shortest path, and whether it can learn more complex dynamic routing algorithms well is worth further discussion. In addition, the existing deep learning-based intelligent routing algorithms cannot guarantee their security and robustness in complex and changeable network environments, and require high deployment costs. Therefore, deep learning-based routing algorithms want to replace traditional routing algorithms and still a long way to go.

3.3. Utilize Intelligent Modules to Assist Routing Calculation. Existing deep learning methods have achieved certain results in network modeling, traffic prediction, and congestion detection [41, 42]. Using the results of deep learning methods in these fields to assist routing calculation is to make routing algorithms more efficient. In routing optimization problems, traditional model-based optimization or heuristic methods often need to involve modules such as network environment modeling, traffic prediction, and congestion detection. Using deep learning methods to replace these modules sometimes achieves better results.

The work of Ref. [40] used a deep neural network predictor based on multitask learning to predict link congestion for each link based on the link historical state data and compared the predicted results with rule-based congestion avoidance and replay. The combination of routing schemes enables routing methods to actively adjust routing before congestion occurs, rather than passively make up for it after it occurs.

The authors in Ref. [30] combined GNN and LSTM model and used a deep learning model based on graph neural network to build the relationship between routing path delay and delay jitter and network topology, traffic matrix, and routing path model, and used the established model to assist the heuristic routing optimization algorithm to calculate the routing strategy. The research results show that the network modeling based on GNN can accurately predict the routing path delay and delay jitter according to the input information and shows good generalization for the topology that does not appear in the training and the dynamically changing routing path. The data-driven network modeling method provides an accurate and efficient routing strategy test environment for the exploration-based heuristic routing optimization algorithm, which enables the heuristic routing optimization algorithm to complete the routing optimization solution process at low cost, while avoiding the need for network optimization. The loss of routing strategy effect was caused by modeling and real environment.

The scheme of using the deep learning model to assist the traditional routing algorithm can effectively improve the performance of the traditional routing optimization algorithm, and at the same time, the traditional routing optimization algorithm ensures that the intelligent routing scheme has stronger reliability and interpretability. Therefore, combining traditional routing optimization algorithms with deep learning models may be a way to develop intelligent routing algorithms in the future.

4. Intelligent Routing Algorithm Based on Reinforcement Learning

4.1. Overview of Reinforcement Learning Methods Applied in Intelligent Routing. A standard reinforcement learning process can be viewed as a process in which a reinforcement learning unit interacts with the environment in discrete time steps. At each time point t, the reinforcement learning unit takes an action at according to the state s_t and receives a feedback reward r_t. The goal of reinforcement learning is to find a policy $\pi(s)$, the policy function is a mapping from state to action and can maximize the decreasing reward, and $\sum_{t=0}^{T} \gamma^t r_t, \gamma \in [0,1]$ is the reward discount factor.

The Q-learning method uses a Q-function to predict the maximum decreasing reward sum corresponding to the state s_t and the action at observed at time t. The Q-function is defined as

$$Q(s_t, a_t) = \max_{\pi} \{E[R_t | s_t, a_t, \pi]\}. \tag{2}$$

For the calculation of the Q-function, there are two methods: model-based and model-independent. The model-based method directly solves the Q-function through the correlation model between the states in the Markov decision-making process, which is formally expressed as

$$\begin{aligned} Q(s_t, a_t) &= r_t + \gamma \sum_{s_{t+1} \in S} P_{s_t s_{t+1}}^{a_t} V(s_{t+1}), \\ V(s) &= \max_{a} \{Q(s,a)\} \frac{1}{2}. \end{aligned} \tag{3}$$

Among them, the V function is the state value function, which represents the maximum decreasing reward sum that can be obtained in the corresponding state, and $P_{s_t s_{t+1}}^{a_t}$ represents the state transition probability of the reinforcement learning task corresponding to the Markov decision process. In reinforcement learning tasks, the state transition probability is not always easy to obtain, and the state-independent method can be used to estimate the Q-function:

$$Q(s_t, a_t) = (1-\alpha) Q(s_t, a_t) + \alpha [r_t + \gamma V(s_{t+1})], \tag{4}$$

where α is the model learning rate. Compared with the model-based Q-function calculation method, the model-independent Q-function calculation method usually requires a longer convergence time.

In the traditional Q-learning method, the Q-function is a mapping from the finite state decision space $S \times A$ to the real number space R. In order to deal with the reinforcement learning problem on the continuous high-dimensional state decision space, researchers introduce the deep learning model into the reinforcement learning framework, a variety of deep reinforcement learning (DRL) models have been designed.

The Google DeepMind institute proposed deep Q-learning (DQN) [43]. It uses a deep neural network (DNN) instead of the original Q-value table to approximate the Q-function and trains it through the squared error:

$$L(\theta^Q) = E\left[\left(y_t - Q(s_t, a_t | \theta^Q)\right)^2\right], \tag{5}$$

where θ^Q is the parameter of DQN and (y_t is the target value, which can be calculated as

$$y_t = r_t + \gamma Q(s_{t+1}, \pi(s_{t+1}) | \theta^Q), \tag{6}$$

where $\pi(\cdot)$ is a policy function that can maximize the expected total return, and a commonly used asynchronous strategy is to choose actions in a greedy way:

$$\pi(s_t) = \underset{a_t}{\operatorname{argmax}} Q(s_t, a_t). \tag{7}$$

Corresponding to the DQN method based on Q-function estimation is the policy gradient method [44]. The policy gradient method uses the deep learning model as the policy function $\pi_\theta(s,a)$ and directly optimizes the policy function by calculating the policy gradient.

In order to further improve the performance of the policy gradient method and accelerate the convergence speed of the reinforcement learning model, we can combine the Q-value learning and the policy gradient method, and use the value estimation function to predict the value that will be obtained after the action is taken in the current state, and use the prediction result. The policy model is trained, which is the Actor Evaluator (AC) framework for reinforcement learning.

A commonly used AC framework based on online strategy uses an action advantage function $A(s,a)$ to estimate the advantages and disadvantages of the strategy, and the policy gradient after introducing the advantage function is

$$\nabla J(\theta) = E_{\tau \sim p\theta(\tau)} [\nabla_\theta \log \pi_\theta(s,a) A(s,a)], \tag{8}$$

where τ represents the state-action tuple (s_t, a_t).

The reinforcement learning method based on the online strategy needs to synchronize the training process with the data collection and achieve parameter convergence through the iterative process of updating the parameters for multiple rounds of data collection. In order to decouple the data collection and model training process, an offline reinforcement learning method, a commonly used offline policy-based AC framework deep reinforcement learning model is deterministic policy gradient (DPG) [45]. The method directly uses the value network gradient backhaul to calculate the policy gradient and has achieved good results in the continuous action space reinforcement learning problem. An improved version of this method, deep deterministic policy gradient (DDPG) [46], has been widely used to solve routing optimization problems in continuous action spaces.

In recent year researches, in order to solve the problem of excessive policy update in the trust region policy optimization (TRPO) algorithm, extensive literature has been proposed [47]. Although the second-order method has better convergence guarantee than the first-order method, its high computational complexity limits its application scenarios. Based on the idea of TRPO, OpenAI and DeepMind proposed a proximal policy optimization (PPO) [48] algorithm, which combines the efficiency and ease of implementation of traditional first-order methods and the data efficiency and reliable performance of confidence region algorithms. It is one of the current mainstream reinforcement learning algorithms.

4.2. Intelligent Routing Algorithm Based on Q-Learning. The authors of Ref. [16] proposed Q-routing and for the first time applied Q-learning in routing algorithms. The Q-routing uses the Markov decision process (MDP) to represent the routing forwarding process, treating each routing node as a state in the MDP, the neighbor node picked by the routing next hop as the MDP action, and the routing node selected by each hop as the MDP action. The feedback value acquired by reinforcement learning an action is the time delay. In Q-routing, the Q-value function $Q_x(d, y)$ is used to predict the time it takes to use the next hop node y from the current node x to the target node d. Whenever node x sends a packet to neighbor node y, node y will immediately return the estimated remaining distance delay t to x, which is expressed as

$$t = \min_{z \in \text{neighbors of } y} Q_y(d, z). \tag{9}$$

At this time, using the model-based Q-Learning method, node x can dynamically update its corresponding Q-value function information, formally:

$$\Delta Q_x(d, y) = \eta\left(q + s + t - Q_x(d, y)\right), \tag{10}$$

where η is the learning rate of the algorithm, and q and s are the queue delay and transmission delay from x to y, respectively. According to the dynamically updated Q-value function, for each data packet, Q-routing can adapt to the dynamically changing network state and choose the routing path with the minimum latency. In contrast to the typical shortest path routing method, Q-routing measures the length of the path using time rather than routing hops, allowing it to efficiently avoid network congestion.

In order to achieve fast perception of congestion recovery, Ref. [17] modeled the relationship between the congestion recovery process and time in Q-routing and proposed to use the R function to estimate the rate of change of the Q-function with time and then estimate the rate of change of the Q-function over time. The R function is used to calculate the Q-value corresponding to each current neighbor node when making routing decisions. The experiments show that the Q-routing scheme based on the change of Q-value prediction is used in the situation of frequent network congestion. Compared with the original Q-routing scheme, it has better convergence speed and stability. In addition, Ref. [18] used dual reinforcement learning to improve the Q-routing and obtained better performance.

Reference [19] applied the Q-learning method to WSN and proposed the QELAR scheme. Due to the complex working environment of WSN and the frequent changes of network topology, traditional routing methods often fail to achieve good results in the WSN environment. The QELAR mainly solves the lifetime problem of WSN. Similar to Q-routing, the QELAR also uses the Markov process to model the process of data packet transmission in the network. Combining numbers as reinforcement learning, the feedback makes the routing algorithm able to make intelligent routing decisions according to the current state of the remaining energy of the system, so as to ensure the normal working time of the WSN network as long as possible.

After QELAR, Ref. [20, 21] proposed the MARLIN and MARLIN-Q models, and used MDP to model the packet sending and retransmission process of the WSN network. Figure 7 shows a schematic diagram of the state transition model of each routing node controlling the forwarding of data packets in the MARLIN-Q scheme. In the work of MARLIN and MARLIN-Q, the data packet p is defined in the state space S of each routing node according to the current data packet retransmission times as follows:

$$S = \{0, 1, \ldots, K-1\} \cup \{\text{rcv}, \text{drop}\}. \tag{11}$$

The action space that each routing ith node can perform in the sth state includes the selected modem type and the next hop routing node that the corresponding modem can reach

$$A_i^M(s) = \{a = \langle j, m \rangle \mid m \in M, j \in \text{Neighbor}_i^m\}, \tag{12}$$

where M is the set of modem types that the node has and Neighbor_i^m represents the set of neighbor nodes that the node can reach by using the modem type m. The MARLIN series algorithm cleverly designs the feedback function so that the feedback value obtained by the reinforcement learning model of each node is positively correlated with the data packet transmission delay and at the same time imposes a large penalty on a packet loss (*drop*) behavior, which can be used for reliable and low-latency data transmission of underwater sensor networks. In the real network scenario, through continuous trial and learning, the MARLIN series models can adaptively calculate the state transition probability $P_{i,s \longrightarrow rcv}^{(j,m)}$ through historical data and then ensure the route quality-of-service (QoS) of WSN network. In addition, by changing the maximum number of retransmissions K in the MDP process, The MARLIN-Q can support different types of QoS requirements, such as accelerated forwarding services requiring low latency and reliable transmission services requiring guaranteed reliability. The MARLIN-Q has tested the algorithm performance under different network parameters and loads in the simulation environment, and the results show that compared with the existing state-of-the-art underwater sensor network routing and transmission algorithm CARP [49] and QELAR optimized for

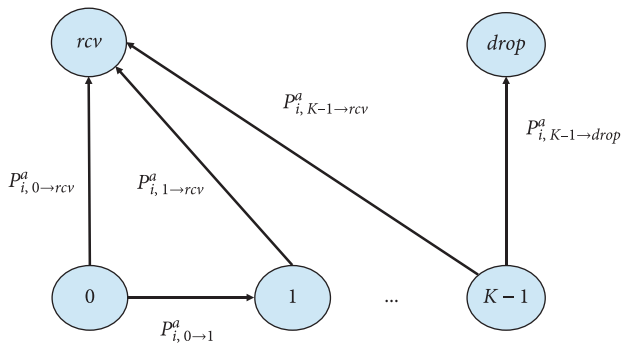

Figure 7: Illustration of MARLIN-Q transitions states.

network lifetime, the MARLIN-Q algorithm can effectively avoid the failure retransmission in the process of data packet transmission and have better performance in terms of effective throughput, delay, and energy consumption.

After investigation, most of the existing intelligent routing algorithms based on the Q-learning model the forwarding process of data packets in the network with MDP and then convert the routing optimization problem into a model-based Q-learning problem, and build on this basis. Due to the characteristics of MDP modeling and model-based Q-learning, its optimization objectives are mainly performance evaluation indicators that can be accumulated hop by hop, such as delay, throughput, and energy consumption. The intelligent routing algorithm designed using the model-based Q-Learning method can adapt itself to the dynamically changing network environment, and because its MDP model is known, its decision-making process has better interpretability than other deep learning-based methods. So it has a wide range of applications in the scenarios where the network state fluctuates greatly, such as the WSN network. However, for routing optimization problems with higher input and output dimensions and more complex optimization objectives, it is very difficult to explicitly establish an MDP model. In addition, the packet-level routing control methods commonly used in the existing Q-learning-based routing optimization methods are difficult to meet the requirements of the backbone network. Therefore, the application scenarios of existing intelligent routing algorithms based on Q-Learning still have great limitations.

4.3. Intelligent Routing Algorithm Based on Deep Reinforcement Learning. With the development of deep learning technology in recent years, researchers have begun to try to apply deep reinforcement learning (DRL) technology to intelligent routing and traffic engineering scheme design. Compared with Q-learning, the DRL methods can learn more complex strategies to solve routing optimization problems with larger states, larger decision spaces, and more complex optimization objectives.

Reference [14] applied deep reinforcement learning to intradomain traffic engineering (DRL-TE) scheme. Similar to the classic semi-state-independent traffic engineering (SMORE) scheme proposed by [7] in 2018, the DRL-TE divides the traffic engineering problem into two parts: static multipath solution and online dynamic adjustment of path split ratio. The DRL-TE uses traditional methods to generate paths and utilizes a deep reinforcement learning unit to complete the process of dynamically adjusting the path split ratio online. In this scheme, the deep reinforcement learning model takes the current delay and throughput corresponding to each session as the state of reinforcement learning, the path split ratio as the action of reinforcement learning, and the performance evaluation function of each session as the feedback of reinforcement learning. In this way, the network status information is dynamically sensed, the distribution ratio of each path is controlled, and the optimal distribution is learned adaptively according to the feedback results of each session. In order to deal with the continuous action space problem caused by the split ratio, the DRL-TE adopts the deep deterministic policy gradient algorithm (DDPG) as the reinforcement learning model and adopts the experience playback method specially designed for traffic engineering to ensure the convergence of the reinforcement learning model. Compared with SMORE, which needs to accurately predict the traffic matrix at the next moment in order to use the linear programming model to solve the optimal split ratio and can only optimize a limited target (such as maximum link utilization), DRL-TE only needs traffic characteristic information can automatically predict future traffic changes and make decisions that maximize the value of the total benefit function of each session. Therefore, it has better generality and robustness than SMORE method, which requires less assumptions about application scenarios. It is simulated in the NS-3 environment, and the experimental results show that compared with traditional routing and traffic engineering algorithms, the DRL-TE has obvious advantages in terms of delay, throughput and the utility function index. In addition, the comparative experiment directly using the original DDPG algorithm shows that the machine learning model is used to solve the problem. It is necessary to improve the original machine learning algorithms in traffic engineering problems, and it may be difficult to achieve ideal results by directly applying the existing machine learning models to routing optimization and traffic engineering problems.

In addition to the field of traffic engineering, DRL has also been applied to the optimization task of intelligent routing configuration. Reference [31] tried to use a DRL unit to predict the future network traffic based on historical traffic data and calculated the appropriate routing configuration based on the traffic prediction ability of the reinforcement learning model. It takes the historical traffic matrix as the input of the reinforcement learning model, the weight of each link is used as the output of the reinforcement learning model, and the reinforcement learning model (TRPO) passes the historical traffic according to the learned experience and knowledge. The matrix predicts the future traffic and performs routing configuration by adjusting the link weights, so as to achieve the goal of optimizing the maximum link utilization of the entire network and completing the load balancing. It is also pointed out that the representation of routing rules has a strong correlation with

the convergence of reinforcement learning models. For a network topology $G(V, E)$, a destination node-based routing rule form with an output dimension of $|V|.|E|$ is directly used as the output action of the above reinforcement learning model. That is, for each node v for each destination node d, set a split ratio to all its neighbor nodes, and then, the above reinforcement learning model will be difficult to converge due to the high output dimension. Therefore, the action of the reinforcement learning model in this work sets a real weight for each link, and the link weight is mapped into a routing rule through a traditional rule-based approach. This reduces the output dimension of the reinforcement learning model to $|E|$, so as to reduce the size of the action space of the reinforcement learning model, reduce the difficulty of exploration and learning, and achieve the effect of accelerating the convergence. In this work, sparse and nonsparse gravity/bimodal models are used to generate different types of flow matrix sequences to test the performance of the algorithm. The simulation results show that for the traffic matrix with obvious regular characteristics, the reinforcement learning model can achieve good routing configuration through traffic prediction, which is better than the traffic-independent optimal routing [50] and close to the optimal routing configuration effect. However, when the traffic matrix no longer has obvious regular characteristics, the performance of this method will drop significantly. In fact, traffic changes in real scenarios may be irregular, including many burst traffic, so the traffic prediction and routing configuration capabilities of the above models under real traffic data are still a problem worth exploring.

Although the DRL model can theoretically predict the future traffic and make optimal routing decisions based on the network state data or historical information, the results of the DRL model in the current experiments are far from optimal. Ref. [38] compared the effects of several reinforcement learning models on routing tasks and put forward some guiding suggestions for using reinforcement learning models to solve routing problems. First of all, the author through a simple scenario deployment experiment of a Q-routing model [16] shows that the reinforcement learning intelligent routing model of packet-level routing control is difficult to apply to application scenarios with high throughput, and the time-segment-level routing control model will be a more recommended way. Secondly, the intelligent routing scheme that uses explicit path selection as the action of reinforcement learning unit is difficult to converge to the ideal result. As mentioned in Section 3.2, the number of paths increases exponentially with the growth of the network size, and the path selection-based scheme will undoubtedly greatly increase the learning and exploration capabilities of the reinforcement learning model. Based on the above two points, this article also chooses the scheme of controlling the link weight through the reinforcement learning model and then indirectly realizing the routing control. Compared with the direct generation of real link weights by Ref. [37], Ref. [38] scheme discretizes the link weights, further reduces the size of the action space from infinite to finite, and selects the corresponding weights for each link. The process is processed by a single reinforcement learning model, which further reduces the decision difficulty and exploration space of each reinforcement learning model. The generated link weight is used as the edge weight of the shortest path algorithm for routing calculation. In order to ensure the policy consistency of this multiagent cooperative routing model, Ref. [50] used the latest multiagent deep deterministic policy gradient (MADDPG) algorithm [51] to train the model. The final experimental results show that the reinforcement learning intelligent routing algorithm based on the offline link weight has better load balancing characteristics than the shortest path routing, that is, the shorter router average waiting time.

Existing intelligent routing schemes based on deep reinforcement learning have achieved certain results in intradomain traffic engineering and intelligent routing optimization tasks. The deep reinforcement learning model has good versatility and generalization. It can not only optimize the global performance evaluation indicators of the network, such as the maximum link utilization rate of the entire network and the average waiting length of routers, but also optimize the private benefit value corresponding to each session function. In addition, compared with traditional routing optimization algorithms based on rules or mathematical models, intelligent routing algorithms based on deep reinforcement learning do not need to make assumptions about the environment and can adapt to dynamically changing network environments. However, it is not difficult to find that there is a strong correlation between the convergence of a deep reinforcement learning model and the form of routing rules generated, and an excessively high output dimension often makes the deep reinforcement learning model unable to converge. Therefore, in the existing research work, the deep reinforcement learning model generally completes the flow control indirectly by controlling the path split ratio or link weight, rather than directly generating the routing path by path selection or path generation. In fact, even though the existing work has tried to reduce the routing decision difficulty of deep reinforcement learning units as much as possible, and has made significant progress, there is still a lot of room for improvement in the performance of existing solutions in complex application scenarios. In addition, limited by the model performance of deep reinforcement learning, most of the existing schemes adopt time-segment-level routing control methods, while packet-level routing control methods are not suitable for such intelligent routing schemes. Robustness and reliability are very important properties for routing algorithms, but the existing research on intelligent routing algorithms based on deep reinforcement learning is far from enough.

5. Training and Deployment of Intelligent Routing Algorithms

Although there have been many related works on intelligent routing algorithms based on machine learning in recent years, these works mainly focus on the principle design of intelligent routing algorithms, algorithm accuracy, convergence, and other issues. There is not yet a mature and complete framework for training and deployment. This

article discusses the advantages and disadvantages of different training methods and deployment methods of intelligent routing algorithms and proposes two types of reasonable intelligent routing training and deployment frameworks, so that intelligent routing algorithms can be used in real scenarios with low cost and high reliability.

5.1. Training Method: Online and Offline. The training methods of the intelligent routing algorithm model are mainly divided into two types: online and offline. Figure 7 shows the training method of the existing intelligent routing scheme. The intelligent routing models based on supervised learning are all trained offline, while the models based on reinforcement learning can be trained both online in the real environment and offline in the simulation environment.

Generally speaking, the offline training process of the model first needs to collect data from the real environment, which may be the traffic matrix, the status information of each node in the network, and the corresponding routing decision labels. After the data are processed, it is used in the offline training process of the machine learning model on the server. After the training is completed, the model is deployed to the real environment to make online routing decisions. Offline training and online testing, deployment is a common training deployment method in the field of deep learning. However, for intelligent routing algorithms, offline training often faces three challenges: (1) the collection of training data may require relatively high costs; (2) the network state in the real scene may be different from the training data set, causing the routing algorithm to fail to achieve the expected effect or even to make errors; and (3) for reinforcement learning, it may be difficult to build a simulated training environment similar to the real environment.

For reinforcement learning methods, online training can ensure that the model adapts to changes in the network environment and avoids the difficulties and extra costs brought by the offline simulation environment construction. However, the routing security and reliability problems brought by online training make it difficult to deploy intelligent routing methods that require online training in actual deployment. In fact, in online reinforcement learning, security is an issue that has been widely studied [52, 53]. The reinforcement learning models may produce unpredictable behaviors in the initial stage of training and the exploratory stage in the training process. When reinforcement learning methods are applied to routing tasks, these unpredictable behaviors may cause serious consequences including routing loops and link congestion. Therefore, ensuring the security and reliability of the online reinforcement learning routing algorithm training process will be an important prerequisite for its deployment in real scenarios.

5.2. Deployment Method: Centralized and Distributed. As there are many intelligent routing algorithms proposed, how to deploy these algorithms in the existing computer network architecture is receiving more attention. The deployment methods of intelligent routing algorithms are mainly divided into two types: distributed and centralized.

Figure 8 shows the schematic diagrams of the framework structures of the two deployment schemes. The intelligent routing algorithm is deployed in the centralized controller, and the routing decision is made dynamically according to the network state information collected by the controller, and the routing decision is sent to each routing node through the centralized controller. The proposal of the SDN network structure provides the theoretical possibility for the centralized deployment of intelligent routing algorithms, and the above centralized control process can be completed by using the intelligent routing control unit as an application on the SDN controller. In a relatively independent application scenario such as data center network traffic engineering, it is a feasible solution to deploy the intelligent routing scheduling scheme using a centralized method.

The deployment of a centralized solution requires deploying a centralized routing controller in the network and designing a centralized routing control protocol. However, the routing protocols in the current computer network architecture are still dominated by distributed routing protocols.

Compared with centralized routing protocols, distributed routing protocols have better scalability. As can be seen from Figure 7, there are many existing intelligent routing algorithms that can support distributed routing decisions. These distributed intelligent routing algorithms have made progress in terms of convergence and robustness. The corresponding router hardware needs to be further developed and improved [15]. With the development of programmable routing devices, it will be possible to deploy distributed intelligent routing algorithms in real networks in the future. However, the existing distributed intelligent routing algorithms mainly focus on the accuracy and convergence of routing methods and do not consider the compatibility of existing network layer structures and protocols. For the distributed intelligent routing algorithm, how to carry out incremental deployment on the basis of compatibility with the existing network layer structure will be a problem worth thinking about in the future.

5.3. Intelligent Routing Training and Deployment Model Design. Based on the above discussion, this section summarizes and proposes two types of future feasible intelligent routing training and deployment frameworks: (1) an intelligent routing framework combining centralized offline training and online decision-making; and (2) a secure online reinforcement learning routing framework.

Figure 9 shows the workflow of the intelligent routing deployment framework combining centralized offline training and online routing decision-making. In this intelligent routing deployment scheme, the router data plane needs to collect the network traffic characteristic information and pass it up to the control layer to complete the intelligent routing model training and online routing decision-making process. The intelligent routing decision-making model uses historical network state information and network simulation environment to complete offline training in a single node with sufficient computing power

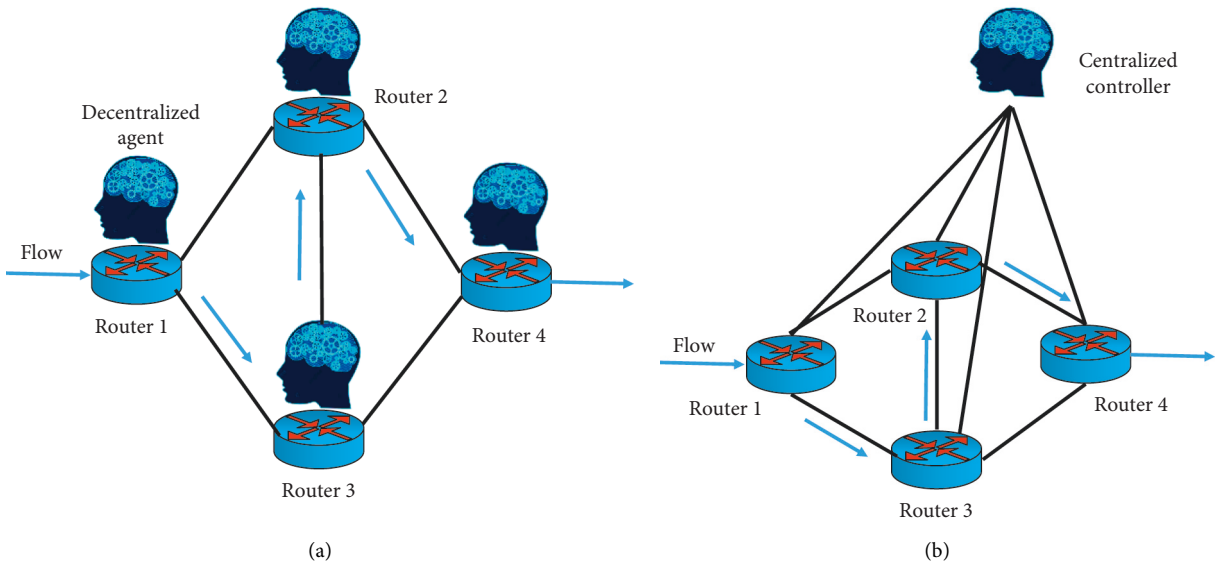

Figure 8: Illustrations of ML routing structures.

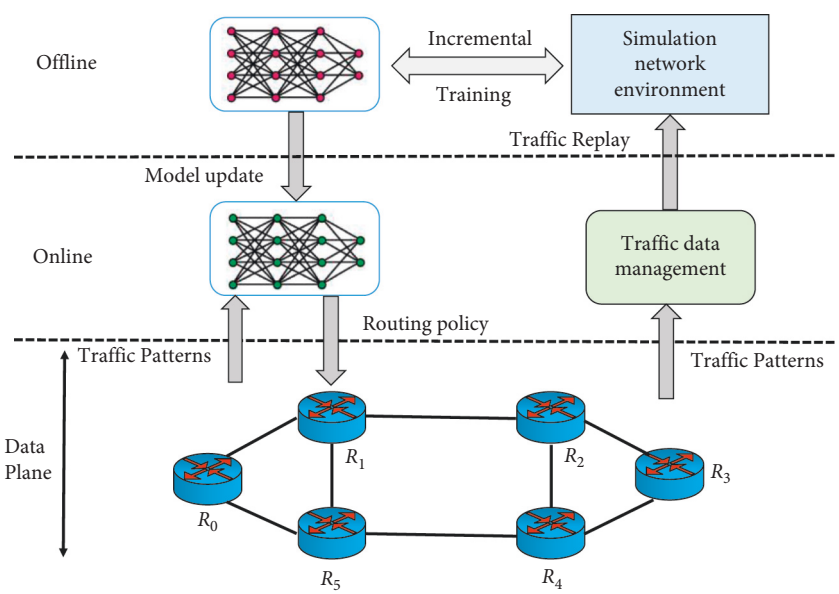

Figure 9: ML-based routing architecture for training and deployment.

and publishes the trained model parameters to the online routing decision-making unit. The corresponding routing decision unit can either deploy the online intelligent routing unit to the control plane of each router by means of distributed deployment or place the intelligent routing unit in a centralized routing controller by means of centralized deployment. For example, in order to adapt to the network topology and traffic characteristics that change dynamically with time, the above model adopts the closed-loop learning method to periodically train the intelligent routing model incrementally according to the latest network traffic characteristics. The training process of the intelligent routing model based on machine learning needs to consume a lot of computing and storage resources, and the centralized offline training makes each routing node in the network do not need to deploy these resources, which can effectively reduce the deployment cost of the intelligent routing algorithm.

The intelligent routing deployment scheme of centralized offline training and online routing decision is suitable for most existing intelligent routing algorithms, and is consistent with the idea of offline training and online decision-making in machine learning. However, for reinforcement learning models, whether it is an on-policy model or an off-policy model, the interaction with the environment is an essential part of the learning process. Different from game tasks, it is very difficult to build a simulation environment consistent with the real network environment in routing optimization problems [30]. Correspondingly, the poor strategy at the beginning of the deep reinforcement learning model and its exploratory behavior in the learning

process make it possible to directly train the intelligent routing model based on DRL in a real network environment, in order to solve the challenges faced by the intelligent routing strategy based on DRL in the training process.

In this article, referring to the idea of secure online reinforcement learning [53], an online training scheme of DRL intelligent routing model with reliability guarantee is proposed. Figure 10 shows the working flow of the scheme. Compared with the traditional reinforcement learning method, this scheme introduces a security monitoring module to judge whether the routing decision made by the reinforcement learning unit is safe or not based on rules. When the routing decision made by the reinforcement learning unit may have security risks, for example, including routing loops and triggering network congestion, the reinforcement learning unit uses a simple and reliable routing decision (such as shortest path routing) to replace the original routing decision, and at the same time imposes a penalty factor p on the reinforcement learning unit to avoid the reinforcement learning unit. The related work of online security learning in other network application scenarios shows that the DRL intelligent routing scheme based on online security learning has the ability to ensure the reliability of the routing learning process without affecting the original routing optimization goal [53]. It can not only solve the security problems that have not yet converged, but also ensure the reliability of the model without guaranteeing the interpretability of the model. It concerns about the unpredictability of routing behavior in network emergencies.

For the training and deployment framework of intelligent routing, the existing research work is still relatively small, but this article believes that the uninterpretability of the model and the unpredictability of routing behavior brought by the intelligent routing scheme will be an important challenge in the design of its training and deployment framework. Using the rule-based scheme to constrain the intelligent routing control unit may be an effective means to ensure the reliability of intelligent routing.

6. Opportunities and Challenges Faced by Intelligent Routing Algorithms

In recent years, intelligent routing algorithms have received considerable attention. In this section, the advantages of intelligent routing algorithms in solving the routing optimization problems and the challenges they face in the future development process are discussed.

6.1. Advantages of Intelligent Routing Algorithms. The data-driven intelligent routing algorithms are usually based on deep learning or reinforcement learning, which have five main advantages:

(1) *The Network State is Sensitive*. Compared with the traditional model-based routing algorithm, the intelligent routing algorithm can process higher-dimensional network state feature information, which makes the intelligent routing algorithm more sensitive to changes in the network state, and can quickly converge when the network state changes.

(2) *Data-driven*. Unlike traditional routing algorithms that use a fixed model to solve the routing strategy, the intelligent routing algorithm is data-driven, relies on fewer environmental assumptions, and uses historical data and spontaneous exploration of the environment to automatically model application scenarios and complete routing optimization, allowing it to adapt to different application scenarios and network environment changes.

(3) *Oriented to Service Quality*. Intelligent routing can help facilitate routing requests with varying levels of service quality. The data-driven intelligent routing algorithm can automatically learn the appropriate routing decisions according to the Quality-of-Service (QoS) requirements, unlike the traditional QoS routing optimization scheme, which creates a complex optimization model for each QoS requirement based on a large number of assumptions about the application scenarios.

(4) *Experience-Driven and Memory Characteristics*. Unlike standard routing algorithms based on models and rules, intelligent routing algorithms based on machine learning may remember prior experience by studying historical data, allowing the model to "eat a little and gain a wisdom" similar to a human being. The effect of route optimization improves as the company grows.

(5) *Routing Decisions Consider the Past, Present, and Future*. The recurrent neural network structure (RNN) and its corresponding extensions (GRU, LSTM) can model the past historical information well, and the reinforcement learning model endows the intelligent routing algorithm not only with the current routing effect, but also in predicting the future network state changes, the ability to avoid possible future network congestion in advance.

6.2. Challenges to Intelligent Routing Algorithms. Corresponding to the advantages of intelligent routing algorithms, the future development process of intelligent routing methods also faces many challenges:

(1) *Network Feature Information Extraction*. In the intelligent routing method, the network state information may be organized in the form of topology structure, and due to the dynamic change of the network scene, the dimension of the network state information may change. Traditional machine learning methods have difficulties in processing this type of network state information. Existing intelligent routing algorithms try to use graph neural network model (GNN) to model and extract network state information [26, 30]. The GNN method has good generalization for different topological structures, but whether the existing GNN methods can complete the modeling of dynamic large-scale

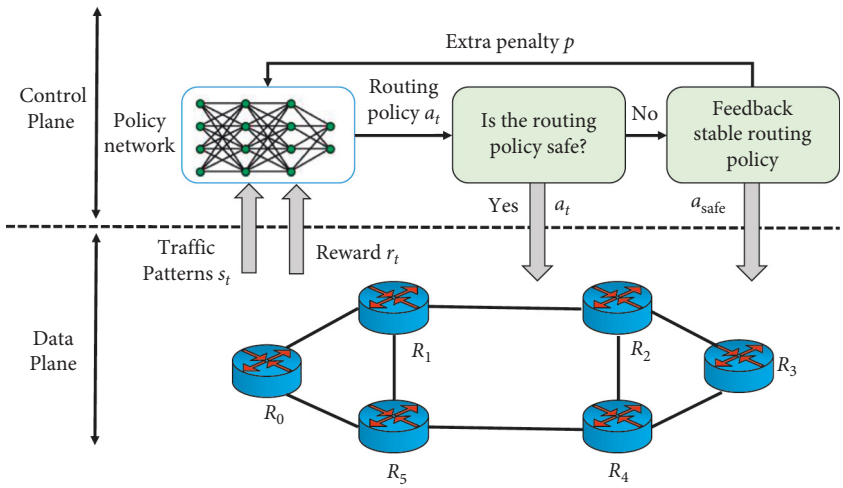

Figure 10: DRL-based framework for secure online learning in routing.

topological structures in real scenarios of routing optimization problems still lacks sufficient experimental support.

(2) *Algorithm Convergence*. Compared with games, image recognition, natural language processing, and other scenarios where machine learning has been widely used, the input and output dimensions of routing optimization problems are higher, and the target strategy is more complex. Existing research shows that for complex routing optimization with high input and output dimensions. However, the existing machine learning schemes are often difficult to converge to the optimal solution. In order to solve the problem that the model is difficult to converge, it is often necessary to reduce the input and output dimensions, discretize the decision space, or use indirect control of routing decisions to simplify the policy complexity to reduce the convergence difficulty of the model. However, even with these schemes, many convergence results are still far from the theoretical optimal value.

(3) *Algorithm Scalability*. Routing algorithms must meet a number of requirements, one of which is scalability. Existing machine learning-based intelligent routing methods are mostly created and tested on small topologies with little more than 20 nodes. A bigger topology results in an exponential growth in the number of network states and a greater difficulty in making routing decisions. The design of intelligent routing algorithms in the future will have a problem in ensuring that the algorithm can still get good results in a big topology. Furthermore, when the topology is complex, the centralized routing control method might result in high data exchange costs and network state transfer delays, reducing scalability. The future difficulty of ensuring the consistency of each node's routing strategy under the huge topology of a distributed intelligent routing algorithm will be solved.

(4) *Algorithm Interpretability*. Another problem faced by intelligent routing methods is the unpredictability and uninterpretability of routing strategies. Compared with traditional routing algorithms based on mathematical models, deep learning-based methods often have unpredictable behaviors. When poor routing decisions are made, it is difficult for the operator to locate the cause of the error, and it is almost impossible to correct the model for the error. Therefore, how to improve the interpretability of intelligent routing algorithms will be a challenge in the future development of intelligent routing methods.

(5) *Model Training Cost*. For intelligent routing algorithms based on supervised learning, collecting enough and accurate enough labeled data is sometimes a very expensive thing. Different from face recognition and other application scenarios where training is done once and for all, as the network environment changes, existing intelligent routing may need to repeatedly collect training data and retrain. Therefore, how to improve the data efficiency of the intelligent routing training process is an important challenge in the deployment of intelligent routing solutions. When faced with similar problems, reducing the training cost through meta-learning is a feasible solution [54]; however, there is no perfect research in the field of routing. In addition, for the intelligent routing method based on deep reinforcement learning, whether it is online training or offline training, the high training cost and the hidden reliability risks brought to the system during the training process are challenges that need to be solved urgently.

(6) *Handling of Network Emergencies*. Another issue that intelligent routing algorithms will encounter in the future development phase is figuring out how to cope with network crises. In practice, traffic surges and network state changes induced by network equipment failures are all too prevalent. However, these

crises come in a variety of forms, and many of them have never been seen in training data. It is challenging to verify that these situations are handled effectively with the present data-driven intelligent routing algorithms. Even approaches that can dynamically adjust to environmental changes, such as Q-Learning, cannot cope with unexpected and significant network shifts. To deal with abrupt changes in network circumstances, the concept of "secure online reinforcement learning" [53] is applied. It might be a future solution, but determining how to effectively recognize network crises is an issue.

(7) *Real Scenario Deployment*. For intelligent routing methods, how to deploy them in real scenarios is a huge challenge. Intelligent routing, as compared to standard routing methods, necessitates greater computational resources and higher routing performance. Simultaneously, the training data collecting and routing perception processes for the original routing protocol must be changed so that the intelligent routing algorithm may get data from the intelligent unit. Although the emergence of SDN networks and programmable routing equipment increases the processing capacity of the router control layer, even intelligent routing algorithms remain challenging to deploy on a broad scale under the current network design. It may be the future trend of intelligent routing algorithms to develop routing equipment that matches the intelligent routing scheme while maximizing the performance of intelligent routing algorithms and boosting their compatibility and scalability with traditional routing algorithms.

7. Conclusion

The present intelligent routing algorithms are largely split into two types, based on supervised learning and based on reinforcement learning, according to this article's findings. (1) The supervised learning-based intelligent routing technique primarily completes the routing solution by either replacing the existing routing algorithm with the deep learning model or supporting the traditional routing algorithm. The deep learning method makes the intelligent routing algorithm more sensitive to the environment and has a faster convergence speed. The data-driven auxiliary module can also make the routing decision made by the traditional routing algorithm more accurate and avoid congestion in advance. (2) Reinforcement learning-based routing algorithms can adapt to diverse routing application settings and maximize various network performance metrics. The model-based Q-Learning method is widely used in the routing optimization process of wireless sensor networks, whereas the deep reinforcement learning method is used to solve various complex routing optimization problems like intradomain traffic engineering and intelligent routing algorithms based on traffic prediction.

This article analyzes the advantages and disadvantages of online and offline intelligent routing training schemes, centralized and distributed intelligent routing deployment schemes, and further proposes a closed-loop learning framework of offline centralized training plus online deployment, as well as adaptive online training and security learning. The combined intelligent routing deployment framework has reliable performance. These two frameworks provide the possibility for low-cost and high-reliability deployment of intelligent routing algorithms based on machine learning in real scenarios.

This article discusses the opportunities and challenges in the future development of intelligent routing algorithms and proposes possible future research directions for intelligent routing algorithms based on machine learning in response to these challenges.

Data Availability

The data used for the findings of this study are available from the authors upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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Retraction

Retracted: Interactive Music Teaching Method Based on Big Data and Cloud Computing

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] Y. Hao, "Interactive Music Teaching Method Based on Big Data and Cloud Computing," *Mobile Information Systems*, vol. 2022, Article ID 1803497, 9 pages, 2022.

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Research Article

Interactive Music Teaching Method Based on Big Data and Cloud Computing

Yinan Hao

Department of Musical Instrument Engineering of Xinghai Conservatory of Music, Guangzhou 510006, Guangdong, China

Correspondence should be addressed to Yinan Hao; haoyinan@xhcom.edu.cn

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With the development of contemporary technology and education, there are more and more innovative teaching methods that are helpful to the education and teaching procedure. Interactive teaching method is one of them. Interactive teaching is a teaching modus based on developed on the scaffolding teaching theory that attaches importance to the communication between teachers and learners. Its biggest goal is to develop learner-specific and specific autonomous learning strategies through the communication and collaboration between the teacher and the learner. The advanced nature and effectiveness of interactive teaching methods make it more and more widely used in education, such as in the field of music teaching. Music teaching is a kind of teaching that pays more attention to the communication between teachers and Teachees. This paper aims to study the interactive music teaching method based on BD and CC, that is to design an interactive music teaching method based on big data and cloud computing technology, and conduct practical application experiments on it. The experiment concluded that the interactive music teaching method based on BD and CC has made the students' participation rate in music teaching classrooms reach 88%, and the excellent rate of in-class test scores has reached 90%.

1. Introduction

Interactive teaching is an innovative teaching mode developed in the theory of scaffolding teaching (decompose complex learning tasks in advance to facilitate in-depth learning of learners). It encourages that in the teaching procedure, the use of interactive teaching methods enables teachers' teaching and students' learning to be closely linked and communicated with each other. Interactive teaching method is a meaningful manifestation of modern education in teaching method reform and innovation and has important application value education. With the development of national education, the requirements for innovation and reform of education and teaching methods are becoming more and more strict, and educators have been constantly exploring more advanced teaching methods. The application of interactive teaching methods in the scopes of education is becoming more and more extensive, such as in the field of music teaching. In many teaching fields, music teaching is a basic part of aesthetic education. Music education refers to the use of music to cultivate students' thinking quality, cultivate students' sentiment, and promote students' knowledge and skills growth. It is the main channel for cultivating students' aesthetic awareness and musical ability and can also enrich students' extracurricular entertainment life and appropriately relax students' learning pressure. Therefore, music teaching has accepted more and more attention from the society. In order to improve the quality of music teaching and adapt to the growing trend of society and education, the reform and innovation of music teaching methods are essential. Since the communication between the two sides of teaching is very important in the procedure of music teaching, it is necessary to explore an interactive music teaching method. However, due to the difficulty of organization in interactive teaching and the uncertainty of the control of teaching procedure, the exploration of interactive music teaching methods requires certain scientific and technological support. This article mainly explores the interactive music teaching method based on the key technologies of BD and CC.

The main innovations of this paper are as follows: (1) the interactive teaching method, where BD and CC technology are introduced in detail. The related concepts and algorithm flow of the incremental kernel data clustering algorithm are also introduced. And combined with them, the interactive music teaching method is explored. (2) An interactive music teaching method based on BD and CC technology is designed, the practical application experiment of the method is carried out, and an effective conclusion about the practicability of this method is finally drawn.

2. Related Work

In view of the superiority and extensive application of BD and CC, there has been a lot of research on BD and CC in contemporary society. Among them, Xu's research took a broader perspective on personal data privacy issues in big data and examines various approaches that can help protect sensitive information in big data [1]. The main purpose of Xue's research is to improve the procedureing speed of big data. For this reason, he proposed a method of compressed sensing sampling and proved the effectiveness of this method in practical applications [2]. Kuang mainly studied how to effectively represent and procedure big data with a unified scheme. He proposed a unified tensor model to represent semistructured and structured big data [3]. Deng's research is about the scaling of cloud computing technology and explored the trade-off between power consumption and transmission delay in cloud computing systems [4]. Wei studied the resource scheduling problem of cloud computing architecture and created a cloud resource allocation pattern based on incomplete information game [5]. Stergiou studied the application of cloud computing combined with big data in the field of telecommunications, and he found that the combination of these two technologies can improve the utilization frequency of big data applications [6]. However, the experimental procedures of these studies are relatively complex and not very practical. Moreover, from an experimental point of view and method, these studies are also slightly less innovative.

3. Interactive Music Teaching Method

3.1. Interactive Teaching

3.1.1. "Interactive" Concept. The word "interactive" was first born in the procedure of computer information procedureing, which belongs to a special term for computers, and can also be simply called human-computer communication [7]. However, with the deepening of people's discussion and understanding of the concept of communication, many people have a new understanding of the definition of communication, and the concept of communication has gradually been applied to teaching practice. Communication in the field of teaching means that the communication between the teacher and the recipient should be emphasized in the teaching procedure so as to improve the autonomous thinking and learning ability of the recipient [8].

