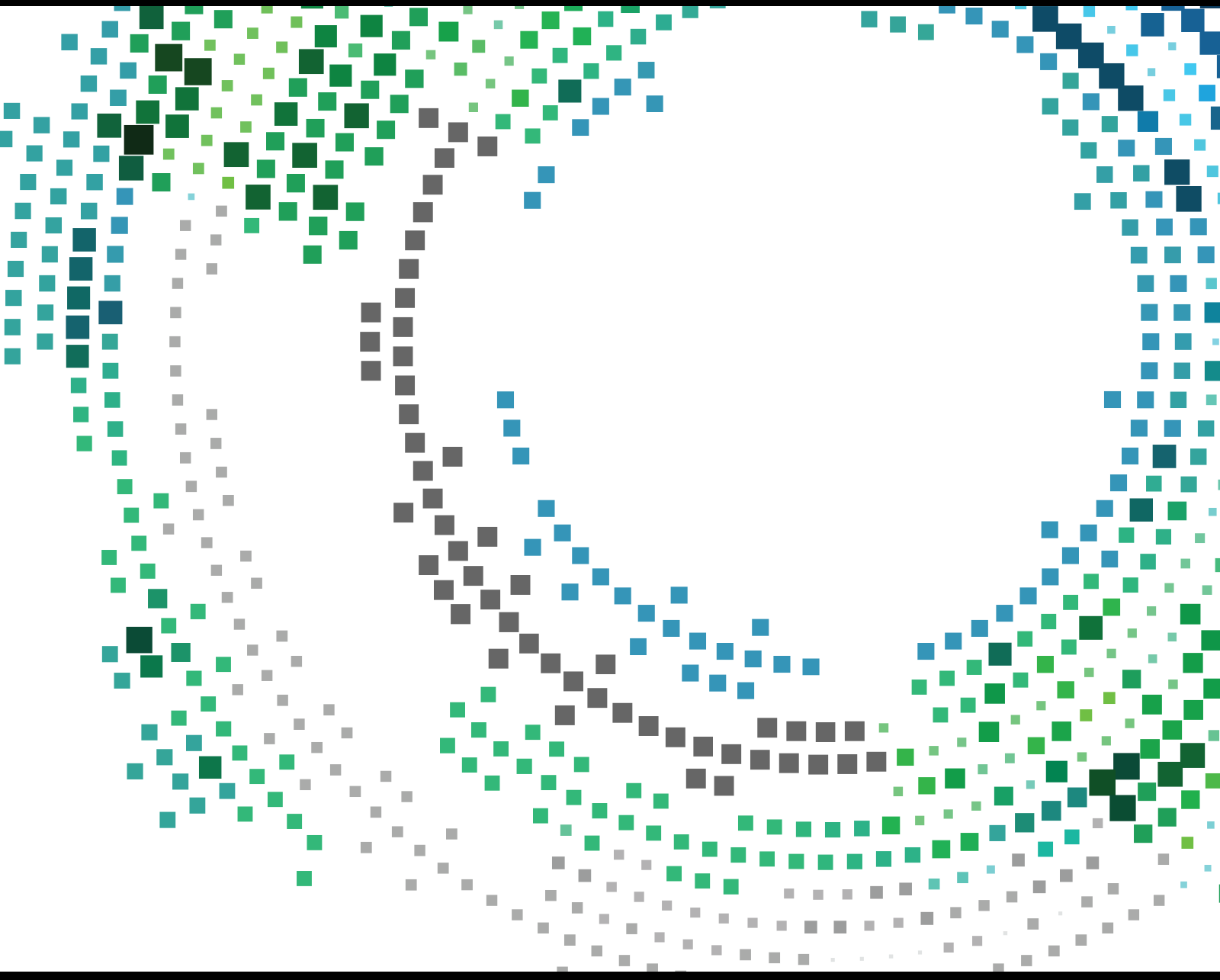
Mobile Information Systems

Energy-Efficient Reconfigurable Mobile Information Systems: Emerging Trends and Challenges

Lead Guest Editor: Wen Zhou
Guest Editors: Asma Benletaifa and Muhammad Waqas



Energy-Efficient Reconfigurable Mobile Information Systems: Emerging Trends and Challenges

Mobile Information Systems

Energy-Efficient Reconfigurable Mobile Information Systems: Emerging Trends and Challenges

Lead Guest Editor: Wen Zhou
Guest Editors: Asma Benletaifa and Muhammad Waqas

Chief Editor

Academic Editors

Contents

Contents

Hindawi
Mobile Information Systems
Volume 2023, Article ID 9834707, 1 page
https://doi.org/10.1155/2023/9834707

Retraction

Retracted: The Construction and Empirical Research of College English Multimodal Teaching from the Perspective of New Media

Mobile Information Systems

Received 8 August 2023; Accepted 8 August 2023; Published 9 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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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.

References

[1] S. Cao, R. Chen, H. Liu, and R. Shi, "The Construction and Empirical Research of College English Multimodal Teaching from the Perspective of New Media," *Mobile Information Systems*, vol. 2022, Article ID 7582536, 12 pages, 2022.

Hindawi
Mobile Information Systems
Volume 2023, Article ID 9816527, 1 page
https://doi.org/10.1155/2023/9816527

Retraction

Retracted: Exploration of Agricultural Economic Management Methods under Internet + Mode

Mobile Information Systems

Received 8 August 2023; Accepted 8 August 2023; Published 9 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.

References

[1] Q. Luo, "Exploration of Agricultural Economic Management Methods under Internet + Mode," *Mobile Information Systems*, vol. 2022, Article ID 9014184, 10 pages, 2022.

Hindawi
Mobile Information Systems
Volume 2023, Article ID 9795729, 1 page
https://doi.org/10.1155/2023/9795729

Retraction

Retracted: Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics

Mobile Information Systems

Received 8 August 2023; Accepted 8 August 2023; Published 9 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.

References

[1] J. Zhang and M. Zhao, "Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics," *Mobile Information Systems*, vol. 2022, Article ID 5610892, 7 pages, 2022.

Hindawi
Mobile Information Systems
Volume 2023, Article ID 9816527, 1 page
https://doi.org/10.1155/2023/9816527

Retraction

Retracted: Exploration of Agricultural Economic Management Methods under Internet + Mode

Mobile Information Systems

Received 8 August 2023; Accepted 8 August 2023; Published 9 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.