3.1.2. Interactive Teaching and Its Educational Philosophy. The initial connotation of interactive teaching is as follows: teaching should be based on students' continuous and active construction of themselves and teachers' appropriate support and help as the basis for cultivating students' autonomous learning ability. Therefore, the whole teaching should be student-centered so that students it can be transformed from passive recipients of external information to subjects of autonomous information procedureing. With the development of society and the advancement of people's thinking concepts, the specific meaning of interactive teaching today is as follows: in the teaching procedure, teachers and students participate in teaching activities together, and they recognize and respect each other through a variety of ways to support, communicate, and exchange with each other, continuously improve students' autonomous learning ability, and promote students' comprehensive and harmonious development. There is no doubt that interactive teaching has evolved into an open, constructive, and innovative teaching mode that adapts to the fierce educational competition environment and the new needs of educational development. It can be seen that interactive teaching is the most advanced educational concept of "people-oriented" in the context of the course innovation. It can maximize the improvement of students' potential, mobilize students' learning initiative, and improve students' capability to explore and innovate. And it can effectively cultivate students' collective consciousness and teamwork ability and then can continuously improve the comprehensive student's comprehensive development [9, 10].

The interactive teaching mode is shown in Figure 1.

3.2. Big Data. Big data refers to a collection of information data that is so large that it cannot be acquired, managed, processed, and organized into a set of information that can be helpful to the information decision-making process within a reasonable time through conventional software tools [11]. To put it another way, big data must be processed using a new efficient procedureing mode in order for the obtained data to have greater decision-making power and procedure optimization capability, allowing it to adapt to the condition of vast data expansion and diversification.

The basic unit definitions of big data are revealed in Table 1.

Combined with the above definitions, the following are the primary properties of big data.

3.2.1. The Amount of Data Is Huge. Big data typically has data volumes in excess of 1 petabyte. Such a huge amount of data is largely due to the extensive use of different sensors during data processing, which enables people to collect different types of data. In addition, due to the close relationship between people and the need for real-time and low-interval communication methods, the amount of data exchanged increases exponentially [12].

3.2.2. Many Kinds of Data. This is mostly because of the increasing number of sensors used in big data applications

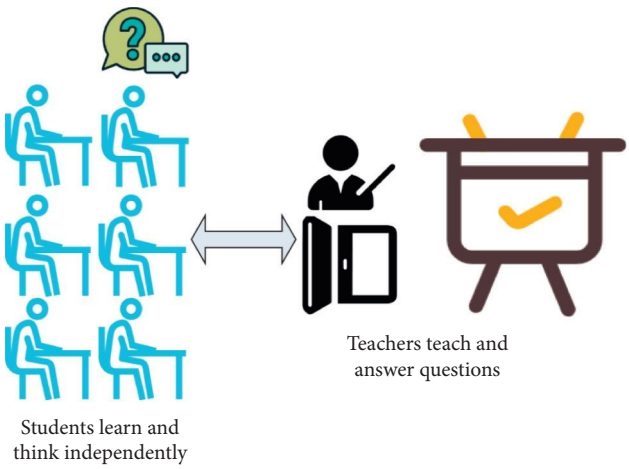

Figure 1: Interactive teaching mode.

Table 1: Definition of big data foundation units.

	Feed rate definition 1	Feed rate definition 2
KB	1024 bytes	8129 bit
MB	1123 KB	1576 bytes
GB	1024 MB	1276 MB
TB	1123 GB	1576 GB

and the wide application of various smart devices, making the type and structure of big data more perplexed. Furthermore, different forms of semistructured and unstructured data such as web pages, sounds, images, and texts have also emerged [13].

3.2.3. Fast Flow Speed. Contemporary society is in an information age where data update and change very fast. A huge amount of data has to be answered in a very limited time. Otherwise, it will expire or be invalid. The characteristics of big data are to emphasize the quickly and moving changes of data and to shape the overall flow of data. The requirement for throughput of data is also one of the key differences between BD technology and traditional data storage technology [14].

3.2.4. Low Value Density. A common feature of all big data is that its value density hangs down. That is, the useful information concealed in massive big data will not grow up even when the data volume increases exponentially, but it will make the procedure of obtaining useful information more difficult. So, it must utilize big data mining techniques to extract large amounts of data and procedure data sets with low value density and facilitate the acquisition of useful data [15].

3.2.5. Accuracy. It is necessary to make sure that the execution of large data is precise enough. In other words, the accuracy of the achieved results cannot be sacrificed to ensure the time of large-scale processing [16]. Data processes and the accuracy of the process occurring, for example, data in a secure manner, should be continuously improved.

The main characteristics of big data are shown in Figure 2.

With the continuous development of big data technology, the application of big data in education is becoming more and more extensive, and the emergence of educational big data will play an important role in the reform and development of education.

3.3. Cloud Computing

3.3.1. Basic Concepts. CC is a kind of computation. It aggregates many computing resources to form a resource-sharing pond. The shared word of this resource department is called "cloud". It transforms computing resources into infrastructure serving the public, which has a significant effect on the application of information technology. Cloud computing improves the utilization of data and makes them more accessible, thereby helping to improve the quick development of the Internet. Cloud computing provides services based on the concepts of "everything is a service" and "on-demand service" so as to meet the needs of users at different levels and angles [17, 18]. Therefore, cloud computing has different technology and service architectures. The following is an introduction to the basic architecture of cloud computing.

3.3.2. Basic Structure. Cloud computing takes providing users with a variety of more convenient and efficient cloud resource services as its core goal. It mainly includes three levels. The first level is SaaS: Software as a Service, that is, cloud computing application services are mostly offered to users in the form of Web. The second level is PaaS : Platform as a Service, that is, cloud computing provides an application platform to users as a service. The last layer is IaaS: that is, cloud computing provides different below network and archive resources as serving to users [19]. The basic architecture of cloud computing is shown in Figure 3.

Among them, SaaS is the most direct and common cloud computing service for end users. IaaS refers to the fact that a provider directly provides end users with the computer resources they need.

3.3.3. Classification. Cloud computing can be divided into three categories: public cloud, private cloud, and hybrid cloud according to the scope of deployment. Private cloud: also known as dedicated cloud, it is widely deployed within an organization and only provides services to specialized agencies and keeps closed to the society. Private cloud has the features of elastic deploy and easy to manage. Public cloud: public cloud is a service that can provide services for specialized agencies, or person in need, usually provided by specialized cloud service providers. Hybrid cloud: hybrid cloud is a mode of combining cloud computing with cloud computing. The use of hybrid air can enhance the power of public and private clouds.

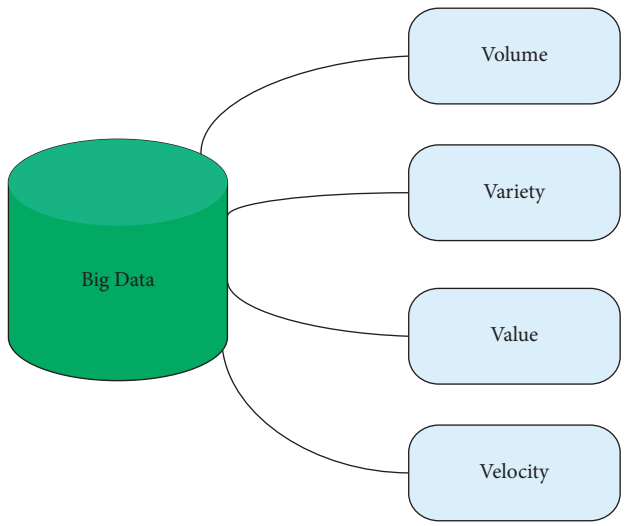

Figure 2: Main characteristics of big data.

Cloud computing classification can be shown in Figure 4.

3.4. Incremental Kernel Data Clustering Algorithm. Among the many big data clustering algorithms, the incremental kernel data clustering algorithm is one of the most frequently used data clustering algorithms. It assigns different weight values according to the importance of data points within the FCM algorithm, thereby performing the clustering process. For a given data set $X = \{x_1, x_2, \ldots x_n\}$, let $\omega_i\,(i = 1, 2, \ldots, n)$ be the weight for data point x_i. The above procedure is repeated continuously until the convergence criterion is reached. The calculation procedure is as follows:

$$u_{ij} = \sum_{i=1}^{k}\left(\frac{x}{\omega_n}\right), \qquad V_i = \frac{\sum_{i=1}^{n}\omega_i}{u_n}. \tag{1}$$

Among them, $i = 1,2, \ldots, n$, $j = 1,2, \ldots, k$, j represents the blurry modulus. V_i represents the cluster center, and u_{ij} on behalf of the degree to which the data point x_i belongs to the cluster center. The distance from this data point to the cluster center can be concluded by the following formula:

$$d_{ij} = \left\|x_i - v_j\right\|. \tag{2}$$

In general, the calculation method of the convergence criterion function of this algorithm is as follows:

$$J(U, V) = \sum j \sum_{i=1}^{n} k\omega_i u_{ij}. \tag{3}$$

The definition of the kernel function is as follows:

$$k\left(x_i, x_j\right) = \varnothing\left(x_i\right)\varnothing\left(x_j\right). \tag{4}$$

Among them, $\varnothing$ is the mapping function.

In this algorithm, the distance is defined as follows:

$$d_{ij}^2 = \left\|\varnothing\left(x_i\right) - \varnothing\left(y_j\right)\right\|. \tag{5}$$

Another expression is

$$d_{ij}^2 = k_{xi} + k_{ij} - 2k_{xj}. \tag{6}$$

Combining the above formula, the calculation formula of membership degree in this algorithm can be obtained from

$$u_{ij} = \sum_{i=1}^{k}\frac{\varnothing\left(x_i\right) - \varnothing\left(y_i\right)}{\left\|\varnothing\left(x_i\right)\right\|}. \tag{7}$$

The update formula of the bunch center is as follows:

$$\varnothing\left(V_j\right) = \frac{\sum_{i=1}^{n}\omega_i u_{ij}\left(x_i\right)}{\sum_{i=1}^{n}u_{ij}}. \tag{8}$$

Let $A_l = \{a_1, a_2, \ldots, a_k\}$ denote the set of points mapped by the result of clustering at time t–1, and we can make

$$a_j = \sum_{t=1}^{n} a\varnothing\left(x_i^t\right). \tag{9}$$

Since A_l is mapped from V_{t-1}, it can be obtained by the following formula:

$$\min\left\|\varnothing\left(v_j\right) - a_j^t\right\|. \tag{10}$$

The representation method of the cluster center obtained by the t-step clustering is as follows:

$$\varnothing\left(V_j^t\right) = \sum_{t=1}^{n}\varnothing\left(x_i^t\right). \tag{11}$$

Among them,

$$q_{ij}^t = \frac{\omega_t\sum_{s=1}^{k}u_{is}}{\sum_{s=1}^{nt}\omega_s}. \tag{12}$$

For data point x_t^i, its weight value is generally set to 1, and the calculation of the weight value of transfer point a_j^t can be gained by the following formula:

$$\omega_j = \sum_{t}^{n} u_j^i\omega_s + (a\,(t-1). \tag{13}$$

At this time, the membership calculation formula of data point x_i is

$$u_t^i = \sum_{k=1}^{n_t}\left\|\varnothing\left(x_t^i\right) - \varnothing\left(v_j\right)\right\|. \tag{14}$$

The calculation formula of the degree coefficient u_j of the transfer point a_j^t is

$$u_j = \sum_{l=1}^{k}\frac{\left\|\varnothing\left(x_t^i\right) - \varnothing\left(v_j\right)\right\|}{\left(v_j\right)^2}. \tag{15}$$

To sum up, the incremental algorithm is a procedure of continuously reclustering new data blocks and clustered results.

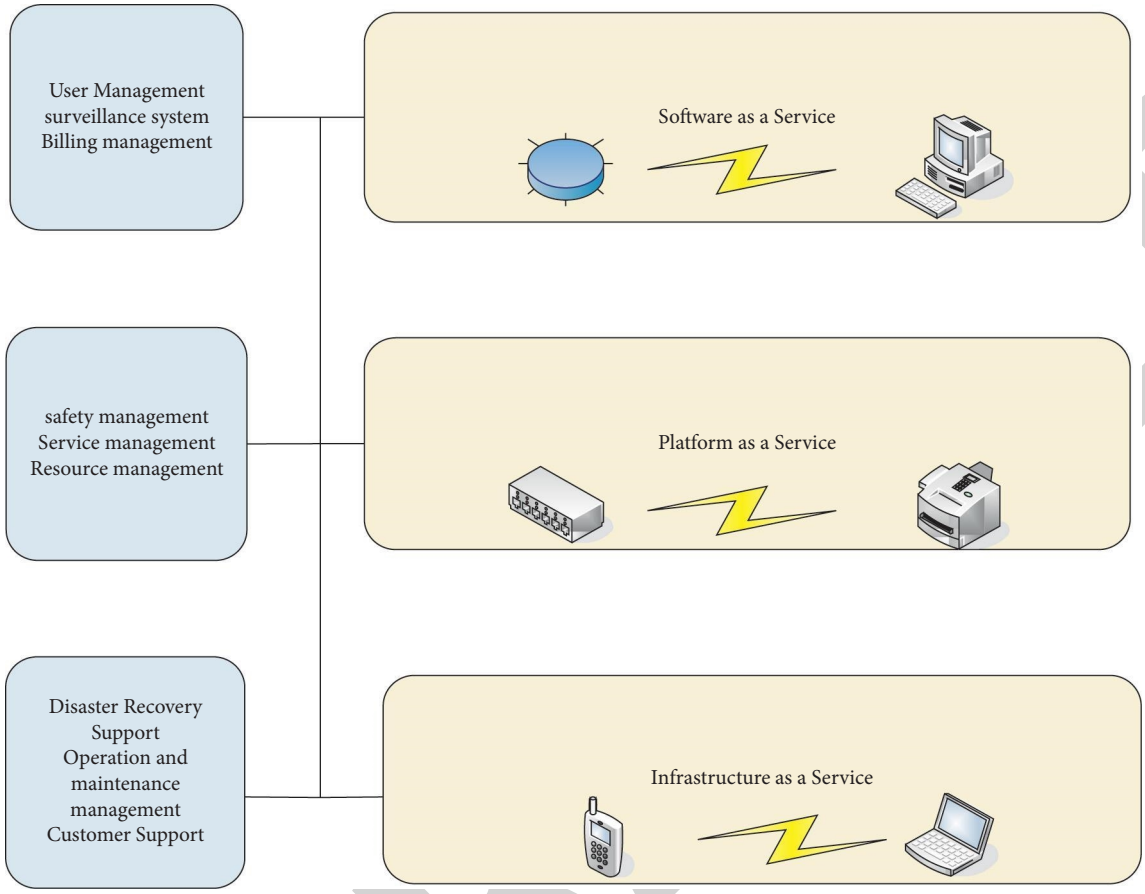

Figure 3: Basic architecture of cloud computing.

4. Interactive Music Teaching Experiment

4.1. Experimental Design. Firstly, using BD and CC technology, combined with incremental kernel data clustering algorithm, an interactive music teaching method was designed. This method is based on the concept of interactive teaching, with big data and cloud computing technology as the main technical support, emphasizing the interaction and cooperation between teachers and students in the teaching process. Then, students from 4 classes of a junior high school in Guangzhou (120 students in total) were selected as the experimental objects of this interactive music teaching experiment. The interactive teaching method designed in this paper to teach music to students in these 4 classes was used. And the actual utilization consequent of the interactive music teaching method designed based on BD and CC technology in this paper is judged by the results of the student participation rate and the excellent rate of the in-class test in the interactive music teaching of these four classes.

The relevant data of the students in the four classes selected in this experiment can be seen in Table 2.

It can be seen from Table 1 that the number of students in each of the four selected classes is about 30, and the proportion of male and female students is also relatively balanced. Such experimental objects can ensure the universality of the experimental conclusions to the greatest extent.

4.2. Student Participation Rate. In this interactive music teaching experiment, the participation rate of students was judged by counting the number of students in the four classes who answered the teacher's questions during the teaching procedure and who submitted the test papers in the classroom. The statistical results are shown in Figures 5 and 6.

Combining Figures 5 and 6, it can be seen that among all the students in the 4 selected classes, the total number of students who answered the teacher's questions in the interactive music teaching class was 102. The total number of students who submitted the in-class test papers was 108. It can be seen that the total participation rate of students in this interactive music teaching experiment is 88%. This shows that this interactive music teaching has a certain appeal to students, which makes the participation rate of students high.

4.3. Excellent Rate of In-Class Test Results. In this interactive music teaching class, according to the correction results of the in-class test papers submitted by the students in these

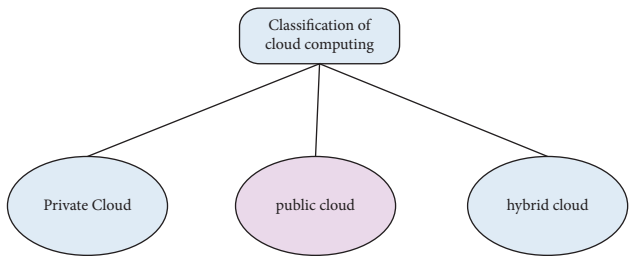

Figure 4: Cloud computing classification.

Table 2: Student data for selected 4 classes.

	Total students	Boys	Girls
Class 1	32	15	17
Class 2	28	18	10
Class 3	29	16	13
Class 4	31	17	14

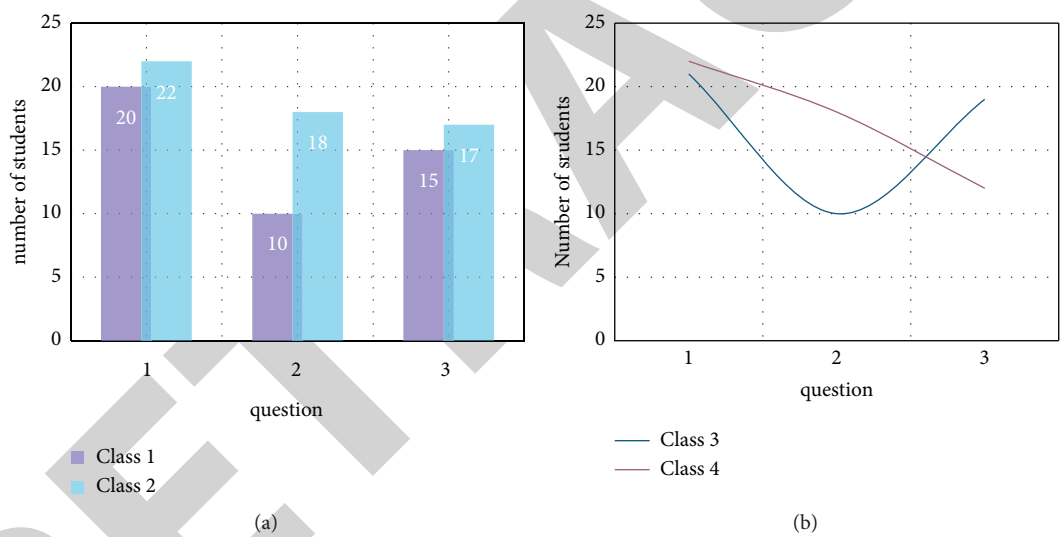

Figure 5: The number of students in the 4 classes who answered the teacher's question. (a) Number of questions answered by classes 1 and 2; (b) number of questions answered by classes 3 and 4.

four classes, the results of the in-class test of all the students who submitted the papers are shown in Figure 7.

From Figure 7, the amount of students who have achieved grades of 80–90 in class 1 and class 2 is significantly more than the number of students in classes 3 and 4 in this grade.

Figure 8 shows the specific results of the excellent rate of all students who handed in the papers in the 4 classes.

As can be seen from Figure 8, in the classroom test of this interactive music teaching, the total excellent rate of all the students who submitted papers in the 4 classes reached 90%. This shows that the interactive music teaching method has a significant effect on improving the students' music test scores, making the students' achievement rate higher.

In summary, this experiment draws the following conclusions: the interactive music teaching way based on BD and CC has a certain positive effect on attracting Teachee's interest in music study and improving their academic performance. It enables students to participate in the classroom to 88%, and the excellent rate of the in-class test has reached 90%.

5. Discussion

Interactive teaching method pays attention to the communication and collaboration between teachers and Teachees and has certain application value in many teaching fields. The application of interactive teaching methods in

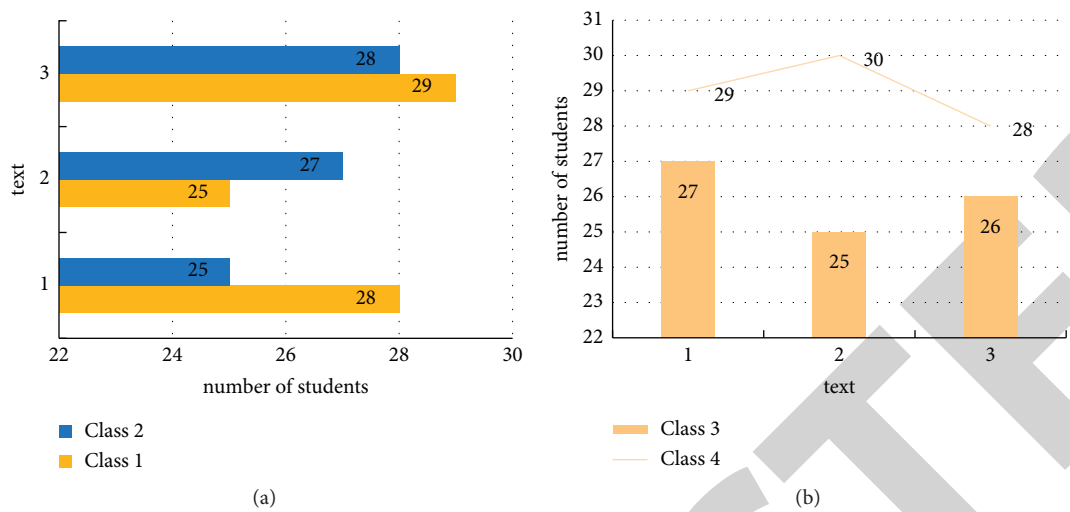

Figure 6: Number of students who submitted in-class test papers in 4 classes. (a) The number of people who handed in the papers in classes 1 and 2; (b) the number of people who handed in papers in classes 3 and 4.

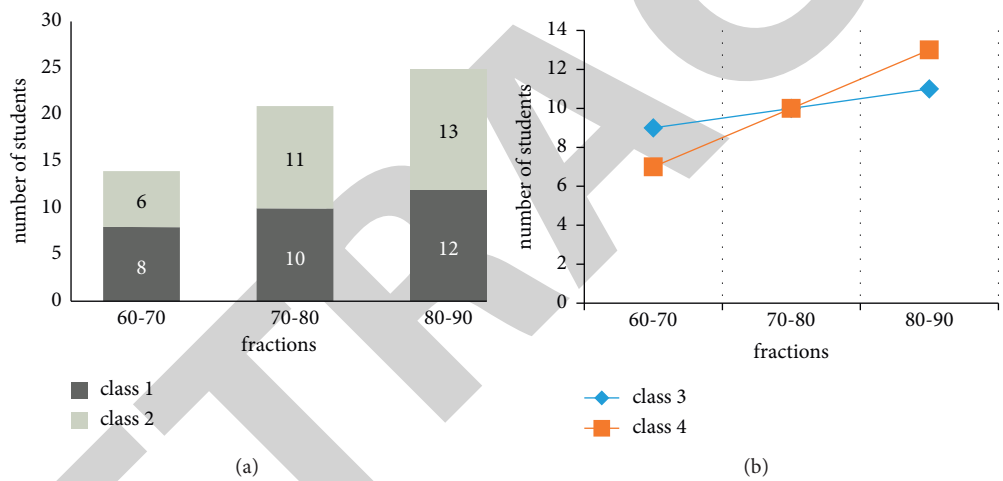

Figure 7: The total results of the in-class test of the students who handed in the papers in 4 classes. (a) Summary of grades 1 and 2; (b) summary of grades 3 and 4.

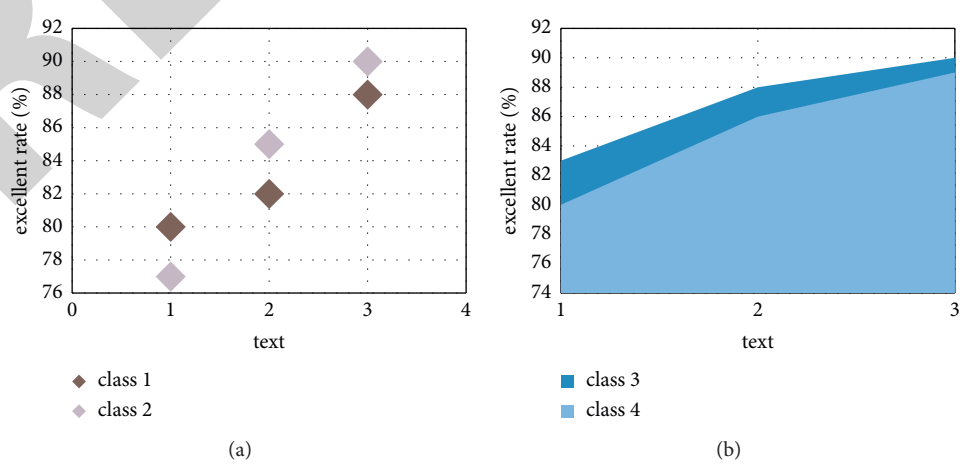

Figure 8: The specific results of the outstanding performance rate of all the students who handed in the papers in the 4 classes. (a) Excellent rate of classes 1 and 2; (b) excellent rate of classes 3 and 4.

music teaching just meets the requirements of music teaching focusing on teacher-student communication, and it is helpful to ameliorate music teaching.

While the interactive teaching method also has some organizational difficulties in the actual application procedure, certain technical support is needed to assist the application of the interactive teaching method. As an important product of contemporary technological development, big data and cloud computing technology have strong technical advantages in data information services. This paper mainly studies the application effect of interactive music teaching method based on BD and CC technology.

In this paper, the study on the application effect of the interactive music teaching modus in view of BD and CC is mainly carried out through experimental analysis. The interactive music teaching experiment designed in this paper designs an interactive music teaching method based on BD and CC. Then, the effectiveness of the method is judged by analyzing the participation rate of the class students participating in this interactive music teaching class and the excellent rate of the in-class test. The experimental results show that the interactive music teaching method based on BD and CC has a significant effect on raising students' interest in music study and academic performance. It has resulted in an 88% student participation rate and a 90% academic excellence rate.

6. Conclusions

This paper firstly introduces technologies such as BD and CC and then designs an interactive music teaching method based on these technologies and conducts application experiments on the method. Through the statistics and analysis of the participation rate of students participating in the experimental classroom and the excellent rate of the test in the classroom, the experiment finally draws a conclusion. The final conclusion of the experiment is that the excellent rate of the test in the classroom has reached 90%. This fully demonstrates the superiority of the interactive music teaching method based on BD and CC in raising students' interest in music learning and academic performance. The research conclusions drawn in this paper have a certain reference value for promoting the application of BD and CC in the design of interactive music teaching methods and also have a certain meaning for boosting the development of music teaching. However, due to the limitations of research conditions and levels, the research in this paper still has some deficiencies in the design of interactive music teaching methods based on big data and cloud computing, and we hope to continue to explore and improve in future research. It is wished that the study in this article can contribute to the application and development of interactive music teaching methods.

Data Availability

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

Disclosure

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

Conflicts of Interest

The author declares no conflicts of interest in our paper.

Authors' Contributions

The author has seen the manuscript and approved to submit it to your journal.

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Retraction

Retracted: Mechanical Motion Trajectory Control Tracking System Based on Machine Learning Algorithm

Mobile Information Systems

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 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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Research Article

Mechanical Motion Trajectory Control Tracking System Based on Machine Learning Algorithm

Zhongyi Zhao and Shenyu Wang

College of Mechanical Engineering and Automation, Liaoning University of Technology, Jinzhou 121001, Liaoning, China

Correspondence should be addressed to Zhongyi Zhao; jxzhaozy@lnut.edu.cn

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Machine learning is a key problem in the field of artificial intelligence. It is the study of statistical learning methods. It enables computers to simulate the learning behavior of humans, accumulate experience, and continuously improve and perfect their performances. Mechanical motion has always been an important subject in the field of automation, and trajectory tracking control is an important technology for mobile robots. Therefore, its research has important theoretical and practical significance. This study proposes a research based on the machine learning algorithm applied to the control and tracking system of mechanical motion trajectory. It expounds the neural network model, support vector machine algorithm, clustering algorithm, and K-means algorithm. Zeroing in on the issue of mechanical movement direction following control, this study concentrates on the plan of the mechanical movement direction following regulator in view of the BP brain network in the AI calculation and checks the accuracy and plausibility of the regulator plan. The exploratory outcomes demonstrate the way that the ideal following direction can be acquired by taking $\varepsilon = 5$. It makes the tracking trajectory more accurate, and the error convergence speed is faster.

1. Introduction

In information processing, many practical problems can actually be transformed into data classification, while data and information processing are studied based on machine learning. With the development of science and technology, machine learning algorithms have been widely used. Machine learning techniques facilitate many aspects of modern society. The success of machine learning algorithms often depends on the representation of the data because different representations can more or less hide the interpretation of the various factors behind the data. The establishment of mechanical kinematics is the highest sense of automation in contemporary times. The development of control theory can be divided into three stages: classical control theory based on regulation principle, modern control theory based on the mathematical model, and the intelligent and artificial neural network control method based on the complex system. With the continuous progress and development of science and technology, mechanical movement plays an important role in industrial production and services. It has also become an indispensable automation equipment in the field of industrial manufacturing.

Machine learning can solve large-scale data problems that currently cannot be solved by human beings. It has strong self-learning ability, self-optimization ability, and strong generalization ability. This study lays a theoretical and algorithmic basis for computers to replace human beings in large-scale data processing and analysis. In addition, intelligent mobile robots can improve the reliability of detection and reduce risks. In the field of environmental protection and household services, the development of low-cost intelligent mobile robots will bring great convenience to people's lives.

The innovation of this study is as follows: (1) it applies the intelligent learning algorithm to the mechanical motion trajectory control and tracking system, which is innovative and practical; (2) it uses the proposed model to study the mechanical motion trajectory to achieve high accuracy.

2. Related Work

With the advancement of science and innovation, AI innovation has infiltrated into all parts of individuals' lives, and that is just the beginning and more researchers are concentrating on it. In a past report, Grassi et al. fostered a superior execution, clinically translatable AI calculation for anticipating gentle mental impairment [1]. Park et al. proposed a technique to rapidly apply AI-based calculations through effective asset allocation [2]. Teluguntla et al.'s exploration has fostered an exact Landsat 30-meter-inferred cropland region item for Australia and China, two vital, special, and different powers. This study utilized eight groups of information from like clockwork activity of the Land Imager (OLI) from 2013 to 2015 [3]. Dicky et al.'s examination was to accomplish framework versatility while managing huge information. Moreover, AI calculations are executed in the gig recommender to produce exact occupation recommendation [4]. Zhang desired to utilize the development of the piece scoring model to additionally form a PC scoring framework for school English translation [5]. Olanrewaju et al. showed great execution when prepared and tried utilizing approval procedures. They proposed an intrusion detection model based on the C4.5 algorithm. The outcomes showed that the typical identification pace of the model is 99.62%, and the misleading positive rate is diminished by 0.38% [6]. Gao et al. concentrated on a two-venture harm conclusion structure for warm security frameworks in light of quantile irregular timberland and self-coordinating guide (SOM) brain organization. Gao et al. purposed a mix of actual understanding and information driven strategies to examine the strain inconsistencies of TPS examples. They acquired a physical issue determination, including the area of the injury, the impacted region, and the injury classification [7]. The drawback of these examinations, nonetheless, was that the contemplations are not adequately thorough to adjust to additional complicated circumstances, and accuracy should be gotten to the next level.

3. Machine Learning Algorithms

Machine learning algorithms aim to autonomously find patterns from a class of unknown data. They then use this rule to classify the remaining data or make an advance prediction of the next incoming data. At the end of the 20th century, a discipline emerged covering multiple disciplines such as approximation theory, probability theory, convex analysis, statistics, and algorithmic complexity theory. Therefore, the purpose of machine learning is to design algorithms that allow computers to learn autonomously, thereby realizing the application of artificial intelligence [8].

There are three primary kinds of AI calculations, to be specific: administered learning calculations, solo learning calculations, and support learning calculations. There are presently just ten AI calculations, to be specific: choice tree, k-implies calculation, guileless Bayesian, KNN calculation, affiliation rule calculation, grouping, brain organization, SVM, gathering learning, and head part examination.

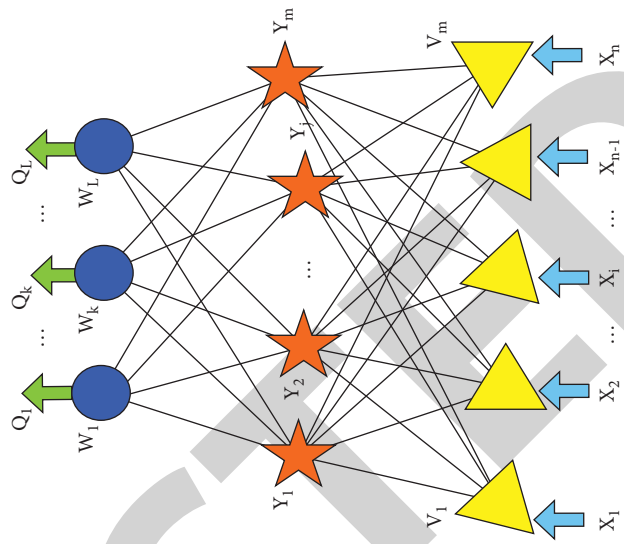

Figure 1: The structure of the BP network.

In recent years, artificial intelligence has become more and more popular. Many companies are more or less involved in artificial intelligence; otherwise, they will be regarded as not keeping up with the trend of the times. Moreover, AI in light of huge information has become hot, since it can give assurance and premise to information forecast and dynamic through the estimation of enormous information and the mining of stowed away information [9].

This part mostly sums up four sorts of BP brain organization, support vector machine, bunching calculation, and K-implies calculation. It utilizes the numerical model of these boundaries to create the information expected for the examination by programmatic experience.

3.1. Supervised Learning. Supervised learning is also known as teacher-led learning. It first identifies and trains the data and obtains a definite result, or a real result. It then classifies the unknown data with the trained rules [10].

3.1.1. BP Neural Network and Its Algorithm. The error backpropagation (BP) neural network is one of the most widely used network models in ANNs. It builds a multilayer model by imitating the process of human brain neurons responding to external signals. It is iteratively educated by two cycles of sign forward engendering and blunder input change. It has great cooperative memory capacity and successfully tackles complex issues like nonlinear grouping, work estimate, and clinical discovery. The structure of the BP network is shown in Figure 1.

(1) The Basic Structure of the BP Neural Network. The signal of the BP neural network is forward conduction [11]. The signal is transmitted from the input node to the hidden layer node through weighting and function transformation, and its value is

$$D_j = F(net_j), j = 1, 2, \ldots, m, \tag{1}$$

$$net_j = \sum_{i=0}^{n} U_{ij} G_i, j = 1, 2, \ldots, m. \tag{2}$$

For the BP network with multihidden layer structure, the signal is transmitted from the hidden layer of the previous layer to the next hidden layer. For the single hidden layer structure shown in the figure, the signal is directly transmitted from the hidden layer to the output layer, as follows:

$$V_k = F(net_k), j = 1, 2, \ldots, k, \tag{3}$$

$$net_k = \sum_{j=0}^{m} R_{jk} G_j, k = 1, 2, \ldots, s. \tag{4}$$

Among them, $F(X)$ is called the transfer function. The unipolar Sigmoid function (hyperbolic tangent function) is generally used:

$$F(X) = \frac{1}{1 + E^{-X}}. \tag{5}$$

This makes it differentiable, continuous, and

$$F'(X) = F(X)[1 - F(X)]. \tag{6}$$

Sometimes, depending on the application needs, a bipolar sigmoid function can also be used:

$$F(X) = \frac{1 - E^{-X}}{1 + E^{-X}}. \tag{7}$$

(2) BP Learning Algorithm. The core idea of the BP learning algorithm is to repeat the process of forward conduction and reverse conduction of error until the output error reaches the design requirements [12].

The expected output of the neural network is $Y = (Y_1, Y_2, \ldots, Y_l)^T$, and the output error e is defined as

$$e = \frac{1}{2}(Y - L)^2 = \frac{1}{2}\sum_{k=1}^{s}(Y_k - L_k)^2. \tag{8}$$

It expands the above formula layer by layer in reverse. For the hidden layer, there are

$$e = \frac{1}{2}\sum_{k=1}^{s}[Y_k - F(net_k)]^2 = \frac{1}{2}\sum_{k=1}^{s}\left[Y_k - F\left(\sum_{j=0}^{m} V_{jk} D_j\right)\right]^2. \tag{9}$$

It is further expanded to the output layer, with

$$\begin{aligned} e &= \frac{1}{2}\sum_{k=1}^{s}\left\{Y_k - F\left(\sum_{j=0}^{m} V_{jk} F(net_k)\right)\right\}^2 \\ &= \frac{1}{2}\sum_{k=1}^{s}\left\{Y_k - F\left(\sum_{j=0}^{m} V_{jk} F\left(\sum_{i=0}^{n} U_{ij} X_i\right)\right)\right\}^2. \end{aligned} \tag{10}$$

It can be seen from the above formula that the output error e is subject to the connection weights V_{jk} and U_{ij} between the layers. The purpose of BP learning is to adjust the weight matrices V and U to reduce the output error e to the minimum value. It makes the adjustment of the weights proportional to the gradient descent of the error.

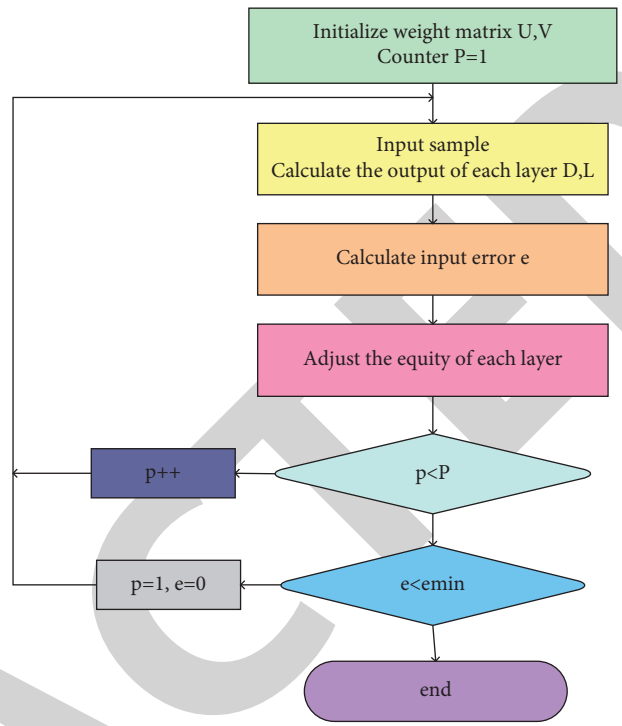

Figure 2: Standard BP network program flowchart.

$$\Delta V_{jk} = -\eta \frac{\partial e}{\partial v_{jk}}, \tag{11}$$

$$\Delta U_{ij} = -\eta \frac{\partial e}{\partial U_{ij}}. \tag{12}$$

In the above two formulas, the constant η is the learning rate, which can affect the speed of weight adjustment, which in turn affects the speed of the entire learning process. When $\eta \in (0, 1)$ and η are larger, it is easier to jump out of the local minimum interval of the output error e, and the learning speed is faster, but the adjustment accuracy is poor [13].

It substitutes the expression of E in formulas (9) and (10) into the gradient adjustment formulas (11) and (12), and the weight adjustment formula of the 3-layer BPNN can be obtained:

$$\Delta V_{jk} = \eta(Y_k - L_k)L_k(1 - L_k)D_j, \tag{13}$$

$$\Delta U_{ij} = \eta\left(\sum_{k=1}^{s}(Y_k - L_k)L_k(1 - L_k)V_{jk}\right)D_j(1 - D_j)X_i. \tag{14}$$

The derivative of the unipolar sigmoid function, formula (14), is applied. For multihidden layer BPNN, it is only necessary to reversely derive the weight adjustment formula according to the above rules [14]. The flowchart of the standard BP network program is shown in Figure 2.

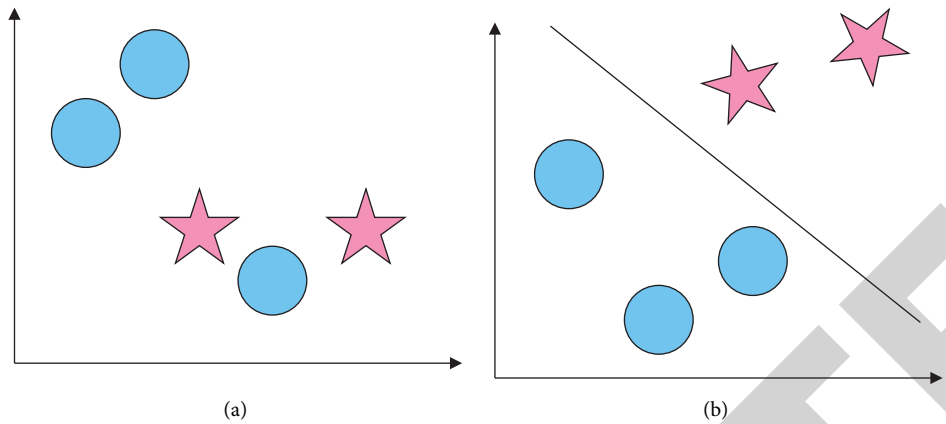

Figure 3: Basic idea of support vector machine.

3.1.2. Support Vector Machine Algorithm. Support vector machines are a directed learning technique. It is fundamentally utilized for information investigation, design acknowledgment, grouping examination, and relapse examination of information. In AI, support vector machines are directed learning models with related learning calculations. It is utilized for grouping examination and relapse investigation information. The basic idea of SVM is shown in Figure 3.

It first nondirectly maps the preparation dataset to a high-layered include space. The reason for this nonlinear planning is to change the directly indistinguishable dataset in the info space into a straightly divisible dataset in the wake of planning it to a high-layered highlight space. It then lays out an ideal isolating hyperplane with the biggest confinement distance in the element space. This is likewise identical to creating an ideal nonlinear choice limit in the information space.

A help vector machine can be seen as a brain network with stowed away layers. It makes sense of SVM from a brain network point of view, as shown in Figure 4 [15].

Compared with other algorithms, the support vector machine algorithm has the following incomparable advantages. The specific advantages are as follows: the support vector machine can fully reflect the principle of structural risk minimization; for data outside the sample set, the support vector machine shows a good generalization ability; based on the linear classifier, the support vector machine realizes the transformation from linear to nonlinear through the kernel function, which can effectively solve the nonlinear problem; the support vector machine method can well solve the multidimensional problems existing in high-dimensional space; for the solution problem of the support vector machine, the support vector machine can transform the problem into a quadratic optimization problem, and there is a unique extremum point where the optimal solution exists; and support vector machines can be effectively combined with a variety of algorithms and can establish models with similar patterns, thereby effectively simplifying complex problems.

(1) Linearly Separable Support Vector Machine. Linearly separable support vector machines are the simplest and

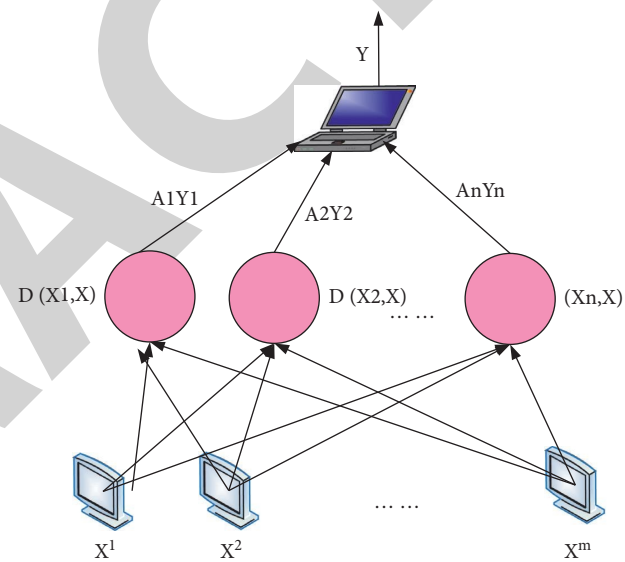

Figure 4: Schematic diagram of the structure of the support vector machine.

easiest to understand [16]. If the sample set can be correctly separated by a straight line, then there must be an optimal partitioning hyperplane in the case of the largest interval, so that the two types of samples in the training set are on both sides of the hyperplane. The hyperplane is

$$(F \bullet X) + G = 0. \tag{15}$$

Among them, F is the normal direction, and G is the offset. The two boundary hyperplanes are L_1: $(F \bullet X) + G = 1$ and L_2: $(F \bullet X) + G = -1$ to construct the optimal partitioning hyperplane, which can be expressed as the following optimization problem:

$$\begin{aligned} &\min_{K,G} \frac{1}{2}\|K\|^2, \\ &st. Y_i\left(K \bullet X_i + G\right) \geq 1 - \xi_i, \\ &i = 1, 2, \cdots, L. \end{aligned} \tag{16}$$

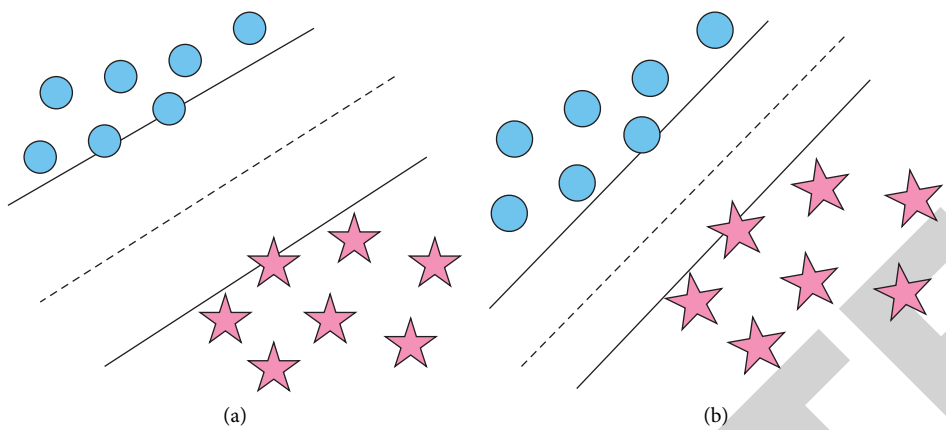

Figure 5: Spacer plane. (a) The plane with the largest spacing. (b) The plane with the smallest spacing.

The result obtained by solving the dual problem of the original problem is as follows:

$$\min_{O} \frac{1}{2}\sum_{i=1}^{L}\sum_{j=1}^{L} Y_i Y_j O_i O_j \left(X_i \bullet X_j\right) - \sum_{j=1}^{L} O_j,$$
$$st. \sum_{i=0}^{L} Y_i O_i = 0, \tag{17}$$
$$O_i \geq 0, i = 1, 2, \cdots, L.$$

So, the decision function is

$$F(X) = \operatorname{sgn}\left(\left(K^* \bullet X\right) + G^*\right). \tag{18}$$

It assumes that the training dataset T is linearly separable. The purpose of learning is to construct a decision hyperplane to separate the two types of samples as far as possible, but there are infinitely many such decision hyperplanes. As shown in Figure 5, it can be intuitively seen that the classification interval shown in Figure 5(a) is the largest [17, 18].

(2) Linear Inseparable Support Vector Machine. The linear inseparability problem is because there is no straight line that separates the two classes of samples correctly. Then, under the premise of allowing some samples to be wrongly classified, by introducing slack variable ξ, the corresponding optimal classification hyperplane can be found, and the constraint condition is $Y_i(F \bullet X_i + G) \geq 1 - \xi, i = 1, 2, \cdots, L$. Then, the original problem can be modified into the following form:

$$\min_{K,G,\xi} \frac{1}{2}\|K\|^2 + C\sum_{i=1}^{L} \xi_i,$$
$$st. Y_t\left(K \bullet X_i + G\right) \geq 1 - \xi_i, \tag{19}$$
$$\xi_i \geq 0, i = 1, 2, \cdots, L.$$

Among them, $C > 0$ is a compromise parameter, indicating the degree of error separation that can be tolerated within the maximum interval [19, 20].

Table 1: Kernel functions.

RBF kernel function	$D(X, X') = EXP(-\gamma\|X - X'\|^2)$
Linear kernel function	$D(X, X') = X \bullet X'$
Polynomial kernel function	$D(X, X') = (X \bullet X' + 1)^k$
Sigmoid kernel function	$D(X, X') = \tanh(\alpha < X, X' > + R)$

$$\min_{O} \frac{1}{2}\sum_{i=1}^{L}\sum_{j=1}^{L} Y_i Y_j O_i O_j \left(X_i \bullet X_j\right) - \sum_{j=1}^{L} O_j,$$
$$st. \sum_{i=0}^{L} Y_i O_i = 0, \tag{20}$$
$$0 \leq O_i \leq C, i = 1, 2, \cdots, L.$$

So, the decision function is

$$F(X) = \operatorname{sgn}\left(\left(K * \bullet X\right) + G *\right). \tag{21}$$

(3) Nonlinear Separable Support Vector Machine. When dealing with linear datasets, linear support vector machines are a very efficient way. However, in real-world tasks, datasets are usually not linearly separable. That is, there is no hyperplane that can accurately separate the two sorts of tests in the first space. No matter how the separating hyperplane is placed, all the samples cannot be classified correctly, and the nonlinear separability appears at this time. The kernel functions are given in Table 1 [21].

Commonly used positive definite kernel functions are given in Table 1. Linear kernels and Gaussian kernels are generally used, that is, linear kernels and RBF kernels. Which kernel function to use depends on the dataset and requirements. Generally speaking, there are the following summaries of experience:

(1) If the number of features is large, similar to the number of samples, a linear kernel should be used at this time because the ineffective features can be filtered out

(2) If the number of features is relatively small and the number of samples is general, a nonlinear kernel

should be used at this time. Generally, the RBF kernel is used, and the method of calculating the kernel matrix is still relatively fast.

(3) If the number of features is relatively small, the number of samples is large, and the amount of calculation of the kernel matrix that needs to be calculated is relatively large, and the linear kernel is generally used [22, 23].

3.2. Unsupervised Learning. The difference between unsupervised learning and supervised learning is that data does not need to be identified in advance. According to different learning method rules and the clustering characteristics of the data itself, it finds the corresponding internal rules and finds useful hidden information in the complex and disordered data [24, 25].

3.2.1. Clustering Algorithm. The clustering algorithm is a kind of classification and grouping of things with the same attributes. It classifies cluttered sets of data into meaningful clusters. The essence of clustering problem is optimization problem. However, this optimization must satisfy certain clustering conditions or clustering rules. The advantages of clustering are fast processing time, simple operation, and easy interpretation. The disadvantage is that parameters need to be set when using, and sometimes the result may appear to be locally optimal. The classification of clustering algorithms is shown in Figure 6 [26, 27].

(1) Data Standardization. In order to eliminate the influence of different dimensions of the original data, this study adopts the cluster analysis method in the data preprocessing, and the original data needs to be standardized. The normalized formula is

$$X_{mn} = \frac{Y_{mn} - \overline{Y_n}}{\sqrt{\operatorname{var}(Y_n)}} \, (m = 1, 2, \cdots, j), \tag{22}$$

$$\overline{Y_n} = \frac{1}{j} = \sum_{m=1}^{J} Y_{mn}, \tag{23}$$

$$\sqrt{\operatorname{var}(Y_n)} = \sqrt{\frac{1}{j} \sum_{m=1}^{j} (Y_{mn} - Y_n)^2}, \tag{24}$$

where $\overline{Y}$ and $\sqrt{\operatorname{var}(Y_n)}$ are the mean and variance of the nth variable, respectively. Y_{mn} is the index value before standardization, and X_{mn} is the index value after standardization.

(2) Defining the Distance. Assuming that there are j sample data in a b-dimensional space, the formula for calculating the distance between sample m and sample n is as follows:

$$D_{mn} = \sum_{k-1}^{b} |X_{mk} - X_{nk}|. \tag{25}$$

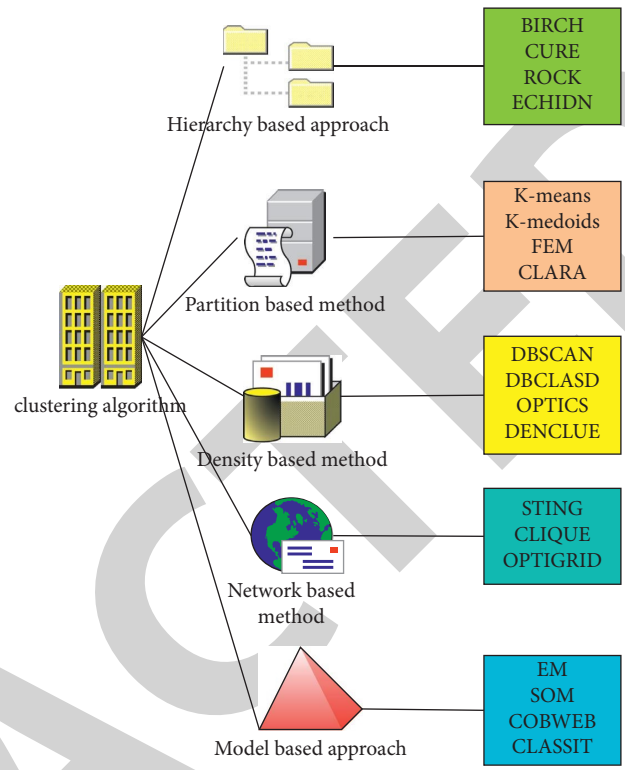

Figure 6: Classification of clustering algorithms.

The above formula calculates the absolute value distance.

$$D_{mn} = \sqrt{\sum_{k=1}^{b} (X_{nk} - X_{mk})^2}. \tag{26}$$

The above formula calculates the Euclidean distance.

$$D_{mn} = MAX_{1 \le k \le b} |X_{mk} - X_{nk}|. \tag{27}$$

The above formula calculates the Chebyshev distance.

Usually, the smaller the above distance is, the closer the similarity of the sample objects of the study is.

(3) Similarity Coefficient. The similarity coefficient of any two b-dimensional vectors can be used to measure the similarity of the two vectors in the b-dimensional space. This similarity coefficient is represented by C_{mn}, where m and n are the two vectors to be compared. C_{mn} satisfies the symmetry; that is, the two vectors to be compared satisfy $C_{mn} = C_{nm}$. In general, the cosine of the angle between two vectors is a common similarity coefficient:

$$\cos(\theta_{mn}) = \frac{\sum_{k=1}^{b} X_{mk} X_{nk}}{\sqrt{\sum_{k=1}^{b} X_{mn}^2 X_{nk}^2}}. \tag{28}$$

The advantages and disadvantages of various algorithms are compared and analyzed as given in Table 2.

The algorithms reviewed above each have their own characteristics, and the comparison results of various methods are given in Table 2. According to the comparison of various algorithms in Table 2, conclusions can be drawn.

Table 2: Comparison and analysis table of the advantages and disadvantages of various algorithms.

Method	Accuracy	Operation difficulty	Running time	Dealing with fuzzy situations	Interpretability of results	Parameter dependence
Statistical analysis	Low	Simple	Short	No	Interpretable	Self-learning
Decision tree method	Commonly	Commonly	Long	No	Interpretable	Dependence
Neural network algorithm	High	More difficult	Long	No	Unexplainable	Self-learning
Clustering algorithm	Commonly	Simple	Short	Yes	Interpretable	Dependence

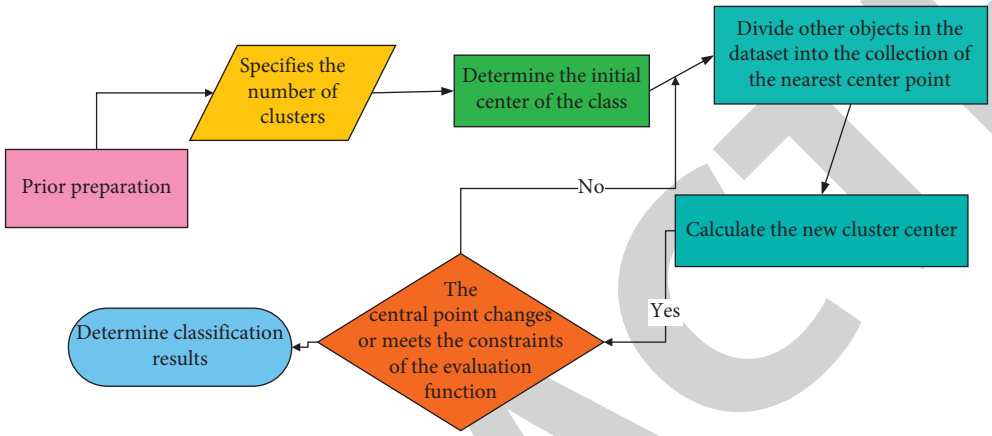

Figure 7: Flowchart of the classic K-means algorithm.

Table 3: Subsample mean square error sum of each training sample.

Training sample Sum of mean square error	Group 1	Group 2	Group 3	Group 4	Group 5
Group 1 samples	0	0	0	0	0
Group 2 samples	3.6	12.2	10.5	6.2	0.4
Group 3 samples	22	9.5	12.5	5.79	4.98
Group 4 samples	3.33	22.9	3.45	98.55	35.5
Group 5 samples	3.59	2.22	1.2	4.78	43.89
Group 6 samples	3.59	55.2	6.2	12.31	78.44
Group 7 samples	12.22	5.56	5.32	4.23	54.56
Group 8 samples	10.2	34.4	4.29	9.56	98.44
Group 9 samples	30.48	11.23	54.39	44.89	6.42
Group 10 samples	30.4	40.61	15.89	34.55	3.4

Statistical analysis methods are simple and can process data quickly, but are difficult to handle complex data and have low precision. Decision tree methods are too parameter-dependent and take a long time to compute. It requires complete data information, such as missing data, which greatly affects the processing effect. The advantage of the neural network is that it has strong stability and fault tolerance when dealing with noisy data, but the disadvantage is that the operation is complicated and the cost is high. Cluster analysis has fast processing time, simple operation, and easy understanding. The disadvantage is that it depends on parameters, and the accuracy is general [28].

3.2.2. K-Means Algorithm. The K-means algorithm first randomly divides the input points into k initialized groups. It can use certain rules to group and then calculate the center point of these groups of data. Second, it regroups the data, dividing some data close to the center point together. The above process is repeated, and the data center is repeatedly calculated until the position of the data center does not change; that is, the convergence is stopped. Figure 7 is a flowchart of the classic K-means algorithm.

4. Simulation Experiment Research of Mechanical Motion Trajectory Control and Tracking System

This chapter will use MATLAB software to conduct simulation experiments on the trajectory tracking controller based on the BP neural network to verify the correctness and effectiveness of the algorithm.

4.1. Simulation Experiment of Trajectory Tracking Based on the BP Neural Network. This section verifies the effectiveness and accuracy of the designed tracking control algorithm

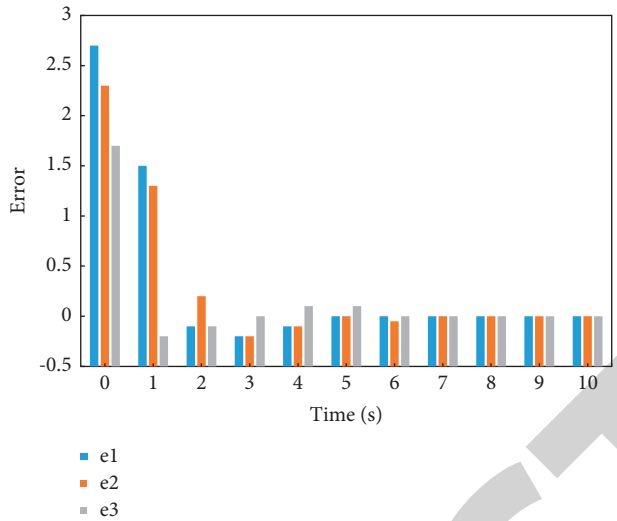

Figure 8: Mobile robot pose error.

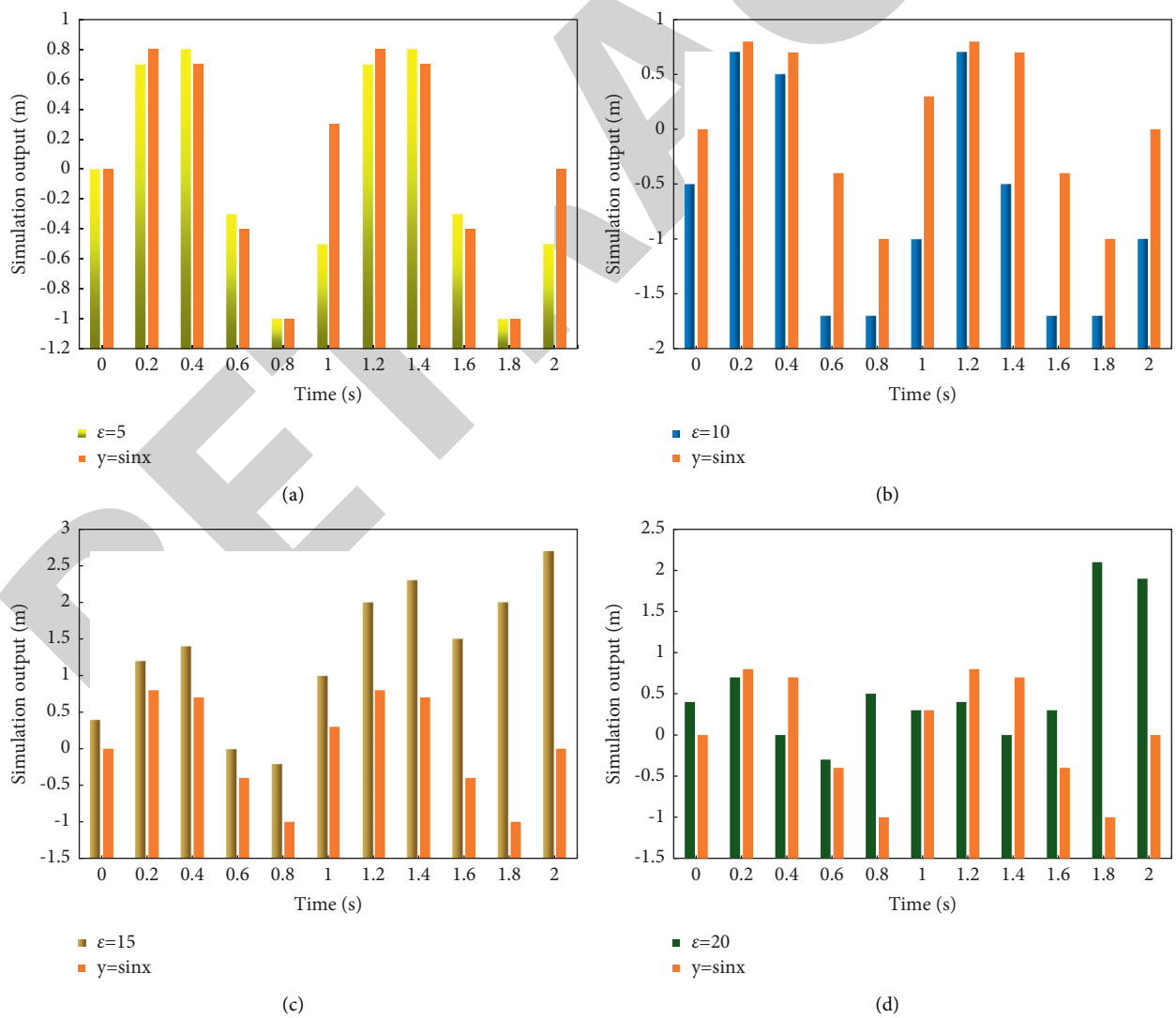

Figure 9: The trajectory tracking curve of the improved BP algorithm with different values.

through the tracking simulation of the mobile robot's pose error and sinusoidal trajectory on the computer. It also compares the trajectory tracking graph based on the BP neural network and other algorithms to verify that the BP neural network has stronger advantages.

In this study, 10 gatherings of tests are taken for preparing, and each gathering of tests is similarly separated into 5 gatherings of subtests. The comparing subtest mean square blunder and information of each gathering of tests are given in Table 3. The posture blunder bend of the portable robot is shown in Figure 8. It tends to be seen that the blunders at last unite to 0, and the combination speed is quick, and agreeable outcomes are accomplished.

4.2. The Trajectory Tracking Curve of the Improved BP Algorithm with Different Values of ε. As given in Table 3, $\varepsilon = 5$, $\varepsilon = 10$, $\varepsilon = 15$, and $\varepsilon = 20$ are taken separately. Utilizing the superior BP brain network calculation for preparing, the direction following bend shown in Figure 9 is acquired. It can be seen from Figure 9 that the bigger the worth of ε, the quicker the preparation speed, yet the following precision will diminish. In this study, $\varepsilon = 5$ is taken to get an optimal following direction.

5. Discussion

The present society is a data society, with the fast improvement of science and innovation, and the extending of organization applications. The global economy tends to develop in an integrated manner, and international exchanges are increasingly close. Network information has greatly changed the living environment, social concept, and production mode of human beings. The social division of labor has undergone tremendous changes, and we are in an era of unprecedented information explosion. It is undoubtedly of vital significance to carry out information extraction and knowledge mining in this massive information to obtain the required information. As for the analysis of the underlying knowledge, information, and rules in data mining, there is a wide range of needs. However, these massive amounts of data are beyond what people can handle. Therefore, we need to use computers to conduct large-scale data analysis to find useful knowledge and data mining patterns.

The machine learning method is one of the main methods for solving statistical learning problems in academia and industry. Machine learning includes supervised and unsupervised methods, among which the neural network is also one of the important contents. With the advancement of science and innovation, support vector machines can be utilized to further develop work effectiveness and lessen the likelihood of blunders in manual acknowledgment. To start with, under the state of obscure boundaries and dubious unsettling influences, the superior BP brain network is utilized to track and control the mechanical movement direction. Then, at that point, the better BP brain network is utilized for movement direction following, and MATLAB is utilized for mechanical plan.

Machine learning is a method of improving learning performance through continuous learning and large amounts of data. Classification algorithms for machine learning are divided into two processes: model design and classification. It selects the classification algorithm, obtains the classification model through the parameters of the training dataset, and then uses the training model to name the unknown sample data. As a firmly coupled time-fluctuating nonlinear framework, the direction arranging and direction following control of mechanical movement is an exceptionally intricate interaction. In this way, the exploration on conventional mechanical movement direction arranging and direction following control strategies is of extraordinary importance.

6. Conclusion

Based on gathering and counseling countless homegrown and unfamiliar written works, this study takes the nonholonomic mechanical movement as the exploration object. It plans the regulator through the superior BP brain organization and finishes the hypothetical exploration on the issue of mechanical movement direction control. In view of a ton of exploration, this study gives a brief and essential outline from help vector machine and BP brain organization, bunching calculation, and K-implies calculation. The primary work of this study is to utilize BP brain organization to plan the direction following regulator of portable robot. The powerful regulator is streamlined by BP brain organization, and the direction following control of mechanical movement is understood. In a word, there are still many problems in the current method of tracking and controlling the mechanical motion trajectory worthy of exploration and research. It is hoped that the work done in this subject has certain reference value.

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

Characteristic Differences between Novices and Experts in Different Shooting Stages

Shuyu Shao,[1] **Shike Zhang**,[1] **and Liwei Zhang**[2]

[1]*School of Logistics, Beijing Wuzi University, Beijing, China*
[2]*Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing, China*

Correspondence should be addressed to Shuyu Shao; shaoshuyu@bwu.edu.cn

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Attention is the most important psychological factor affecting shooting performance. The wavelet packet energy analysis method was used to explore the differences in EEG characteristics and brain activity between experts and novices while aiming and shooting in real shooting environments. Results show that the frontal and occipital regions of novices were more active when they were aiming, while the frontal, central, and occipital regions of experts were more active when they were shooting. Overall, the frontal, central, and occipital regions of novices were more active ($p < 0.05$), whereas for experts, it was the frontal, central, parietal, and occipital regions that were more active ($p < 0.05$). Brain activity was mainly concentrated in the left hemisphere of the brain for experts, indicating that they began to take action when aiming and had higher neural efficiency. This study can help the selection and training of personnel for typical tasks that require attention by monitoring and analyzing the EEG signals of operators of different skill levels.

1. Introduction

Shooting is a goal-directed precision task where the cognitive process involves vigilance, orientation, and exclusive attention [1, 2]. Shooting accuracy plays an important role in military combat, during emergency situations, in sporting events, and so on. As the key element in a man-gun system, the shooter needs a high degree of concentration during shooting [3]. In the man-gun system, the reaction time and accuracy of capturing a target are the main factors affecting performance. The shooting process includes three psychological states, which are noticing the target, determining the position of the target [4], and shooting. Shooting performance depends on hold control, aiming accuracy, and trigger control [2]. In order to continuously improve the overall motion and coordination, the sensory system and motor system need to work together while continuously monitoring external stimuli and flexibly switching the focus of attention [5]. In addition, the visual system must orient and process the most significant perceptual cues in order to determine distance and direction information [6], which requires functional control of central nervous system and a higher level of brain function.

Studies have shown that attention is the most important psychological factor affecting shooting performance [3, 7]; focusing attention on adequate sensory information is a key factor of shooting performance [8]. Brain function coupling is stronger in experts than in novices [9]. The cognitive load theory emphasizes that the appropriate allocation of available cognitive resources is beneficial for performance [10], and determining the psychological state of a shooter during shooting is very important for setting a psychological training plan that is suitable for their skill level [11]. Therefore, an increasing number of studies have focused on the dynamics of the cerebral cortex in order to clarify the cognitive process that occurs during the execution of skills that require a high degree of attention [12, 13].

Different shooting stages correspond to different cognitive states of brain. Electroencephalogram (EEG) can detect attention, information processing, and working memory in cognitive process [14], which has been used to investigate neural activity and cognitive processes in the

brain [15, 16]. To explore the influence of visual spatial cues in the shooting process on the cerebral cortex neural networks [17], and the differences in shooting performance and neural efficiency among individuals [18], scholars have mainly used EEG coupling together with some operational psychological measurement methods, questionnaire surveys, and other comprehensive evaluation and monitoring methods [7, 19]. Results have shown that different brain regions are activated for different tasks [17] and that brain activity has a certain correlation with operation performance and neural efficiency [9, 20].

Researchers have found that long-term participation in specific competitions can improve a shooter's physical reaction speed and the efficiency of psychological decision-making, therefore, experienced athletes tend to be more efficient in decision-making tasks [21]. Some studies have especially focused on the psychophysiological differences between experts and novices [15], athletes at different technical levels were compared and their brain activities were recorded during the actual sporting events [22], which included different visual attention prompts [1]. Since brain waves and frequencies will change during different stages of shooting, it is necessary to study the main visual areas of the brain that receive visual stimuli, and then direct them to the secondary visual areas of the cortex for further processing. It is important to determine how the brain processes information to produce internal representations of external phenomena [15, 17], in order to clarify the basic mechanism for achieving the best line of sight and higher shooting efficiency [23]. Studies have proven that shooting performance is related to EEG signal amplitude and changes in the power spectrum [24]. According to the requirements of cognitive resources, other autonomic parameters of brain activity in the θ and α frequency bands were combined as an index to evaluate the learning progress and the final skill level of the subjects [25]. Studies have shown that the functional connection strengths of the α and β bands are significant features of experts and novices [14]. Changes in low frequency α in the parietal and occipital regions are related to skillful cognitive motor performance; thus α is considered to be an indicator of changes in neural responses [13].

Previous studies have been helpful for providing athletes with information on their mental states. Improvements in operational performance and integration of memory leads to an improvement in skill level [26]. Memories contain many domain-specific patterns that can be described as hierarchical organizations, allowing people to classify different problem states to determine the most appropriate solution. However, the underlying neural mechanism of behavioral differences between motor skill levels is still unclear [26], due to lack of research on the brain states corresponding to each action in the shooting process. The purpose of this study was to investigate the psychophysiological differences of shooters during different stages of shooting. Real-life shooting scenarios were executed to analyze the EEG characteristics of experts and novices during aiming and shooting, and to determine the mental status and active brain regions in different shooting stages. Differences in the EEG characteristics between the experts and novices were analyzed for different stages. Training simulation interfaces can be designed according to the EEG characteristics of different personnel, for the development of mental training programs, for training the neural state of novices, and also for monitoring the EEG signals of personnel. A closed-loop human-computer interaction was used as the foundation to realize the two-way transmission of information.

2. Materials and Methods

2.1. Participants. Seventeen healthy male experts with rifle shooting experience and fifteen healthy male novices with no shooting experience were recruited; their mean (± SD) age was 25.83 (± 2.46) years. All participants were right-handed and had no major brain disease and their mental states were well. The visual acuity or corrected visual acuity of the participants was 4.8 or higher. The participants were to ensure that they had adequate sleep two days before the experiment and they were forbidden from ingesting stimulating drinks, such as strong tea or coffee.

2.2. Procedures. The participants conducted five shooting exercises to warm up with semi-automatic sniper rifles before the formal experiment. After warming up, the participants were required to complete six rounds of shooting, including 10 trials with intervals of one minute between each round of shooting. The experimental process is shown in Figure 1. Each participant understood the process of the experiment, took the experiment seriously, and maintained a consistent mental state. The distance between the chest ring targets and the participants was 70 m. The participants were in a sitting position and their guns were supported by instruments. Each shooting process was divided into three stages: holding stage, aiming stage, and shooting stage. A sound was played to signal the beginning of the gun and aiming stages, and there was 1 second between each shooting stage for the participants to make adjustments. A stopwatch was used to record the aiming time of the shooter, which was used to verify the aiming time recorded by the EEG recording software.

2.3. EEG Recording and Preprocessing. Continuous EEG recordings were obtained using a SynAmps2 amplifier (Compumedics Neuroscan, Charlotte, NC, USA). The EEG acquisition equipment included an EEG amplifier (Brain Products, actiCHamp), 32-channel active electrode EEG acquisition cap, EEG synchronous acquisition system, and an ERP/EEG stimulation system. The ERP/EEG stimulation system was mainly used for the subjects who completed the tasks according to the guidelines, and the screen refresh frequency was 60 Hz. The EEG synchronous acquisition system collected, recorded, and saved the brain signals during the shooting tasks by integrating the signal amplification and acquisition software. The electrodes were placed on the participants according to the international 10–20 system, the reference electrode was set as Fz, the prefrontal lobe was grounded, the sampling rate was 1000 Hz, and the

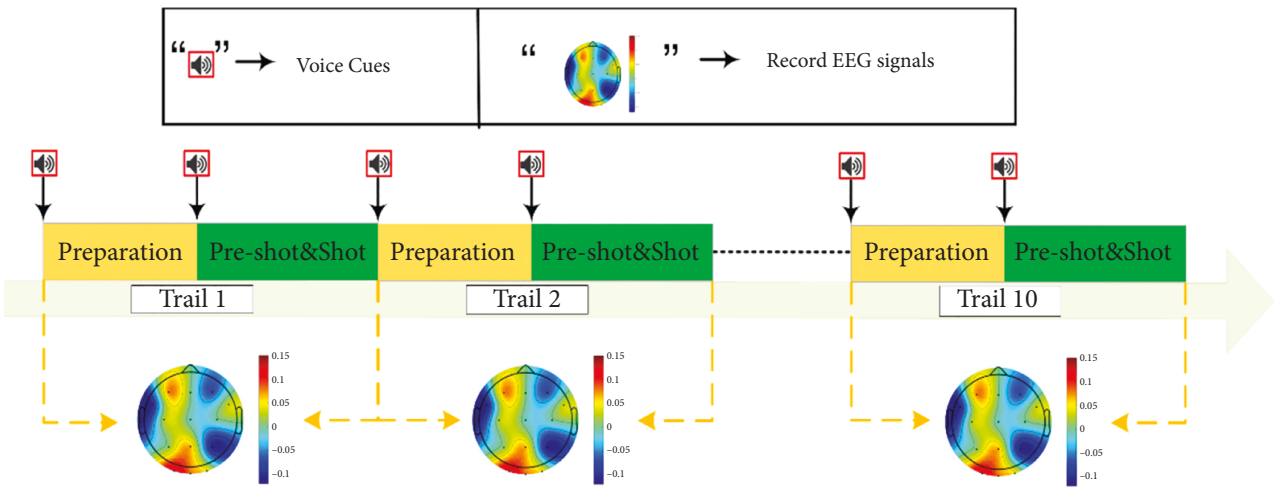

Figure 1: Experiment design and procedure.

impedance of the electrode was kept below 5K Ω during the acquisition process.

Independent component analysis (EEGLAB) was used to correct the artifact signal caused by blinking. Using the multi-resolution characteristics of wavelet transform, the EEG signal was decomposed into multiple scales and five independent frequency bands, thus showing different rhythmic information in the frequency band [27, 28]. In order to reduce the time and space complexity of the wavelet packet decomposition, the signal was desampled. The EEG sampling rate decreased from 1000 Hz to 256 Hz.

After the EEG signals from the shooting process were segmented, the data for each participant was grouped into three sets: holding stage data, aiming stage data, and shooting stage data. Each data set was measured over a period of 2 seconds, and the sampling rate was 1000 Hz. During the aiming phase, eye closure had a great influence on the FP1 and FP2 signals in the frontal region; hence the FP1 and FP2 data were not processed in this study, while the temporal area was mainly occupied with hearing and did not do any processing. Finally, out of the 32 channels, we only analyzed the EEG data from 14 channels in the frontal region (F3, Fz, F4), frontal-central region (FC5, FC6, C3, Cz, C4), parietal region (P3, Pz, P4), and occipital region (O1, Oz, O2). Using the multi-resolution analysis characteristics of the wavelet transform, the preprocessed EEG signals were decomposed into five sub-frequency bands using multi-scale decomposition. The relative wavelet packet energy and three wavelet packet energy ratios for the five frequency segments of the EEG data were calculated for each of the three shooting stages. The five frequency bands were delta (δ: 0-4 Hz), theta (θ: 4-8 Hz), alpha (σ: 8–13 Hz), beta (β: 14–30 Hz), and gamma (γ: 31–40 Hz).

Next, the relative wavelet packet energy parameters for all the leads from each subject were calculated for the three shooting stages. Comparative histograms were drawn for the relative wavelet packet energy of the different shooting stages, and separate brain topographic maps were drawn for the aiming state (aiming state = aiming stage wavelet packet energy-holding stage wavelet packet energy) and shooting state (shooting state = shooting stage wavelet packet energy-holding stage wavelet packet energy).

3. Results

3.1. Wavelet Packet Energy of Novices. Figure 2 shows the brain topographic maps of differences in the wavelet packet energy characteristics between the aiming and holding stages in novices. It can be seen that the wavelet packet energy of the β frequency band F3, Pz, O1, O2, Oz, γ frequency F3, Fz, FC6, P3, Pz, Oz, F3, Fz of α/θ, F3, and Oz of frequency parameter β/α increased significantly in the aiming stage as compared with the holding stage. These results indicate that the novices were in a state of high vigilance and the EEG energy of the β frequency was more concentrated [29], which is in line with the previous work.

Figure 3 shows the brain topographic maps of the differences in wavelet packet energy characteristics between the shooting and aiming stages in novices, which can be compared with the holding stage. During the shooting phase, the wavelet packet energy of EEG in F3, Fz, FC6, Cz, Pz, O1, O2, Oz of β band, F3, F4, Fz, FC5, C4, Cz, P3, Pz, Oz leads in γ frequency band, F3, Cz, Pz, O1, O2 leads in frequency parameter α/θ, and the F3, C3, P3, Pz, O1, O2, Oz leads in β/α increased significantly. The results showed that the main areas that changed in novices during shooting were the frontal area, the central area, and the occipital area, indicating that the novices not only performed the shooting action during the shooting stage, but also maintained visual attention, which was due to visually induced motion perception which relied on visual-vestibular interactions [30].

3.2. Wavelet Packet Energy of Experts. Figure 4 shows the brain topographic maps of the differences in wavelet packet energy characteristics between the aiming stage and holding stages. It can be concluded that the wavelet packet energy of the F3, Fz, C3, Cz, O2, Oz leads in β, F3, Fz, C3, Cz, Oz leads in γ, and the C3, P3, O2, Oz leads in β/α were significantly increased in the aiming stage as compared with the holding

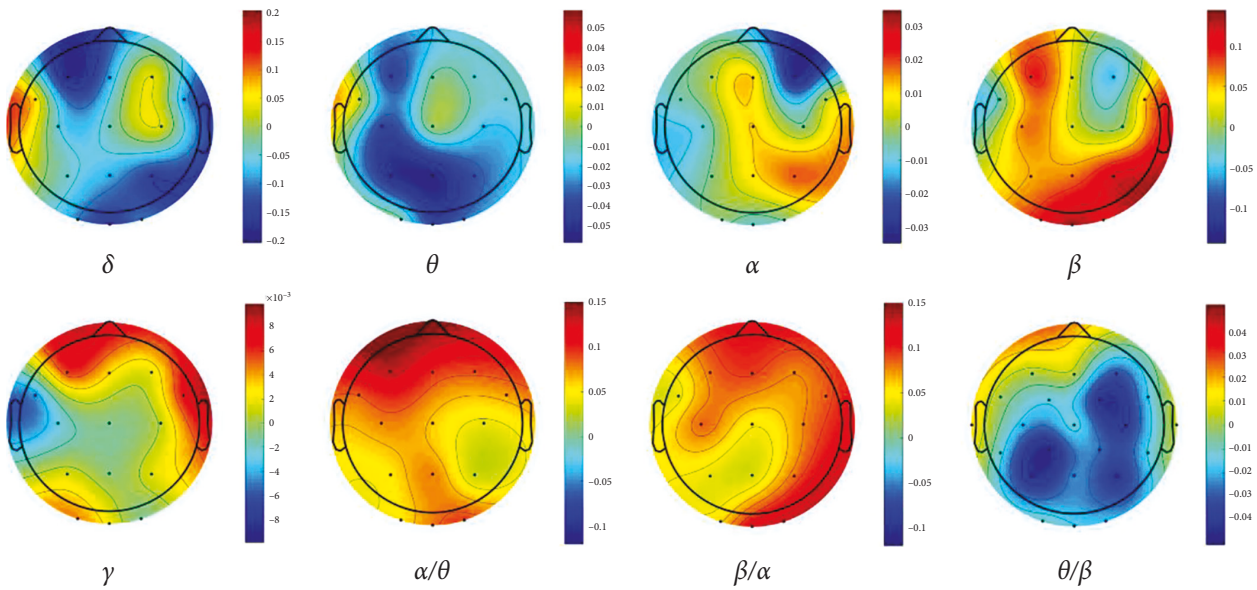

Figure 2: Brain topographic map of wavelet packet energy difference between aiming and holding stage in novices.

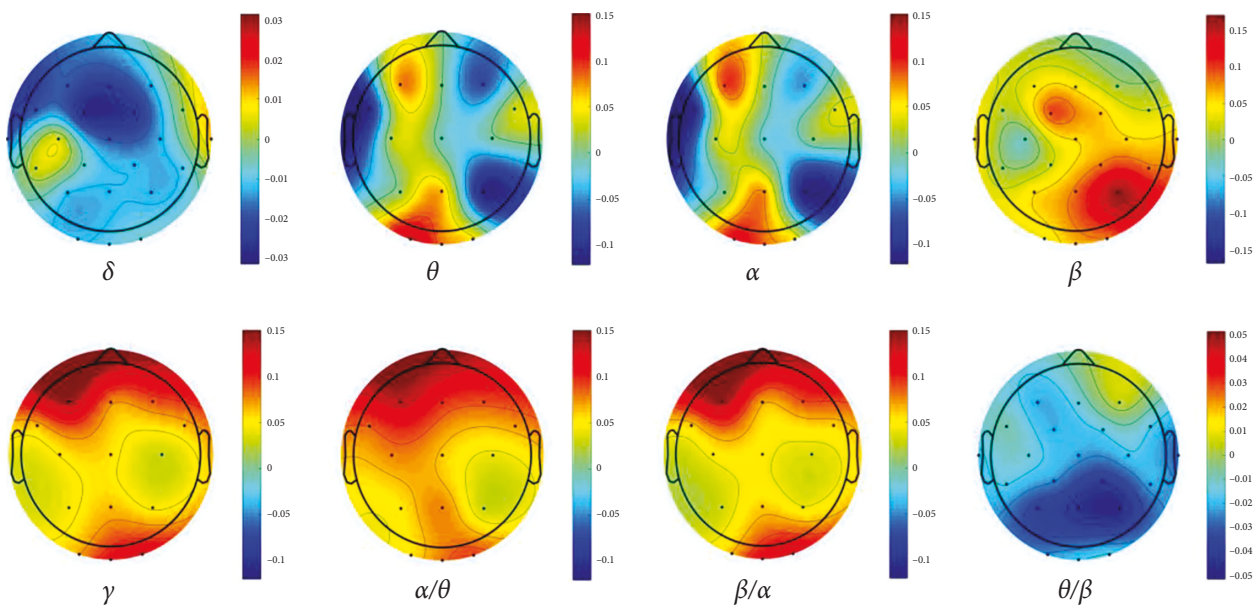

Figure 3: Brain topographic map of wavelet packet energy difference between shooting and aiming stage in novices. $^{*}p < 0.05$

stage. The results show that the frontal, central, and occipital regions were the main areas of change during the aiming state, which is consistent with the conclusion that the central area is related to exercise planning [24].

Figure 5 shows that, in the shooting stage, the wavelet packet energy of almost all the expert leads in β, γ, α/θ, and β/α is higher than that in the holding stage, and significant changes were observed in the frontal, central, parietal, and occipital regions of the experts during the shooting state. These results show that the experts exhibited higher levels of vigilance and attention in the shooting stage than in the aiming stage, which is similar to Haufler's study that showed experts exhibited lower cortical activity during aiming [31]. Compared with Figure 4, the decrease of α rhythms shows that the non-task-related cognitive processes were suppressed shortly before shooting [7], and the gradual decrease of γ rhythm means that the brain is activated, which indicates that γ rhythm is related to attention, arousal, and object recognition [32]. This might be explained by the experts' long-term training which caused specific changes in areas of the experts' brains that were associated with the shooting exercise, i.e., a neuroplasticity effect [9].

3.3. Difference between Novices and Experts. Figure 6 and Figure 7 show the difference of wavelet packet energy characteristics between novices and experts in aiming and shooting stages. Values of F3, C3, P3, O1, Fz, Cz, Pz, O2 in β

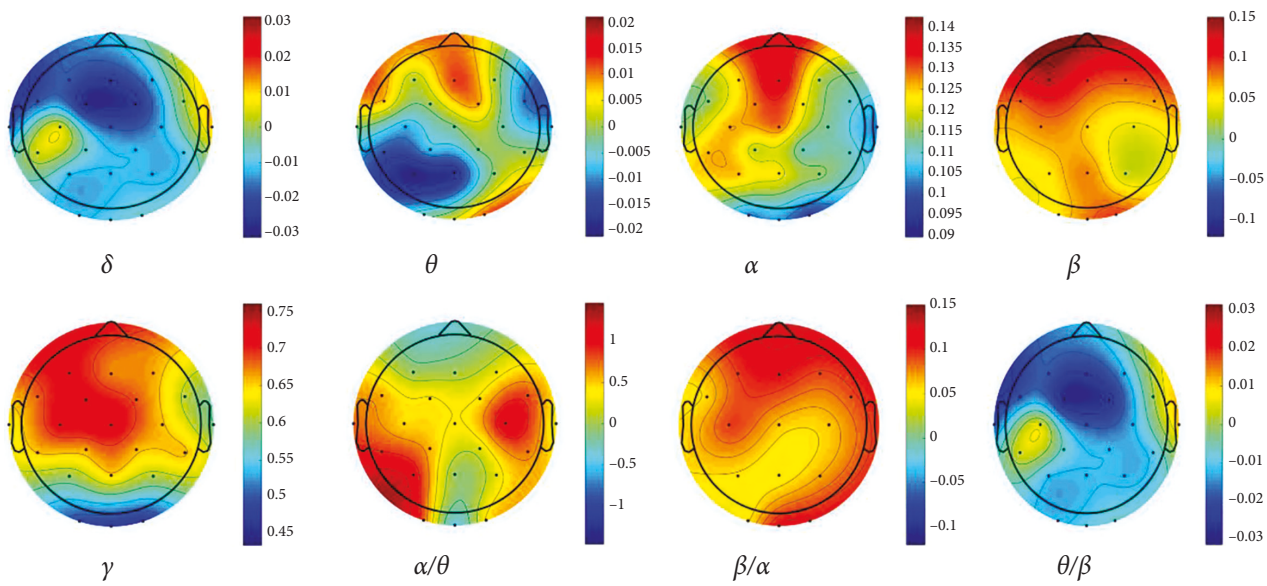

Figure 4: Brain topographic map of wavelet packet energy difference between aiming and holding stage in experts.

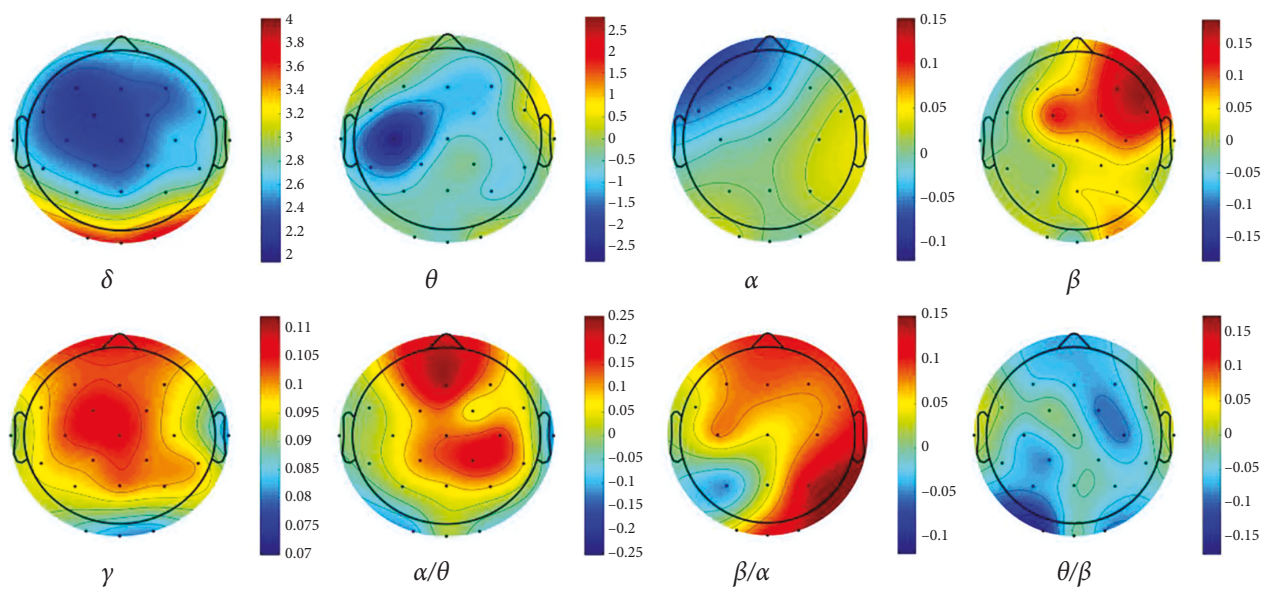

Figure 5: Brain topographic map of wavelet packet energy difference between shooting and aiming stage in experts.

band had group main effect, values of FC5, C3, P3, Pz, Oz, F4, C4, P4, O2 in γ band had group main effect, ratios of FC5, C3, P3, Pz, Oz, F4, C4, P4, O2 in α/θ band had group main effect, and ratios of F3, FC5, C3, P3, Cz, Oz, F4, FC6, C4 in β/α had group main effect.

In the aiming stage, the P4 and Pz of novices in the β and γ bands, and the C3 and C4 of the γ band, were significantly higher than those of the experts, indicating that for the novices the parietal region was precisely the location of the functional brain region during aiming [33].

For the experts, their functional brain region was the central region, which corresponds to the area of action. These results reflect that experts had already planned the shooting action in the aiming stage, and the parietal region was responsive to the main activity area [13], indicating that novices were more attentive during the aiming state. This shows that there was a difference in the brain characteristics of novices and experts during the aiming state.