References

[1] Q. Luo, "Exploration of Agricultural Economic Management Methods under Internet + Mode," *Mobile Information Systems*, vol. 2022, Article ID 9014184, 10 pages, 2022.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 9014184, 10 pages
https://doi.org/10.1155/2022/9014184

Research Article

Exploration of Agricultural Economic Management Methods under Internet + Mode

Qian Luo

Hunan Open University, Changsha, Hunan 410004, China

Correspondence should be addressed to Qian Luo; luoqian0722@126.com

Received 18 July 2022; Revised 22 August 2022; Accepted 30 August 2022; Published 22 September 2022

Academic Editor: Wen Zhou

In order to solve the problems that the production management of agricultural greenhouses consumes large human resources, low management efficiency, and the limitations of environmental monitoring, a visualized smart agriculture based on ZigBee and WiFi dual-protocol fusion Wireless Sensor Networks (WSNs) technology is proposed. A management system is proposed. The system takes STM32 as the main control core and builds a visual cloud computing platform based on the ESP8266WiFi module. The environmental parameters of the greenhouse are sent to the ZigBee terminal device through the serial port, and the user can remotely monitor the environmental parameters of the greenhouse in real time through the computer and mobile client, and control the working status of each actuator. The test results show that: (Transmission Control Protocol/Internet Protocol, TCP/IP) communication is not abnormal; under the control of the visual management system, when the system sends out control commands, the response time of each output terminal is basically between 1 and 2 s. The response of the output control unit has high sensitivity. Affected by the network delay, the fourth group of test data is larger, and in the case of network delay, the response sensitivity of each output terminal of the system decreases accordingly. *Conclusion*. The system has high accuracy of data collection, strong work reliability, can realize precise remote control, and has low cost, high stability, easy operation, and has certain promotion value.

1. Introduction

Agriculture is the basic industry of the national economy, providing basic material guarantees for people's lives, industrial production, and social progress. Traditional agriculture is a manual agricultural labor method based on human, animal power, hand tools, iron tools, etc. under natural economic conditions. It is characterized by the use of spontaneous and primitive allocation of labor and production materials, with planting as the center, and the combination of agriculture and animal husbandry. The regionalization of the agricultural economy is obvious, and the development is unbalanced. After entering the industrial society, traditional agriculture gradually transforms into modern agriculture. Modern agriculture is a socialized agriculture that applies modern technology and means of production provided by modern industry and scientific management methods [1]. Its characteristics are as follows. The agricultural production technology has changed from experience to science, and agricultural science and technology such as breeding, cultivation, feeding, soil improvement, plant protection, and animal protection have been rapidly improved and widely used. The self-sufficiency production in China has been replaced by the highly specialized and commercialized production. The agricultural production process is closely integrated with processing, sales, and the manufacture and supply of production materials, resulting in the integration of agriculture and industry, economic mathematics methods, electronic computers, and networks. Modern science technology is more and more widely used in modern agricultural macro-management and micro-management, and management methods have been significantly improved.

Modern agricultural production includes the cultivation of agricultural product seedlings, field management, processing of agricultural and livestock products, preservation,

circulation, and market sales. This industrial chain model combines the production, processing, and sales of agricultural products to form a mechanism of sharing benefits and risks, and expand the external scale of agricultural production and farmers' operations. It is conducive to connecting small-scale farmers' operations with large markets at home and abroad, and is conducive to the use of advanced agricultural technologies and materials and equipment to improve agricultural productivity and economic efficiency, and is conducive to improving the level of specialization, commercialization, and modernization of China's agriculture. Modern agriculture has given birth to the agricultural economic management. Its goal is to scientifically plan and guide the country's agricultural production. Through effective management of the agricultural product processing industry chain, the production and circulation costs of agricultural and sideline products can be reduced, so that the agricultural and sideline products produced by farmers can realize their value and use value as much as possible, so that the rural labor force can participate in sharing the value-added of agricultural and sideline products in the logistics process, thereby improving the overall efficiency of the agricultural production [2, 3]. In modern agricultural economic management, agricultural product information, market information, and circulation information are the basis for the implementation of management measures such as agricultural production status analysis, industrial planning and guidance policy formulation, agricultural production structure optimization, and agricultural economic system formulation. The nervous system in the industrial chain, the level of information processing, and utilization have a very important impact on the operation and management of the modern agricultural economy.

2. Literature Review

Prasad et al. developed an intelligent greenhouse management system. The system was based on wireless sensor networks, which can detect the humidity, temperature, photosynthetic radiation, and other parameters in the greenhouse in real time. The system improved the management efficiency of crops and saved a lot of manpower and material resources [4]. Meng et al. is committed to designing and researching a crop growth monitoring system with strong reliability and high stability. The system was based on a wireless sensor network, with a variety of sensors as acquisition nodes, and red pepper as the experimental object to collect its growth environment parameters. The collected data was transmitted through the ZigBee network, which was convenient for farmers to inquire about the growth status of red peppers on agricultural sites [5]. In order to solve the problem of frost in greenhouses in winter, Sharma et al. personnel launched a greenhouse temperature control system. Frost could bring great harm to crops and inhibit the healthy growth of crops [6]. The system was guided by the wireless sensing technology, and terminal sensors were arranged in the agricultural field, and the collected information was sent to the server through the aggregation node. The remote server system compared the received on-site environmental information with the expert database to control the on-site boiler heating, thus effectively solving the problem of frost on the foliage of crops. Liu used multiple ZigBee terminal nodes and a ZigBee coordinator to build a wireless sensor network (WSNs) and set up an environmental parameter information collection system, so as to realize the intelligent sensing function of environmental parameters [7]. And based on WSNs technology, a cost-effective ginseng cultivation system was developed, which realized real-time collection of ginseng growth environment parameters, and formulated an effective plan to ensure the healthy growth of ginseng. Based on the modeling technology, Husseinet al. built a smart agriculture platform. And based on the experimental results of the platform, he proposed that the development of smart agriculture must be inseparable from the construction of models. And relying on the model basis, the future development goals of smart agriculture were planned, and the importance of the model in the development of smart agriculture was given full play [8]. Taking CC2530 chip as the main control core, a greenhouse control system based on wireless Mesh network was proposed by Xiao and Li. The system used ZigBee as the terminal control node, and sent the collected environmental parameter information of the greenhouse to the human–computer interaction interface for users to view. Through the user's remote control, multiple sets of low-voltage relays were driven to control shading curtains, thermal insulation films, water pumps, fans, and other equipment to work [9]. Shao et al. studied the effects of air temperature and humidity, light intensity, CO_2 concentration, and other environmental parameters on the growth process of strawberries, and deeply studied various problems encountered in the growth process of strawberries through the analysis. With PLC as the main controller, a monitoring platform was built through WinCC, and a set of strawberry growth environment monitoring and control system was built by using ProfiNet communication mode, so that the users could query the historical curve of strawberry growth environment parameters, which ensured the healthy growth of strawberries and provided a theoretical basis and practical experience for the development of modernized agriculture [10].