In Figure 7, the energy levels of the experts in the F4, FC5, P3 leads of the β band, FC5, C3 leads of the γ band, F4 leads of α/θ and F3, Fz, FC5, Cz, P3 leads of β/α were significantly higher during the shooting stage than those of the novices. In other words, the bands on multiple thresholds of shooting for the experts were significantly different from those of the novices, which indicates that the frontal and central regions of the left hemisphere of the brain remained active for experts for a period of time during the shooting stage, which may be the maintenance of the shooting state.

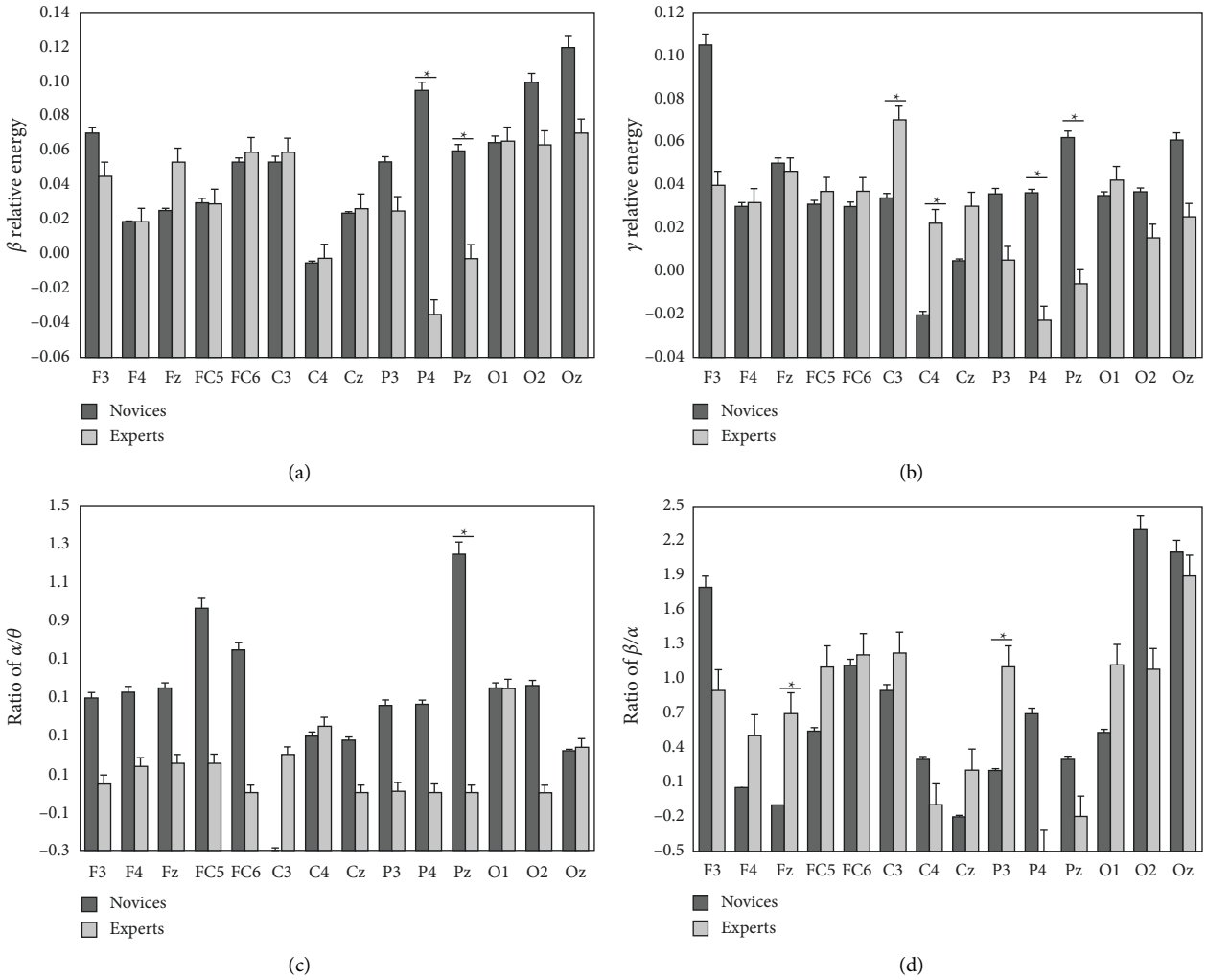

Figure 6: Significant differences of wavelet packet energy between novices and experts in aiming phase. $^{*}p < 0.05$.

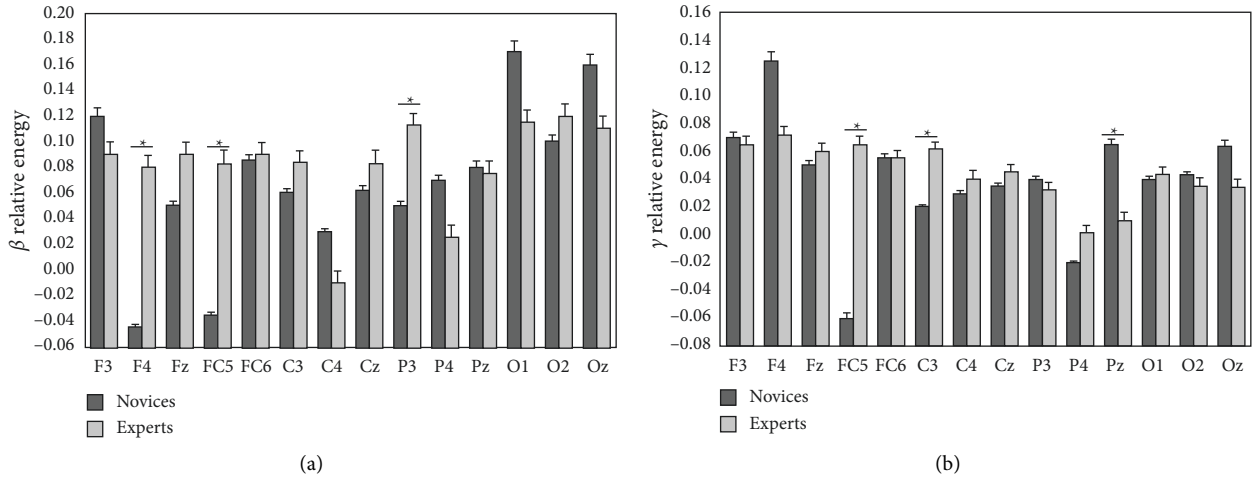

Figure 7: Continued.

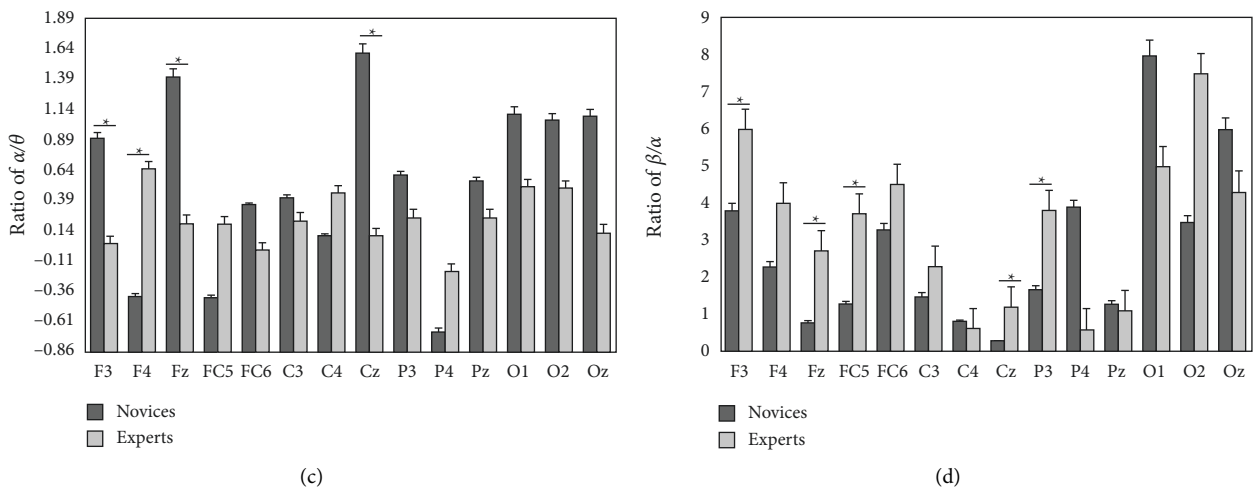

Figure 7: Comparison of wavelet packet energy difference between novices and experts in shooting phase. $^{*}p < 0.05$.

4. Discussion

In this study, an offline wavelet packet energy analysis was conducted using multi-lead EEG data to quantify the energy characteristics of each frequency band for different lead EEG signals in different shooting stages. The differences in wavelet packet energy characteristics of the experts' and novice' EEG signals were analyzed at different frequency bands.

Results showed that, in the aiming state, the frontal and occipital regions changed the most for novices, while the frontal, central, and occipital regions changed the most for experts. The frontal, central, and occipital regions are related to attention and vision, indicating that visual attention was more highly activated in the aiming stage. Furthermore, the main changes in the brain areas occurred in the frontal and occipital regions, which are biased to the left side of the brain [34]. In the shooting stage, the main changes in the novices occurred in the frontal, central, and occipital areas, while the main change in the experts was in the frontal, central, parietal, and occipital areas. This shows that for the shooting stage, regardless of whether the participant is an expert or a novice, progress can be achieved by developing adaptive strategies, suppressing task-independent stimuli, processing environmental stimuli, and refining internally generated clues, making the shotter maintain visual attention. In particular, compared with the gun stage, the experts paid more attention to shooting efficiency if they had paid more attention during the aiming stage, and the EEG power of the parietal and occipital regions of the experts was higher [22].

By comparing the characteristics of the wavelet packet energy of the novices and experts, it was found that the wavelet packet energy of experts was significantly lower than that of novices in the β and γ frequency bands of the aiming state. The γ band was regulated by sensory input, which was related to working memory, learning, and attention [35], which shows that the novice's parietal region needs more resources to integrate different types of sensory information to produce spatial awareness and improve the accuracy of their aim. From the characteristics of the wavelet packet of the aiming state, it was seen that the experts' neural efficiency (a lower consumption of energy represents more effective tissue cortical functions) was higher, indicating that the experts' attention strategy and visual search mode were more efficient [24].

It should be noted that the changes of the θ frequency band of the novices during the aiming and shooting stages were equivalent to those changes that occurred in the experts. In addition, the largest θ change in the experts occurred in the aiming stage, indicating that the lower θ activity in the novices may be the result of a lower degree of automation in their shooting process [31]. Comparing results with the novices in the study by Doppelmayr et al., the conclusion of the θ activity of the frontal region of the experts in both studies was consistent to within about half a second before shooting [7]. θ was obviously distributed in the forehead and central region, which can be used as a neural marker to distinguish the performance state between experts and novices [1].

The above conclusions provide support for the neural or processing efficiency theory. That is, not only were the brain regions of novices and experts activated in relation to the task, but they also inhibited the brain regions that were not related to the task, and different regions were activated during different shooting tasks. Therefore, we can select, train, and supervise personnel at different levels of proficiency and performance according to EEG signals.

A limitation of this study is that we did not take into account the differences in EEG signals between the experts and novices when paying attention to related tasks. By comparing the EEG characteristics that affect the shooting performance of experts and novices, the training stimulation interface can be designed according to their characteristics, such as making special marks on the identified objects, increasing the recognition direction, and so on, which would not only conserve equipment resources, but also improve the progression from novice to expert.

5. Conclusion

Combined with the EEG characteristics of shooter's aiming state and the mechanism of visual spatial selective attention, we studied the changes of EEG signals of shooters in the process of holding gun, aiming, and shooting in real shooting environment. Based on the frequency domain characteristics of EEG signals, the wavelet packet energy analysis method is used to analyze the EEG characteristics of professional shooting and novice shooting. Based on the EEG signals in the holding phase, the differences of brain regions and EEG characteristics of brain activity between experts and novices in the aiming and shooting stages were explored, and the brain regions and locations of the leads were determined. One of the innovations of this study is that we extract and classify the EEG characteristics of operators with different proficiency levels when performing typical tasks that require attention.

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 no conflicts of interest.

Authors' Contributions

Shuyu Shao contributed to original draft preparation. Shike Zhang contributed to editing and supervision. Liwei Zhang contributed to reviewing the manuscript.

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Research Article

Physical Education Resource Information Management System Based on Big Data Artificial Intelligence

Guiyun Liu

College of Physical Education, Jianghan University, Wuhan 430056, Hubei, China

Correspondence should be addressed to Guiyun Liu; yunjuanyunshu@jhun.edu.cn

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With the rapid development of artificial intelligence technology, the combination of physical education and modern technology has become the development trend of today's physical education. Especially in the context of the reform of the education system, the connection between artificial intelligence and physical education is getting closer and closer and it has penetrated into all aspects of physical education. In terms of sports management, the sports management method based on big data artificial intelligence has gradually replaced the traditional manual management method and promoted the development of physical education. Strengthening the information management of physical education teaching and providing high-quality and efficient physical education information for physical education managers and teachers are an important part of the current school physical education teaching work. The establishment of sports resource information big data platform is the key to the integration and sharing of sports resources. This paper discusses the relevant theories of artificial intelligence and studies the current status of the application of sports resources. A physical education resource information management system based on artificial intelligence is constructed. The feasibility of the system is verified by the number of system visitors and the distribution of user populations, and the real-time information, effectiveness, students' learning initiative, and teachers' teaching initiative of this system and the original system are compared and analyzed. The results show that the average score of the real-time information of the original system is 74.28 points, the average score of effective information is 82.29 points, the average score of students' learning initiative is 74.97 points, and the average score of teachers' teaching initiative is 82.98 points. The average score of real-time information in the new system is 92.05 points, the average score of information effectiveness is 93.34 points, the average score of students' learning initiative is 82.69 points, and the average score of teachers' teaching initiative is 90.46 points. The real-time information and information effectiveness scores of the new system are higher than those of the original system, and the scores of students' learning initiative and teachers' teaching initiative are higher than those of the original system.

1. Introduction

As an emerging discipline with broad application prospects, artificial intelligence is an important topic in the current field of computer science and technology. The in-depth application of artificial intelligence technology has become an inevitable choice for the modernization of national governance capabilities, opening a new digital era, and technologies such as big data and cloud computing have emerged. Big data is a collection of massive amounts of data. General software cannot process it in a short time.

Sports is a manifestation of the overall strength of a country. Previously, the Chinese education department has listed physical education as the main teaching content at all stages. With the increasing number of course management and course evaluation, the traditional teaching methods cannot meet the requirements of the new era. In the face of massive sports management data, the requirements for school sports information management are also increasing. Manual management of these complex data is not only labor-intensive, but also prone to errors. This requires the use of scientific and technological means and information technology to standardize and manage these data. In the context of the development of artificial intelligence technology and big data technology, the management system of school sports information is becoming increasingly

intelligent. Artificial intelligence uses information technology to manage, plan, and evaluate courses. It can accurately and quickly allocate teaching tasks reasonably for managers and can automatically give modified results according to changes in tasks. Therefore, it is necessary to combine the multidisciplinary knowledge and methods such as information network technology and educational technology to establish a system suitable for the characteristics of physical education teaching. Digital technology can provide educational big data information for education authorities and provide reference data for future physical education work. Through the information management of school physical education teaching, the administrator can flexibly and accurately control the students' sports situation. At the same time, teachers can also develop a scientific teaching plan for students. It is found that the intelligent management method of school sports information is of great significance. Under the premise of ensuring the maintainability, stability, and compatibility of the system, each functional module is designed for different objects, the management structure of the data structure in the system is described, and its composition is analyzed in detail.

2. Related Work

With the development of social economy and the rapid development of big data and artificial intelligence technology, it has been widely used in all walks of life. Through the systematic retrieval of eight electronic databases, N. Lander learned about the types and number of teachers' training in school physical exercise and basic sports ability, as well as the impact of teacher training on the effect of intervention and evaluated the influencing factors of school sports activities, including sports intervention provided by school teachers, including quantitative evaluation of FMS ability and PA. The results show that teachers can significantly improve students' performance in PA and FMS [1]. Sun et al. studied physical education from the perspective of self-determination theory. They explored the impact of self-determination theory on students' physical education learning from the areas of cognitive, psychomotor, and affective learning. They also illustrated the relationship between students' perceptions of the nature of autonomously supportive or controlled learning environments, needs satisfaction, and autonomous motivation [2]. Liu et al. explored the impact of conceptual physical education courses on the health quality of college freshmen. They conducted an experiment with 50 freshmen at a US university. The experiment found that students' aerobic, upper body, endurance, and abdominal muscles have been significantly improved, and body fat percentage was reduced. Conceptual physical education courses can significantly improve the health quality of freshmen [3]. Escrivaboulley et al., based on the cluster random control experiment, discussed the role of teachers' incentive factors in college students' physical exercise. They studied 15 primary school teachers and 293 students. Teachers in the experimental group participated in four seminars in a school year, while teachers in the control group carried out normal teaching activities. The experiment shows that, during school, the teachers in the experimental group increased the support for students' psychological needs, and the students in the experimental group spent significantly more time on physical activities [4]. Mooses et al. measured physical activity for 1 school year in 504 first-grade (7–9 years) and second-grade (10–12 years) children. This analysis uses the linear mixture method. According to the data, compared with time without physical activity, it has been confirmed that physical education can significantly increase physical activity and reduce sedentary time [5]. Sato and Haegele described the practical experience of mentoring severely disabled students in physical education. Using a descriptive qualitative approach, the research is conducted on real case studies and explained through the lens of occupational socialization theory. They studied three themes: the role of teachers in guiding physical education for analysis of vocational skill needs of disabled college students, and the resistance encountered in reality [6]. Silverman studied the attitudes of teachers and students in physical education. He used regression models in attitude research for analysis and discussed parameters and measurement issues in attitude research. He graded the attitudes of teachers and students and evaluated the impact of attitudes on sports performance [7].

3. Artificial Intelligence and Physical Education

3.1. Artificial Intelligence. Artificial intelligence is a combination of artificial science that integrates acting, development, simulation, and expansion of human beings. It has been used in machine and software development for a long time. It is moving in the direction of strong artificial intelligence and super artificial intelligence. The so-called strong AI is a human-like artificial intelligence that can think, plan, and solve problems. And it can understand complex concepts and learn quickly. Super artificial intelligence has far more intelligence than humans. Some scholars believe that super artificial intelligence will be the ultimate invention of human beings. From now on, all inventions will be done by it [8]. Artificial intelligence technology originated at the Dartmouth Conference in 1956. At the conference, scholars discussed a series of related issues in simulating intelligence with machines, marking the birth of the concept of artificial intelligence [9]. Academia has conducted in-depth research on knowledge representation, reasoning, and other issues. Artificial intelligence technology is very popular, covering fields such as education, physiology, medicine, logic, automation, and cybernetics. Its research scope includes information identification, acquisition and processing, search engine optimization, intelligent robots, and automatic learning and reasoning.

Google's R&D personnel successfully developed the first self-driving car in October 2010 and successfully tested it on the streets of California [10]. The application of intelligent driverless vehicles in the market has become more and more extensive. Tencent obtained the test license for ICVs in May 2018 [11], marking the cross-industry development of artificial intelligence technology to a mature stage. The artificial intelligence Go master (AlphaGo) defeated the Chinese

Go player with a score of 3:0 in May 2017 and won the high praise of the world for artificial intelligence technology [12]. Artificial intelligence technology is being combined with technologies in multiple industries, and its development prospects are worthy of in-depth exploration.

3.1.1. ANN. ANN is not only a calculation model, but also a data model. It mainly uses the biological neural network construction principle and function [13] and uses this topology to study the relationship between nodes or objects. The schematic diagram is shown in Figure 1. The idea of artificial neural network comes from the functional operation of biological neural network. It is an adaptive system that is not affected by external data information. Each node represents an excitation function, and the links between nodes are represented by weights. This weight can be understood as the memory of the neural network [14].

3.1.2. RBF Neural Network Algorithm. RBF neural network is a feedforward neural network with good performance [15]. Interpolation is an important part of function approximation. Its characteristic is to obtain an unknown continuous function under the constraint of discrete point set M. The function is defined on a continuous set S $(M \subseteq S)$ to obtain the overall regularity. The interpolation problem can be defined as follows.

Given datasets X and Y, where X is a set with N data points, and the dimension n of each data point in X, that is, $\{X_i \in R^n \mathrm{I}, i = 1, 2, ..., N\}$, Y is a set $\{Y_i \in R^m \mathrm{I}, i = 1, 2, ..., N\}$ with N m-dimensional data points. Find a function F: $R^n \longrightarrow R^m$ that satisfies the following condition:

$$F(X_i) = Y_i, \quad (i = 1, 2, ..., N). \tag{1}$$

Strict interpolation requires that all known data points lie on the constructed interpolation surface (i.e., function F). In the final analysis, RBF neural network technology is to construct such a function F. The function has the following form:

$$F(X) = \sum_{i=1}^{N} w_i \phi(\|X - X_i\|). \tag{2}$$

Here, $\{\varphi(X - X_i)\}$ is the set of N RBFs, and $\|\cdot\|$ represents the Euclidean norm. Take the known data point $X_i \in R^n$ defined as the center of the RBF, $i = 1, 2, ..., N$.

Bringing the interpolation conditions of formula (1) into formula (2), a set of linear formulas about N unknown weight coefficient vectors w_i can be obtained:

$$\begin{bmatrix} \phi_{11} & \phi_{12} & \cdots & \phi_{1N} \\ \phi_{21} & \phi_{22} & \cdots & \phi_{2N} \\ \cdots & \cdots & \cdots & \cdots \\ \phi_{N1} & \phi_{N2} & \cdots & \phi_{NN} \end{bmatrix} \begin{bmatrix} w_1^T \\ w_2^T \\ \cdots \\ w_N^T \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ \cdots \\ Y_N \end{bmatrix}. \tag{3}$$

Here, $\varphi_{ji} = \varphi(X_j - X_i)$, and $w_i = [w_{i1}, w_{i2}, ..., w_{im}]^T$, where $i, j = 1, 2, ..., N$

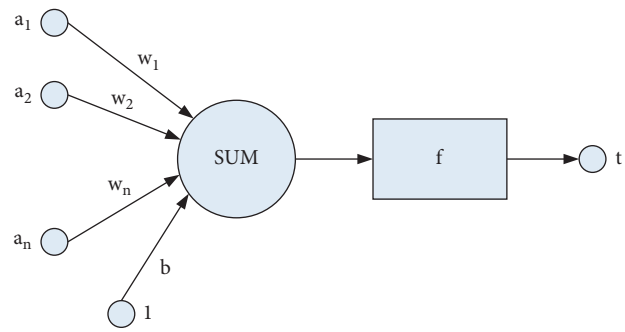

Figure 1: Schematic diagram of the artificial neural network.

Let $\Phi = \{\varphi_{ji}\mathrm{I}\ (j, i) = 1, 2, ..., N\}$. W denotes an $N \times m$ connection weight matrix. Y represents the desired output matrix. Φ with dimension $N \times m$ represents an $N \times N$ interpolation matrix. Formula (3) can be written in compact form:

$$\Phi W = Y. \tag{4}$$

Commonly used basis functions are as follows:

$$\begin{aligned} \phi(x) &= \exp\left(-\frac{x^2}{2\sigma^2}\right), \quad (\sigma > 0, x \in R), \\ \phi(x) &= \left(c^2 + x^2\right)^{1/2}, \quad (c > 0, x \in R), \\ \phi(x) &= \frac{1}{\left(c^2 + x^2\right)^{1/2}}, \quad (c > 0, x \in R). \end{aligned} \tag{5}$$

These functions are all radially symmetric. One of the most widely used is the Gaussian function, which has the form:

$$\phi_i(x) = \exp\left(-\frac{\|x - c_i\|^2}{2\sigma_i^2}\right), \quad (i = 1, 2, \ldots, m). \tag{6}$$

Among them, i determines the width of the center of the RBF; $x - c_i$ represents the distance between x and c_i and i.

Unlike strict interpolation problems, RBF is used when designing neural network structures. If a basis function is introduced for each sample point so that the number of neurons is equal to the number of input samples, the network structure will be too large, resulting in overfitting or network paralysis [16].

Continue to make adjustments through network training until you get really close to the data sample. This improved network input-output mapping model is expressed as

$$F(X) = \sum_{i=1}^{h} w_i \phi(\|X - C_i\|). \tag{7}$$

Here, $C_i \in R^n$ is the base function center; h represents the number of hidden layer units. On this basis, this paper gives the topology of RBF network, as shown in Figure 2.

The gradient training method is selected to learn the RBF neural network. This is a supervised learning algorithm that minimizes the objective function that the network learns.

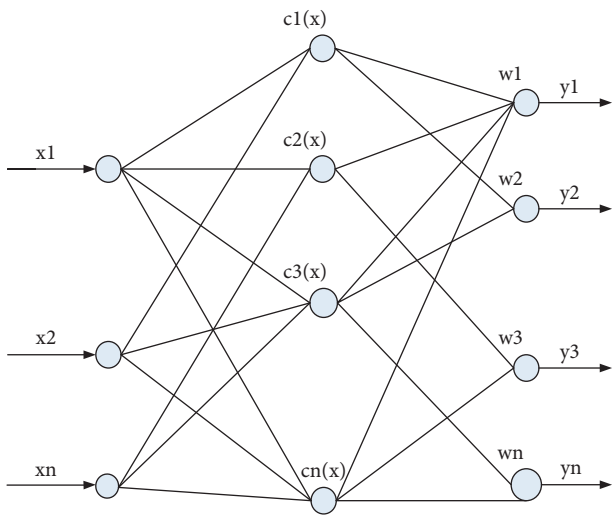

Figure 2: Topological structure of RBF neural network.

The iterative method is used to adjust the basis function center, the number of hidden layers and output layers in RBF neural network. Assuming that the one-dimensional network is the first output, the training gradient can be described in detail.

The objective function of neural network learning is

$$E = \frac{1}{2}\sum_{i=1}^{N}\beta_i e_i^2. \tag{8}$$

Here, β_i is the forgetting factor. This method is a training method with forgetting factor. The error function e_i is defined as

$$\begin{aligned} e_i &= y_i - F(x_i) \\ &= y_i - \sum_{j=1}^{h} w_j \Phi_j(x_i). \end{aligned} \tag{9}$$

The partial derivatives of the error function to the RBF center c_i, width σ_i, and output weight w_i are

$$\begin{aligned} \frac{\partial E}{\partial c_j} &= -\sum_{i=1}^{N}\beta_i e_i w_j \frac{\partial \phi_j}{\partial c_j}, \\ \frac{\partial E}{\partial \sigma_j} &= -\sum_{i=1}^{N}\beta_i e_i w_j \frac{\partial \phi_j}{\partial \sigma_j}, \\ \frac{\partial E}{\partial w_j} &= -\sum_{i=1}^{N}\beta_i e_i \phi_j. \end{aligned} \tag{10}$$

The partial derivatives of RBF with respect to center c_i, width σ_i, and output weight w_i are, respectively,

$$\begin{aligned} \frac{\partial \phi_j}{\partial c_j} &= 2\phi_j(x_i)\frac{\left\|x_i - c_j\right\|}{\sigma_j^2}, \\ \frac{\partial \phi_j}{\partial \sigma_j} &= 2\phi_j(x_i)\frac{\left\|x_i - c_j\right\|^2}{\sigma_j^3}, \\ \frac{\partial \phi_j}{\partial w_j} &= \phi_j(x_i). \end{aligned} \tag{11}$$

Then, the update formula of the hidden layer center c_i, width σ_i, and output weight w_i of the RBF neural network is

$$\begin{aligned} \sigma_j(k+1) &= \sigma_j(k) + \Delta\sigma_j = \sigma_j(k) + \eta_2\frac{\partial E}{\partial \sigma_j} \\ &= \sigma_j(k) - \eta_2\sum_{i=1}^{N}\beta_i e_i \phi_j, c_j(k+1) \\ &= c_j(k) + \Delta c_j = c_j(k) + \eta_1\frac{\partial E}{\partial c_j} \\ &= c_j(k) - \eta_1\sum_{i=1}^{N}\beta_i e_i w_j \frac{\partial \phi_j}{\partial \sigma_j}, w_j(k+1) \\ &= w_j(k) + \Delta w_j = w_j(k) + \eta_3\frac{\partial E}{\partial w_j} \\ &= w_j(k) - \eta_3\sum_{i=1}^{N}\beta_i e_i w_j \frac{\partial \phi_j}{\partial c_j}. \end{aligned} \tag{12}$$

Here, η_1, η_2, η_3 are the learning rates, which generally take different values.

According to the above formula, the network parameters are continuously cyclically corrected, and the final network performance will reach the required performance index. Compared with feedforward neural networks such as perceptrons and BP neural networks, the topology of RBF neural networks uses radially symmetric kernel functions. In particular, the Gaussian function greatly accelerates the efficiency of e-learning, avoids the problem of local minima, and has the ability to approximate the global optimum [17].

3.2. Physical Education Teaching. "Artificial intelligence + - physical education" is a new teaching mode that transforms teaching resource structure and feedback evaluation mechanism into intelligent teaching. Through artificial intelligence technology, the resources and information connection between teachers and students can be realized, so as to form a new teaching system of "artificial intelligence + physical education" with multiple levels, wide fields, and multiple elements. The current domestic sports courses in China are mainly guided by digital teaching methods and focus on the diversification and reoptimization of information [18]. Therefore, artificial intelligence is a highly intelligent novel and advanced teaching system constructed by many artificial intelligence devices and information processing centers. Physical education resource information management is the main part of sports management. The normative and scientific nature of its management will affect the teaching effect. In practical application, it is divided into three distinct levels: teaching resource management, teaching operation management, and teaching quality and evaluation management. The coordinated operation of all levels together constitutes the "artificial intelligence + - physical education" ecosystem. If you want the intelligent development of physical education, we must comply with

the national sports policy and development trend and combine with modern science and technology [19]. The overall design that follows a top-down approach to form an overall operation mechanism model of "artificial intelligence + physical education" was constructed, as shown in Figure 3.

The overall design follows a top-down approach to form an overall operation mechanism model of "artificial intelligence + sports," as shown in Figure 3.

Each course and exercise will provide a lot of information. These materials can not only be used as a reference index for the final results of the physical education class but also provide training guidance for the next physical education class. However, in practice, we ignore data collection and analysis. Physical education teachers only rely on past experience to teach, adjust the teaching content, and lack the collection and analysis of data [20]. After scientific analysis and intelligent processing, managers can effectively understand the academic progress of teachers and students and better formulate overall plans, and teachers can find educational methods that are more beneficial to schools. The big data analysis of classroom teaching can evaluate the quality of the curriculum and reflect the educational goals and tasks of the school. The analysis of heart rate, steps, blood pressure, and other data can become indicators of sports health supervision. The data mining of teaching evaluation can help to adjust the teacher's curriculum and teaching content. Using big data for intelligent management and scientific analysis can become an important index to measure the quality of physical education in campus. This kind of powerful data analysis needs to be linked with the smart information management system for feedback and needs to be continuously optimized and rectified. By constantly using new technologies to support smart platforms, big data analysis information can be more accurately managed and scientifically classified, combining with large numbers to separate the management of physical education teaching mode and management of physical education and the transformation of teachers' functions and effectively reflect the physical needs and actual conditions of the vast majority of students.

This paper constructs the sports information management system into a three-tier structure. They are presentation layer, functional layer, and application layer. They ensure that system users can practically apply the system, ensure that users can rely on the campus network, and ensure that users can conduct real-time anticounterfeiting of the system through the Internet to enhance the use value of the system, as shown in Figure 4.

In the system architecture, it is necessary to ensure that users can click through the different functions of the system through a web browser. Afterwards, based on the response of ASP.NET and the application server, the user's needs can be assigned to different system function modules to ensure that the system can feed the user's demand results back to the user.

The traditional teaching management method is mainly based on filling in forms. Whether it is manual declaration or electronic entry, there are certain defects. Its characteristics are that it needs to fill in and manage a lot of data, the data redundancy is large, the data query is time-consuming, and the data is inconvenient to use. The comprehensive evaluation of the data requires a lot of data collection, classification, calculation, etc., which cannot be fully utilized. The integrated functions such as data statistics and analysis can only realize the completion of a single work task and simple backup. Comprehensive and flexible sports information big data has realized the informatization of educational resources and greatly improves the development environment. The flexible object model and the functions of the classes and subclasses used constitute a new software development program. Its biggest feature is that it can perform remote control in the local database and connect the remote data with the local database.

4. Operation Process of the Physical Education Information Management System

The database management system is mainly divided into teacher end and student end, and each end has its own access and modification authority. The physical education comprehensive information management system is mainly the management model of these two levels. In this way, management and query can be separated, which is convenient for system design and maintenance and more conducive to protecting the security of data. The teacher-side model has functions such as grade entry and grade evaluation. It can manage students' physical education results and physical health test results and enter various types of information through the form mode. The internal form structure is used to store data, and the model is shown in Figure 5.

The student-side model has functions such as score query, score evaluation query, and teacher evaluation, as shown in Figure 6. Through inquiries, students can know their physical education class results and physical health test results, can inquire about the evaluation results, and can understand the current state of their own physical fitness, so as to take targeted methods to improve their physical fitness, make it meet the requirements of college sports standards as soon as possible, and establish a certain communication mechanism with teachers.

The database is composed of data access component and SQL server to build sports information management system. In practice, the database can be accessed directly through MTS, and the corresponding data can be processed with ADO.Net, or the data interface can be used to access and control the database management system SQL Server. In this system design, its main database table design contents include administrator information table, teacher data sheet, and teaching and student data sheet. Table 1 is the administrator information table in the system.

Table 2 is the teacher information table in the system. This table holds basic information for all PE teachers. The teacher and the job number are uniquely corresponding, so the teacher's job number is used as the system login account and initial password. Teachers have the right to query and modify personal information, and students only have the right to query the teacher's public information. Physical

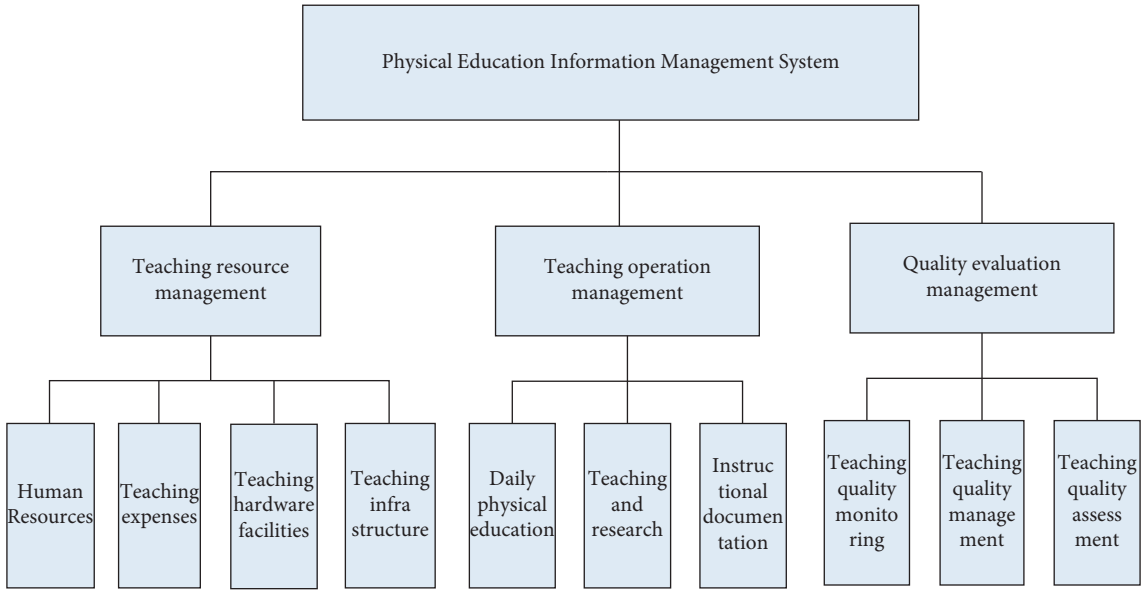

Figure 3: Overall structure diagram of the physical education information management system.

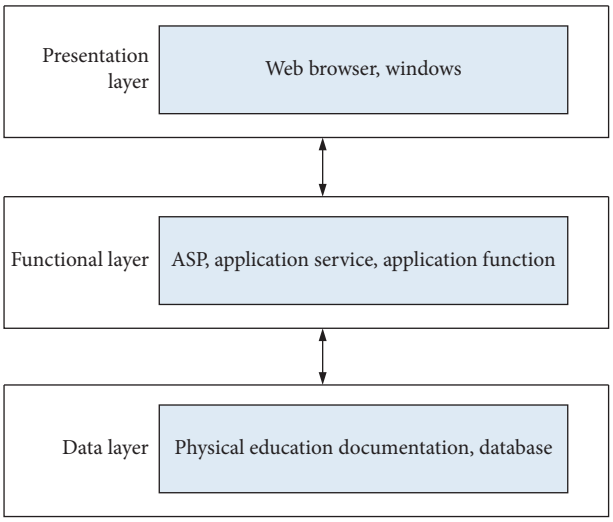

Figure 4: Architecture diagram of the physical education information management design.

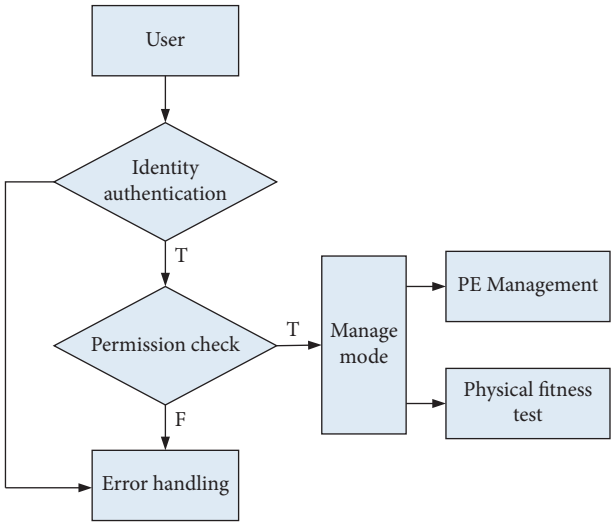

Figure 5: Teacher-side model of the physical education information management design.

education administrators can add, delete, query, and modify information on students and teachers.

At the same time, in the system database, there is also a table of teaching resources, as shown in Table 3. It is mainly used to store various teaching resources. It can store not only "pictures, audios, documents," but also the physical education resources uploaded by teachers. At the same time, it can automatically record this information in the database of the system to fill the loophole of students' download demand and query and browse these files according to their learning.

The student information table is shown in Table 4, which stores basic information such as student ID and name. The physical education administrator logs into the physical education management system, imports student information according to the format requirements, and forms a student information table. Student and student numbers are unique. Therefore, the student ID is used as the account and initial password to log in to the system. Students have the right to inquire and modify personal information. Teachers have the right to query the information of students in their own classes. The physical education administrator has the authority to add, delete, query, and modify the information of teachers and students.

5. Experimental Verification of Physical Education Information Management

Based on big data artificial intelligence, this paper makes a systematic research on sports information management system. At the same time, it also proves whether the system can provide convenience for students. This study takes the Physical Education Department of the middle school

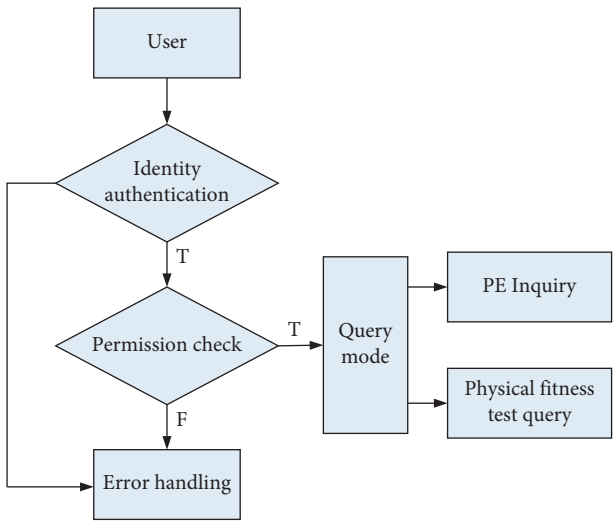

Figure 6: Student-side model of the physical education information management design.

Table 1: Master administrator table in the designed system.

	Column	Type	Length
Username	MasterID	varchar	20
Password	MPwd	varchar	20
Permission flag	PowerFlag	char	4
Name	MName	varchar	50
Department	MDept	varchar	50
Telephone	Mphone	varchar	30

Table 2: Teacher user table in the designed system.

	Column	Type	Length
Teacher	TeacherID	varchar	20
Password	TPwd	varchar	20
Name	TName	varchar	50
Telephone	Tphone	varchar	30

affiliated to Jiangxi Normal University as the research object and processes the data based on SQL Server database.

Then, through the statistics and analysis of the developed teaching resources, this paper makes a preliminary discussion on the system. By comparing the system visits and user population distribution of the new system and the original system in one day, the comprehensive effectiveness of the new system to complete physical education teaching design resource information management system is evaluated. The specific comparison results are shown in Figures 7 and 8. Figure 7 shows the visits of the old and new systems at different time periods in one day. Figure 8 shows the distribution of user populations in the old and new systems.

As can be seen from Figure 7, the total number of visits of the original system in one day is 36747 times. Among them, 14:00–16:00 has the largest number of visits, 10,248 times, followed by 10:00–12:00, with 9,600 visits. The two time periods of 8:00–10:00 and 16:00–18:00 have relatively few visits, 8225 times and 8674 times, respectively. The total number of visits to the new system in one day was 39,816.

Table 3: Resource of teaching in the designed system.

	Column	Type	Length
Introduction	Remark	varchar	100
Resource name	ResName	varchar	30
Storage address	Resaddr	varchar	150
Resource number	ResID	varchar	30

Table 4: Student user table in the designed system.

	Column	Type	Length
Password	SPwd	varchar	20
Class number	SClassID	varchar	30
Dormitory number	SHouseID	varchar	30
Name	SName	varchar	50
Student number	Student ID	varchar	20
Telephone	Sphone	varchar	30

Among them, 14:00–16:00 has the largest number of visits, 10,846 times, followed by 10:00–12:00, with 10,420 visits. The two time periods of 8:00–10:00 and 16:00–18:00 have relatively few visits, 9072 and 9478, respectively. The number of visits to the new system in a day is higher than the number of visits to the old system.

As shown in Figure 8, the main user groups of the original system are students and managers, accounting for 42.86% and 34.03%, respectively. The proportion of teachers is 21.91%, and the proportion of sports practitioners who have graduated is the least, which is 1.2%. The main users of the new system are managers, reaching 39.2%. Then, the students and teachers accounted for 32.29% and 23.67%, respectively. Graduated sports practitioners accounted for 4.84%. The proportion of managers and graduate sports practitioners in the new system is higher than that in the original system. Through the research, it is found that the practicability of this system is very high. Then, these two teaching management systems are used to compare the real-time information, effectiveness, students' learning initiative, and teachers' teaching initiative. Figure 9 shows the real-time information and information effectiveness scores of the old and new systems. Figure 10 shows the scores of students' learning initiative and teachers' teaching initiative in the old and new systems.

As can be seen from Figure 9, the average score of real-time information of the original system is 74.28. Among them, the highest score is 78.4 points, and the lowest score is 70.1 points; the average score of the new system's real-time information is 92.05 points. The highest score is 94.6 points and the lowest score is 89.2 points. The average score of the information validity of the original system is 82.29 points. Among them, the highest score is 84.7 points, and the lowest score is 80.4 points; the average score of information effectiveness of the new system is 93.34 points. The highest score is 96.2 points and the lowest score is 90.7 points. The real-time information and information effectiveness scores of the new system are better.

By analyzing Figure 10, the average score of students' learning initiative in the original system is 74.97. Among them, the highest score is 77.5 points, and the lowest score is

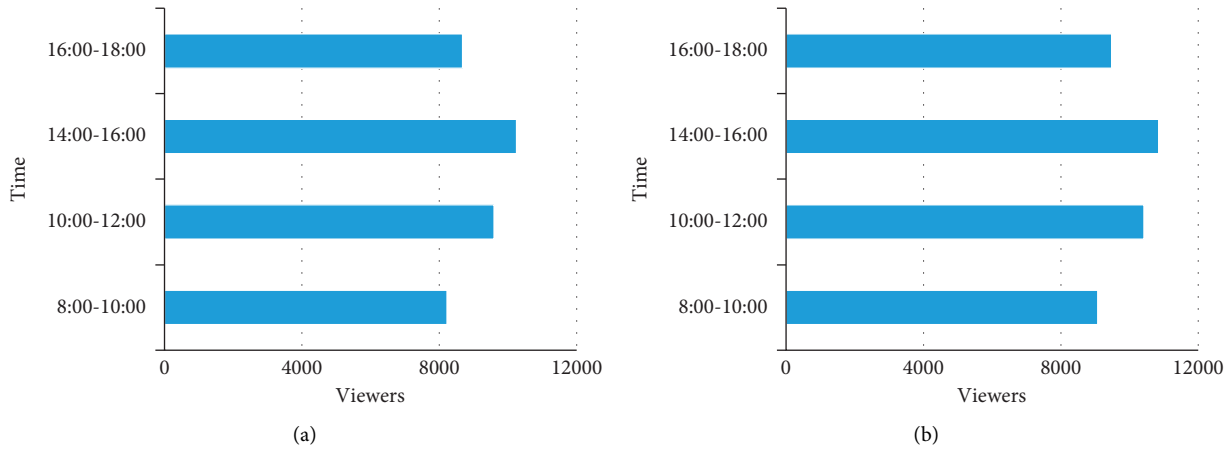

Figure 7: Comparison of the number of visitors to the two systems. (a) The number of visits of the original system in different time periods in a day. (b) The number of visits to the new system at different time periods in a day.

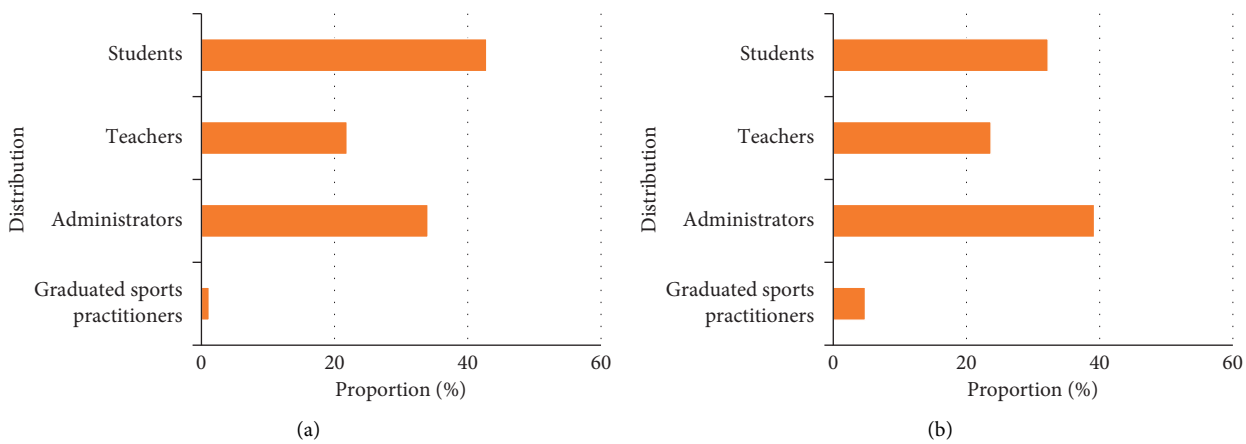

Figure 8: Distribution graph of the user population of the two systems. (a) The user population distribution map of the original system. (b) The user population distribution of the new system.

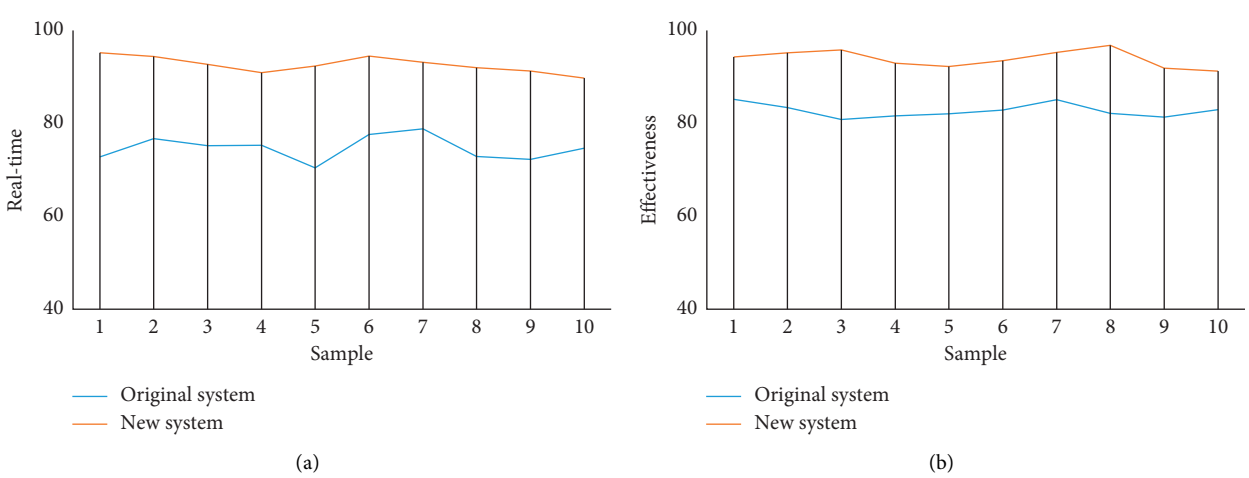

Figure 9: Real-time information and information effectiveness scores of the two systems. (a) The real-time information scores of the original system and the new system. (b) The information effectiveness scores of the original system and the new system.

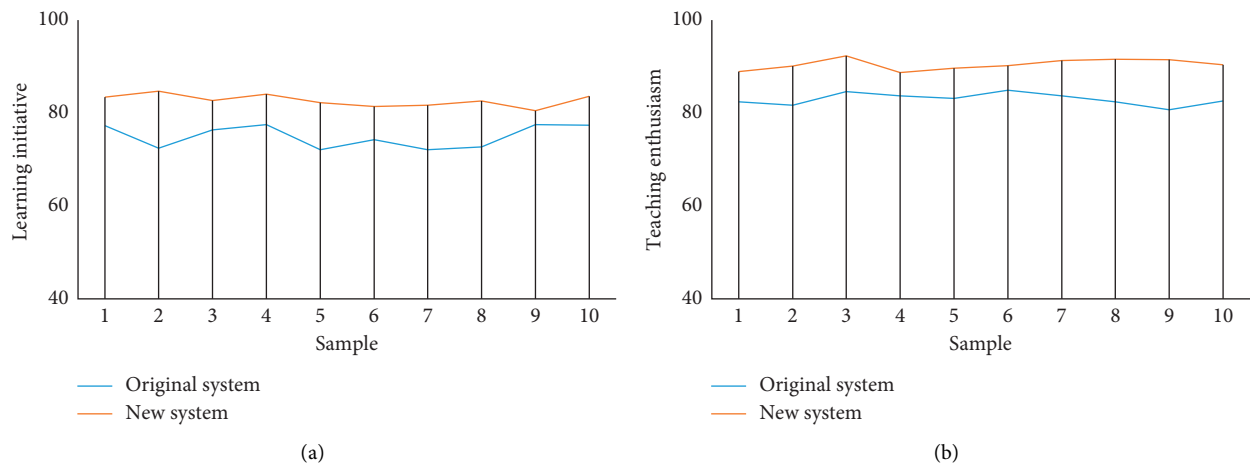

Figure 10: Initiation scores of teachers and students of the original system and the new system. (a) The students' learning initiative scores in the original system and the new system. (b) The teacher's teaching initiative scores in the original system and the new system.

72.1 points; the average score of students' learning initiative in the new system is 82.69 points. The highest score is 84.7 points and the lowest score is 80.5 points. The average score of teachers' teaching initiative in the original system is 82.98 points. Among them, the highest score is 84.9 points, and the lowest score is 80.7 points; the average score of teachers' teaching initiative in the new system is 90.46 points. The highest score was 91.6 points and the lowest score was 88.7 points. Under the new system, students' learning enthusiasm and teachers' enthusiasm are higher than those of the old system.

6. Conclusion

As the development of artificial intelligence has a more and more profound impact on physical education activities, physical education teachers and managers should actively adapt to the trend of informatization and intelligence in physical education teaching and actively introduce artificial intelligence technology. Only in this way can we further strengthen the contents and methods of sports activities and cultivate students' enthusiasm to participate in sports. Using the artificial intelligence technology of big data, the information management of physical education teaching resources is realized, in addition to grades and physical fitness test results. It enables students to easily check their physical education selection, grades, and physical fitness indicators. It achieves convenient management and achieves the function of simple and rapid query, which reduces data redundancy and repeated manual operations in data management. The workload of physical education teachers is greatly reduced, and students can understand and master personal data and information at any time. The development of a comprehensive management system for physical education resources information provides strong support for the scientific, standardized, and computerized implementation of physical education management. On the basis of the design and implementation of the system platform, the relevant functional design can be further improved according to the school physical education curriculum setting and physical education research. It also discusses the effective connection with the school's comprehensive teaching management platform, and the integrated development with other management databases. In this way, the important position of physical education teaching in personnel training is more prominent. This paper studies and analyzes the physical education resource information management system completely. However, the system still has defects in function and data analysis, and there are still many needs to be optimized in practical operation.

Data Availability

The data that support the findings of this study are available from the author upon reasonable request.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Construction of Mathematical Model of Enterprise Marketing Economic Analysis Based on Neutral Analytic Hierarchy Process

Xin Zhang[1] **and Haoyu Zhang**[2]

[1]*School of Economics, Guizhou University of Finance and Economics, Guiyang 550025, Guizhou, China*
[2]*Chongqing Transmission Shaft CO., LTD., Chongqing 402560, China*

Correspondence should be addressed to Xin Zhang; xinzhang@mail.gufe.edu.cn

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With the gradual opening of the market, the overall development of Chinese enterprises is "rapid development, gradual improvement of industry status, and promising prospects." Not only the development of Chinese local enterprises is getting better and better, but also a large number of foreign-funded enterprises are pouring into the domestic market, and the competition pressure on domestic enterprises is increasing. The purpose of this study is to study the effect of neutral AHP on the establishment of the mathematical model of enterprise marketing economic analysis and to use the method of structural judgment matrix and hierarchical structural model to put forward a concrete practical analysis of enterprise marketing cost and business performance. The experimental results of this study show that the establishment of an enterprise marketing economic mathematical model based on AHP can help group companies maintain an annual revenue growth rate of more than 5.8%, while the annual revenue economic growth rate is less than 5% for companies that establish a mathematical model.

1. Introduction

Enterprise management is an important activity to promote the development of the socialist market economy. It plays a very important role in improving people's quality of life, safeguarding national security, and promoting social and economic development and progress. It is an important part of the market economy. At this stage, our country's major small and medium-sized enterprises are showing a development trend of "fast development, steady growth, and good prospects." However, the rapid development of large and medium-sized enterprises is also accompanied by problems such as a large number of enterprises, small scale, lack of concentration, strong innovation ability, market chaos, and low profits. The main reason is that the enterprise marketing model is outdated and relies on an extensive imitation and development model, which leads to the occurrence of market chaos and commercial bribery in the industry. On the other hand, more and more large foreign enterprises have entered the Chinese market, the competitiveness of local enterprises is insufficient, and the competitive pressure on Chinese enterprises is gradually increasing. The transition of the economy from a stage of high-speed growth to a stage of high-quality development is a distinctive feature of socialism with Chinese characteristics entering a new era, and it is also a historic change ushered in by China's economic development. In order to regulate the market behavior of Chinese enterprises and effectively improve industrial problems, the Chinese government has issued the latest market economic system reform policy. The implementation of the new market economy system reform policy will promote the optimization and upgrading of Chinese enterprises, and the reform from organizational structure to business strategy will be fully implemented.

The main content of the new economic system is as follows: on the basis of centralized leadership and departmental management, we expand the autonomy of enterprises in operation and production, adopt the method of combining economics and administration to manage the economy, and gradually transition to economic

management, economic strengthening of the role of economic leverage, and material stimulus.

With the reform of China's market economy system, more and more enterprises use AHP to study the economic development of enterprises. At present, the overall situation of China's economic development is good. The economic growth has changed from policy stimulus to independent growth in an orderly manner and continues to develop in the expected direction of macrocontrol. The AHP emerged as a system analysis method in the 1970s. This method is mainly suitable for analyzing complex systems, especially those that are difficult to describe. At present, the domestic enterprises' research on the establishment of the mathematical model of enterprise marketing economic analysis is not perfect. This thesis is mainly based on the research on Chinese enterprises, using AHP to establish a systematic and scientific mathematical model of business marketing economics to help Chinese enterprises improve the competitiveness of their production and operation activities.

With the continuous development of society, more and more people have studied the mathematical model of constructing business marketing economic analysis. Among them, most choose to use AHP to study such large-scale mathematical models. Felber et al. developed a self-administered questionnaire using the analytic hierarchy process (AHP) in a medical study. Data collection was carried out in group discussions using a paper questionnaire supported by an item response system. To evaluate patient-related outcomes, an eigenvector approach was applied [1]. In one experiment, Al Qubaisi et al. established a standard weight and developed a method commonly referred to as school inspection by comparing the output of the school inspection with the model output in a sample of schools by using an AHP-based framework in the experiment, school performance system. [2]. In the practical application of the neutrosophic analytic hierarchy process, Neumaier S takes full advantage of the neutrosophic analytic hierarchy process (AHP) to promote the integration of various data quality dimensions and end-user preferences and develops an open data portal quality (ODPQ) framework, enabling end users to easily and realistically evaluate/rank open data portals [3]. In terms of disaster prevention, Wang et al. developed a new evaluation model based on fractal theory and improved the analytic hierarchy process (IAHP) to predict the possibility of water inrush, thus greatly reducing the damage of sudden water inrush to enterprises and work and causing serious injury to personnel [4], of course, not only in disasters but also in the application of grading methods in urban construction. The Ahmed et al. study proposes an objective-based AHP process in which pairwise comparison values are assigned based on field data collected from the Mumbai road network, which consists of 28 road segments. The final ranking table of candidate road segments takes into account the priority weights of candidate road segments and reflects road conditions. This research method largely solves the problem of inaccurate subjectivity of urban road maintenance prioritization [5]. Of course, the accuracy and advancement of the method in the actual process provide an important guarantee for our practice, but a correct and advanced mathematical model is also more conducive to the success of our practice. Zagzoule and Marc-Vergnes established a mathematical model of the cerebral circulation and applied this model to simulate the network of the entire cerebrovascular system, including the carotid and vertebral arteries to the sinuses and jugular veins. This model is also used to study autoregulation during arterial hypotension, so as to obtain the close relationship between cerebral blood flow and capillary pressure [6]. Not only that, in enterprise production, in order to effectively and accurately control the influence of tipping paper, and tipping paper and cigarette paper parameters on cigarette tar rate, Yin et al. established a mathematical prediction model of projection tracking regression (PPR). It is compared with a traditional multiparameter regression model. Finally, practical comparisons show that the PPR model is more accurate than the traditional model [7]. Mathematical models are scientific or engineering models constructed using mathematical logic methods and mathematical language. Although experts and scholars have adopted the state-of-the-art methods and techniques in the above practices, these techniques have long iterative update times and are not fully applicable to most of our practices.

For the economy to develop, enterprises must go first. In China, the business activities of enterprises are the embodiment of the prosperity of China's market economy. The innovation of this study is that the company uses the analytic hierarchy process to study the construction of the mathematical model of enterprise marketing economic analysis. This approach is neither the ordinary use of high-level mathematical thinking, nor it is solely derived from the behavior and logical reasoning. Mathematical modeling is a process by which pure mathematicians (referring to mathematicians who only know mathematics but do not understand the application of mathematics in practice) become physicists, biologists, economists, and even psychologists. The AHP is more about combining multiple methods to decompose a large and incomprehensible system, which is more conducive to acceptance. Moreover, this method can also decompose difficult problems into multi-level monocular problems and then achieve relatively simple calculations through simple data comparison. The calculation is simple, and the obtained results are simple and clear, which is convenient for decision-makers to understand and master.

2. Construction of the Mathematical Model of Business Marketing Economic Analysis Based on Neutral AHP

2.1. N-Neutrosophic AHP Process. The AHP incorporates complex and multipurpose decision-making problems into the system, divides them into multiple benchmarks, decomposes some benchmarks, obtains some goals and benchmarks after decomposition, and finally obtains the hierarchical order through fuzzy quantification and a systematic approach to determine the meaning of the target [8]. The AHP mainly decomposes the decision-making problems

required by various hierarchical structures such as main objectives, secondary objectives, evaluation criteria, and specific investment plans. After the various hierarchical structures are split, the method of solving the inherent vector of the determined matrix is used to obtain the priority between different levels. Finally, the one with the highest weight is considered the best solution [9].

2.1.1. Construct Judgment Matrix. For a goal, we compare the programs within it and then rank them according to the degree of importance achieved. The division of grades is conducive to quantitative evaluation, and also makes the cultivation and development oriented. Generally speaking, it is more common to divide an indicator into 4–5 grades.

$$a(xy) = \frac{1}{a(xy)}. \tag{1}$$

Among them, $a(xy)$ is the result of comparing the importance of element x and element y.

2.1.2. Hierarchical List Sorting and Its Consistency Check. Carbon monoxide is a carbon-oxygen compound with a chemical formula of CO and a molecular weight of 28.0101. It is usually a colorless, odorless, and tasteless gas. The consistency index is calculated in CO, and the smaller the CO, the greater the consistency. The consistency index is defined as follows:

$$\mathrm{CO} = \frac{\lambda - n}{n - 1}. \tag{2}$$

Among them, CO = 0, and there is 100% consistency; CO is close to 0, and there is greater consistency; and the greater the CO, the lower the consistency. To measure the size of CO, a random consistency index RI is introduced in the following:

$$\mathrm{RI} = \frac{\mathrm{CI}_1 + \mathrm{CU}_2 + \cdots + \mathrm{CI}_n}{n}. \tag{3}$$

Because the reasons for the smaller consistency may be caused by chance, in the method of verifying whether the judgment matrix has the larger consistency, the CO and TY should also be compared to obtain the consistency of the test. For the coefficient OP, the formula is as follows:

$$\mathrm{OP} = \frac{\mathrm{CO}}{\mathrm{TY}}. \tag{4}$$

2.1.3. Zhongzhi AHP Hierarchical Model. The first problem to be solved by the AHP is to establish a hierarchical model of the decision-making problem and, through some investigations, clarify the relationship between the scope of the decision-making problem and the objectives and various factors [10]. Then, elements of the same category are grouped according to the relevant criteria. Then, through other criteria, the unclassified factors are sorted and aggregated according to relevant rules [11]. The following plans are the ones that decision-makers must choose, and the central plan represents several intermediate links. Analytic hierarchy processes usually start from the high level of the hierarchical process, go through multilevel benchmarks and low-level benchmarks, and reach the lowest level of the program level [12]. In a layered model, action lines represent connections between upper and lower layers, as shown in Figure 1.

2.2. Mathematical Model

2.2.1. Mathematical Model Expression Based on AHP. The AHP model mainly solves evaluation problems. Evaluation problems can be solved in a form of scoring, which will involve weights. This weight can be understood by the degree of importance. In the end, the sum of the weights of all solutions is 1. The weights are normalized. Under the relevant conditions of a certain area, different types of customers have their own characteristics, and their sales concepts will also have different preferences due to individuals, resulting in a large number of text messages often containing various concepts. To make the classification of customers more difficult [13], and to better represent the user's mathematical model, the weights of topics in documents are calculated. In this section, we label each record in the data as Y, which can be represented by the following formula:

$$Y = \{(x1, y1m)(x2, y2m)(x3, y3m) \ldots\ldots (xi, yim)\}. \tag{5}$$

Among them, xi represents the keyword abstract extracted from m. The meaning of yim is the relative importance of keywords in m. For Y, the importance of the subject heading can be recorded as follows:

$$xfv = \frac{freqv}{\max i(freqv)}. \tag{6}$$

In the formula, $freq$ represents the number of times the ordinal a is in the interest class y. max ($freq$) represents the maximum term frequency of the subject term in y. The frequency of occurrence of the subject word a in a document can be calculated by the following formula:

$$fa = \log \frac{Wa}{wa}. \tag{7}$$

In the above formula, Wa refers to the number of evaluation records in the dataset, and wa refers to the number of data items containing the subject word a. Therefore, the relative importance of feature word a in the entire data record can be formalized as follows:

$$Pv = afv * fa. \tag{8}$$

Using cosine similarity to calculate the similarity of two pieces of information, we use the formula to express the following:

$$\cos(\theta) = \frac{a * b}{\|a\| * \|b\|}. \tag{9}$$

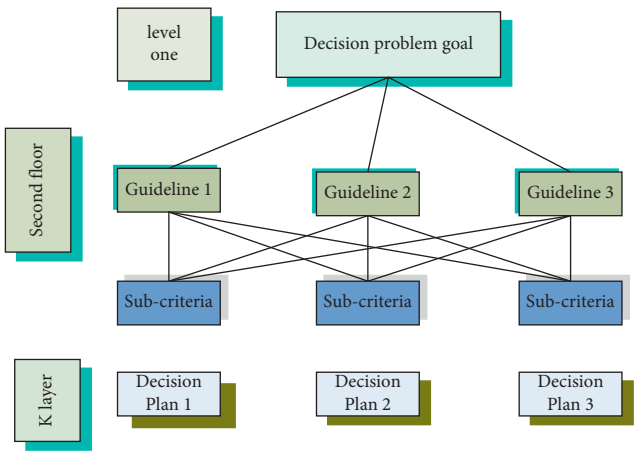

Figure 1: AHP hierarchical model.

The formula performs a normalization process in the model, assigns a value of 1 or 0 to the target layer, and then uses this value as a weight to assign to different factors. The weight of the corresponding factor represents the importance of the factor in the entire selection process.

2.2.2. Enterprise Product Attribute Modeling. We propose modeling based on the features of each attribute of enterprise products [14]. For all users who visit the company's experience store or online store, it is worthwhile for the relationship between them to lead to the user's interest, which means that if user A is very interested in a product, a product that is very similar to this product will make the customer favored [8]. M finds the nearest candidate set recommended by the top according to the nearest-neighbor function. The nearest-neighbor learning is not to estimate the objective function in the whole sample space at one time but to make a local objective function approximation or estimation for each sample to be tested, as shown in Figure 2.

2.3. Corporate Marketing. Corporate marketing refers to the business activities of a company to sell its own products or merchandise to customers. Enterprise marketing also needs to spend a certain amount of marketing costs on the production activities of the enterprise [15].

2.3.1. The Marketing Cost Is Divided into Two Aspects: The Total Marketing Cost and the Cost of Each Marketing Activity. The basic fitting multiple linear regression model includes the following two forms:

$$\mathrm{PF} = \alpha + \beta_1 \mathrm{MC} + \beta_2 \mathit{Scale} + \beta_3 \mathrm{Socon} + \varepsilon,$$
$$\mathrm{PF} = \alpha + \beta_1 \mathrm{AD} + \beta_2 \mathrm{PR} + \beta_3 \mathrm{PS} + \beta_4 \mathit{Scale} + \beta_5 \mathit{Scale} + \beta_6 \mathrm{Socon} + \varepsilon. \quad (10)$$

The PF is corporate performance. MC is the total marketing cost. AD is advertising expense. PR is PR cost. BP is the cost of business promotion. PS is the cost of sales of personnel. Size is the size of the company. Socon is the ownership concentration, and α is the model. The intercept and β are the regression coefficients for the corresponding study variables, and ε is the error value [16].

2.3.2. Marketing Costs and Operating Performance of the Company. From the test results in Table 1, we can see that a company's total marketing costs have a positive impact on operating income. Through marketing activities, companies can improve their business performance to a certain extent. Therefore, enterprises should attach great importance to marketing strategies in their daily operations. We develop a scientific and reasonable marketing budget [17].

3. Experimental Process and Result Analysis

3.1. Economic Analysis of Enterprise Marketing. Usually, enterprises should classify the internal simulation marketing market-binding indicators and comprehensive expansion indicators on a monthly basis, conduct internal analysis and evaluation every month, and identify problems and causes within a certain period of time [18]. The completion analysis of marketing economic quantity mainly compares the actual completed quantity, the accumulated basic marketing economic quantity, and the marketing economic quantity index of the planned overall expansion, confirms whether the planning is completed, and makes some types of comparisons [19]. Categorized marketing economic quantity and indicators: the classified marketing economic quantity determines the status of each classified marketing economic quantity to complete the planned task, the reasons that affect the total marketing economic volume, the planned task or the unfinished task, and then the monthly marketing. The study found that economic plans will provide decision-making reference and a basis for business managers [20].

3.2. Growth of Marketing Economic Volume of Classified Enterprises. The market economic growth analysis is mainly to determine the growth of the total market economy and marketing categories by comparing the actual completed market economic aggregate and category market economy this month with the same period last year [21].

Table 1 shows the growth of the market economy for a company over a two-year period. The company can judge the future development direction of the company by the market economic growth in the past two years [22]. At the same time, data analysis can also be used to find out the problems existing in the process of enterprise development and formulate solutions in time. The specific data are shown in Table 2.

In the marketing process, companies often market in a variety of ways. Through the comparison of the proportion of marketing classification, it can well show the marketing advantages of the company in various aspects and provide a more effective reference for the distribution of the company's marketing methods. As shown in Figure 3, the proportion of a company's product marketing volume is as follows.

It can be concluded by analyzing Figure 3. The company accounts for a large proportion of live broadcast marketing,

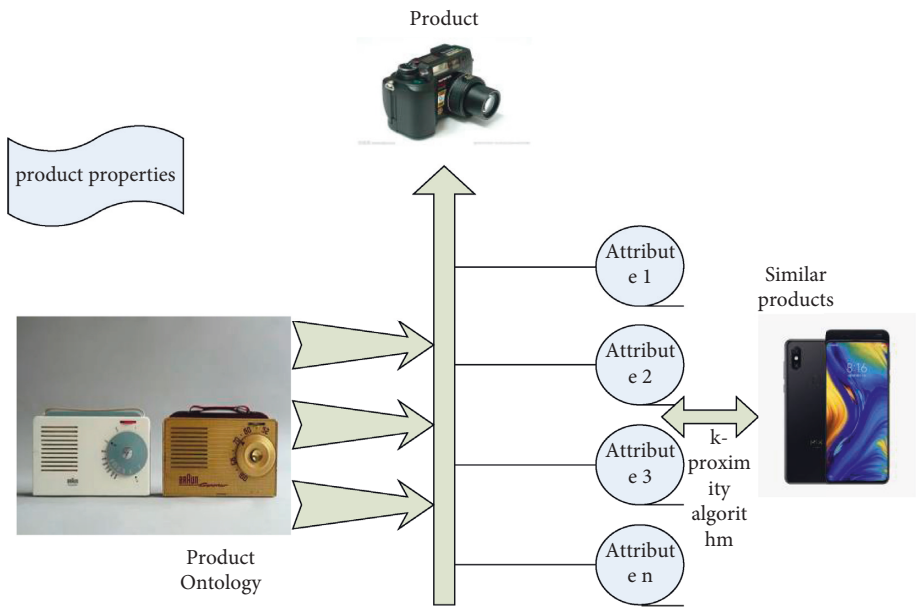

Figure 2: Enterprise product attributes.

Table 1: Whole sample analysis.

Independent variable	Model (1)	VIF
MC	0.33ˆˆˆ (14.96)	1.14
Scale	0.68ˆˆˆ (29.49)	1.03
Sokon	0.03 (1.42)	1.08
R^*R	0.85	
Adjust $-R^*R$	0.85	
F-statistic	874.39ˆˆˆ	
Observe the sample	468	

ˆˆˆ, ˆˆ and ˆ represent the significance levels of 2%, 6%, and 12%, respectively; () is the estimated m value of the parameter.

and the company can increase its live broadcast efforts to promote the sales of the company's products.

3.3. The Changing Trend of Marketing Economic Quantity Based on AHP. By comparing the marketing economic volume data of a company this year and judging the changing trend of the marketing economic volume in the current month, we can roughly understand the evolution of the marketing economic volume this year. In addition, by comparing the data trend of the same period, compared with the data of the same period last year, we can know the monthly growth of the market economy, as shown in Figure 4.

Through the analysis of the results in Figures 4 and 5, it can be concluded that due to the rapid development of online shopping and live streaming, especially some large e-commerce companies are often affected by the activities of online shopping platforms, and the market economy of these companies often fluctuates. Therefore, large-scale online e-commerce companies should always pay attention to market changes, implement online sales platform policies, and prescribe the right medicine to achieve the goal of sustainable growth in supply and sales. At the same time, with the deepening of the reform of the national market economic system, most of the enterprises in our country are prosperous, and their economic income is also increasing year by year.

4. Discussion

4.1. Average Unit Price of Enterprise Marketing Economy. The average unit price of an enterprise's market economy is an important indicator that affects the economic benefits of an enterprise. The average unit price of an enterprise's marketing economy reflects the average price of the entire enterprise's products and is closely related to economic indicators such as product sales, sales revenue, and sales profits. The average unit price of the company's market economy has certain influences and constraints on the company's product revenue and benefits, and comprehensively reflects the company's operating level. Product manufacturers and sales prices of enterprise products must conform to the catalog product prices uniformly formulated by the State Price Bureau. Similar to other countries in the world, our country has also implemented a product classification system for a long time. The corresponding selling price of the product varies with the number of buyers and the quality level of the product. The easy way to sell prices is as follows: customers who do a single catalog product sale price buy the product at a price equal to the price specified in the catalog. It is also very complicated: the price of implementing staged product pricing is different from the price of a single catalog product. The average product price = (flat segment price × flat segment number + peak segment price × peak segment number + valley segment price × valley segment number + basic sales price) price × billing capacity + interest rate adjustment price)/(number of flat segments + number of peak segments + number of valley segments). Although catalog products for all product categories are uniform and constant,

Table 2: Growth of a company's marketing economy.

Marketing	This month		Cumulative this month		Value added		Growth rate (%)		Part (%)	
	This year	Last year	This year	Last year	This Moon	Grand total	This month	Grand total	Cumulative this year	Cumulative last year
Online store	20	19	560	520	12	56	1.25	0.58	12.45	11.5
On-site delivery	35	25	692	800	20	83	20.5	15.8	37.55	45.5
Physical store	159	150	658	726	64	80	2.5	1.58	25.8	12.7
Group buy	123	105	596	714	63	72	2.9	4.5	24.2	27.3
All	337	299	2506	2760	159	291	27.15	2.46	100	100

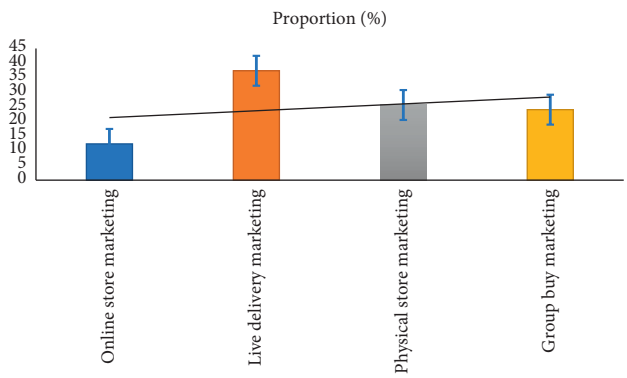

Figure 3: The proportion of product marketing volume classification.

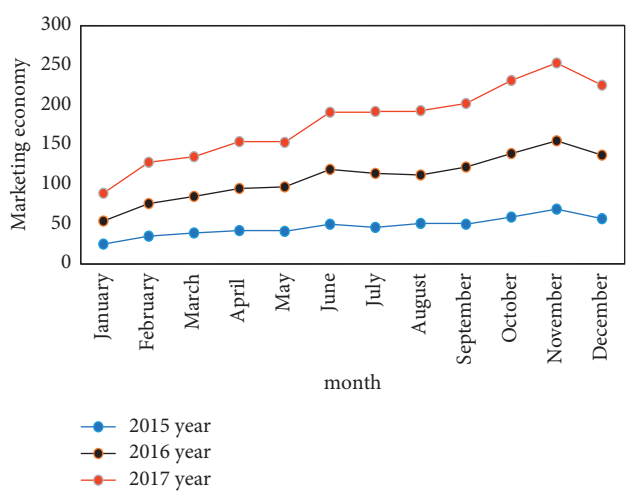

Figure 4: A company's 2015–2017 marketing economic trend chart.

in reality, for product manufacturers, the price of each buyer's product varies with the purchase of customers in that category. At the same time, the total average unit price of products sold varies on a case-by-case basis for each customer. Therefore, when analyzing the average unit price of product marketing, it is very necessary to analyze the classified selling price, unified selling price, and their impact on the average unit price of the entire product marketing. The product marketing revenue and product marketing average unit price mentioned in this study are based on comparable standards.

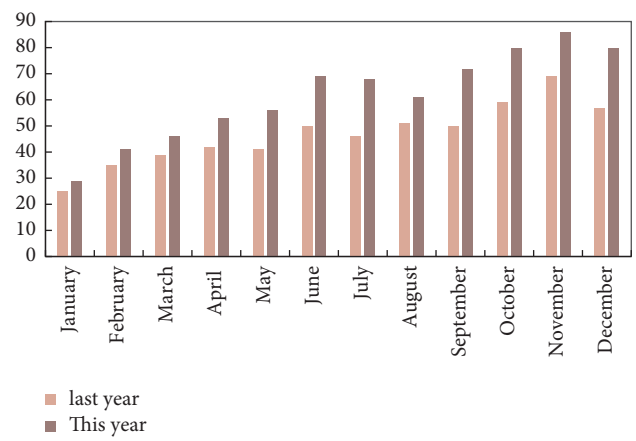

Figure 5: Comparison table of marketing economic quantity of enterprises in the same period.

4.2. The Impact of Changes in Product Sales Composition on the Average Unit Price of Products. The formula for the impact of changes in product sales composition on the average unit price of products is as follows:

$$K_{ai} = \Delta ai * (P_{I0} - P_0). \tag{11}$$

From the impact formula, it can be seen that the impact of changes in product sales composition on the average unit price of products depends on the degree of change in the proportion of the sales price of classified products, and the second is the difference in product sales composition, the sales price of the classified products, and the average unit price of the products in the same period. When the sales price of a product in the same period is higher than the average unit price of the product in the same period, the change in the sales ratio of the product will affect the average unit price of the product, and vice versa.

5. Conclusions

A case study of an enterprise shows that using the AHP to analyze the market economy of the enterprise and establish the corresponding mathematical model can not only help the enterprise to further expand the scope of production and operation, but also help the enterprise avoid the problems in daily marketing activities. Some unknown risks further pushed the company to develop in the direction of "higher, farther, and stronger." This study mainly uses the data in the

daily production and operation of the enterprise to make a level comparison, so as to obtain a more scientific and accurate mathematical model, and guide the enterprise to develop in a better direction. Of course, with the continuous progress of the society and the continuous development of the market economy, the marketing activities of enterprises are also facing more and more difficulties, which also guide enterprises to embark on a more scientific and sustainable development path.

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 they have no conflicts of interest.

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Research Article

English Language Features in Linguistics by High-Performance Computing

Dongyan Chen,[1,2] **Suryani Awang**,[3] **and Zaemah Abdul Kadir**[2]

[1]*College of International Studies, Beibu Gulf University, Qinzhou 535015, Guangxi, China*
[2]*Akademi Pengajian Bahasa Shah Alam, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[3]*Akademi Pengajian Bahasa, Universiti Teknologi MARA Cawangan Kelantan, Bukit Ilmu 18500, Machang, Kelantan, Malaysia*

Correspondence should be addressed to Dongyan Chen; chendongyan@bbgu.edu.cn

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High-performance computing clusters are mainly used to deal with complex computing problems and are widely used in the fields of meteorology, ocean, environment, life science, and computer-aided engineering. Language is the way humans communicate and communicate. Linguistic features are the stylistic features that distinguish all languages from other languages. This paper aims to study how to analyze English language features based on high-performance computing. This paper addresses the problem of linguistic feature analysis, which is built on high-performance computing. Therefore, this paper expounds the related concepts and algorithms, and designs and analyzes the characteristics of English language. The experimental results show that among the 160 English sentences in two different journals, complex sentences are the most used, with a total of 55 sentences, accounting for 34.38%. The second is mixed sentence types, 47 of which are mixed sentence structures, accounting for 29.38%. Among them, the combination of simple sentences + coordinating complex sentences + complex sentences constitutes the most mixed sentences, which appear 12 times and 8 times in ELT Journal and SSCI, respectively, accounting for 15.00% and 10.00% of their respective corpora.

1. Introduction

In the face of high concurrency, multicomputing models, and high-performance computing under big data storage, the timeliness of data and user response cannot be truly improved. How to allocate tasks and call resources for high-performance clusters is the key to improving performance. Among the more than 5,000 languages in the world, English is the most widely spoken language. For half a century, English has become the lingua franca. It is estimated that by the end of the twenty-first century, the total number of English speakers in the world will reach 2.1 billion. From the Eastern Hemisphere to the Western Hemisphere, one can hear all kinds of "English," which means that there are many varieties of English. English in the twenty-first century has become a multiethnic, multicultural, and multifunctional international language. Besides native speakers, many non-native speakers also use it for international and domestic communication. The globalization of English has led to its extensive localization, and the concepts of English Variations and World Englishes have emerged around the world.

Language is the carrier of human thinking, a necessary tool for people to communicate with each other, and an integral part of human civilization. Linguistic features have been widely used in article style analysis, and quantitative analysis of language features can be used to distinguish the style and type of text, and to analyze the correlation between language features and quality of text. The national language features are the symbols and symbols of the national spirit. The research and analysis of English language features provide a broad space for the emergence and development of English.

The innovations of this paper are as follows: (1) This paper combines language features with high-performance algorithms and introduces the theory and related methods of high-performance algorithms in detail. This paper mainly

introduces the parallel algorithm and GPU-based parallel ant colony optimization algorithm. (2) In the face of analyzing language features, this paper classifies the structure of sentences. This paper compares the language features in different journals and concludes that the mixed sentence type is the mainstream of English language features.

2. Related Work

With the progress of society, more and more people have studied high-performance computing. Interactive high-performance computing undoubtedly benefits many computational science and engineering applications when simulation results need to be visualized in real time, that is, during computation. However, interactive HPC presents a number of new challenges that must be addressed - one of which is solving the problem of fast and efficient data transfer between the simulation backend and the visualization frontend. Because gigabytes of data per second is not uncommon for simulations running on around (hundred thousand) cores. Mundani et al. [1] introduced a new method based on sliding windows and small-scale simulations, which can address any limitations of the user on interactive windows [1]. The problem of simulating microscale urban traffic in large-scale environments presents a great opportunity for the utilization of HPC systems. Parallel implementation of such computations (which must synchronize complex data-intensive processing) is not trivial. The simulation proposed by Turek W is based on the concept of controlled desynchronization of computation, which does not violate the model. The implementation in Erlang language uses the Erlang distribution mechanism to build and manage computing clusters [2]. The complexity and uncertainty of bridge construction projects require simulation analysis and planning for these projects. On the other hand, optimization can be used to address the inverse relationship between project cost and time, and find the right trade-off between these two key factors. Furthermore, the large amount of resources required for large bridge construction projects results in a very large search space. Therefore, it is necessary to use parallel computing to reduce the computation time of simulation-based optimization problems. Another problem in this area is that most construction simulation tools require an integrated platform to combine with optimization techniques. To alleviate these limitations, Salimi et al. [3] develop a simulation-based integrated optimization framework on a high-performance computing (HPC) platform and analyze its performance through case studies. They employ a master-slave (or global) parallel genetic algorithm (GA) to reduce computation time and efficiently utilize the full capacity of the computer. In addition, sensitivity analysis is applied to determine promising genetic algorithm configurations and the optimal number of cores for parallel use, and to analyze the impact of genetic algorithm parameters on the overall performance of the simulation-based optimization model [3]. The Neuroscience Initiative aims to develop new techniques and tools to measure and manipulate neuronal circuits. To handle the large volumes of data generated by these tools, Bouchard et al. [4] envisions co-locating open data repositories in standard formats with high-performance computing hardware using open-source optimized analysis code [4]. Hybrid cloud has gained popularity in various organizations in recent years due to its ability to provide additional capacity in public cloud, augmenting private cloud capacity when needed. However, scheduling jobs for distributed applications on hybrid cloud resources brings new challenges. A key concern is the risk of exposing private data and jobs in third-party public cloud infrastructure. The problem to be solved by Sharif et al. [5] is to design workflow scheduling algorithms to meet client deadlines without compromising data and task privacy requirements. The work of Sharif et al. [5] differs from most studies on workflow scheduling, where the main goal of workflow scheduling is to achieve a balance between ideal but incompatible constraints, such as meeting deadlines and/or minimizing execution time [5]. Noda et al. [6] will present the roadmap and research questions related to multiagent social simulation to illustrate the direction of technological achievements in this field [6]. However, the shortcoming of these studies is that the problems arising from high-performance computing are not properly dealt with.

3. Approaches to High-Performance Computing

3.1. Theoretical Basis of HPC. High-performance computing (HPC) refers to a computer system and environment consisting of multiple processors or multiple computers in a high-performance cluster. It can provide much higher computing power than traditional computers for large-scale data analysis and processing supercomputers [7].

With the continuous development of application requirements, the improvement of existing computer speed cannot keep up with the increase in computing speed requirements, especially in complex scientific computing, digital model analysis, simulation, engineering problems, and other application fields that require large-scale data volume and complex computing. All calculations and processing are required to be completed within an acceptable time [8]. However, it is limited to further increase the operation speed of a single processor. Therefore, the research on high-performance computing technology focuses on the development of supercomputers, and the study of parallel computing algorithms and software. Both high-performance computing and cloud computing models have their strengths and weaknesses. Table 1 summarizes some key features of HPC and cloud computing, and it can be seen that no single model can be the best solution for all features.

In the traditional high-performance computing model, computing workloads are processed in a well-managed and secure environment. However, computing capacity is fixed and rarely supports virtualization and resource sharing.

In view of the respective advantages and disadvantages of high-performance computing and cloud computing, many systems seek to improve these two computing modes, most of which are combined with grid computing. Combining high-performance computing and grid computing models is a practice in many scientific workflows to increase the

Table 1: Comparison of key features of HPC and cloud computing.

Characteristic	High performance computing	Cloud computing
Calculation quantity	Changeless	Increase in demand elasticity
Computational performance	Very high	Below average
Support virtual machine	Little support	Always support
Resource heterogeneity	Very low	Below average
Interoperability	Not applicable	Lower
Security	High	Below average

computational volume of high-performance computing by combining distributed grid resources. This method has been widely used in many projects [9, 10]. For computing tasks with computing performance as the bottleneck, this paper proposes a scientific cloud such as grid cloud. It is oriented towards scientific computing needs and implements infrastructure-as-a-service cloud computing solutions through open-source tools, such as Grid Nimbus.

It can be seen from the global high-performance computer TOP500 rankings that the architectures adopted by the high-performance computers on the rankings are mainly based on cluster technology and large-scale parallel processing technology. The high-performance computing cluster job processing architecture is shown in Figure 1. After the job is submitted, it is queued, assigned by the management node, and assigned to the computing node for processing. At present, high-performance computing usually adopts blade servers, and blade servers refer to high-availability, high-density, and low-cost server platforms [11]. Blade server refers to a standard-height rack-type chassis that can be plugged into multiple card-type server units. It is a low-cost server platform that realizes HAHD (High Availability High Density). It is a special application industry. And high-density computing environments are specially designed. Blade servers are like "blades," and each "blade" is actually a system motherboard.

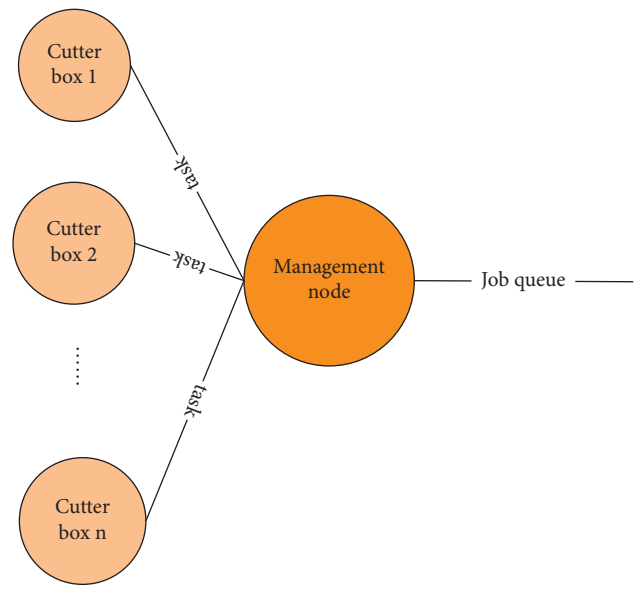

Figure 1: High-performance computing cluster job processing architecture diagram.

3.2. Parallel Computing. High-performance computing is an important branch of computer science, with the main goal of developing high-performance computers, researching parallel algorithms, and developing related software. High-performance computing is mainly measured by the speed of floating-point operations. Theoretical chemical calculations require an efficient and stable system environment. The availability of an environment for parallel computing and a job submission system directly affects the speed and quality of scientific research in theoretical chemical computing. High performance computers have floating-point performance.

Parallel computing is synonymous with supercomputing and high-performance computing, and is one of the important directions in the development of computer technology [12]. Figure 2 is a diagram of the parallel solution process of the problem.

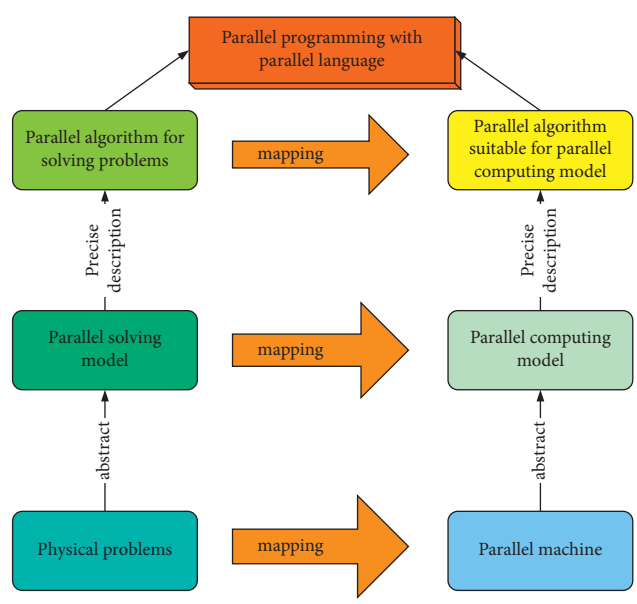

Figure 2: Diagram of the parallel solution process of the problem.

3.2.1. Parallel Computing Architecture. Compared with serial computing, parallel computing is divided into time parallelism and space parallelism. Time parallelism is the instruction pipeline technology. It decomposes the execution process of an instruction into several steps, and each step is completed by an independent component, thereby shortening the execution time of the entire task by executing

different instructions concurrently by independent components. Pipelining does not shorten the execution time of each instruction but improves performance by increasing the throughput of the microprocessor executing instructions. Whereas, spatially parallelism refers to the use of multiple processors or the use of multicore processors to perform computations concurrently. This paper mainly studies space-based parallelism. Common parallel architectures include SMP (symmetric multiprocessing), DSM (distributed shared memory), MPP (massively parallel processors), and cluster [13, 14]. The following comparison chart shows the differences between the four architectures, as shown in Figure 3.

3.2.2. Parallel Program Execution Time. Execution time refers to the time taken from the start of parallel program execution to the completion of all processes. It can be further divided into computation time, communication time, synchronization overhead time, and process idle time caused by synchronization. Computation time refers to the time spent by the process instruction execution, which can be divided into the time occupied by the program itself, namely the user time and the time spent by the operating system in order to maintain the execution of the program, that is, the system time [15]. The parallel execution time graph is shown in Figure 4.