The traditional extensive artificial greenhouse management technology not only consumes huge manpower and material resources, but also requires farmers to spend a lot of time to ventilate, light, fertilize, and irrigate the greenhouse. And the efficiency is not high. Therefore, it is necessary to design a visual, intelligent, and digital modern smart agricultural management system. The "Thirteenth Five-Year Plan" clearly includes smart agriculture into it, and the development goal of agriculture is still to further advance towards modernization. Under the great wave of "Internet +" proposed by Premier Li Keqiang, network agriculture has shown a good development trend [11]. Under the development trend of such agricultural modernization, wireless sensing, automatic control, wireless network, and other technologies are organically combined with agriculture in the system, aiming to make breakthroughs in the agricultural production.

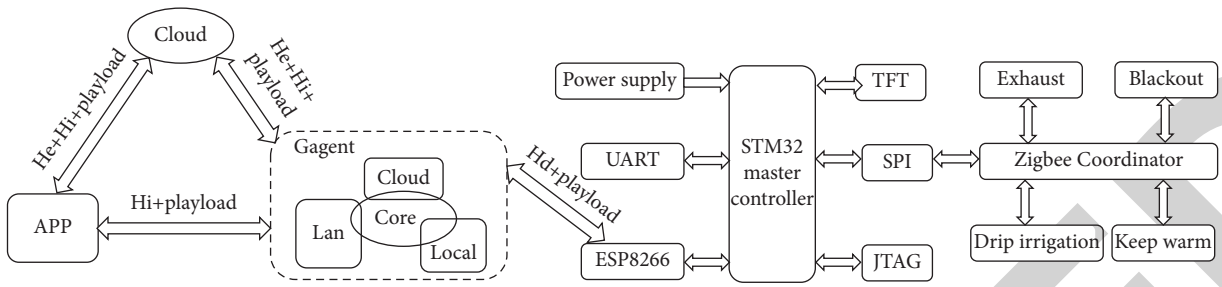


Figure 1: Overall system design.

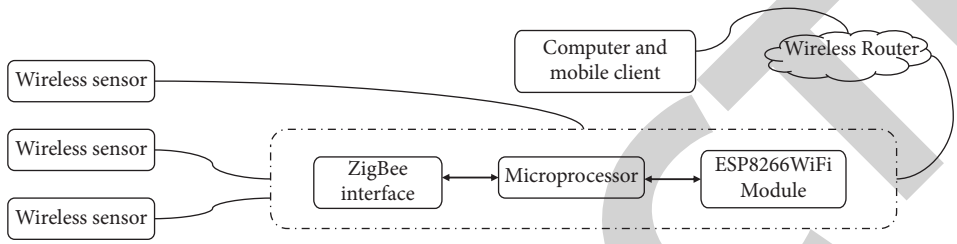


Figure 2: The overall hardware design of the system.

3. Research Methods

3.1. Overall System Scheme. In the running state, the system collects environmental parameters such as temperature and humidity, light value, CO_2 concentration, and soil moisture in the greenhouse through ZigBee nodes. The environmental parameters are uploaded to the cloud computing platform through wireless network transparent transmission. The master controller controls the output state of each actuator through the algorithm comparison and the set value comparison. In addition, users can also monitor all environmental parameters of greenhouse in real time in the cloud platform management system through computer and mobile phone client, and remotely control the working status of each actuators (controlling greenhouse ventilation, lighting, irrigation, and heat preservation) [12]. When network failure occurs in the system, each actuator can be controlled in manual mode to meet the multi-mode intelligent management of greenhouse. The overall design of the system is shown in Figure 1.

3.2. The Hardware Design of the System. The system collects all environmental parameters in the greenhouse through wireless sensor nodes, and sends the collected data to the ZigBee-WiFi gateway through ZigBee protocol. ZigBee cannot be directly integrated with the external network, so WiFi technology must be used as the transfer, and WiFi becomes the bridge of protocol conversion.

By converting the protocol gateway, data between ZigBee and WiFi can be transmitted and applied. At the same time, the cloud computing technology is used to establish data storage and access private clouds, which can support computers and mobile phone clients to view all the environmental parameters online in real time, so that the users can accurately manage greenhouses. Its hardware structure is shown in Figure 2.

3.2.1. Terminal Node Baseplate Design. The terminal equipment node mainly realizes the collection of environmental data of greenhouse, the control of equipment status, and the wireless transmission of data information. The control circuit consists of power supply module, debugging and downloading circuit, data acquisition circuit, and relay.

(1) Power supply circuit: The terminal node control chip is CC2530 with rated working voltage of 3.3 V, but the STM32 master controller, all data acquisition modules and relays need 5 V power supply, so 5 V power input is adopted, and 3.3 V voltage is output for CC2530 through ASM-1117 voltage regulator chip.

(2) Relay circuit: Relay is simple to control and easy to use, so the state of terminal node equipment is mainly controlled by relay. The relay control input pin is directly connected with the STM32 pin, and the output pin is connected with the terminal device. And the device state can be controlled by controlling the pin level of the MAIN controller of STM32.

3.2.2. ZigBee Module Design. ZigBee technology is popular among users for its low power consumption and wireless transmission. The main control chip is CC2530 chip. The CC2530 features a powerful low-power, enhanced 8051 core with a built-in analog/digital converter that supports up to 12 bits of ENOB (valid data) and can meet the design requirements by writing data to memory via DMA. ZigBee network is mainly composed of star, tree, and mesh structure. Among them, the mesh structure connects all ZigBee terminal nodes, as shown in Figure 3. The mesh topology has short delay and strong reliability, so the system is designed as a mesh wireless network [13].