3.2.3. Acceleration Coefficient. When measuring the performance of a multiprocessor system, an indicator usually used is called the acceleration factor, which is defined as follows:

$$V(h) = \frac{t_1}{t_h}. \tag{1}$$

t_1 represents the best serial algorithm that uses a single processor to execute a serial program. Sometimes it also represents the execution time of a parallel algorithm on a single processor. These two representations are still different. t_h represents the execution time required for a parallel program to execute using h processors.

A parallel program can generally be divided into a serial part and a parallel part. If the second representation method is adopted, then t_1 and t_h can be expressed as follows:

$$\begin{aligned} t_1 &= g \bullet t_1 + (1-g) \bullet t_1, \\ t_h &= g \bullet t_1 + (1-g) \bullet \frac{t_1}{h}. \end{aligned} \tag{2}$$

Because:

$$\begin{aligned} V(h) &= \frac{1}{(g + ((1-g)/h))}, \\ \frac{1}{(g + ((1-g)/h))} &= \frac{h}{g \bullet h + 1 - g}. \end{aligned} \tag{3}$$

Then:

$$V(h) = \frac{h}{g \bullet h + 1 - g}. \tag{4}$$

Because:

$$\frac{h}{g \bullet h + 1 - g} \leq \frac{1}{g}. \tag{5}$$

So:

$$V(h) \leq \frac{1}{g}. \tag{6}$$

If the serial part of a parallel program accounts for 10%, that is, $g = 0.10$, according to this formula, no matter how many processors are used, the acceleration factor will be less than 10, which is the famous Amdahl formula.

3.2.4. Efficiency.

$$\mathrm{Eff}\,p = \frac{Vh}{h}. \tag{7}$$

Vh is the acceleration coefficient represented by formula (1), h represents the number of processor cores, and Eff$p$ represents the performance-cost ratio obtained by using h processors or cores for parallel processing, which is generally less than 1. The value is an internationally common criterion for measuring the floating-point performance of high-performance computer systems. It is used to evaluate the floating-point performance of high-performance computers by testing the ability to solve linear algebraic equations.

3.3. GPU-Based Parallel Ant Colony Optimization Algorithm. In recent years, GPU (Graphics Processing Unit) parallel computing technology has become a research hotspot in the field of high-performance computing. GPU hardware has powerful floating-point computing capabilities, providing good support for large-scale scientific computing and engineering computing problems. Currently, in addition to traditional HPC applications, the demand for emerging HPC applications is also growing [16].

High-performance cloud computing can solve the user service problems faced in traditional high-performance computing. The hardware architecture of the GPU cluster is shown in Figure 5. Due to the common influence of various factors such as semiconductor technology, manufacturing technology, power consumption, etc., the current processor architecture presents a diversified development trend. Among them, GPU, as a kind of coprocessor, has become one of the important components of contemporary high-performance computer systems and has developed rapidly. Its functions have developed from a single graphics display to high-speed parallel computing (General Purpose GPU, General Purpose GPU, GPGPU) in just ten years [17].

3.3.1. Basic Principles. Ant colonies, or more generally social insect colonies, are a distributed system. Although the individuals in the system are very simple, the whole system can

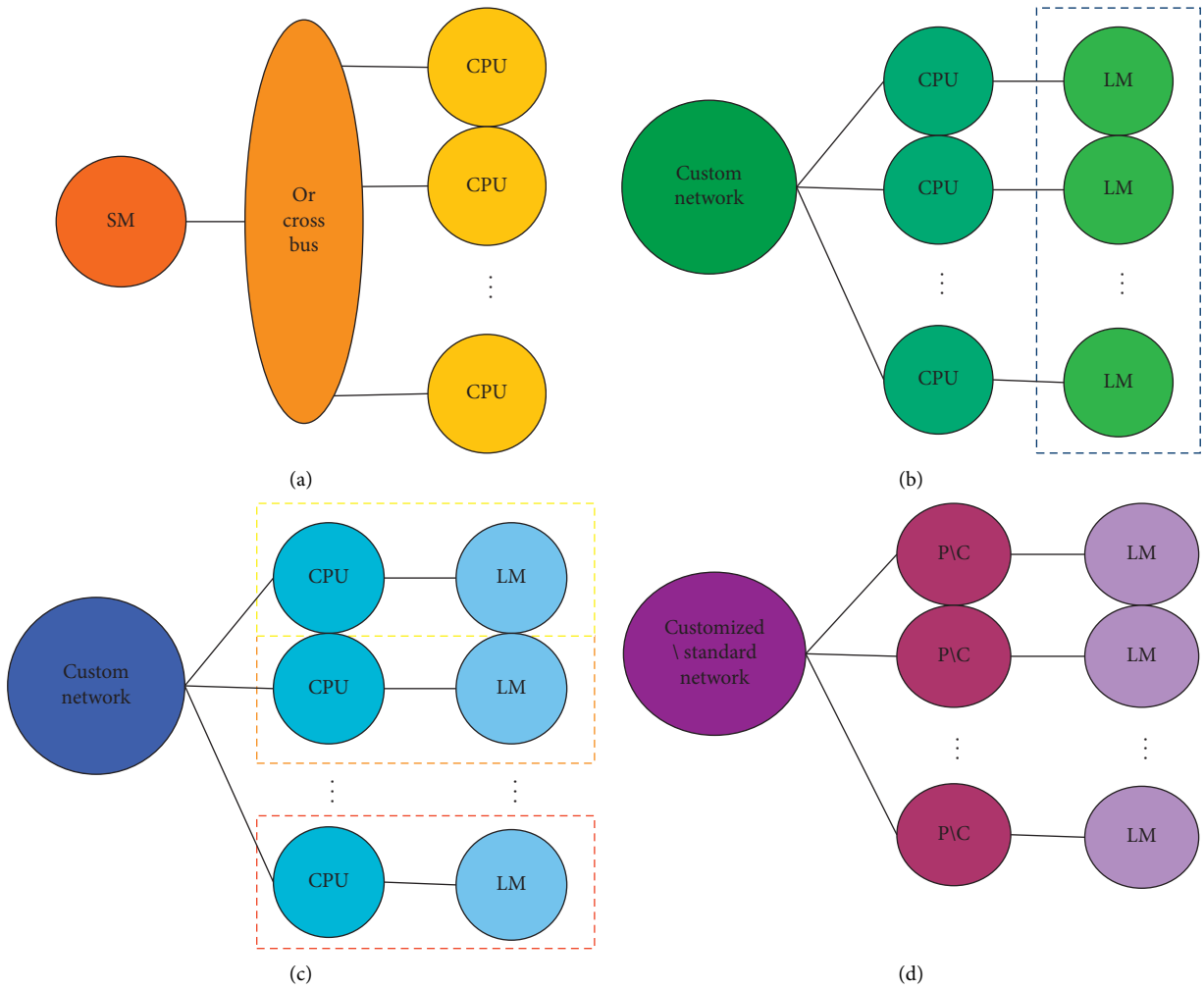

Figure 3: Four architecture diagrams. (a) SMP, physically single address space. (b) DSM, logically single address space. (c) MPP, physical\logically multiple address spaces. (d) Cluster, physical\logical multiple address space.

present a highly structured colony organization. Observations show that ants leave a secretion during their movement, and ants behind them can make a biased path choice based on the secretion left by the ants in front. This constitutes a positive feedback mechanism for learning information, and ants seek the shortest path to food through this information exchange [18, 19].

(1) Form description

$$GA = (P(0), N, L, Q, G, P, F, Z). \tag{8}$$

(2) Performance evaluation

The online performance is represented by the average value from the first generation to the current generation. Let $X_E(Q)$ be the linear performance of the strategy Q in the environment E, and $F_E(Z)$ be the objective function or the average fitness function corresponding to the environment E in the time Z or the Zth generation, then:

$$X_E(Q) = \frac{1}{Z}\sum_{L}^{T} F_E(Z). \tag{9}$$

The online performance represents the average value of the performance during the time period from the beginning of the algorithm to the current time, reflecting the dynamic performance of the algorithm.

Offline performance is the cumulative average of the best performance. Let $X_E^*(Q)$ be the linear performance of policy Q under environment E, then:

$$X_E(Q) = \frac{1}{Z}\sum_{L}^{Z} F_E^*(Z), \tag{10}$$

where

$$F_E^*(Z) = \mathrm{BEST}\left(F_E^{(1)}, F_E^{(2)}, \ldots, F_E^{(Z)}\right). \tag{11}$$

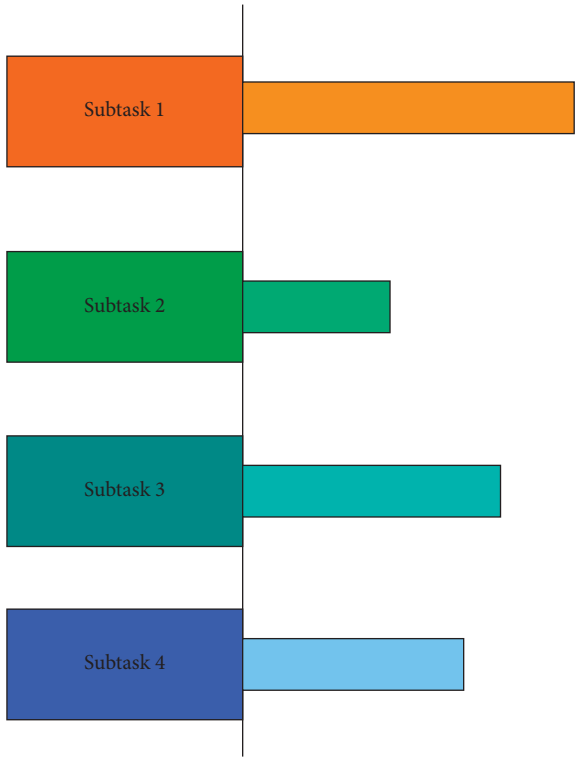

Figure 4: Parallel execution time graph.

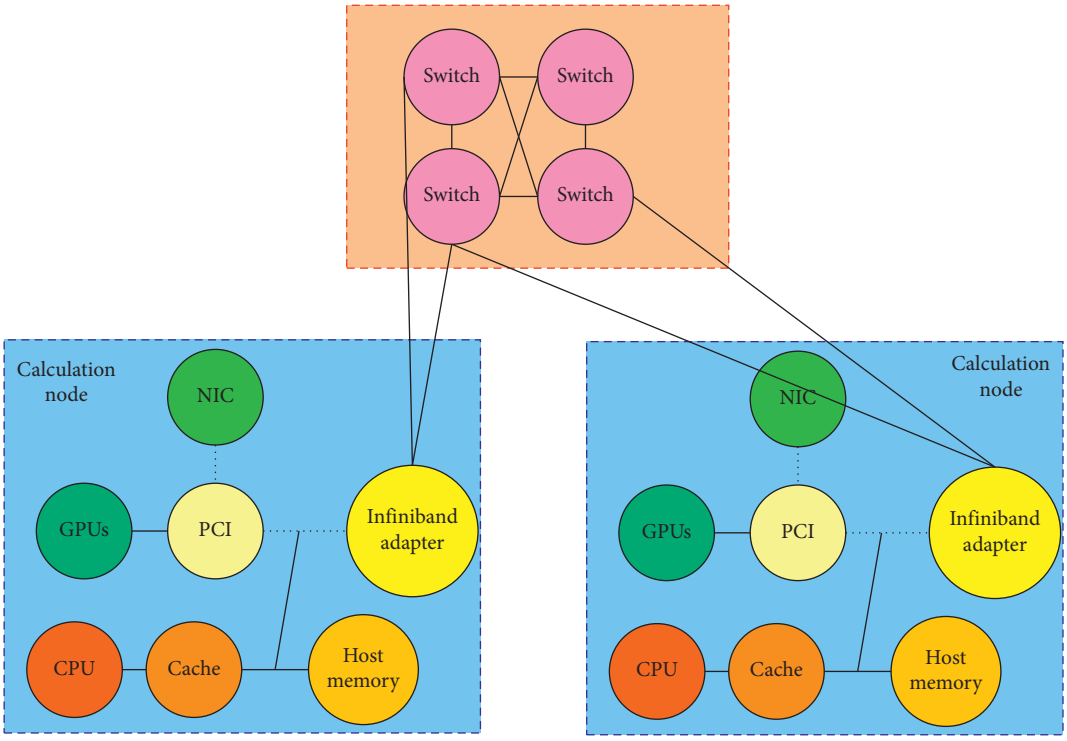

Figure 5: Hardware architecture of GPU cluster.

Offline performance represents the cumulative average of the best performance values of each evolutionary generation during the running of the algorithm, which reflects the convergence performance of the algorithm.

3.3.2. Algorithm Process. The process of ant colony algorithm optimization is actually controlled by three variables, namely state transition rule, pheromone local update rule, and pheromone global update rule.

The algorithm flow can be simply described as follows: each ant traverses all the cities according to the state transition rules and finds its own shortest path until all ants find their own solutions. Every time an iteration is completed, the pheromone on all paths is updated and the shortest path generated after this iteration is recorded until the termination condition is satisfied and the iteration ends [20]. In this process, the state transition probability can be defined as

$$P_{IJ}^{K}(Z) = \frac{\mu_{IJ}^{a}(Z)v_{IJ}^{b}(Z)}{\sum_{J=1}^{N}\mu_{IJ}^{a}(Z)v_{IJ}^{b}}. \tag{12}$$

Among them, v_{IJ} represents the visibility between the two places I and J, μ_{IJ} represents the concentration between the two places, a represents the importance of the pheromone concentration between the two places, and b represents the importance of the visibility between the two places.

Using the memory list to record the list of cities that ant K has walked through, the formula can be updated as

$$\begin{aligned} \mu_{IJ}(Z+1) &= w\mu_{IJ}(Z) + \Delta\mu_{IJ}(Z+1), \\ \Delta\mu_{IJ}(Z+1) &= \sum_{K=1}^{M}\Delta\mu_{IJ}^{K}(Z, Z+1), \\ \Delta\mu_{IJ}^{K}(Z, Z+1) &= \begin{cases} \dfrac{O}{L_K}, \text{exit}, \\ 0. \end{cases} \end{aligned} \tag{13}$$

Among them, $\Delta\mu_{IJ}^{K}(Z, Z+1)$ represents the amount of pheromone left on the path (I, J) by the movement of the Kth ant at time $(Z, Z+1)$. $\Delta\mu_{IJ}(T, T+1)$ represents the amount of all ant pheromones in this process, and O represents the sum of all path pheromones. L_K represents the total length of the path taken by the Kth ant, and w is the attenuation coefficient of the pheromone trajectory. Figures 6 and 7 are the standard path construction diagram and the path construction diagram of the prospect strategy, respectively.

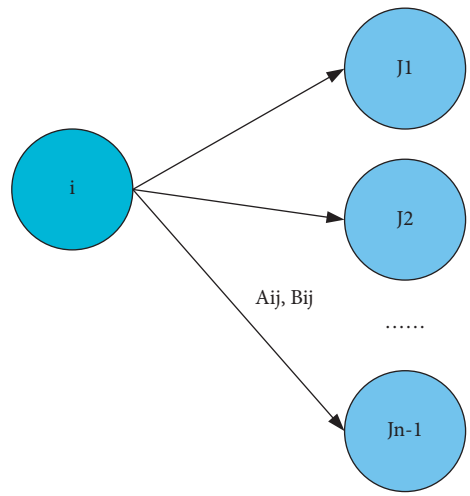

Figure 6: Standard path construction.

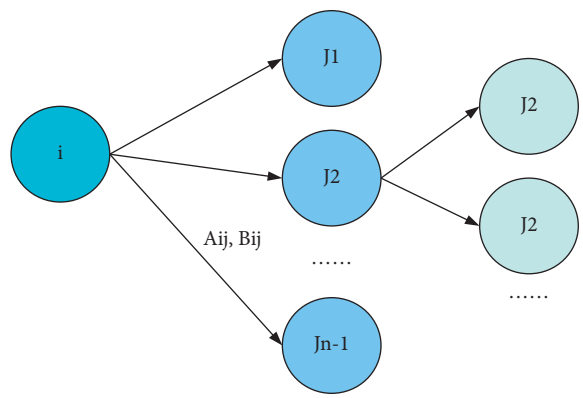

Figure 7: Path building for the outlook strategy.

4. English Language Feature Experiment and Analysis

4.1. Survey of the Corpus. This study extracted 160 article titles from ELT Journal and SSCI in 2020-2021 and used UAM Corpus version 2.0 to count them. Table 2 lists the basic information of the two journal corpora.

As shown in Table 2, the average length of sample titles in ELT Journal is 13.025 words, and the average length of sample titles in SSCI is 11.575 words. The average length of the two journal titles is basically the same, and both are around 12.300 words per title.

4.2. English Feature Structure Types. Based on some existing literature reference standards, this paper first divides the surface structure of sentences into the following four types.

Simple sentences are what we often call "subject-predicate structure" and "subject-predicate-object structure." A simple sentence usually contains a main clause and a predicate, but sometimes a simple sentence also contains multiple subjects and predicates.

A coordinating compound sentence is a sentence consisting of two or three subordinate clauses. They are usually made up of coordinating connectives linked together. The main coordinating conjunctions are as follows: and, nor, but, or, yet, so, for, etc. In addition to using conjunctions to link, it can also use semicolons to link two parallel sentences.

A complex sentence is a sentence that consists of two or more subordinate clauses joined together using subordinating conjunctions. Common subordinating conjunctions are as follows: after, although, as, as if, as long as, as much as, as soon as, as though, because, before, even if, even though, once, until, when, since, so that, that, though, unless, in case, in order, whenever, where, wherever, what, whatever, etc. For example: I want to go to bed, because I am very tired.

Table 2: Basic information of ELT Journal and SSCI journal corpus.

Project	Number of titles	Number of words	Average title length (words/title)
ELT journal	80	1042	13.025
SSCI	80	926	11.575
Sum	160	1969	12.300

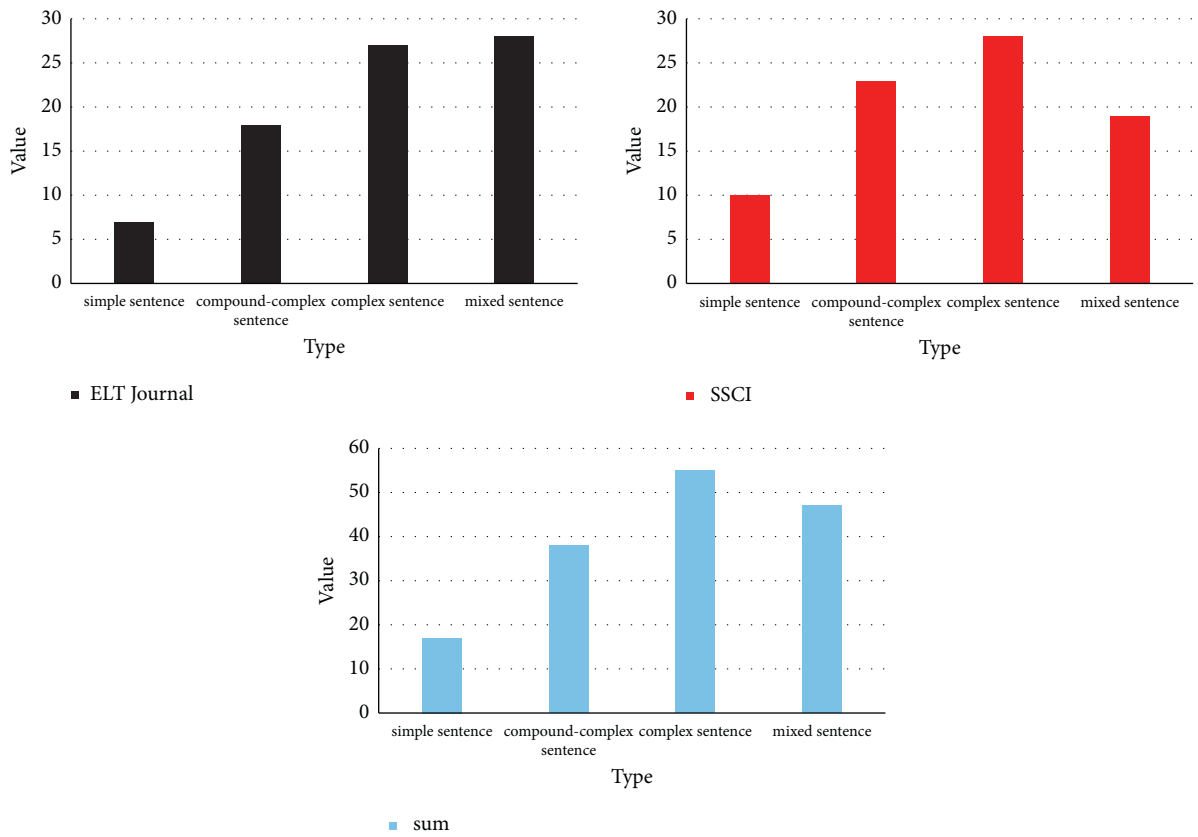

Figure 8: ELT Journal and SSCI English sentence structure types.

Simple sentences, coordinating compound sentences, and complex sentences can appear in a compound sentence. We often say that the subordinate clause is a typical mixed sentence. For example: the car, which is my father's, is in the garage.

4.3. Feature Analysis. It can be seen from Figure 8 that in ELT Journal, there are 7 simple sentences, accounting for 8.75%. There are 18 juxtaposed compound sentences, accounting for 22.50%, 27 complex sentences, accounting for 33.75%, and 28 mixed sentences, accounting for 35.00%. In SSCI, there are 10 simple sentences, accounting for 12.50%, 23 complex sentences, accounting for 28.75%, 28 complex sentences, accounting for 35.00%, and 19 mixed sentences, accounting for 23.75%.

Analysis of the data in Figure 8 shows that among the 160 English sentences in this article, complex sentences are the most used, with a total of 55 sentences, accounting for 34.38% of the sample. Complex sentences have a better connection between the upper and lower sentences, making the sentences more fluent and related.

In addition to the complex sentence result sentences mentioned, the second in this study is the sentence of mixed sentence type. The data collected by the author has a total of 160 sentences, of which 47 are mixed sentences, accounting for 29.38% of the sample. In terms of structure and function, mixed sentences can be regarded as an extension of simple sentences or as a simplified form of complex sentences. Generally speaking, it can convey or record more information with the help of premodifier or postmodifier through fewer words and simple structure. The distribution of mixed sentence structure types in the two journals is shown in Figure 9. For the convenience of expression, the simple sentence + coordinating compound sentence is expressed as SS + CCS, the simple sentence + complex sentence is expressed as SS + CS, and the coordinating compound sentence + complex sentence is expressed as CCS + CS. Simple sentences + coordinating compound sentences + complex sentences are expressed as SS + CCS + CS.

According to the analysis and as shown in Figure 9, the overall trend of ELT Journal and SSCI sentences is the same, and the three sentence structures (SS + CCS + CS) combine the most. Its frequency in ELT Journal and SSCI is 12 and 8

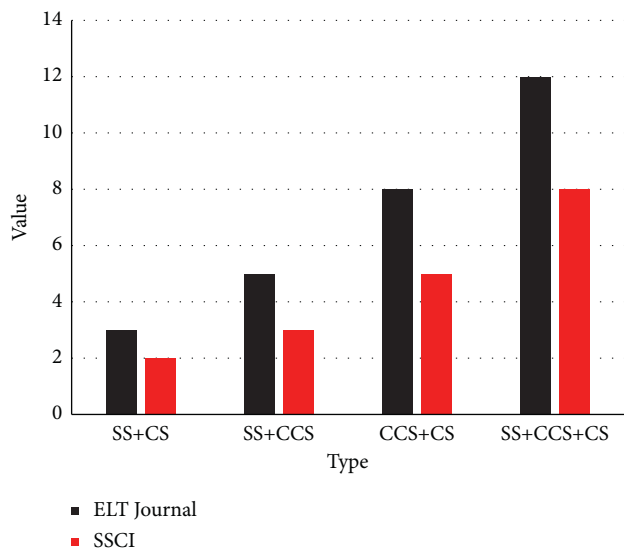

Figure 9: Distribution of mixed sentence structure types in ELT Journal and SSCI.

times, respectively, accounting for 15.00% and 10.00% of their respective corpora. Next is the statement of the compound sentence + complex sentence (CCS + CS) type, the highest proportion is 8 times and 5 times, accounting for 10% and 25%, respectively. From the point of view of collocation, the continuity of conjunction collocation is very strong. Different combinations of subordinate words and phrases can express different concepts, form different tense meanings, and convey different grammatical functions. Therefore, the structure of compound sentence + compound sentence (CCS + CS) helps scholars to provide research content and research methods more accurately.

5. Discussion

In recent years, GPU parallel computer technology has become a hot spot in the field of high-performance computers. Graphics hardware with powerful floating-point performance provides good support for large-scale scientific computing and engineering. At present, in addition to the traditional high-performance computer applications, the demand for high-performance computer applications is also increasing. In terms of user services, HPC faces many challenges: how to provide users with flexible services that allow users to independently manage data processing resources. How to save scalable dynamic computer resources and improve the utilization of high-performance computers [21].

With the deepening of research and the requirements of computing precision, the amount of data increases exponentially, which puts forward higher requirements for storage, computing, node communication, job allocation, and resource scheduling of high-performance computing clusters. Blindly adding hardware devices to improve computing performance not only brings huge power consumption but also has a bottleneck. Researching resource scheduling strategies to maximize efficiency has always been the direction of high-performance development and the focus of scientific research.

Through the experimental analysis, it can be seen that the surface structure of sentences includes four types of structures: simple sentences, coordinating complex sentences, complex sentences, and mixed sentences. Based on the relevant corpus research, this paper mainly takes ELT Journal and SSCI as examples to discuss the structure and linguistic features of English sentences. From the statistical results, it can be concluded that the structure and linguistic features of English sentences in ELT Journal and SSCI are roughly equivalent. Among them, the mixed sentences appear the most, which are mainstream sentences, and in the mixed sentences, the sentence features that combine the three types of sentences account for the majority.

6. Conclusion

Language is a part of social culture, language problems are always closely linked with social problems, and all social, cultural and psychological factors limit the use of language. The results of this study show that although ELT Journal and SSCI cover a wide range of research areas, English sentences of the two journals share some commonalities in the structure and use of linguistic features. This is mainly reflected in the frequent use of mixed sentence structures. In terms of academic paper writing, the differences between Chinese scholars in spoken English and English writing require more in-depth comparative analysis and further academic research in the future [22]. It is hoped this article can help Chinese readers understand the use of international Frontier journal sentences in English linguistics and provide learners with a useful reference.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare no conflicts of interest. And author have seen the manuscript and approved to submit to your journal.

Acknowledgments

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Retraction

Retracted: Music Timbre Extracted from Audio Signal Features

Mobile Information Systems

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 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. Mo, "Music Timbre Extracted from Audio Signal Features," *Mobile Information Systems*, vol. 2022, Article ID 1349935, 13 pages, 2022.

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Research Article

Music Timbre Extracted from Audio Signal Features

Ying Mo

Music College, Wenzhou University, Wenzhou 325035, Zhejiang, China

Correspondence should be addressed to Ying Mo; 00071027@wzu.edu.cn

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Among the basic elements of music, timbre is one of the most important elements of sound, and it is also the main basis for distinguishing one pronunciation from another. People usually have the ability to "listen and argue" because everyone's pronunciation is different. However, the existing audio extraction technology has low efficiency and low accuracy. Therefore, this paper aims to discuss the algorithm that can make music timbre feature extraction more accurate and efficient. For audio signal feature extraction, this paper proposed an audio feature based on harmonic components to describe the harmonic structure information in the audio signal spectrum. The algorithm in this paper extracts timbre features from the sound data of Western musical instruments and national musical instruments and analyzes the recognition accuracy. The experimental results showed that the classification accuracy of the four feature extractors is above 92%, among which B has the worst effect, with an accuracy of 92.42%, and *D* has the best classification effect, with an accuracy of 99.15%, which shows that the feature extraction algorithm designed in this paper combined with the traditional feature extraction algorithm can achieve better results.

1. Introduction

Sound is one of nature's most common signals. Sound is produced by the vibration of objects. Its existence even predates the existence of living things. As long as there is the vibration and transmission medium of objects, there is the generation of sound signals. Since the birth of human beings, sound has always occupied the most important part of people's lives. For example, natural sounds convey the information of nature to people: if you hear the wind, it means the wind is coming; if you hear the sound of rain, it means it is raining; if you hear the sound of water, it means there are rivers and oceans nearby. Language is the most important communication tool in human society, as a signal for transmitting messages between people. It is convenient, natural, and efficient, and can accurately convey various messages. As for music, its content has risen to the height of human art. People can use different musical instruments to play music in various poses and sounds, and express their emotions such as happiness, anger, sorrow, and music with the help of music.

In the subject of sound, the component analysis of audio signals has always occupied the mainstream of audio signal analysis technology. Various components of the audio signals determine the theme emotion expressed by the music signals. By analyzing the characteristics of various components of the audio signal, the characteristic parameters of the music can be extracted, and the music signal can be classified, identified, and retrieved. This is of great significance for establishing a high-performance and high-accuracy music retrieval database and implementing music classification algorithms based on music style, music content, and musical instruments.

The main innovations of this paper are as follows: (1) feature extraction—this part mainly analyzes the characteristics of the audio signal on the basis of preprocessing and then extracts the characteristic curve of the audio signal to pave the way for the subsequent audio melody matching. (2) Audio feature library construction—this part mainly studies the music in MIDI file format and uses the improved contour algorithm to build the audio feature library, which is used as the data source for melody matching. This plays an

important role in the timbre analysis of various musical instruments in the text, and he can distinguish the timbres of various musical instruments.

2. Related Work

The timbre analysis is of great significance not only to music and musical instruments, but also to the current simultaneous interpretation, speech recognition, etc., so there are many studies on timbre analysis. Kim et al. have done research on classifying musical instruments from polyphonic music, which he believes is a challenging but important task in music information retrieval [1]. Tatar et al. introduce latent timbre synthesis, a new approach to audio synthesis using deep learning. This synthesis method allows composers and sound designers to interpolate and extrapolate between the timbres of multiple sounds in the latent space of audio frames [2]. Banerjee et al. believe that the analysis of sound signals in the linear deterministic approach reached a new dimension and developed many well-equipped software to precisely measure and control the basic parameters of sound, such as pitch, intensity, and rhythm [3]. Rossetti and Manzolli believe that analyzing electroacoustic music is a challenging task that can be solved by different strategies. He proposed to use representations of complex dynamical systems (such as phase space graphs) in music analysis to reveal the timbre characteristics that arise in acoustic music based on particle techniques [4].

It can be seen that most of the timbre analysis uses audio signal extraction technology and deep learning technology. There are also many studies on the extraction of audio signal features. An overview and benchmarking of Sharan et al. test various audio signal representation techniques for classification using CNNs, including methods for processing signals of different lengths and combining multiple representations to improve classification accuracy [5]. Santosh et al. believe that speech, music, and audio signals are essential for communication (e.g., sharing information) and entertainment. This automatic processing of signal processing reduced expert and/or human intervention [6]. Baxter believes that audio metering and monitoring can be described as the ability to audibly or visually determine certain characteristics of an audio signal. For example, loudness measurements are accumulated over a period of time, and it may be difficult for a mixer to detect changes in audio by ear through control room speakers, but the changes obtained through LKFS meters are noticeable [7]. However, it can also be clearly found that most of the current audio signal extraction technology is limited to signal extraction, and the accuracy in removing noise and identifying timbre is not high enough, so this article will conduct in-depth research on this.

3. Music Tone and Its Principle

3.1. Principle of Hearing. The process of human perception of audio information is carried out through the hearing of the human ear. The process of hearing includes from sound vibrations to changes in electrical potential and the release of chemicals, to the emergence of nerve impulses, and finally to central information processing. Therefore, to understand the human perception and cognitive mechanism of audio information, it is necessary to start from the physiological structure of the human ear and the process of auditory perception.

The ear is an important human sense. The function of the ear is to first receive external sounds and then convert the received sounds into neural signals that humans can recognize. Sound perception refers to the internal processing of the received sound through the brain and finally converts it into semantics that humans can understand [8, 9]. The human ear consists of three parts: the outer ear, the middle ear, and the inner ear. The cochlea of the ear is the human auditory sense; the inner ear is responsible for position determination and balance; the outer ear is responsible for sensing external sounds; the middle ear is responsible for transmitting external sounds to the inner ear; the inner ear is responsible for converting the incoming sound energy into human nerve stimulation. The structure of the human ear is shown in Figure 1.

The perception process of the human ear is inseparable from the brain, which is a very sensitive organ. The eardrum vibrates when sound waves from the external environment travel through the air in the external auditory canal to the eardrum. The vibration of the tympanic membrane is transmitted by the ossicles through the middle ear. During the transmission process, the ossicles vibrate the cochlear fluid, which in turn causes the basilar membrane to vibrate and finally generates traveling waves. Different sounds produce different traveling waves. When the organ of Corti with the basement membrane vibrates, electrical potentials appear on the hair cells. The characteristic of this potential is that the frequency and waveform are the same as the external stimulus sound. This potential also stimulates the nerve fibers in the lower part of the hair cells, generating action potentials. This action potential causes a change in the electrical potential between the auditory nerve and the hair cell, which in turn creates a chemical reaction. A certain substance produced by the chemical reaction will stimulate the nerve endings and finally transmit the excitement generated by the nerve endings to the nerve center.

3.2. Tone. The basic knowledge of music theory is essential, and all music production is closely related to this knowledge. These music theory knowledge can help us better understand the elements in music. Music melody includes many elements: melody, rhythm, beat, speed, dynamics, range, pitch, sound intensity, sound value, timbre, etc. [10]. The common physical quantities of sound, such as loudness, pitch, and timbre, are shown in Figure 2.

Timbre: the timbre of the sound. The difference in timbre is mainly due to the different inherent properties of objects. Different timbres can be combined into a different very nice music, and the timbre can also determine the image of the music.

From a disciplinary point of view, the concept of timbre contains multiple attributes such as physical and

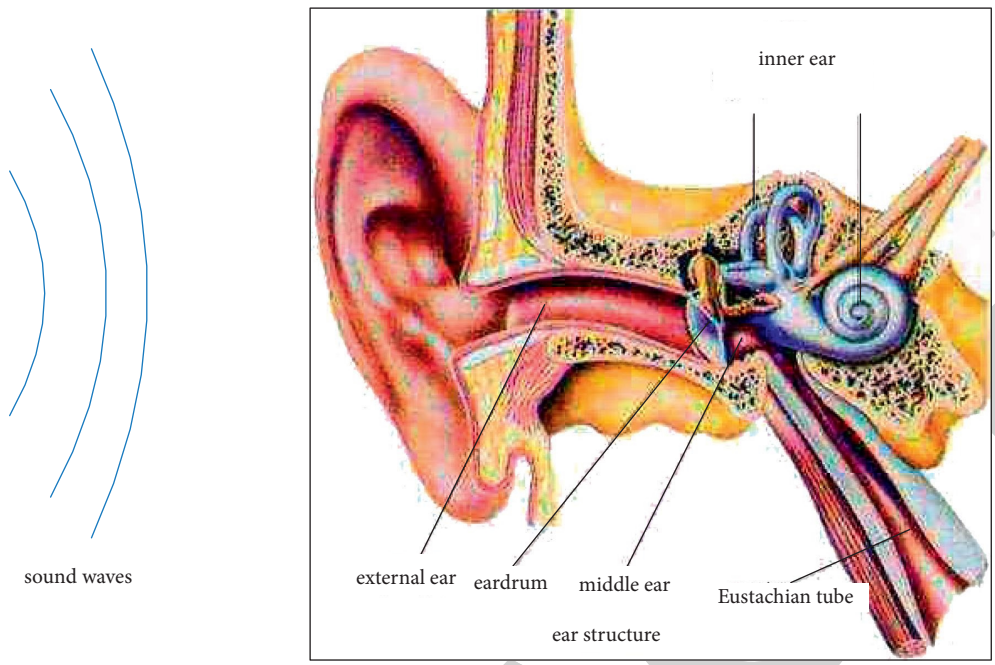


Figure 1: The principle of human hearing.

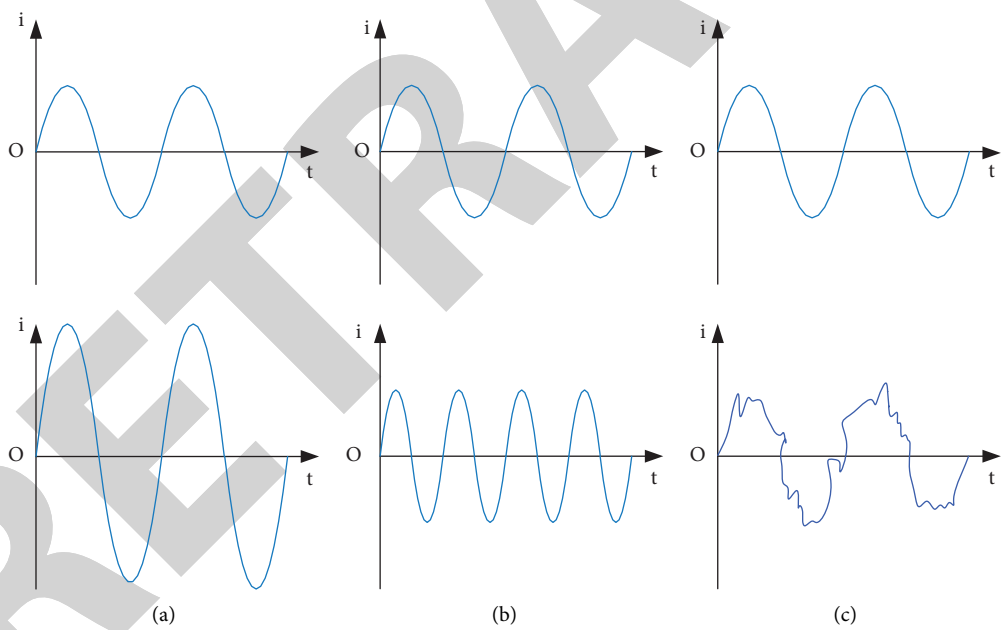


Figure 2: Volume, tone, and timbre. (a) Volume level. (b) Pitch high and low. (c) The timbre is different.

psychological. In different academic fields, the definition of timbre and its impact will also be different. From the point of view of physical acoustics, timbre is a certain property of sound produced by hearing, and it is a kind of vibration wave propagating in the medium. The timbre usually heard is a composite tone composed of the fundamental tone and an overtone produced by the sounding body. Therefore, the structure, material, shape of the sounding body, the number of overtones above the fundamental sound generated by these factors of the sounding body, and the amplitude of each overtone are the fundamental reasons that affect the timbre. Therefore, in physical acoustics, the difference in timbre depends on the distribution and intensity of each overtone [11, 12].

From a psychological point of view, timbre is a key factor in creating an auditory linkage between performers and listeners. The performer can convey the musical mood and musical image of the musical work to the audience through the timbre, so that the audience can produce synesthesia in the auditory through the unique timbre perception. This synesthesia effect directly affects people's emotions and subjective cognition, which is an important basis for music

therapy. Music therapy is one of the important methods and means of psychotherapy, which is to relieve emotions and cure diseases through music [13, 14]. It uses various forms of musical activities, including listening, singing, playing, rhythm, and other means to stimulate and hypnotize people and stimulate physical responses to sound, so that people can achieve health goals. Among them, the choice of different timbres and different sound qualities has an essential and even decisive influence on the treatment. It is mentioned in "Huangdi Neijing" that the melodious, quiet, honest, and solemn tone is as broad and firm as "earth" and can enter the spleen.

In the theory of musicology, timbre is an auditory property, and the timbre of a musical tone refers to the sound property produced by a musical instrument when a note is played. When different musical instruments play notes of the same pitch, strength, and time value, the listeners will perceive the sound perception of different attributes, that is, the difference in timbre.

3.3. Tone Classification

3.3.1. Tone Classification of a Single Instrument. There are many kinds of musical instruments, and understanding each musical instrument and its classification will help us learn and train timbres. This paper discusses the classification of musical instrument timbres into the two categories of Chinese national musical instruments and Western musical instruments. In the classification of traditional Chinese national musical instruments, the "Introduction to Ethnic Art" of the Chinese Academy of Arts divides musical instruments into wind instruments, stringed instruments, plucked instruments, and percussion instruments according to the performance of the instruments themselves and the differences in their playing methods.

In the orchestration method, according to the principle of orchestration, various Western musical instruments divide the modern symphony orchestra into different musical instrument groups according to their own materials, structure, sounding methods, and performance skills: woodwinds, brass, percussion, plucked, bowed, and keyboards. Some of the Western and ethnic musical instruments are shown in Figure 3.

To sum up, to have a clearer understanding of the classification of musical instrument timbres, the author divides the common Western musical instruments in the table through first-level classification, second-level classification, and third-level classification. The sound classification of each musical instrument is shown in Tables 1 and 2.

3.3.2. Tone Classification of Musical Instrument Combinations. In this paper, according to the classification of a single instrument timbre, the instrument combination timbre is defined as the combination of two or more musical instrument timbres. The definition of instrument combination is extremely simple, but the form of instrument combination tone is very rich, there are two instruments playing in unison at the same time, and there are also band formations formed by a combination of multiple instruments. According to the division of musical instrument timbre types in this section, the timbres of musical instruments can also be divided into two types: national orchestra and Western orchestra. The national orchestra includes four categories of wind instruments, stringed instruments, plucked instruments, and percussion instruments. Western orchestras are also known as symphony orchestras. Western musical instruments can also be divided into four groups according to the origin and timbre of the instruments—woodwind, brass, strings, and percussion. The combination forms of the two bands are extremely rich. With the development of composition technology and the development of cultural exchanges, Chinese and Western instruments also appear in many musical works at the same time. Due to the wide variety of Chinese and Western musical instruments, the combinations are endless. In this article, the author takes Western musical instruments and Western orchestras as the main content and conducts research and discussion on musical instrument timbre perception training [15, 16].

3.3.3. Classification of Human Voices. In the classification of vocal timbre, according to the bel canto method, the timbre difference of human voice can be divided into children's voice, male voice, and female voice according to age and gender; according to the division of the range, it can be divided into soprano, alto, and bass; in the field of mixed chorus, it can be divided into soprano, mezzo-soprano, tenor, and bass. After synthesizing various vocals, it is divided into children's voices, male voices, and female voices as a whole. To sum up, most scholars divide human voices into children's voices, male voices (tenor, baritone, bass), and female voices (soprano, mezzo-soprano, and alto) after synthesizing the above classification basis.

4. Audio Feature Extraction Based on Harmonic Components

This chapter proposes an audio feature based on harmonic components to describe the harmonic structure information in the audio signal spectrum. This chapter first introduces the commonly used frequency-domain features and then introduces the human brain's perception characteristics of harmonic signals. In particular, the research results in psychoacoustics on the use of fundamental frequency, spectral peaks, and timbre in the harmonic signal by the human brain to distinguish different audio signal types. On this basis, a harmonic dictionary is proposed, which describes the harmonic structure in the spectrum by constructing harmonic atoms composed of fundamental frequency, formant, and overtone energy decay rates in the frequency domain.

4.1. Frequency-Domain Features of Audio. Sound is a mechanical wave that can be transmitted by vibrations in solids, liquids, and gases. Most commonly, it is airborne to the human ear. There are cilia of different lengths in the inner

tribal instrument western musical instruments

Figure 3: Some ethnic and Western musical instruments.

Table 1: Classification of Western musical instruments.

Stringed instrument	Bowed string instrument	Violin, viola, cello, double bass
	Plucked instruments	Harp
Wind instrument	Woodwind	Flute, clarinet, oboe, bassoon
	Brass instruments	Trumpet, horn, trombone, large
Percussion	Has a fixed pitch	Timpani, xylophone, carillon, row bell, etc.
	No fixed pitch	Snare drum, bass drum, triangle, cymbal, tambourine, gong, etc.
Keyboard instrument	—	Piano, celesta
Electric musical instrument	—	Electronic organ, electric piano, etc.

Table 2: National instruments.

Wind instrument	Whistleless musical instrument	Flute, pan flute, etc.
	Whistle instrument	Pipe, suona
	Reed instrument	Sheng
Stringed instrument	—	Gaohu, jinghu, erhu, banhu, zhonghu, zuihu, etc.
Plucked instruments	Play musical instrument	Pipa, ruan, sanxian, yueqin, etc.
	Flat musical instrument	Zither, guqin
	Stringed instrument	Dulcimer
Percussion	Drums	Drums, war drums, waist drums, long drums, etc.
	Gong class	Big gong, small gong, cloud gong, etc.
	Cymbals	Large cymbals, small cymbals, cymbals, etc.
	Bang class	Board, clapper, wooden fish, etc.

ear of the human ear. Through the resonance of the cilia, the mechanical vibrations are converted into nerve impulses. After the impulses reach the brain, they "hear" the sound through a series of higher-level perceptions [17, 18]. Since ciliary resonance reflects that the human ear can convert time-domain signals into frequency-domain signals, researchers have proposed a variety of frequency-domain features that reflect spectral characteristics. The discrete Fourier transform (DFT) can transform a sequence of time-domain samples of an audio signal into the frequency domain, converting the audio signal x_m of the mth frame length of N sampling points to the frequency domain; X_m can be calculated by the following formula:

$$X_m(k) = \sum_{n=1}^{N} x_m(ne)^{-2i\pi nk/N}. \quad (1)$$

Among them, n $(1 \le n \le N)$ and k $(1 \le k \le K)$ are the time-domain and frequency-domain sampling indices, respectively, and K is the DFT length. On this basis, there are various spectral features used to describe the distribution characteristics of the spectrum:

(1) Bandwidth. The bandwidth of an audio signal describes whether the frequency distribution of the signal is more dispersed or relatively concentrated and is defined as follows:

$$BW_m = \sqrt{\frac{\sum_{k=1}^{K} (k - SC_m)^2 |X_m(k)|^2}{E_m}}. \quad (2)$$

The bandwidth of speech is generally 300~3400 Hz, and the bandwidth of music is usually much larger

than that of speech, which can be as high as 22 KHz [19].

(2) Sub-band energy ratio. The spectral distribution of audio signals generated by different sound sources is different. For example, the spectral energy of speech signals is mainly concentrated in the low-frequency part, while the spectral distribution of music signals is relatively average. Therefore, by dividing the frequency band into several sub-bands, and separately calculating the energy ratio of each sub-band to the entire spectrum, the distribution characteristics of the spectral energy can be roughly described.

$$SER_{m,i} = \frac{\sum_{k=L_i}^{H_i} |X_m(k)|^2}{E_m}. \quad (3)$$

Among them, H_i and L_i, respectively, represent the upper and lower frequency of the ith sub-band, and the sub-band bandwidth $H_i - L_i$ can be divided into equal or unequal lengths.

(3) Sub-band spectral flux. Sub-band spectral flow refers to the cumulative change of the corresponding intensity of adjacent frequencies in each sub-band of the spectrum, which can be used to detect the frequency components of sudden changes in each sub-band, and is defined as

$$SF_{m,i} = \frac{1}{H_i - L_i} \sum_{k=L_i}^{H_i} \left| \widehat{X}_m(k+1) - \widehat{X}_m(k) \right|. \quad (4)$$

Among them, $\widehat{X}_m(k)$ refers to the normalized spectral signal. The normalization is to avoid the scale difference between different frames due to different energies. It is achieved by converting the spectral energy into a decibel scale and normalizing it to unit energy, that is,

$$\widehat{X}_m(k) = \frac{10\log_{10} X_m(k)}{\sqrt{\sum_{k=1}^{k} \left|10\log_{10} X_m(k)\right|^2}}. \quad (5)$$

(4) Spectral roll-off point. The spectral roll-off point is defined as at frequency RP_m, the sum of the spectral amplitudes less than this frequency accounts for 85% of the sum of the entire spectral amplitudes, that is,

$$\sum_{k=1}^{RP_m} X_m(k) = 0.85 \sum_{k=1}^{K} X_m(k). \quad (6)$$

The spectral roll-off point describes the energy ratio of the low-frequency part and the overall shape of the spectrum.

(5) Linear prediction coefficient (LPC) and linear spectrum pair (LSP). Linear prediction coefficient refers to the method of describing the vocal tract model that produces speech using linear prediction analysis [20], as shown in Figure 4.

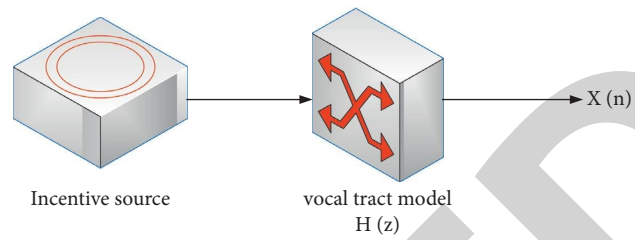


Figure 4: Linear prediction model for speech production.

Usually, an all-pole model is used to describe the vocal tract model, as

$$H_p(z) = \frac{G}{A_p(z)} = \frac{G}{1 - \sum_{i=1}^{p} a_i z^{-i}}. \quad (7)$$

Among them, G is the gain, $A_p(z)$ is the transfer function of the p-order linear filter, and a_i, $i = 1, \ldots, p$ represents the linear prediction coefficient, that is, the filter parameter. The prediction coefficient is usually obtained by minimizing the prediction error, and the solution algorithms include covariance method, autocorrelation method, and Levinson–Durbin grid method. Among them, the Levinson–Durbin algorithm is the most commonly used [21, 22].

Line spectrum pair is a feature based on linear prediction and a deduction parameter of linear prediction coefficient. In harmonic signals, this feature describes the distribution characteristics of formants (i.e., peaks of spectral envelope). The line spectrum pair feature treats the channel as a cascade of $p+1$ resonant cavities, which represent the resonant frequencies of the resonators when the excitation energy is at a local minimum or a local maximum, respectively. In speech signal processing, it corresponds to the resonant frequency of the vocal tract when the glottis is fully closed or fully opened.

The recurrence relation of the transfer function can be obtained by the Levinson–Durbin algorithm,

$$A_{p+1}(z) = A_p(z) - k_{p+1} z^{-(P+1)} A_p\left(z^{-1}\right). \quad (8)$$

Among them, the reflection coefficients $k_{p+1} = 1$ and $k_p = -1$ correspond to the boundary conditions when the glottal door is closed and opened, respectively, and $P(z)$ and $Q(z)$ are used to represent $A_{p+1}(z)$ when $k_{p+1} = 1$ and $k_p = -1$ are, respectively,

$$P(z) = A_p(z) - z^{-(P+1)} A_p\left(z^{-1}\right), \quad (9)$$

$$Q(z) = A_p(z) + z^{-(P+1)} A_p\left(z^{-1}\right), \quad (10)$$

$$A_p(z) = \frac{1}{2}\left[P(z) + Q(z)\right]. \quad (11)$$

The roots of equations (9) and (10) both lie on the unit circle of the z-plane and alternate, representing $P(z)$ and $Q(z)$ in the form of factorization, respectively,

$$P(z) = \left(1 - z^{-1}\right) \prod_{i=1}^{p/2} \left(1 - 2\cos w_i z^{-1} + z^{-2}\right),$$
$$Q(z) = \left(1 + z^{-1}\right) \prod_{i=1}^{p/2} \left(1 - 2\cos \theta_i z^{-1} + z^{-2}\right), \tag{12}$$

where roots w_i and θ_i satisfy

$$0 < w_1 < \theta_1 < \ldots < w_{p/2} < \theta_{p/2} < \pi. \tag{13}$$

The factorization coefficients w_i and θ_i appear in pairs and reflect the spectral resonance frequencies, so they are called line spectral pairs. Because of its good quantization and interpolation properties, it is widely used in the research on vocoders for speech coding.

4.2. Harmonic Dictionary. Humans can hear sounds with frequencies between 20 and 20 KHz. The objective description indicators of sound waves include frequency (fundamental frequency), harmonic components, sound pressure, and amplitude. Human perception of sound includes loudness, pitch, and timbre. Harmonic means that a signal can be decomposed into a fundamental frequency sine wave plus several other higher frequency sine waves, and each higher frequency is an integer multiple of the fundamental frequency. The frequency components of these octaves are usually called overtones (Overtones), for example, the 2 times the frequency components of the fundamental frequency are called the second harmonic or the first overtone. Usually, the generation of harmonic signals is due to the resonance phenomenon when the excitation source passes through a resonant cavity. The frequency of the excitation source corresponds to the fundamental frequency of the harmonic signal, and the resonance frequency of the resonant cavity is reflected in the frequency spectrum as the formant frequency. Taking speech as an example, the opening and closing cycle of the glottis determines the fundamental frequency, while the vocal tract as a resonant cavity determines the formant frequency. More commonly, many musical instruments such as violins, pianos, and guitars generate scales by resonating strings and resonating boxes with different vibration frequencies. The vibration frequency of strings is determined by the length, thickness, and material of the strings. Instruments such as violins and guitars control their fundamental frequency by changing the length of the part of the string that can vibrate by pressing a finger on the string. Harmonic characteristics can be used to distinguish sound sources with and without resonant cavities. Sound sources with resonant cavities can generate harmonic signals, such as the resonant cavities of speech and music, which are the vocal tract and the resonance box, respectively; sound sources without resonant cavities produce nonharmonic signals, such as the sound of brakes and the sound of a river, and some researchers have proposed algorithms to distinguish the two types of signals. While DFT is capable of converting a time-domain audio signal to the frequency domain, this method of extracting frequencies is different from how humans perceive them. According to the research results of psychoacoustics, when people hear a sound with harmonic structure, they do not perceive the frequency of each single overtone in turn, but perceive the signal as a fundamental frequency as a whole. The number of overtones, energy size, and overtone energy decay rate is perceived as timbres. This perceptual fusion phenomenon is due to the brain's ability to use harmonic relationships to organize complex acoustic environments into independent acoustic targets. An intuitive example of this brain function is when two speakers have a difference in fundamental frequency, even if they speak at the same time, a person can easily distinguish two speakers.

Fundamental frequency refers to the greatest common divisor of each octave in a harmonic signal and is an objective measure. Pitch refers to the pitch perceived by people, which mainly depends on the fundamental frequency, intensity, and subjective feelings of people. The fundamental frequency detection algorithm can be performed in the time domain or the frequency domain, usually using the method of directly finding the peak and trough positions, the autocorrelation function method, and the comb filter. The methods in the frequency domain include cepstral method, maximum similarity method, and methods based on wavelet transform. Timbre involves many fields related to psychology and is related to human perception and various characteristics of sound, including the nature, material, and shape of the sound source, the number of overtones, the rate of energy decay, and the shape of the spectral envelope. As shown in Figure 5, the time-domain waveforms and power spectrograms of the clarinet and violin in a short time frame (16 kHz sampling rate, 32 ms frame length) are shown. The overtone energy of the black tube attenuates quickly, the number of overtones is small, and its second formant appears around 1718 Hz. The violin has more overtones, and the second formant appears around 3125 Hz. These factors together determine the timbre characteristics of the clarinet's low sound and the violin's clearer sound.

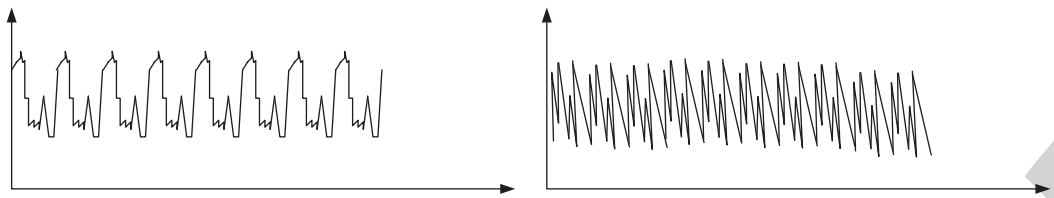
In this section, the signal spectrum is decomposed using the proposed harmonic dictionary and matching pursuit algorithm. Harmonic spectral component extraction technology is usually used in music signals, such as multi-fundamental frequency detection by decomposing the power spectrum of the signal into a series of base vectors.

The power spectrum s of a short-duration audio frame can be represented as a linear combination of a set of basis vectors.

$$s = \sum_{(f_{\max}, w, \sigma) \in A} \delta_{f_{\max}, w, \sigma} d_{f_{\max}, w, \sigma} + r. \tag{14}$$

Among them, $d_{f_{\max}, w, \sigma}$ are the atom in the dictionary, $\delta_{f_{\max}, w, \sigma}$ are the scale corresponding to the atom, and the $f_{\max}, w, \sigma$ parameters, respectively, represent the fundamental frequency, the center frequency, and the side lobe decay rate. A is the set of parameters for the selected atoms in the sparse representation, and r is the residual.

The solution process of the sparse representation adopts an iterative process based on the matching pursuit algorithm. In the ith iteration, a basis vector $d_{(f_{\max}, w, \sigma)^i}$ is chosen,



(a) (b)

Figure 5: Black pipe and violin waveforms. (a) Black pipe time-domain waveform. (b) Violin time-domain waveform.

multiplied by scale $\delta_{(f_{\max},w,\sigma)^i}$ and subtracted from the residual s^{i-1} of the spectrum.

$$s^i = s^{i-1} - d_{(f_{\max},w,\sigma)^i}\delta_{(f_{\max},w,\sigma)^i}. \tag{15}$$

This iterative process involves two key issues: one is how to choose the basis vector $d_{(f_{\max},w,\sigma)^i}$, and the other is how to find its scale. For the first problem, since the harmonic structure is essential for audio classification, each harmonic basis vector can be represented as a linear sum of a set of instantaneous basis vectors. Therefore, the harmonic components should be extracted from the spectrum first, and then the nonharmonic components should be extracted. In addition, since the basis vector with the highest correlation with the residual spectrum reflects the most significant structure in the residual spectrum, in each iteration, the optimal basis vector should have a high correlation with the residual spectrum. Therefore, in each step of selection, a basis vector with a harmonic structure and a high correlation with the residual spectrum is selected.

To prevent the spectral aliasing phenomenon of the signals obtained after framing, there will be several repetition points in the two frames before and after the music signal, and only a small section in the middle is a different signal. At the same time, the signal needs to be windowed during the framing process. Moreover to prevent the occurrence of spectral aliasing, the window function can choose rectangular windows and Hamming windows. The framing process is shown in Figure 6.

A sparse representation of the audio spectrum can be obtained through the MP algorithm; that is, a set of selected basis functions and their scales are used to characterize the power spectrum of the original signal. Among them, the parameters of the basis function characterize the fundamental frequency, center frequency, and frequency multiplication attenuation rate of the spectrum, and the scale indicates the proportion of the basis function in the signal power spectrum. Thus, the mean value of each parameter value weighted by the scale indicates the mean property of the signal power spectrum. In addition, the variance of each parameter can characterize the distribution range of each parameter. Therefore, by using the combination of the weighted mean and variance, the distribution of each parameter can be roughly depicted, reflecting the characteristics of the signal power spectrum.

It is assumed that the parameter set of the basis function selected by the sparse representation is $(f_{\max}, w, \sigma)^i$, $1 \le i \le I$, and I is the number of basis functions selected in the sparse representation. The scale set is δ^i, $1 \le i \le I$. Then, the weighted parameter mean values are, respectively,

$$\begin{aligned} \overline{f}_{\max} &= \frac{\sum_{i=1}^{I} \delta^i f^i_{\max}}{\sum_{i=1}^{I} \delta^i}, \\ \overline{w} &= \frac{\sum_{i=1}^{I} \delta^i w^i}{\sum_{i=1}^{I} \delta^i}, \\ \overline{\sigma} &= \frac{\sum_{i=1}^{I} \delta^i \sigma^i}{\sum_{i=1}^{I} \delta^i}. \end{aligned} \tag{16}$$

The variances of the parameters are, respectively,

$$\begin{aligned} \Delta f_{\max} &= \frac{1}{I}\sum_{i=1}^{I}\left(f^i_{\max} - \overline{f}_{\max}\right)^2, \\ \Delta w &= \frac{1}{I}\sum_{i=1}^{I}\left(w^i - \overline{w}\right)^2, \\ \Delta \sigma &= \frac{1}{I}\sum_{i=1}^{I}\left(\sigma^i - \overline{\sigma}\right)^2. \end{aligned} \tag{17}$$

The audio feature vector is represented as $[\overline{f}_{\max}, \overline{w}, \overline{\sigma}, \Delta f_{\max}, \Delta w, \Delta\sigma]$.

5. Extraction Experiment

This chapter mainly conducts simulation, verification, and analysis on the application performance of different classification models in musical instrument classification scenarios. Using the feature parameter extraction method in the previous chapter, the timbre feature parameter set of the existing music data source is extracted. Combined with pattern recognition technology, different classifiers are used for classification, training, and cross-validation of timbre feature parameter sets. And it compares and analyzes the classification results of different classification models, compares the advantages and disadvantages of each classifier, and lays the algorithm foundation for the design and implementation of the timbre analysis system. The overall flow of simulation analysis is shown in Figure 7.

After preparing the data source for the experimental simulation, first use the content of Chapter 2 to extract the timbre feature parameters of the data source in MATLAB and then convert the extracted timbre feature parameter

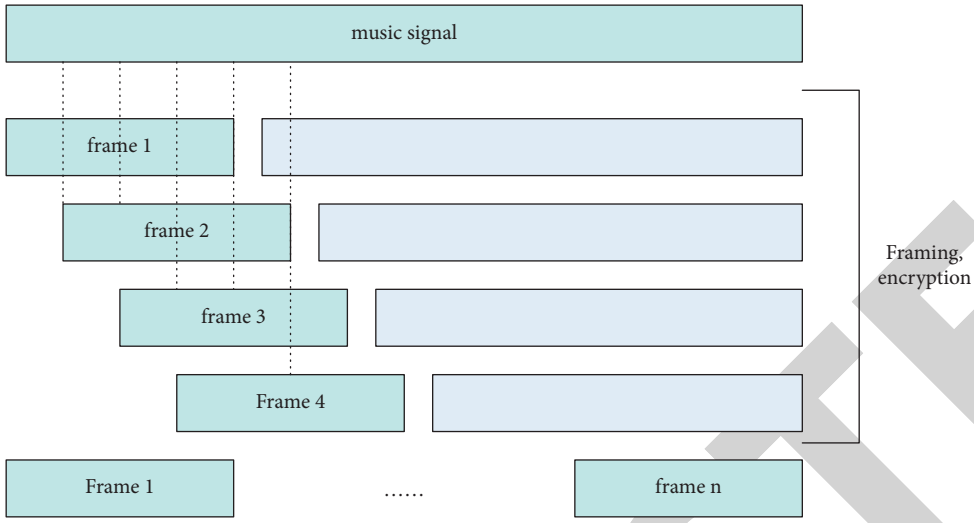


Figure 6: Framing process.

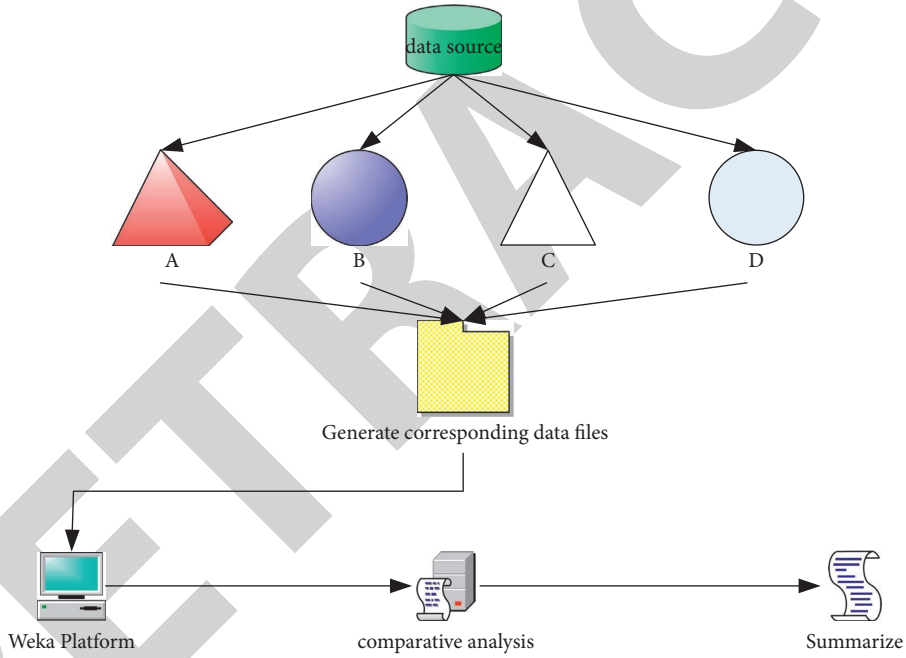


Figure 7: Overall flowchart of experimental simulation.

vector into the arf format that can be recognized by the Weka data mining tool text file. Based on the Weka platform, the feature parameter vector is classified, and some test data are provided to calculate the accuracy of the classification results. Finally, it is necessary to compare and analyze the classification results, summarize the advantages and disadvantages of different classification models, and lay the algorithm foundation for the design and implementation of the timbre analysis system in the next step.

5.1. Tone Feature Data Collection. To obtain comprehensive and accurate simulation results, the data sources used as learning samples and test samples in the simulation come from the Internet, recording equipment and musical instrument sound effects synthesized by software. All pieces are solo pieces played by a single instrument. To cover a wide range of music, this experiment selected eight instruments as sound sources, four of which were Western instruments: piano, violin, saxophone, and guitar; four oriental instruments are pipa, guzheng, flute, and erhu. In addition, among the eight musical instruments, violin, piano, guitar, pipa, guzheng, and erhu are percussion instruments, while flute and erhu are wind instruments, so that we can compare and analyze the timbre of musical instruments with similar pronunciation principles.

In the selection of music repertoire, the influence of performance style is also taken into account, and a considerable number of repertoires with fast, medium, and slow rhythms are selected for the repertoire played by each type of

instrument. In addition, to simplify the experimental data, this paper does not strictly distinguish the test data and the training learning samples, but inputs all data into the Weka tool platform for cross-validation.

The audio file format selected in this article is the audio in MP3 format, which is the most common audio file and has a suitable size. In addition, due to the limitation of practical conditions, this paper adopts the method of dividing a track into music segments ranging from 10 s to 30 s to expand the database, which has two advantages: one is to verify the effect of playing time on the classification results; the other is to eliminate the influence of other factors except timbre on the experiment. Of course, the method of segmenting music may have a certain impact on the accuracy of the experimental results, so there may be a certain deviation between the data obtained by the classification accuracy rate and the actual accuracy rate at the end. However, this does not affect the horizontal comparison between the various classifiers, nor does it affect the algorithm selection of the timbre analysis system design.

When slicing music files, it is necessary to eliminate the silent sections in the track, because these silent sections do not contain data, so it does not make any sense for this experiment. These silent segments need to be filtered, and this experiment uses endpoint detection to eliminate silent segments. The specific processing process of the endpoint detection algorithm is shown in Figure 8.

(A) Preprocess the music signal. The specific process is introduced in detail in the second chapter, namely, noise reduction, frame separation, etc.

(B) Calculate the short-term energy E of each frame.

(C) Calculate the zero-crossing rate (ZCR) of each frame.

(D) Set the threshold of short-term energy and ZCR, and the short-term energy and ZCR exceeding the threshold value are judged as valid signals.

(E) Delete the silent segment to obtain the output audio signal.

After deleting the silent segment, we use the MP3 cutting tool to cut the audio, and every 10 s-30 s there is a music segment. After cutting, the timbre, feature extraction can be performed.

A total of 950 pieces of music were used in this experiment, each piece being a solo piece for one instrument. A total of 8 musical instruments were collected in the experiment, including 4 Western musical instruments: piano, violin, saxophone, and guitar; 4 oriental musical instruments are pipa, guzheng, erhu, and dizi. Among the 950 pieces of music, there are 98 pieces for flute, 158 pieces for erhu, 122 pieces for piano, 122 pieces for guzheng, 100 pieces for guitar, 146 pieces for pipa, 132 pieces for saxophone, and 72 pieces for violin. The data distribution is shown in Figure 9.

The simulation analysis is carried out on the Weka data mining platform. The minimum distance classifier, decision tree classifier, SVM classifier, and BP neural network implemented by Weka are used to train and learn the timbre feature parameter vector set to establish different classification models. The analysis method of the classification model is carried out by means of cross-validation.

5.2. Simulation Based on Weka. Weka is a completely open-source data mining work platform, designed and implemented by the University of Waikato based on Java language. As a data mining work platform, Weka collects a large number of machine learning algorithms capable of data mining tasks, which can be used directly or invoked in their own Java code. Weka includes tools for data preprocessing, classification, regression, clustering, rule association, and visualization. Weka is also suitable for secondary development of machine learning algorithms on its basis.

The datasets that Weka can handle are datasets in the form of two-dimensional tables. The row of the two-dimensional table represents the instance. In this experiment, one row represents the timbre feature vector (29 dimensions) of a piece of music; the columns of the two-dimensional table represent attributes, and Weka mines the relationship between attributes. The file format that Weka can handle is ARFF (Attribute-Relation File Format) file. In this experiment, after the timbre feature parameter vector set is extracted, it needs to be converted into the corresponding ARFF file that Weka can recognize.

The timbre feature parameter of a piece of music is a 29-dimensional feature vector, so when it is converted into an ARFF file, each feature vector has a total of 30 columns, that is, 30 attributes, because it is necessary to add a one-dimensional column of instruments to the feature vector. In this way, the ARFF file finally generated in this experiment is a $950 * 30$ two-dimensional dataset. The latest Weka3-6 requires running in a JVM with jdkl. 7 or above, and a Java environment needs to be configured before simulation with Weka.

5.3. Summary of Simulation Results. The experimental simulation of training and learning is carried out on the musical instrument timbre dataset, and four different audio feature extraction methods are used to classify musical instrument timbres, namely, MFCC and spectral features (SF). The HCE features proposed in this paper and the spliced MFCC + HCE features are denoted as A, B, C, D for convenience in the text. The two groups of feature parameters with different dimensions are compared and analyzed. Group A is the sample containing only the MFCC parameters, and group B is the sample containing all feature parameters. The simulation results show that the classification accuracy of group B data is higher than that of group A, which shows that the parameters selected in this paper are all effective feature parameters. In this section, the simulation results of group B will be analyzed in detail. The accuracy of the cross-validation results of the classifiers implemented by different algorithms is shown in Table 3.

Analyzing the overall classification situation, it can be seen from Figure 10 that the classification accuracy of the four feature extractors is above 92%. Among them, B has the worst effect, with an accuracy rate of 92.42%, while D has the best classification effect, with an accuracy rate of 99.15%. For

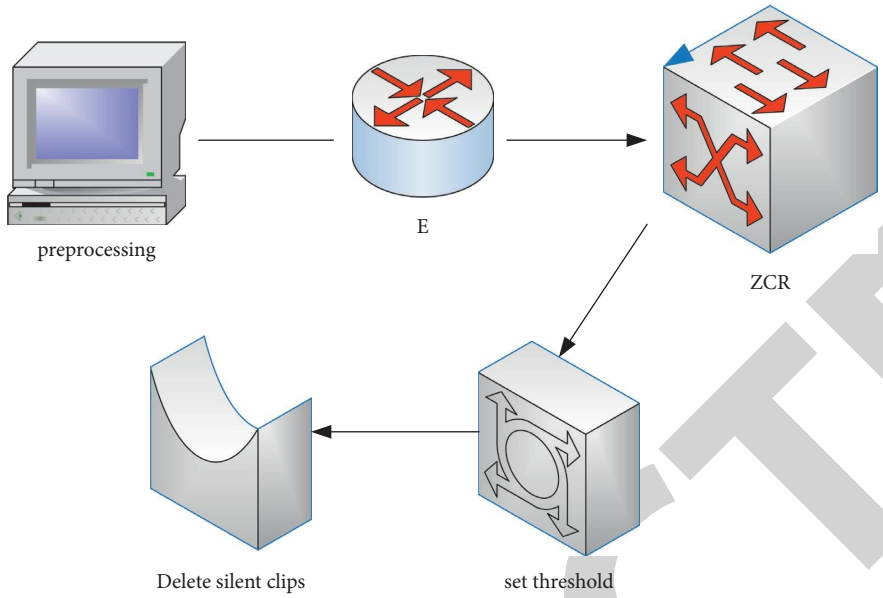


Figure 8: Silence removal process.

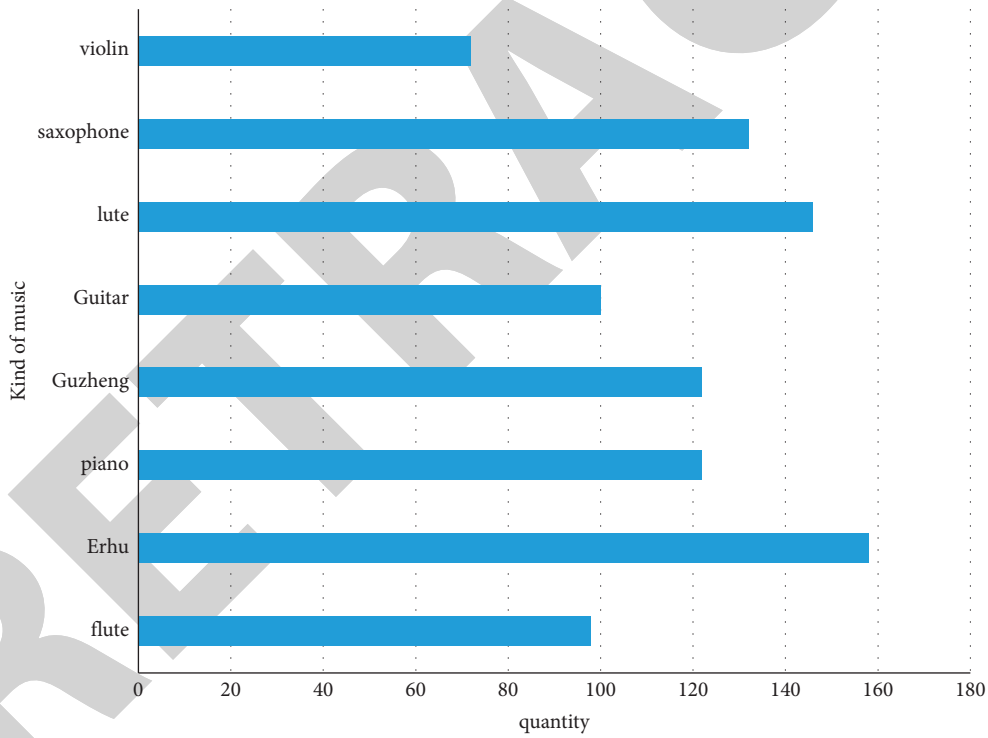


Figure 9: Distribution map of timbre feature dataset.

a single instrument, all 100 guitar samples are correctly classified in the four classifiers, indicating that the guitar timbre has obvious characteristics and is easy to distinguish; there are a few errors in the classification of piano and flute timbres in the four classifiers, as can be seen from the confusion matrix of each classification result in the previous section. Most of the wrong types of piano timbres are classified as guzheng, and the wrong classification of guzheng is also classified as piano, which shows that the timbres of piano and guzheng are relatively similar and easy to be confused. The error situation of the flute is more complicated, indicating that the sound of the flute and valid information have not been found. The violin and saxophone are also easy to be confused, indicating that the tone of the violin and the saxophone has something in common, and the two can bring a similar auditory experience.

Different feature extraction models have different accuracy rates, which shows that the selection of the classification model has a great influence on the classification results. As can be seen from Table 3 and Figure 10, D has the

Table 3: Implementation of different feature extraction algorithms.

Musical instrument		A	B	C	D
Flute	Correct	91	86	89	94
	Mistake	7	12	9	4
Erhu	Correct	154	153	155	158
	Mistake	4	5	3	0
Piano	Correct	116	110	111	118
	Mistake	6	12	11	4
Guzheng	Correct	121	112	111	122
	Mistake	1	10	11	0
Guitar	Correct	100	100	100	100
	Mistake	0	0	0	0
Lute	Correct	144	123	137	146
	Mistake	2	23	9	0
Saxophone	Correct	132	128	132	132
	Mistake	0	4	0	0
Violin	Correct	66	66	72	72
	Mistake	6	6	0	0
Summary	Correct	924	878	279	942
	Mistake	26	72	141	8

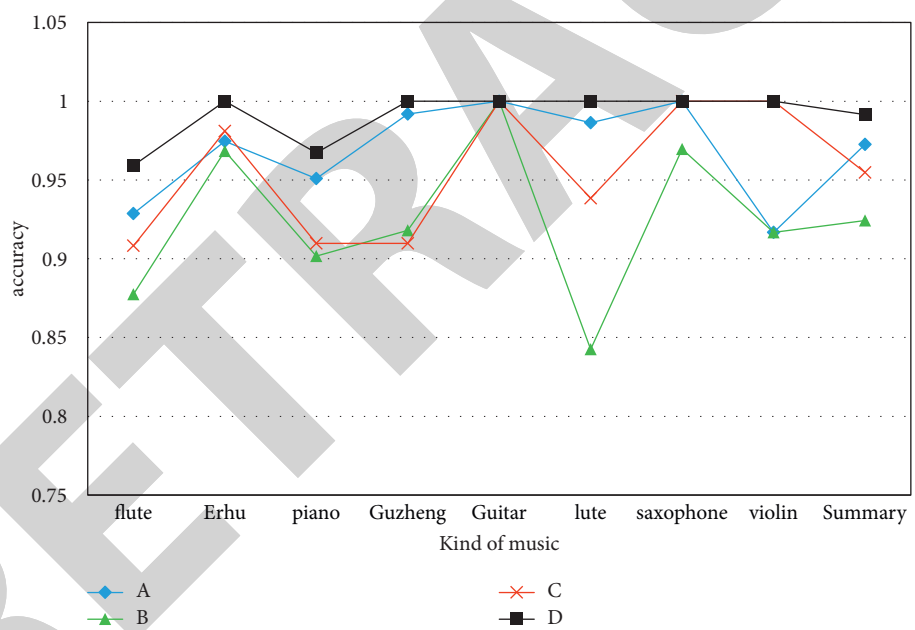


Figure 10: Accuracy achieved by different feature extraction algorithms.

best classification effect, with an accuracy rate of 99.15%, but its time consumption is relatively long, while the second algorithm A has certain advantages in time consumption. For these two classification algorithms, after a trade-off comparison, the classifier implemented by the *D* algorithm is the most suitable for timbre classification. There are two main reasons: first, although the time overhead of the MFCC + HCE feature extraction algorithm is relatively small, its *K* value is an empirical value, and there is currently no scientific method for selecting the *K* value. In the process of training and learning, repeated parameter adjustment is required to ensure the accuracy of the classification model, and the *C* algorithm is not practical when the number of classification categories increases. Although the MFCC + HCE feature extraction algorithm takes a long time, the parameter adjustment of this algorithm is mainly to adjust the weight of the feature parameter vector itself, so it has a similar value method for the same mode, which is more stable than the C algorithm. Second, the generation of the classification model itself can be calculated as an offline method, the result is more important than the process, and the offline calculation is not sensitive to the time overhead. Considering the above two points, the classifier implemented by the MFCC + HCE feature extraction algorithm is the most suitable for musical instrument classification.

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Research Article

Innovative System for Analyzing English Translation Software Based on IoT Big Data

Rongliang Niu[1,2] and Wei Yang[1]

[1]*School of Foreign Languages, Zhanjiang University of Science and Technology, Zhanjiang 524088, Guangdong, China*
[2]*School of Humanities, Universiti Sains Malaysia, Penang 11800, Malaysia*

Correspondence should be addressed to Wei Yang; yangwei@zjkju.edu.cn

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With the continuous expansion and deepening of international exchanges and cooperation, language differences have become the biggest obstacle to exchanges and cooperation. At present, English translation software is the translation between natural languages made by humans on the basis of computers. As an important technical means to break through language barriers, machine translation is a software that uses computers to process spoken or written language. This paper aims to study the innovative system of English translation software, using the Internet of Things and big data algorithms to analyze some loopholes and deficiencies in the innovative system, and provide some data research for the system update. This paper proposes to analyze the innovative system of translation software based on the big data of the Internet of Things (IoT). Among them, the big data of the Internet of Things chooses the dynamic frame time slot ALOHA algorithm and the lower limit estimation algorithm. Its application in system analysis is very innovative. The system consists of a translation engine and a machine dictionary, which solves the basic problem of insufficient translation database of current translations, and plays a role in helping the English translation software innovation system to improve the accuracy of translations. The experimental results of this paper show that the translation system's translation software achieves 61.3% of the A-target fluent translations, and 22.7% of the B-targets can translate the original text. It can be seen that English translation software has important research significance.

1. Introduction

With the increasing globalization of the global economy and the continuous and rapid development of the world's Internet applications, international Internet exchange activities and scientific and technological cooperation will become more and more frequent and the division of labor is meticulous. Language differences have become the two biggest language barriers in the current international information technology exchange and learning and scientific and technological cooperation and development. It is also becoming increasingly important in the global economic development environment and the field of contemporary social life, and it is one of the main focuses of current research and discussion.

Entering the 21st century, with the gradual intensification of international cooperation, exchanges and competition in society, and the arrival of the global Internet era, the level of social informatization in society as a whole will inevitably become higher and higher. In order not to be gradually eliminated by the tide of this era, people have to keep up with the tide of the times and always pay attention to the latest social dynamic information at the forefront. Most of the above dynamic information materials are also the first time that they appear publicly in the form of pure foreign languages on the modern Internet media. Therefore, despite the rapid development of Internet language in recent decades, the existing language machine translation system is still unable to guarantee a satisfactory overall translation effect, especially the translation of some complex sentence sequences and complex chapters. Therefore, the comparative research method of machine language translation effect should not only have important scientific value, but also must have practical application value. The most meaningful point of view is that under the requirements of the

development situation in the new century, it is of extremely practical and far-reaching significance to further develop and study language machine semantic translation comparison technology and improve the overall translation effect in the existing machine language translation comparison system.

The novelty of the article is as follows: (1) this article analyzes the English translation software system by using the method of Internet of Things big data, which greatly improves the analysis efficiency and the evaluation speed of system. (2) Based on the theoretical basis of designing a language framework system, this paper successfully designs and implements other practical functions in the machine vision translation language system. One of the key contents is the realization of the grammar design function of the English-Chinese electronic dictionary system. And it realizes the automatic alignment of English-Chinese sentence structure and the semantic design function of English-Chinese sentence translation system. (3) The translation thesaurus system specially researched and manufactured based on the big data platform of the Internet of Things can also be easily used for various expansion methods such as increasing the number of translation instances and expanding the translation vocabulary. Therefore, it can help people avoid some traditional rules-based machine language translation comprehension methods and apply this method to some more deep linguistic problems and analysis that must be reinterpreted.

2. Related Work

The Internet of Things is the "Internet of Everything Connected," which is an extension and expansion of the Internet based on the Internet. It is a huge network formed by combining various information sensing devices with the network, realizing the interconnection of people, machines, and things at any time and any place. Tallapragada V tracked customer sentiment and provides customer behavioral insights through an IoT-integrated data intelligence system running on Apache Spark Cluster [1]. Philemon Kibiwott proposed a more efficient scheme that borrows computing power from cloud servers to handle expensive computations, while leaving simple operations to users [2]. Jamil et al. proposed a new approach in which IoT data are processed and analyzed in real time using big data tools [3]. Ahmad and Afsal believed that fog computing originates from cloud computing and is implemented on the end user's device to deal with network latency [4]. Shin et al. applied a system for processing informal data by collecting, storing, processing, and analyzing data [5]. Rajeswari et al. used IoT devices to sense agricultural data and store it in a cloud database, using cloud-based big data analytics to analyze the data [6]. Zhao et al. proposed an IoT data credibility detection method based on regional context, which can effectively detect point anomalies, behavior anomalies, and context anomalies [7]. Granat et al. proposed an event detection method for one-dimensional data streams, which relies on an event intensity function and is an extension of the typical "true or false" decision scheme [8]. Wei et al. provided a comprehensive review of IoT data flow management. We first analyze the key challenges faced by IoT data flow and provide a preliminary overview of related technologies in data flow management, spanning data flow perception, mining, control, security, privacy protection, etc. [9]. Palaniswami et al. presented a useful set of visual assessment tools and techniques for clustering trend (VAT). It further highlights how these technologies are advancing IoT through large-scale IoT implementation [10]. Meerja et al. studied IoT data algorithms to share their data with the online world to obtain global knowledge and information with high commercial value [11]. This work by Almeida A involves key performance analysis of an IoT-aware ambient-assisted living (AAL) system for elderly monitoring. The analysis focuses on three main system components: (i) a city-wide data acquisition layer, (ii) a centralized cloud-based data management repository, and (iii) a risk analysis and forecasting module [12]. Ko and Kim's goal in research is to develop a healthcare platform. The platform can receive diabetes information based on remote input, storage, analysis, processing, and visualization of diabetes information generated by various IoT [13]. However, the practicality of these experiments is not too strong, and they only stay in the preliminary theoretical stage.

3. IoT Big Data

3.1. Dynamic Frame Slot ALOHA Algorithm. When the dynamic frame slot ALOHA algorithm faces the number of tags existing in the tag reader, the number of dynamic frame slot tags existing in a dynamic frame domain can also be changed. It is one of the most widely used DFSA algorithms in the Internet of Things [8]. In the DFSA algorithm, it is assumed that the initial frame rate range of the reader to be recognized is L, and the range of the number of tags within the time range set by the reader to be identified is m. Then, the probability that the reader is set with t number of tags at the same time slot to be selected and identified at the same time is

$$P_{m,1/L} = C_m^L * \left(\frac{1}{L}\right)^t * \left(1 - \frac{1}{L}\right)^{m-t}. \tag{1}$$

According to formula (1), the expected value of the idle time slot when $t = 0$ can be obtained:

$$\begin{aligned} E_0 &= L * P_{m,1/L(0)}, \\ &= L * \left(1 - \frac{1}{L}\right)^m. \end{aligned} \tag{2}$$

When $t = 1$, the expected value of correctly identifying the time slot is

$$\begin{aligned} E_1 &= L * P_{m,1/L(1)}, \\ &= m * \left(1 - \frac{1}{L}\right)^{m-1}. \end{aligned} \tag{3}$$

The expected value of the collision slot when $t \geq 2$ is

$$E_t = L - E_0 - E_l. \tag{4}$$

After one round of recognition process, the correct recognition rate of the whole system is

$$\begin{aligned} R &= \frac{E}{L}, \\ &= \frac{m}{L} * \left(1 - \frac{1}{L}\right)^{m-1}. \end{aligned} \tag{5}$$

According to formula R, the derivation of the frame length L can be obtained:

$$\frac{dR}{dL} = \frac{d}{dL}\left(\frac{m}{L} * \left(1 - \frac{1}{L}\right)^{m-1}\right) = 0. \tag{6}$$

It can be obtained from the above formula that when $L \approx m + 1$, the working state of the system reaches the best, and theoretically the maximum throughput rate of the system can be obtained from the following formula to be 36.8%.

$$\begin{aligned} &\lim_{m \longrightarrow \infty} \frac{m}{L} * \left(1 - \frac{1}{L}\right)^{m-1} \\ &= \lim_{m \longrightarrow \infty} \left(1 - \frac{1}{m}\right)^{m-1} \approx 0.36788. \end{aligned} \tag{7}$$

Through the logical derivation and analysis of the above formula, it can be known that during each round of tag recognition in the system, the DFSA algorithm dynamically adjusts the frame length so that the frame length set by the tag reader is approximately matched or basically equal to the number of tags before the system is fully recognized by the tag. Only then can the system maximize the label throughput rate of the entire system.

3.1.1. Lower Limit Estimation Algorithm. The lower limit estimation algorithm assumes that in the identification process of each round, if there is a time slot collision phenomenon in the system, there are only two tags in each collision time slot. Therefore, in this round of label recognition process, the number of labels to be recognized in the next round of recognition process estimated by the lower limit estimation algorithm is

$$N_{\text{est}} = 2 * E_t. \tag{8}$$

The algorithm assumes that only two tags will respond if they choose the same time slot. However, in practical applications, there may be more tags to select the same time slot, so the estimated number of tags in the above situation may be quite different from the actual number of tags. It can be utilized in the instance part and the structure construction part of the system analysis. The use of dynamic frame time slot algorithm to carry out the evaluation stage of the system can make the system evaluation result more accurate.

3.1.2. Three-Dimensional Estimation Algorithm. The 3D estimation algorithm is an effective image denoising algorithm. By matching with adjacent image blocks, several similar blocks are integrated into a three-dimensional matrix, filtered in three-dimensional space, and the result is inversely transformed and fused to two-dimensional to form a denoised image. The denoising effect of this algorithm is remarkable, and the highest peak signal-to-noise ratio can be obtained, but the time complexity is relatively high.

The three-dimensional estimation algorithm is that in the process of reader identification, if t tags select time slot j at the same time, the distribution function of the time slot can be obtained according to the above formula as follows:

$$p_t\{\text{Collision occurs when } t \text{ labels simultaneously select time slot } j\} = \begin{cases} 0 & t = 0.1, \\ \dfrac{p_t}{1 - p_0 - p_l} & t \geq 2. \end{cases} \tag{9}$$

Then, the average number of tags in slot j is

$$e_t = \sum_{t=2}^{l} t * p_t = \frac{\sum_{t=2}^{L} t * C_m^l * (L-1)^{m-1}}{L^m - (L-1)^{m-1} * (L - 1 + m)}. \tag{10}$$

The three-dimensional estimation algorithm estimates the number of tags according to the number of tags e_t and collision probability P_c in the collision time slot in the system, and its expression is as follows:

$$\begin{aligned} e_t &= 1.5 * P_c + 2\, P_c \prec 0.6, \\ e_t &= 12^{P_c - 0.6} + 1.90.6 \leq P_c \leq 0.8, \\ e_t &= 6^{3*(P_c - 0.6)} + 2.53\, P_c \succ 0.8. \end{aligned} \tag{11}$$

The number of tags to be identified in the next round is

$$U_{\text{est}} = e_t * E_t. \tag{12}$$

3.1.3. Schoute Estimation Algorithm. In the Schoute estimation algorithm, assuming that the number of tags in the selected time slot j obeys the Poisson distribution with a mean of 1, then the probability that time slot j is simultaneously selected by t tags is

$$P_t\{t \text{ tags simultaneously select time slot } j\} = e^{-1} * \frac{1}{t!}. \tag{13}$$

When the time slot collides, the number of tags in the selected time slot j can be obtained by the formula:

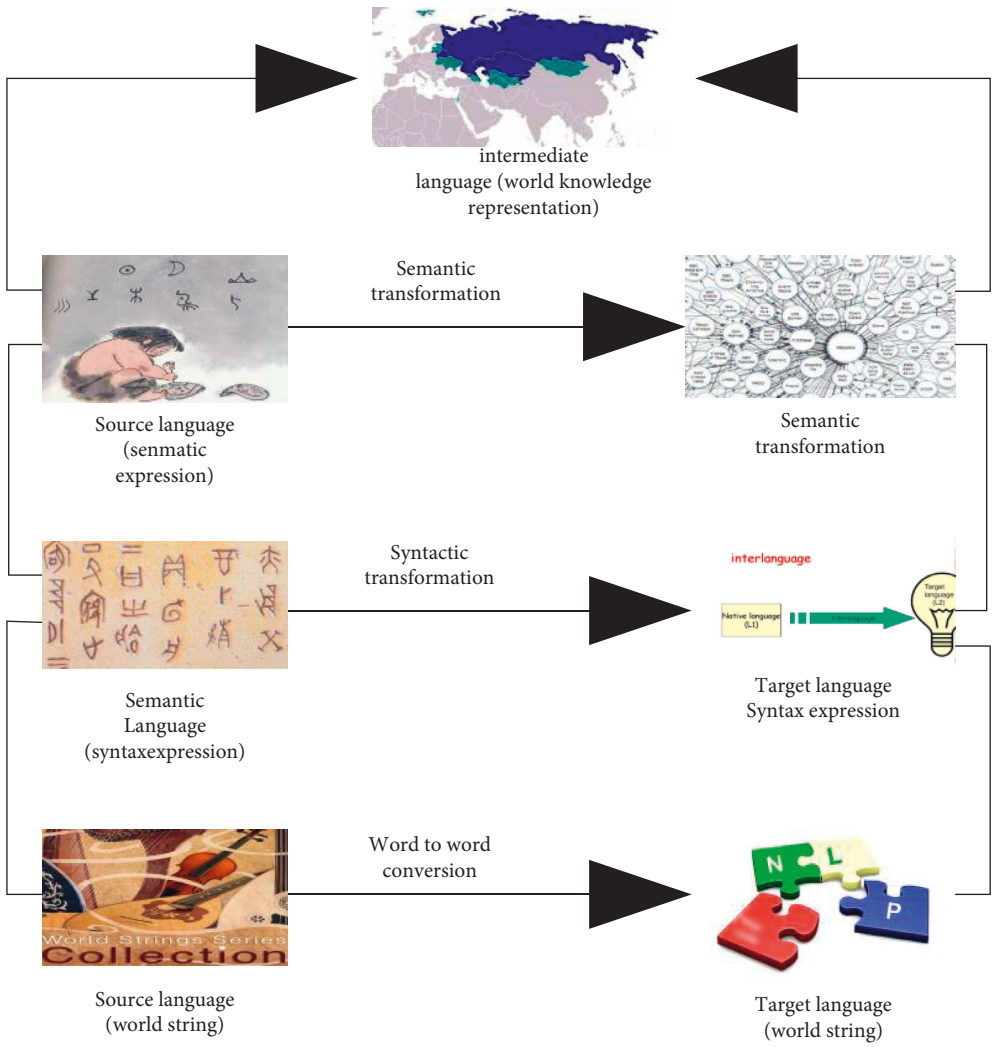

Figure 1: Different rule-based machine translations.

$$\sum_{t=2}^{\infty} t * p_t = \frac{\sum_{t=2}^{x} e^{-1} * 1/(t-1)!}{1-2e^{-1}} = \frac{e-1}{e-2} \approx 2.39. \tag{14}$$

Then, the number of tags to be recognized is

$$\text{Nest} = 2.39 * E_t. \tag{15}$$

3.2. Ant Colony Algorithm in Big Data. Assuming that in a certain environment network, there are m routing request points waiting for routing processing, there are at least n routing access points waiting for routing to perform tasks, and there are at least x ants in each routing group network. Ants will only randomly leave a small amount of pheromone on a certain path node during the whole process of foraging. The pheromone concentration will gradually volatilize with the arrival time. The next ant will only randomly re-select the path based on the remaining pheromone concentration after reaching that moment [9]. The probability that the kth ant chooses to transition from path i to path j is P_{ij}^k, and then the calculation formula of P_{ij}^k is as follows:

$$p_{ij}^k = \begin{cases} \dfrac{(\tau_{ij}^{\alpha})}{\sum_{b \in \text{allow}_k} (\tau_{ij}^{\alpha})(\eta_{ij})^{\beta}}, & j \in \text{allow}_k \\ & \text{else} \end{cases}. \tag{16}$$

Among them, τ_{ij} represents the pheromone in the set from path i to path j, η_{ij} represents the path length from path i to path j, allow_k represents the set of paths that the kth ant is allowed to pass through (unvisited), α and β are control parameters, and the value range is [0, 1].