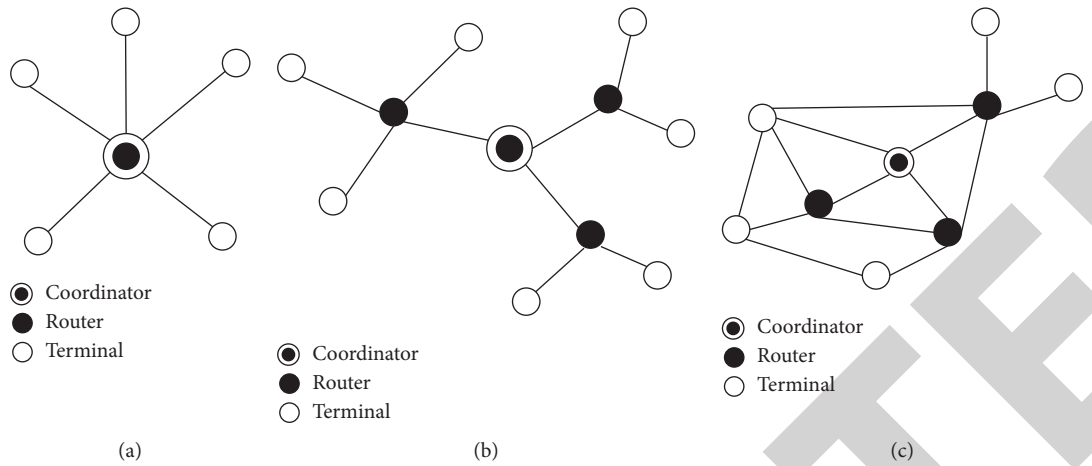


Figure 3: ZigBee network topology. (a) In shape. (b) Tree-like. (c) Mesh.

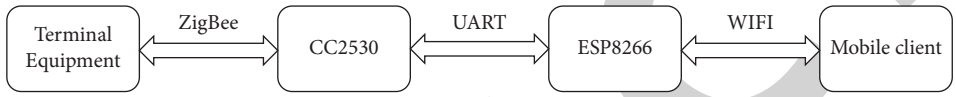


Figure 4: Gateway structure.

3.2.3. ZigBee-Wifi Dual-Protocol Fusion Communication. The ZigBee-wifi wireless gateway takes CC2530 and ESP8266 as the core chips, and the ZigBee-WiFi dual-protocol fusion is realized by codes. The gateway structure is shown in Figure 4.

Gateway structure ZigBee main control chip is CC2530 with IEEE802. 15. 4 standard, with a high working sensitivity and a strong anti-interference ability. The WiFi module chip is ESP8266, which integrates 802.11n radio frequency mechanism to provide the possibility of network coverage, and the integrated chip improves the processing speed. The ESP8266 provides a serial port for connecting to the ZigBee module and embedded TCP/IP protocol for information exchange with the ZigBee network.

In the wireless visualized intelligent agriculture management system, the hierarchical structure is used to build ZigBee network protocol. ZigBee network protocol includes physical layer (PHY), media access control layer (MAC), network layer (NWK), and application support layer (APS) structure. The bottom layer is composed of the physical layer and the media access control layer, which meets IEEE802.15.4 standard protocol and can be directly connected with the RF transceiver [14]. The network layer is concerned with the establishment and maintenance of the entire network. Its main function is to establish the network and select the information transmission path. Meanwhile, it is responsible for the security of the entire network. The application layer mainly includes application object, device object (ZDO), and application support sub-layer (APS), which conforms to the definition of ZigBee protocol. APS is responsible for receiving data sent by the network layer, while ZDO is responsible for network management and provides interface functions between the application layer and the network layer. The ZigBee protocol stack structure is shown in Figure 5.

The entire ZigBee protocol stack structure is complex. And each layer has a huge amount of code, which cannot be achieved only by personal efforts. In this design, ZigBee protocol stack Z-Stack is downloaded from the official website of TI company, and the system is designed by referring to the actual development cases. The program compilation environment of ZigBee chip CC2530 is IAR. IAR compilation environment can simulate various 51 kernel environments, with highly optimized, online debugging and other functions, which greatly saves debugging time. Z-stack is loaded into IAR, and the program can be written. After the program is compiled without error, it can be written into CC2530 chip through the emulator.

The network protocol layer of wireless gateway realizes the mutual integration of ZigBee and WiFi protocols. The terminal node follows IEEE802.15.4 protocol, and the environmental parameters of greenhouse are sent to ZigBee coordinator. Firstly, ZigBee physical layer receives and parses data packets layer by layer, then interprets various environmental parameters of greenhouse by gateway application layer, encapsulates WiFi protocol packet data, and transparently transmits it to the cloud computing platform through network. At the same time, users can monitor greenhouse environmental parameters through the cloud computing platform and issue control instructions, which are sent to the ZigBee coordinator module through the UART serial port and sent to the specified terminal node module through ZigBee to control the execution of greenhouse terminal equipment. The wireless gateway is mainly responsible for the data transmission between the wireless node and the client and the two-way data transmission of the cloud platform. The gateway programming is mainly based on STM32 master controller, the programming language is C language, and the compilation and debugging environment is Keil5. The system gateway program logic is shown in Figure 6.

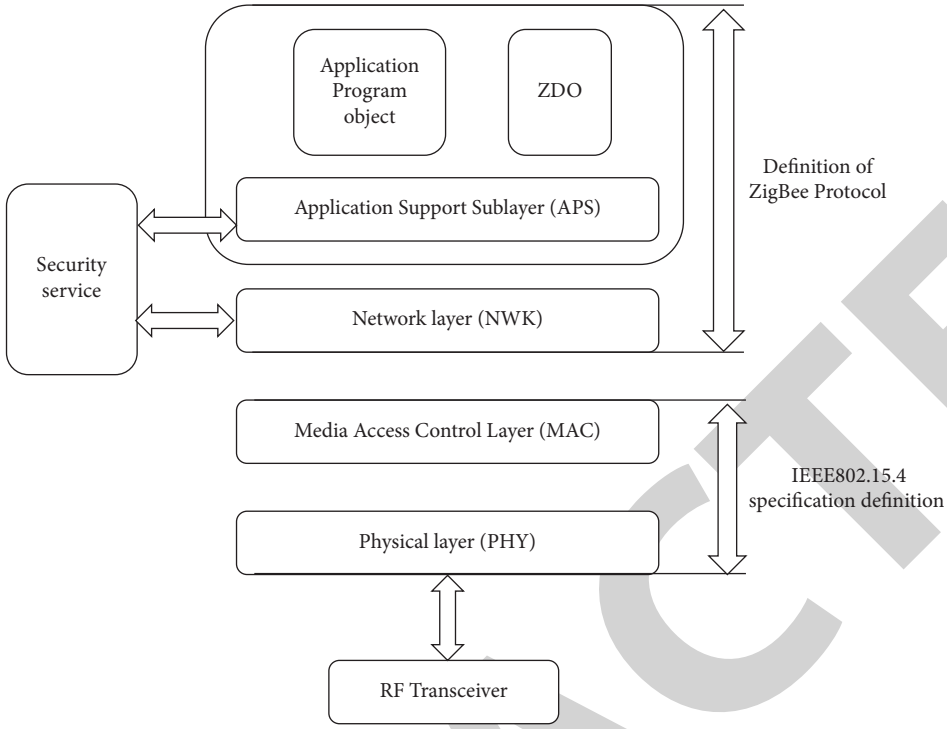


Figure 5: ZigBee protocol stack structure.

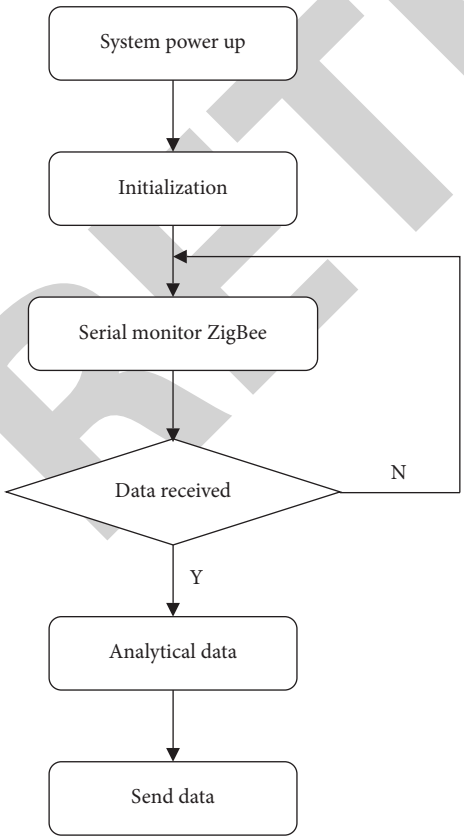


Figure 6: Flowchart of gateway program.

The wireless visualized intelligent agriculture management system is initialized after being powered on. At the same time, the serial port interrupts the monitoring ZigBee module. If the data is monitored, it will be parsed. After the analysis is completed, the data will be sent [15]. Data transmission is mainly as follows. First, serial port 1 receives the data collected by ZigBee terminal node, and the data is sent to the intelligent cloud platform by serial port 3. Second, the ESP8266WiFi module of serial port 3 receives the control instructions issued by the intelligent cloud platform, generates the control instructions for agricultural field equipment of ZigBee terminal node, and transmits them to ZigBee terminal node through serial port 1.

After the wireless visualization smart agriculture system is powered on, network configuration is required. At present, there are two common WiFi network configuration methods, one is Air Link, and the other is Soft AP. In the system, Air Link is used to configure the network. Figure 7 shows the WiFi access configuration. The Air Link protocol consists of the initialization of the protocol header, the assignment of other protocol bits, serial port write operations, and protocol confirmation checking.

3.3. ZigBee Software Design. When designing ZigBee software, each node terminal of the smart agricultural management system meets the specification requirements to ensure the formation of a network between different devices. The user can change the specification according to the specific design. The specification ID number of the protocol stack is set to 0 before each ZigBee node joins the network.

In order to ensure that the environmental parameters collected by each node of ZigBee are sent stably, the

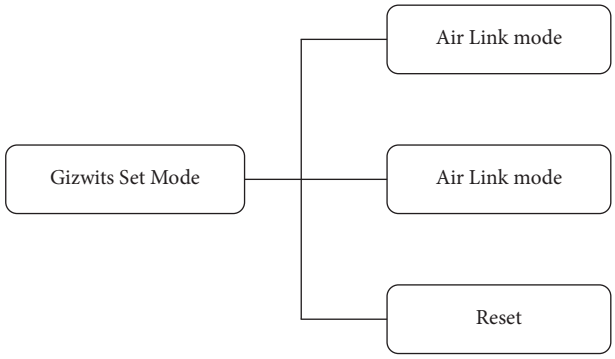


Figure 7: WiFi network access configuration method.

distributed addressing method is adopted to ensure that there is a unique address allocation without confusion [16]. Assuming that the maximum number of sub-devices that the parent device can have is *Fm*, the maximum number of routing sub-devices is *Bm*, and the maximum network depth is *Sm*, then the number of sub-segment addresses that can be allocated by the parent device is:

When $Bm = 1$, there is the following Formula (1).

$$\text{Cskip}(d) = 1 + Fm \cdot (Sm - d - 1). \tag{1}$$

When $Bm \neq 1$, there is the following Formula (2).

$$\text{Cskip}\ (d) = \frac{\left(1 + Fm - Bm - Fm \cdot (Bm)^{(Sm-d-1)}\right)}{(1 - Bm)}. \tag{2}$$

The child node is the short address allocation of the *n*th child router of the parent device, namely, Formulas (3) and (4) below.

$$\text{Achild} = \text{Aparent} + (n-1) \cdot \text{Cskip}(d) + 1, n = 1, \tag{3}$$

$$\text{Achild} = \text{Aparen} + (n-1) \cdot \text{Cskip}(d), n > 1. \tag{4}$$

The short address assignment of the *n*th child terminal of the parent device, that is, Formula (5) below.

$$\text{Achild} = \text{Aparent} + \text{Bm} \cdot \text{Cskip}(d) + n. \tag{5}$$

Fm— The maximum number of child devices that a parent device can have;

Bm— The maximum number of routing sub-devices; *Sm*— The maximum depth of network;

Cskip (d)— The number of sub-segment addresses that can be allocated by the parent device; *n*— The number of sub-routers;

Achild— The child node assigns the short address to the child router of the parent device.

When sending data to the ZigBee terminal device of the smart agricultural management system, the AF_DataRequest( ) function is usually called, and the data packet is sent to a target device of type afAddrType_t (defined in ZComDef.h).

3.4. Design of WiFi Cloud Computing Platform. WiFi (Wireless Fidelity), also known as wireless fidelity technology, is similar to Bluetooth technology. It is widely used indoors and is limited by distance. At present, the official WiFi standards are divided into IEEE802.11a, IEEE802.11b, etc., and the frequency bands used are around 2.4 GHz and 5 GHz. This technology has obvious advantages and is widely favored by the users.