When ants are looking for the optimal path, the update strategy of pheromone concentration is as follows:

$$\tau_{ij}(t+1) = (1+\theta)\tau_{ij} + \sum_{x} \Delta\tau_{ij}^k(t),$$

$$\Delta\tau_{ij}^k(t) = \begin{cases} \dfrac{Q}{d_k}, & \in \text{allow}_k, \\ 0, & \text{else}. \end{cases} \tag{17}$$

It can be seen from the above that the use of dynamic frame time slot ALOHA algorithm, lower bound estimation algorithm, and three-dimensional estimation algorithm in the Internet of Things and big data can be used to analyze innovative systems in English translation software. Then, there is a clearer analysis of its structure, rules, and some specific instances, and the ant colony algorithm is used to evaluate the system, which can make the evaluation results more accurate.

4. English Translation Software

4.1. English-Chinese Machine Translation System

4.1.1. Rule-Based Approach. The language method based on the study of language rules assumes the logical process of translation itself to understand and analyze other kinds of languages [14, 15]. Whether this is a transition language-based translation method or an intermediate transition language-based translation, the emphasis is only on the difference between their comprehensive analysis ability and in-depth mastery of the connotation problems of the switch language and the degree of high abstraction and generalization of the knowledge of the switch language and the connotation of the expression, as shown in Figure 1.

Rule-based methods have always dominated the machine translation community and still play an important role today, and the influential MTSs are now rule-based. However, compared with the traditional rule-based method, the current rule-based method has undergone many changes. These changes are mainly reflected in the following: in the acquisition of rules, traditional rule methods mainly rely on linguists to summarize rules and debug them. However, more emphasis is now placed on automatically obtaining rules from corpora. Traditional rule methods tend to focus on describing coarse-grained and globalized knowledge of large-scale linguistic rules. However, more attention is now paid to describing fine-grained, local, and small-scale linguistic knowledge, showing a trend of "small rule base, big dictionary."

To really develop such a machine semantic translation system based on natural language rules, people must first design a semantic knowledge representation system. All the language knowledge that may need to be used in the process of natural language translation is expressed in the form of an operational language that can be implemented on a computer [16–18], as shown in Figure 2.

4.1.2. The Overall Frame Structure of the System. The system framework is roughly divided into the following three parts:

(1) Translation System Knowledge Base. The learning process of machine language translation can actually be regarded as a process of learning language application-related knowledge to perform semantic reasoning operations. The representation of knowledge is the theoretical basis for understanding the translation process [17]. People often divide the various kinds of knowledge used in machine intelligent translation language into two categories according to the form of representation, such as knowledge inside the machine and knowledge outside the machine.

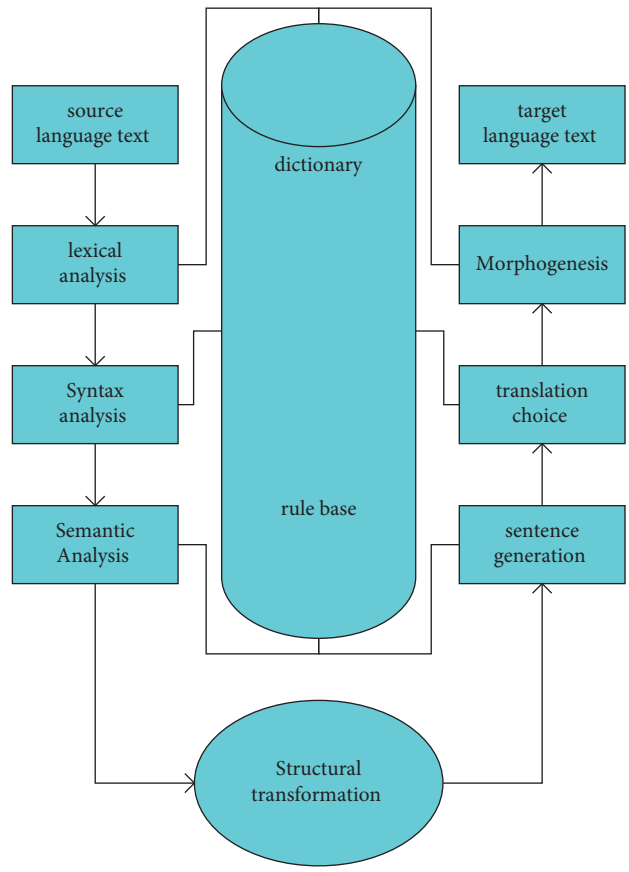

Figure 2: Rule-based transformation.

(2) System Processing Part. The English vocabulary processing part includes automatic English word segmentation processing and English word segmentation processing. These two parts mainly include the theoretical basis of phrases and sentence combinations of English sentence patterns. The automatic word segmentation system uses the highest matching algorithm. And the system can use various rule analysis and statistical analysis methods. In the part of automatic elimination and integration of English rule analysis, the system is divided into two parts: phrase analysis and sentence pattern matching.

(3) User Interface. The debug user interface used is usually divided into a system client and a debug user interface that can be managed by a system administrator. A very good visual effect and practical and concise machine learning translation and dictionary system compiler compilation management page and the management page of the entire compiler debugging work system, which can be specially designed to use a machine translation system, and the operator can also be very intuitive and can simply and accurately complete the compilation and management of all language rules. Therefore, the task implementation efficiency in the entire compiler and debugging work system can be greatly improved, and the overall work efficiency of the

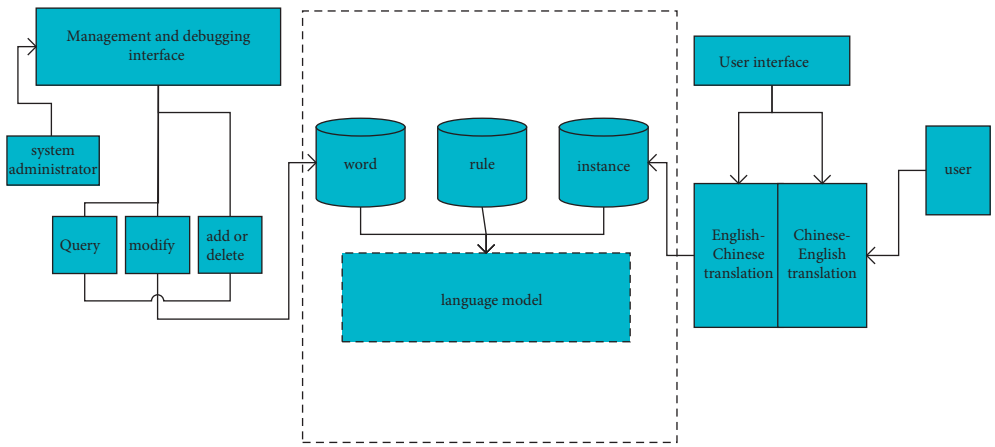

Figure 3: Overall architecture diagram of the system.

entire language knowledge base work system can be improved more efficiently, quickly, and accurately. The overall frame structure of the system is shown in Figure 3.

The knowledge management and debugging function interface that comes with the application system is responsible for two parts: knowledge base establishment, maintenance, operation, and knowledge translation and debugging management of natural language processing [18]. The system administrator can directly display the process of generating any syntactic component of the system and other syntactic feature nodes (attributes and values) corresponding to the system according to their needs.

4.1.3. System Translation Algorithm and Workflow. Many times, when people learn a new language, they learn it the way they did before. In many cases, it is often necessary to solve new grammatical problems based on the experience of people using some translation from the original language [19]. The main language translation information screening workflow involved in this translation system is roughly shown in Figure 4.

Among them, the rule method mainly refers to the translation design method based on transformation, which follows the translation design principle of generating rules while analyzing [20]. The specific translation algorithm is shown in Figure 5.

The input of the original text can use text files, keyboard input, and scan input:

If the text does not have any disambiguation rules, the text is automatically defaulted to the first part of speech. The improved figure parsing algorithm is automatically adopted in the stage of structural analysis. Most of the structural transformation steps use a local subtree transformation algorithm based on a combination of top-down and bottom-up [21]. In the process of constructing the structure, bottom-to-bottom local subtree transformation algorithms are applied, respectively.

4.1.4. Part-of-Speech Tagging and Structural Tagging of Phrases. The part-of-speech process is a scientific process in

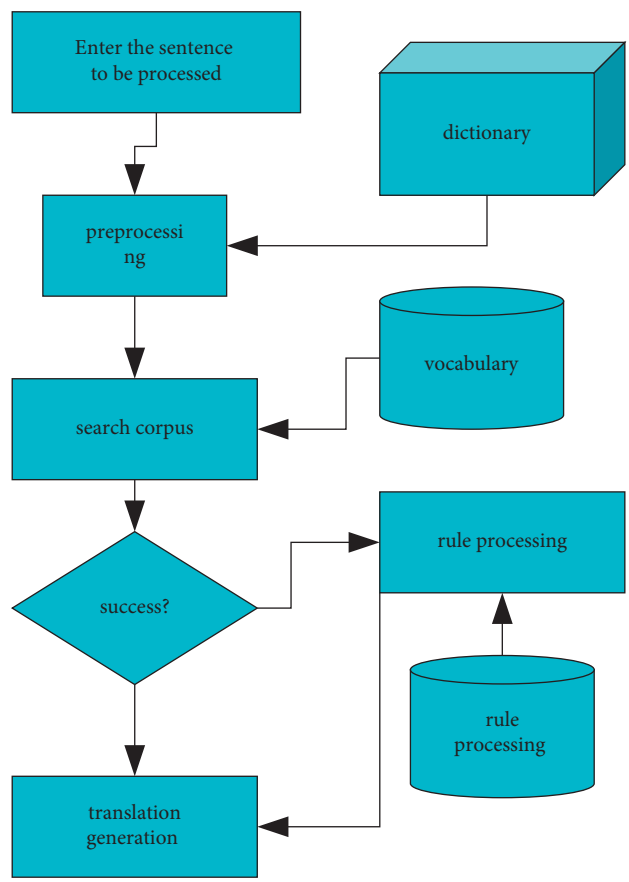

Figure 4: English-Chinese translation process.

which people comprehensively analyze and classify the basic part-of-speech system composed of various words involved in the entire sentence structure and standardize their use. There are mainly open parts of speech, which can continuously appear in large numbers of new English words. The four main types of open language parts of speech that appear in the contemporary English-speaking world are shown in Table 1.

Secondary part of speech is also called closed part of speech. Generally speaking, the number of words in these

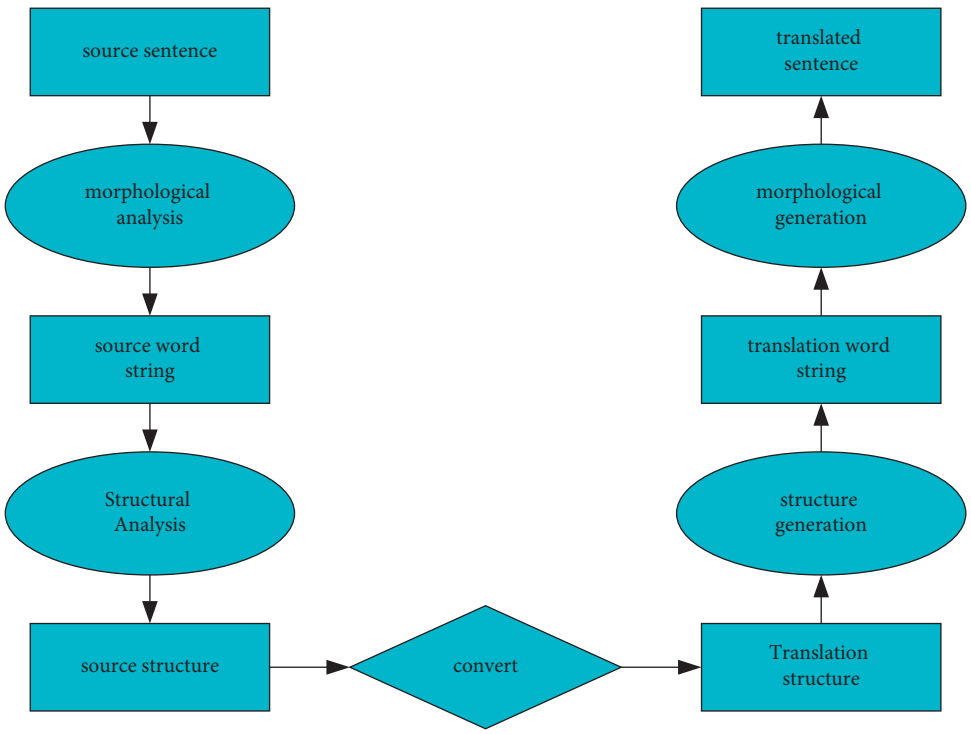

Figure 5: The translation process for rule processing.

Table 1: Main parts of speech in English.

Noun:	Student	Linguistics	Lecture
Verb:	Like	Read	Went
Adjective:	Tall	Lovely	Red
Adverb:	Loudly	Constantly	Hard

parts of speech remains fixed, and generally no other new words are allowed to be added. There are mainly six types of closed parts of speech in modern English vocabulary, as shown in Table 2.

Several words of different types of parts of speech can be individually combined into the same English phrase form or phrase. For example, in the process of syntactic structure analysis in English, one or several English words can form the following phrase structure in Table 3.

In the process of annotating English sentences, different sets of annotations are usually used in different corpora. In order to make the sentence structure more unique and recognizable, this system does not use standard English part-of-speech tagging rules and tagging sets based on context-free grammar. The annotation sets used in this system are shown in Table 4.

The conjugation forms of verbs in English are more complicated. For example, although the infinitive is a form of the verb, it can also function as a noun and retain some characteristics of the verb, so it is also marked as the infinitive phrase inf alone. The gerund form is also a form of the verb, which is also marked separately with the ger tag [22]. In addition, the past participle form of the verb is also marked with ppl.

Table 2: Secondary parts of speech in English.

Determiner	The, a, an
Auxiliary	Can, will, do, be, have
Preposition	In, at, to, on
Pronoun	He, she, us, mine
Conjunction	And, or, but, while
Interjection	Oh, ah, ouch

Table 3: Secondary parts of speech in English.

Noun phrase	A red brick, the beautiful lake
Verb phase	Sing a song, write in ink
Preposition phrase	On the table, at the gate
Adjective phrase	Very clever, quite able

Table 4: Annotation sets used by this system.

Np:	A red brick, the beautiful lake
Vp:	Sing a song, write in ink
Pp:	On the table, at the gate
Adjp:	Very clever, quite able
Advp:	Adverb phrase
S:	Sentence
Inf:	Infinitive
Idiom:	Idiom

In order to facilitate the alignment of English and Chinese words and phrases, the Chinese annotation set is roughly the same as the English one. However, Chinese does not have a variety of verb forms, so at this stage, the Chinese tagging set of this system is a subset of the English tagging set.

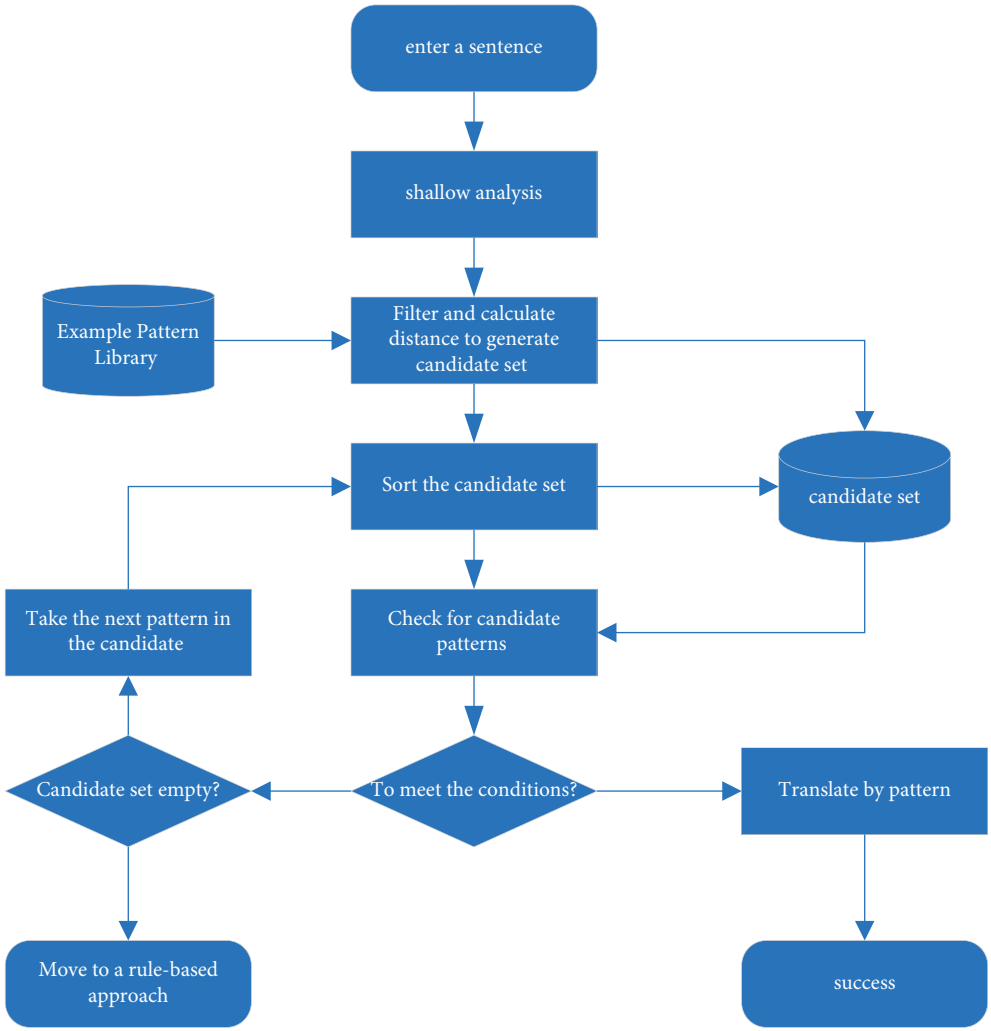

Figure 6: Matching algorithm flow.

4.2. Key Technologies of English-Chinese Translation System

4.2.1. Instance Pattern Matching. The strategy of instance pattern matching is to apply the input sentence and the results of lexical analysis, part-of-speech tagging, and shallow syntactic analysis of the input sentence to match the instance patterns in the library, that is, to calculate the similarity between the two [23]. Select the most basic similar instance pattern in the library as the matching result. At the same time, according to its target language pattern and phrase target pattern generation algorithm, it constructs a sentence and outputs all the translations in the sentence. The algorithm flow of instance pattern matching is shown in Figure 6.

4.2.2. Multi-Engine Translation System. Due to the limitation of corpus size, it is difficult for instance-based machine translation to achieve a high matching rate; people can use a relatively complete standardized translation method, combined with a sample library to take advantage of sequential processing [24].

In view of this, it is natural for people to think of effectively combining the two methods, which will definitely improve the quality of machine translation. As a result, the concept of multi-engine was proposed. The meaning of multi-engine is that a machine translation system adopts multiple translation methods, and each method is an engine, as shown in Figure 7.

It can be seen from the above that we can use the latest and most mature English computer software technology in the world, the advanced and perfect research results of contemporary English grammar theory, and a newly designed English-Chinese bilingual corpus. Constructing a most preliminary and complete contemporary English-Chinese machine language translation application system is the frontier topic that we focus on exploring and solving in this paper [25].

4.2.3. The Overall Design of the Dictionary Base Class. The division principle between the dictionary base class and the dictionary subclass in the dictionary class library: Various operations on the dictionary records of automatic

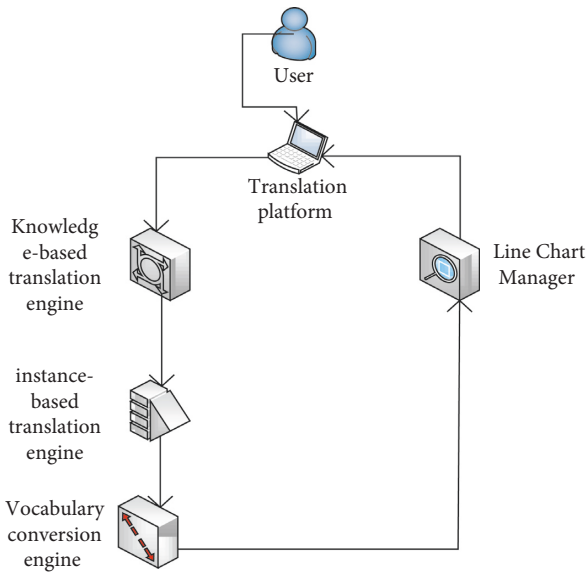

Figure 7: Multi-engine translation system structure.

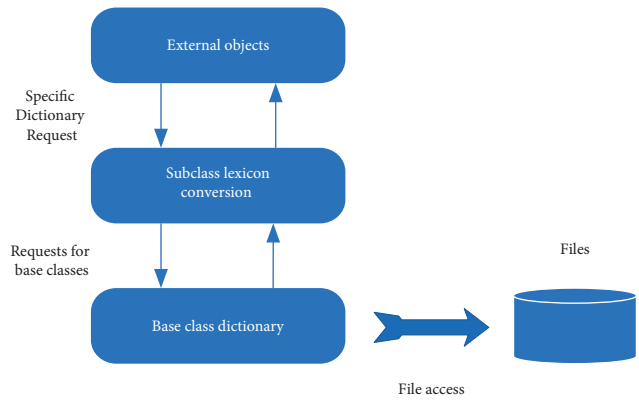

Figure 8: Subclass and superclass model diagram.

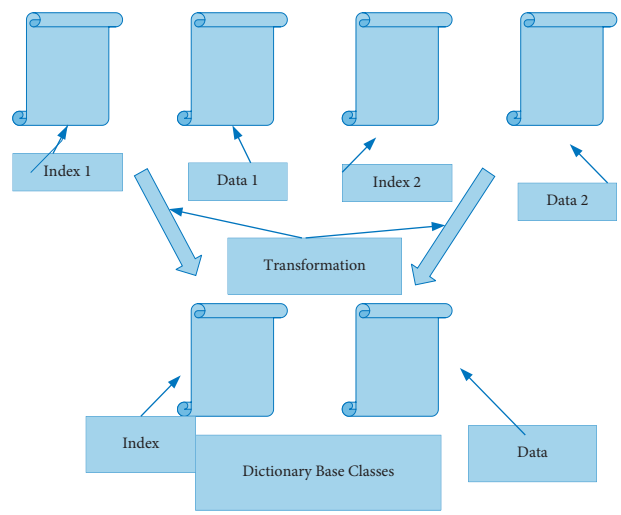

Figure 9: System diagram.

machine translation can be simply and abstractly divided into query, add, delete, and modify operations.

From a dynamic point of view, the subclass derived from the base class dictionary class provides an external calling interface. It can be built in the interface function library model that directly calls the corresponding type of function call. Functions such as direct function calls between the function library and the corresponding subclass functions of the function are automatically converted into the function itself directly calling the functions between the corresponding base class functions [26]. Various operations on external physical files are implemented by the base class. Figure 8 depicts the dynamic model between child and parent classes.

From a static point of view, the data relationship between the subclass and the base class is to map several keywords to one keyword or map several data items to one data item. In this way, the base class can be applied to a wider range. This static relationship can be represented by Figure 9.

5. English Translation System Evaluation and Results

5.1. English Translation System Evaluation. Based on the above proposed machine translation method and analysis, matching, transformation, and object generation methods, we design and implement an English-Chinese machine translation system. The system includes knowledge base subsystem, translation subsystem, knowledge management interface, and user interface. The knowledge base subsystem and translation subsystem are the main parts of the system, which are built on the language model and translation model, respectively, as shown in Figure 10.

Language model theory refers to the research on the definition and description of basic language attributes of natural language features by human systems. It is also a systematic re-understanding of the human natural language grammar model from the perspective of the processing law of speech information. The main types include subject parts of speech, sub-parts of speech, morphological features, semantic classes, syntax classes, sentence features, etc., in English. It is actually the mathematical basis for the application of description algorithms and translation algorithms of system language knowledge.

5.1.1. System Evaluation. In order to test the performance of the machine translation system, we organized relevant experts to form an evaluation team to evaluate the translation quality, translation speed, system maintainability, and scalability of the system. Among them, the dynamic frame time slot algorithm, three-dimensional estimation algorithm, and ant colony algorithm in the big data of the Internet of Things are used to make the results more accurate.

(1) Evaluation Method. The evaluation team consists of 1 machine translation expert, 1 linguistics expert, and 1 business unit expert. The evaluation method mainly adopts two methods: closed test and open test. The closed-ended sentence test means that each expert member of the evaluation team randomly selects some sentences from the

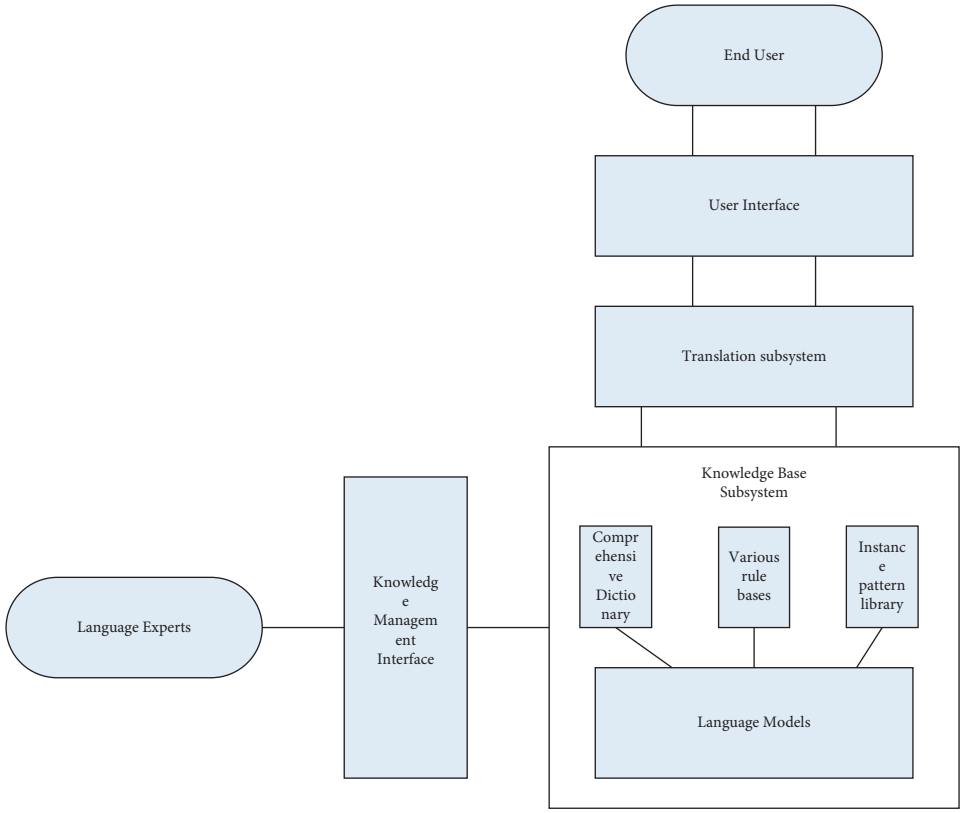

Figure 10: Structure of English-Chinese machine translation system.

sentences in the "English-Chinese Machine Translation Quality Test Outline" compiled by Peking University for closed-ended testing. An open-ended sentence test is a test conducted by English experts on some English sentences designed by them (due to the limited knowledge base of the system, the research group can supplement dictionary knowledge and rule knowledge on-site). After being automatically translated by the system, the experts of the evaluation team give an evaluation level to the translation quality of the translation results of each sentence according to the evaluation standards. Then, according to the evaluation method, the evaluation level is quantified and calculated, and the system translation quality evaluation value is obtained. The contribution of translation speed, system maintainability, and scalability to the system is directly scored by experts in the evaluation group. Finally, the overall evaluation value of the system is obtained, and the evaluation results are given by the evaluation team accordingly.

(2) Evaluation Criteria. According to the evaluation method of the machine translation system of the National 863 Plan, the translation quality is divided into 6 grades as follows: A, B, C, D, E, and F.

(A) The translation is accurate, fluent, and clear. The language accurately conveys all the various textual information contained in the translated original content in the text. Except for some small typos, there is no need to deliberately make any modifications or supplements.

(B) The translation conveys the information of the original. People can fully understand the true meaning of the Chinese translation without referring to the original Chinese text. However, this kind of translation will inevitably have some problems in many aspects, such as grammar, choice of translated words, Chinese vocabulary expression, and customary translation, which need to be revised repeatedly.

(C) The translation has roughly expressed the meaning of the readers' preliminary understanding of the original content, and the partial translation content is similar to the original text or may have some discrepancies.

(D) Part of the translation conforms to part of the meaning of the original text, but the whole sentence is not translated correctly, but the words in the whole sentence of the original text are translated, which is helpful for manual post-editing.

(E) The translation does not make sense, or the meaning is completely wrong. However, I always feel that there are so few partial sentences or some partial words that are well translated.

(F) All translations are not up to standard.

(3) Level Quantification. The quantitative evaluation of the translation quality level requires comprehensive quantification of the evaluation result level and then scoring. First, quantify the following 6 individual evaluation index grades

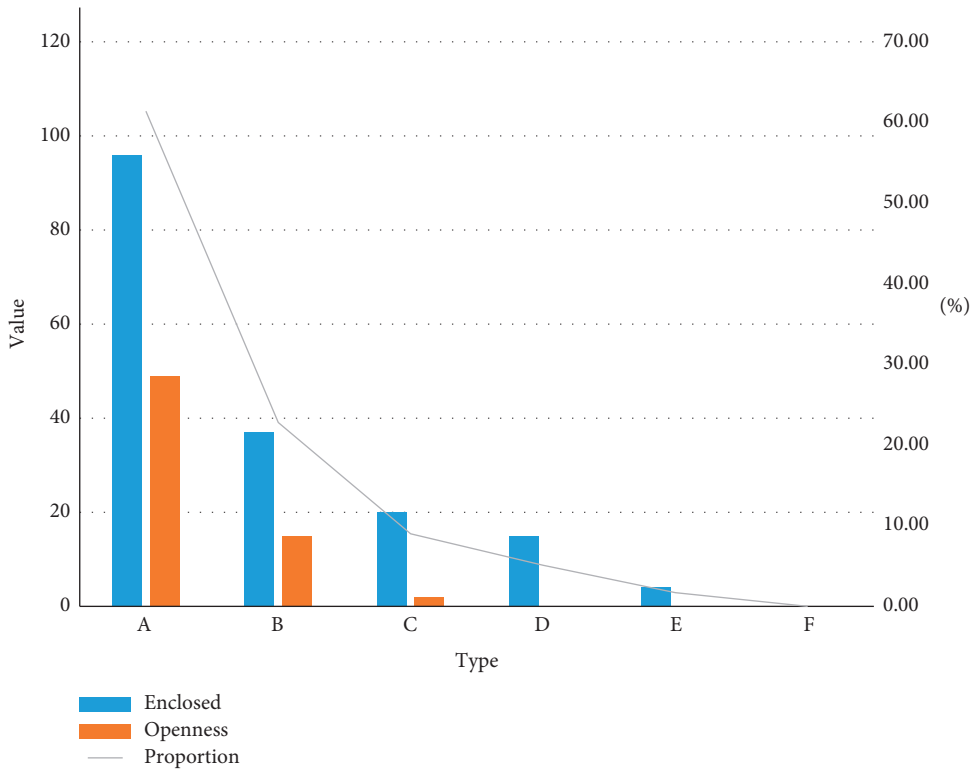

Figure 11: Quality of translation reviews.

in the translation quality: A-100 points, B-80 points, C-60 points, D-40 points, E-20 points, and F-0 points. Then input the corresponding Chinese-English reference sentences for each of the above indicators. After the full-text system is translated and processed, the translation expert team will give the corresponding evaluation level to the translation result according to the final translation quality score. Finally, after summarizing, the evaluation level is converted into a score, and the weighted average is calculated. For translation speed, maintainability, and scalability, the evaluation results are given by the evaluation team experts after evaluation. The total evaluation value of the system is obtained by summarizing [27].

(4) Evaluation Results. The closed test is to randomly select 58 simple sentences from the "Outline of English-Chinese Machine Translation Quality Test" compiled by Peking University and conduct a closed test. The open-ended test was tested by 22 simple sentences independently designed by the evaluation team. The overall test results of the three experts are shown in Figure 11.

5.1.2. Distribution Analysis of Syntactic Equivalence Pairs. To investigate the distribution of syntactic equivalence pairs, we count the number and length of syntactic equivalence pairs in the experiments. In Figure 12, we present the statistics on the number of syntactically equivalent pairs.

The length distribution of the syntactic structure nodes involved in the experiment is counted. The length of a syntactic node refers to the number of words and punctuation included in the segment covered by a syntactic node in a sentence. First, we count the distribution of the number of nodes in the syntactic equivalence pairs whose length is between 1 and 50 in the syntactic structure of the reference translation. Then, we calculated the ratio of the number of nodes in syntactic equivalence pairs to all syntactic nodes of the same length at different lengths [28], as shown in Figure 13.

From the above statistical results, we can find three main information. First, in terms of absolute quantity, it is obvious that the number of small-scale syntactically equivalent nodes is much larger than that of large-scale syntactically equivalent nodes. Second, from the perspective of quantity ratio, the ratio of nodes in syntactic equivalence pairs in large-scale nodes is higher than that in small-scale nodes. This shows that among the syntactic structures of sentences with the same semantics, consistent syntactic structures are more likely to appear in the high-level structures where large-scale nodes are located, and syntactic equivalence pairs exist.

(3) Distance Distribution Analysis of Wrong Word Order Conversion. Next, the distribution of distance information in Bilingual Error Word Order Transformation (Order-iBT) is calculated. First, the distribution of the reference translation lexical distance (RDt) of all Order-iBTs in Chinese-English and English-Chinese translations is calculated, as shown in Figure 14.

Figure 14 gives two pieces of information. First, the number of RDts with short distances is much larger than those with long distances, where ranking errors with distances 2 and 3 are the most common. Second, compared with Chinese-English translation, the distance of target

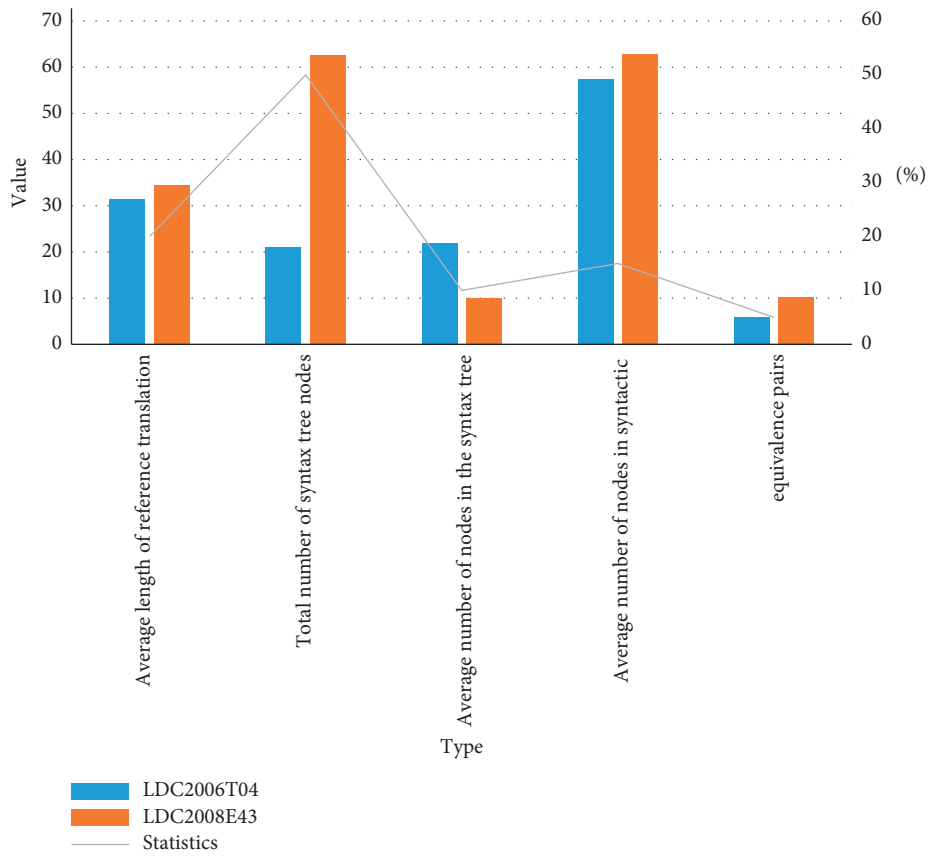

Figure 12: Node statistics in the reference translation syntax tree.

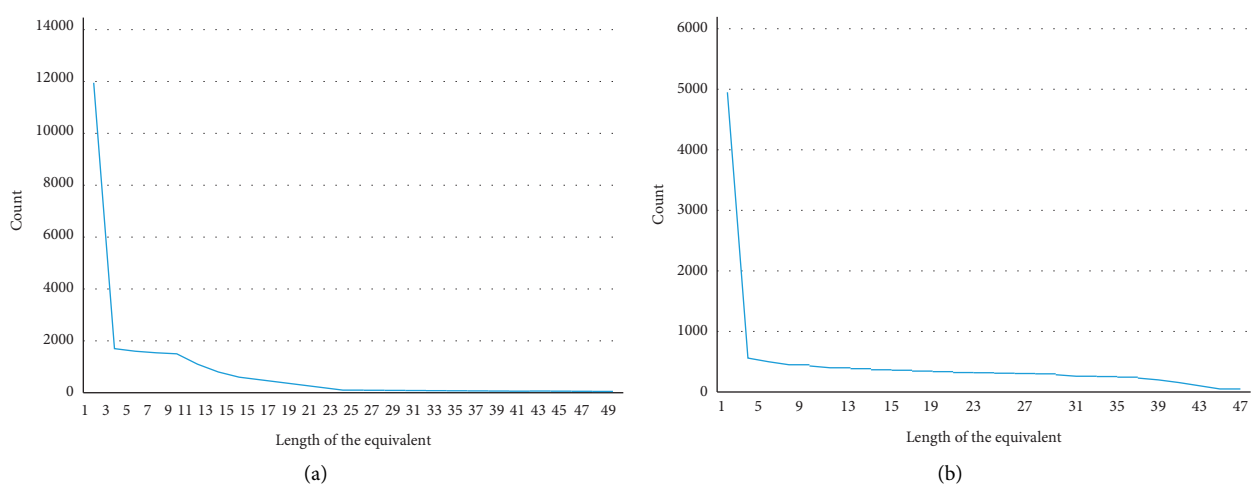

Figure 13: Distribution of syntactic equivalence versus node length. (a) Distribution of syntactic equivalence to node length in LDC2006T04. (b) Distribution of syntactic equivalence to node length in LDC2008E43.

language ordering errors in English-Chinese translation is longer; in other words, compared with English, there are more long-distance ordering problems in Chinese.

5.2. English Translation System Results

5.2.1. Test Results. The machine translation system runs on a PC with a P4 processor and a memory of 256 M. When the system is running, the system occupies about 6 M memory and can process about 8000 words per minute. Judging from the translation results of the above groups of test sentences, the system can solve the ambiguity problems in sentence segmentation, word segmentation, concurrent words, ambiguous structure, and translation selection relatively well. Although this is only a targeted partial test, it cannot be concluded that the English-Chinese machine translation

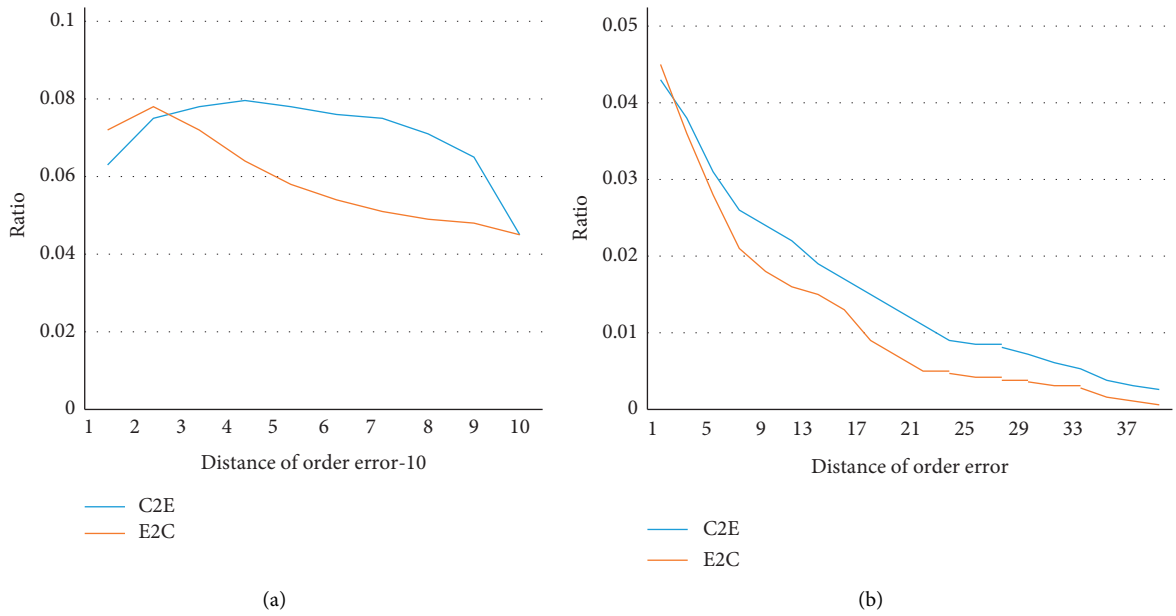

Figure 14: Distribution of RDt values in wrong word order transitions.

system has achieved complete success, it also partially shows the feasibility of the system's design structure and analysis algorithm.

5.2.2. Advantages and Disadvantages of the System. One of the advantages of the system design is that it divides a translation analysis process into six analysis stages before and after and a translation conversion analysis unit with the number of translated clauses as a basic data. It simplifies the analysis and design steps and design implementation of the translation conversion engine function, and improves the overall translation quality accuracy and translation analysis efficiency. The coding scheme used by machine dictionaries describes the syntactic, semantic, and contextual conditions of words in an intuitive and concise manner. A rich source of knowledge provides comprehensive support for disambiguation at all stages of the translation process.

The disadvantage is that if the system is to meet the actual needs, the machine dictionary must reach at least tens of thousands of entries, and the acquisition and writing of vocabulary knowledge will become the bottleneck of the system. And the speed of operation is relatively slow, which cannot achieve the speed and precision required by the market. Because of the lack of entry, some translations will not be fully reflected in the meaning part.

6. Conclusion

The study of linguistic theory is closely linked with the study of machine translation technology. Linguistic theory is the understanding of the regularity of human natural language, and machine translation just needs this linguistic regularity. Linguistic theories at different levels, such as lexical, syntactic, semantic, and pragmatic, all play a guiding role in machine translation [29]. The current situation is that this guiding role is not manifested significantly. For example, the midsection theory, thematic role, and phrase shift in syntactic theory are very good linguistic laws, but they have not been fully utilized in machine translation practice. Therefore, with the help of algorithms based on the Internet of Things and big data, this paper further analyzes the innovative system of English software, fills in the gaps for it, and uses another solution to correct some of the defects that cannot be expressed at the moment. In the next step, the linguistic theories most closely related to machine translation should be systematically studied and studied, and corresponding computational models should be established to guide the subsequent practice of machine translation.

Data Availability

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

Conflicts of Interest

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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