In order to connect terminal devices such as smartphones to the cloud, a cloud computing platform is designed. The system cloud computing platform provides device networking based on the ESP8266 WiFi module, and transplants the GAgent program to the WiFi module to provide a medium for devices to access the cloud computing platform to ensure the normal data forwarding. The projects and data nodes contained in the greenhouse are created in the developer center and virtual devices are added, and then the APP is installed to bind the virtual device. After the APP communicates with the virtual device, the APP can query the value of each environmental parameter in real time and control the output status of each node of ZigBee. With the advancement of the "Internet +" wave, the system development mode has undergone qualitative changes. Traditionally, the development of IoT projects needs to be based on building servers. In order to meet the needs of developers, the concept of cloud servers has emerged. For example, Alibaba Cloud, Baidu Cloud, T-Link Cloud, Gizwits Cloud, etc., their models are similar, they are all external services, with these clouds, developers can solve project needs according to cloud servers, which largely solves customer needs, and provides a broad practice platform for developers. Different cloud platforms have inconsistent development functions. Alibaba Cloud focuses on data analysis, Baidu Cloud focuses on big data storage, and Gizwits is committed to IoT development. On the one hand, for this system, Gizwits fit the theme; on the other hand, in terms of overall performance, Gizwits platform is free to use, and can integrate and develop various interactive interfaces such as WeChat applet, computer client, and mobile APP with powerful functions, so this system uses Gizwits as the Greenhouse development cloud platform. The sensing data collection layer of the Gizwits platform framework mainly includes various environmental monitoring sensors to complete the collection of agricultural field environmental information. The transmission control layer is mainly responsible for sending the greenhouse environmental parameters collected by the terminal sensors to the cloud computing platform. The transmission control layer uses the ESP8266 WiFi module as the medium and is based on the TCP/IP communication protocol to realize the wireless transmission of the environmental parameters of the greenhouse to the cloud computing platform, and realize the storage, analysis, and statistics of the environmental parameters of the greenhouse through the Gizwits cloud platform. In addition, the transmission control layer also needs to transmit the remote control instructions of the Gizwits cloud server to realize the remote control of the water pump, exhaust fan, shading curtain, etc. The user access layer realizes the remote control function of the above-mentioned greenhouse field equipment through intelligent devices such as

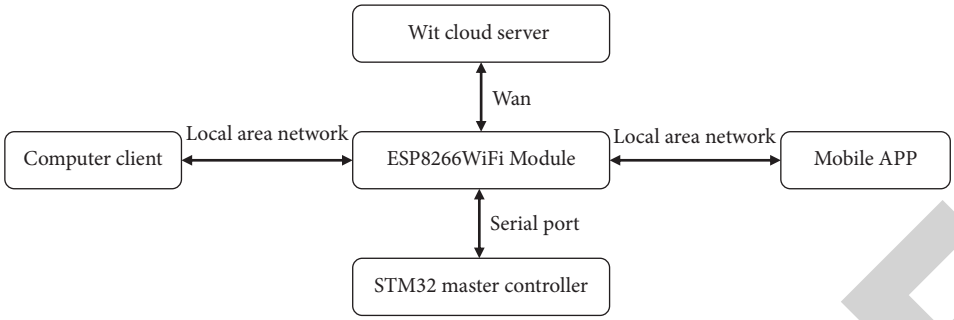


Figure 8: Gizwits platform framework.

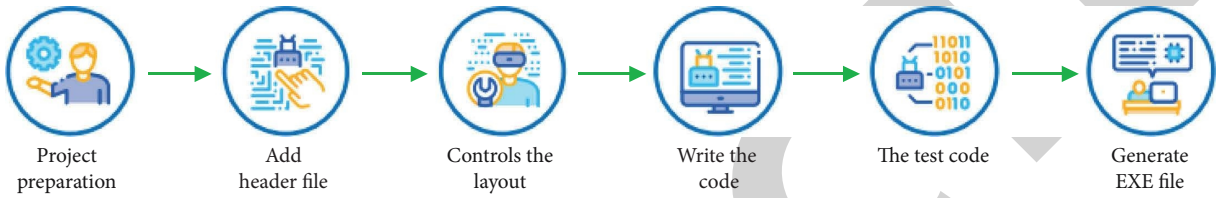


Figure 9: The development flow chart of the host computer.

computer client and mobile APP. The main framework of Gizwits platform is shown in Figure 8.

In the smart agricultural management system, an extension type is designed to realize transparent transmission of fixed-length data points to solve the problem of large data volume. The system uses extended data points to realize the data transmission between the STM32 main controller and the mobile phone APP. The data sent and received by the main controller is output to the serial port, and the working status and environmental parameters of each node of ZigBee are displayed on the TFT liquid crystal.

A product named "Data Transparent Transmission" is created in the personal project of Gizwits official website. After the data point is created, in the independent MCU solution under MCU development, another platform is selected to download the MCU engineering package. After the engineering package is downloaded, the system will use the Gizwits serial port protocol porting. After the porting is successful, the project name is changed to "IOT_Pass-through." The required driver files are added in the project to be applied in the LCD liquid crystal screen, and the path of the driver files are added after the addition is completed [17].

3.5. Design of the Upper Computer Monitoring Platform. The host computer monitoring platform of the wireless visualized smart agricultural management system mainly realizes two functions: real-time query of environmental parameters of greenhouses and remote control of agricultural field terminal equipment [18]. In this system, the computer monitoring software uses MFC as the development environment, Visual Studio 2015 as the debugging platform, and performs programming through C++. The computer hardware configuration requirements are Windows7. The development process of the host computer platform based on MFC is shown in Figure 9.

Before the development of the host computer, the engineering preparation is required first. The engineering preparation includes the addition of header files and library files. In the wireless visualized smart agriculture management system, both header files and library files are designed and developed according to system functions. Part of the information is shown in Table 1.

All header files and library files in the table need to be copied to the host computer project directory, and the above header files must be included in the corresponding.cpp or.h files of the MFC project. The library file CyAPI.lib needs to be added to the additional dependencies of the project. Because the development computer is Win7 64-bit operating system, the corresponding 64-bit library file is selected for this design. After all the preparations are ready, the layout of the controls can be carried out. The layout of the system controls mainly includes the appearance and position design of the control buttons and display ports. The program is written by C++, and the code can be tested when the compilation is correct. When the test result achieves the expected goal, the exe executable software of the entire project is generated.

The upper computer monitoring platform of this system has complete functions, mainly including the password login interface, the system main control interface, the real-time change display interface of environmental parameters, the threshold setting interface, and the weather forecast acquisition interface.

4. Analysis of Results

4.1. System Network Test. In order to verify the stability of the network operation of the wireless visualized smart agricultural management system, the system communication function needs to be tested before the system is officially put into greenhouse applications. The debugging method is: open the network debugging assistant, select the test

Table 1: Documents related to the host computer.

Upper computer file	Filename	Path
The header file	CyAPI.h, cyioctl.h	C\Cypress\Cypress suite \inc
The library files	CyAPI.lib (64-bit system)	C\Cypress\Cypress suite \lib\X64
The library files	CyAPI.lib (32-bit system)	C\Cypress\Cypress suite \lib\X86

protocol type as TCP/IP communication (consistent with the communication method between the host computer and agricultural field equipment), set the remote host address as 192.168.43.221, and set the remote host port as 8080. The TCP/IP test command is sent through the monitoring interface of the upper computer, and the network debugging assistant receives the command sent by the upper computer normally, indicating that the communication is successful. The test results show that there is no abnormality in TCP/IP communication, and the system network can operate normally.

4.2. Environmental Quantity Test. In order to verify the reliability of the environmental quantity detection function of the smart agricultural management system, a number of greenhouses were selected for testing in June 2019 in a city, and the test content was the environmental parameters of each day in the greenhouse. A set of measuring equipment was placed every 10 m in the greenhouse, the environmental parameters were recorded every 1 h, and the average value was taken [19]. Figures 10 and 11 are the average change curves of greenhouse environmental parameters in June 2019.

The climate type of this area is subtropical monsoon climate, and the climate is changeable. According to the meteorological data of the Bureau of Meteorology, the region has less sunshine hours from February to April, and more sunshine hours from July to September. In addition, the annual average temperature is between 16.2 and 19.9°C, with a maximum of 40.4°C in July. Figure 10 shows that the light in the greenhouse maintains a high value, close to 100lex. As the night falls, the light value shows a downward trend. At the same time, the temperature fluctuates between 20 and 35°C. When the illumination increases, the indoor temperature shows an upward trend; when the illumination value decreases, the indoor temperature decreases [20].

The air humidity in this area is relatively high, which is maintained at 67% to 84% all year round. Affected by the rainy season, the "southern wind days" often referred to by locals will appear in March and April, when the relative humidity of the environment will be close to 100%. The average annual rainfall in this area is about 1300–2000 mm, and the average annual rainfall days is about 180 days, which is one of the areas with more rainfall in my country. The seasons of rainfall are concentrated in spring and summer. The rainfall in spring and summer is not much different. In some years, the rainfall in spring will be more than that in summer. Figure 11 shows that the average humidity value of the air in the greenhouse fluctuates between 55% and 62% in one day in June, and the soil humidity changes to a certain extent, which is basically maintained between 45% and 50%.

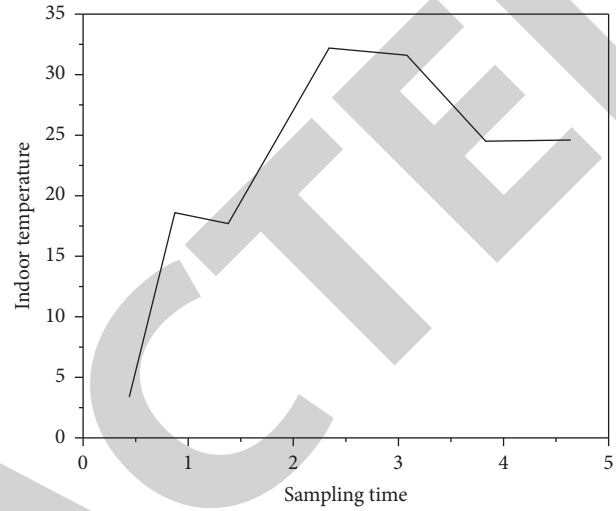


Figure 10: Change curves of light and indoor temperature.

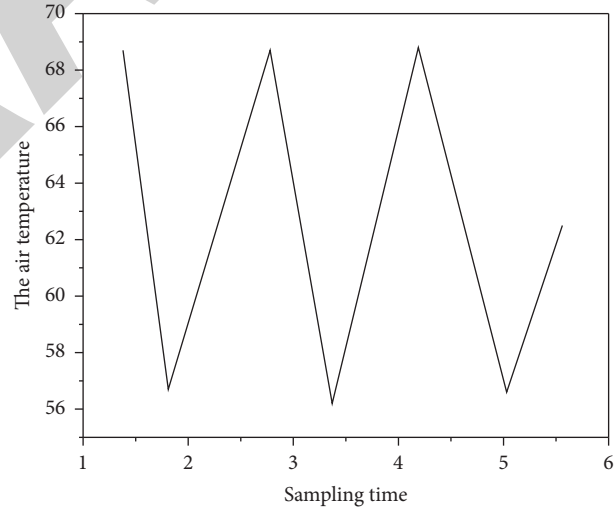


Figure 11: Change curves of air humidity and soil humidity.

When the air humidity value rises, the soil humidity value increases; when the air humidity value decreases, the soil humidity value decreases. Since the process of soil absorbing air moisture is relatively slow, this follow-up characteristic presents a certain delay effect.

4.3. The Functional Stability Test of the Visualization System. In order to verify the stability of the wireless visual smart agricultural management system, the working stability of each ZigBee node and the response sensitivity of each output terminal, the working performance of each smart terminal was tested through the APP visualized interface. The system

Table 2: Lighting system response time.

Number of tests	On	Off
1	1.25	1.48
2	2.02	1.98
3	1.33	1.23
4	2.45	2.12
5	1.55	1.34
6	1.65	2.46

Table 3: Irrigation system response time.

Number of tests	Start	Stop
1	2.14	2.75
2	1.65	1.63
3	1.02	0.88
4	2.48	3.06
5	1.59	1.64
6	1.95	2.05

Table 4: Ventilation system response time.

Number of tests	Start	Stop
1	0.97	1.55
2	1.48	1.37
3	1.61	1.59
4	2.31	1.42
5	1.96	1.44
6	1.56	1.02

Table 5: Daylight system response time.

Number of tests	Start	Stop
1	1.28	1.18
2	2.18	0.84
3	5.12	1.87
4	3.27	2.45
5	1.45	1.12
6	1.37	1.33

test parameters are set as follows. The upper limit of soil moisture is 55%, the upper limit of atmospheric temperature is 30°C, and the lower limit of illuminance is 20lex.

Through the operation of the intelligent device visual cloud computing platform, the execution status of each output end of the system is tested, and the test response time of each ZigBee node is obtained by sorting out the data, as shown in Tables 2 to 5.

It can be seen from the analysis of the test parameters that under the control of the visualized management system, when the system sends control instructions, the response time of each output terminal is basically between 1 and 2 s, and the response of each output control unit has high sensitivity in general. Affected by the network delay, the test data of the fourth group is large. Under the condition of the network delay, the response sensitivity of each output terminal of the system decreases accordingly.

5. Conclusions

A wireless visualized smart agricultural management system based on WSNs is developed, and it is designed through hardware platform, software process implementation, ZigBee-WiFi dual-protocol fusion communication, and cloud computing platform construction. The system realizes the environmental quantity detection of the greenhouse, the intelligent control of each node of ZigBee, and the intelligent decision-making of each output terminal, and the visual display of the environmental quantity parameters. It also realizes the visualization of the environmental quantity of the greenhouse and avoids the blindness of traditional agricultural activities effectively. The realization of ZigBee intelligent terminal control effectively saves a lot of manpower and material resources. The establishment of the WiFi cloud computing platform is connected with the intelligent equipment to realize the intelligent online control of the greenhouse. The test results show that the system has stable working performance, high response sensitivity, easy operation, and high degree of visualization. It realizes the wireless, visualization, and intelligence of greenhouses, which has a broad application prospect.

Data Availability

The labeled data set used to support the findings of this study can be obtained from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work was supported by Hunan Open University.

References

[1] L. Shu, G. P. Hancke, and A. M. Abu-Mahfouz, "Guest editorial: sustainable and intelligent precision agriculture," *IEEE Transactions on Industrial Informatics*, vol. 17, no. 6, pp. 4318–4321, 2021.

[2] A. Sharma, Y. Cai, A. Sharma, and A. Sharma, "Swarm intelligence optimization: an exploration and application of machine learning technology," *Journal of Intelligent Systems*, vol. 30, no. 1, pp. 460–469, 2021.

[3] Q. Li, B. Cao, X. Wang, J. J. Wu, and Y. K. Wang, "Systematic water-saving management for strawberry in basic greenhouses based on the internet of things," *Applied Engineering in Agriculture*, vol. 37, no. 1, pp. 205–217, 2021.

[4] S. J. Suji Prasad, M. Thangatamilan, M. M. Suresh et al., "An efficient lora based smart agriculture management and monitoring system using wireless sensor networks," *International Journal of Ambient Energy*, no. 2, pp. 1–4, 2021.

[5] X. Meng, Y. Bao, H. Liu, A. Zhang, and D. Wang, "Soil classification in typical black soil areas of northeast China based on gaofen-5 images," *Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering*, vol. 36, no. 16, pp. 231–238, 2020.

[6] N. Sharma, U. Batra, and S. Zafar, "Remit accretion in iot networks encircling ingenious firefly algorithm correlating

Hindawi
Mobile Information Systems
Volume 2022, Article ID 9130643, 13 pages
https://doi.org/10.1155/2022/9130643

Research Article

The Impact of Teachers' Instructional Design on the Development of Young Children's Sense of Innovation: An Algorithmic Perspective Analysis

Xinying Li and Leilei Wang

Jeonju University, Jeonju 55069, Jeollabuk-do, Republic of Korea

Correspondence should be addressed to Leilei Wang; 1821010183@stu.cpu.edu.cn

Received 15 July 2022; Revised 11 August 2022; Accepted 23 August 2022; Published 6 September 2022

Academic Editor: Wen Zhou

In the development of education, each new technology applied to the teaching process provides a new dimension of development in line with human needs. In national education, intelligent network teaching plays a role in promoting education informatization, education reform, and the smooth implementation of new curriculum standards, and the quality of education technology is an essential part of the quality structure of teachers and helps to optimize teaching and training innovative talents. Genetic algorithms play an important role in the design of intelligent network teaching systems, so the application of genetic algorithms is of great importance to the development of national education in China. The purpose of the design is to cultivate children's interest and enthusiasm in computer technology from an early age and to form a preliminary understanding of computer technology. In recent years, with the popularity of computers and smart phones, the wave of information technology has accelerated in China. Early childhood IT teaching should be combined with the characteristics of the subject and the special understanding characteristics of the elementary school student group, to help students develop their abilities through technological innovation. This thesis starts from the characteristics of multimedia technology. Combined with the process of teaching design, several thoughts are given on how the teaching design based on multimedia technology can be more scientific and reasonable, hoping to be helpful to the pedagogues.

1. Introduction

In the information age, the daily use of computer technology has become extremely widespread, and computer science and technology, as a discipline that keeps pace with the times, has strong practical application characteristics. The education for young children must give full play to the subjective initiative, combining the frontier knowledge of the discipline and the mainstream market for teaching. Algorithm design and analysis (hereinafter referred to as algorithm) are considered core in the field of modern computer science, which teaches various solutions to practical problems in computer applications and the basic principles, methods, and techniques of various algorithms, emphasizing programming skills, reasonable data organization, and clear and efficient algorithms, which are comprehensive, theoretical, and practical and are easier to achieve in the teaching process to keep up with the times. It is easier to combine the cutting-edge knowledge of disciplines and mainstream market.

Kindergarten education work has a special demand for multimedia technology. As young children do not have enough accumulated knowledge, they often need to display teaching resources in a graphic and animated way, which requires the digital processing of traditional teaching resources. Database technology is the best solution to store different file types of teaching resources. The unified storage of teaching resources enables the unified management of teaching resources and the sharing of teaching resource data among teachers, which greatly improves the circulation of data resources. The application of database technology to kindergarten teaching can maximize the efficiency of

teachers' access to teaching resources, optimize the teaching mode, help in adapting to the learning needs of kindergarten-aged students, and improve teaching efficiency.

1.1. Overview of Innovation Consciousness. Innovation consciousness is the ideology and spirit of courageous pioneering and continuous exploration that people show in the process of pursuing new things cognitively according to their needs. In the innovation activity, innovation consciousness is the basis of innovation activity; moreover, it is where the power of innovation activity lies [1]. In the present era, innovation consciousness is elevated to a kind of spirit, i.e., innovation spirit, which guides the subject in the pursuit of new things; is a kind of positive, courageous exploration, not resting on the status quo; and is a kind of innovation for the self, which is the development of human self-awareness. Innovative consciousness and innovative ability are like "two wheels of a car and two wings of a bird", which determine the development process of innovation. The basic content of innovation consciousness: innovation motivation is the internal motivation of the subject in innovation activities [2]. It is the highest level of motivation of the subject in the innovation process, and it is the root of accomplishing the innovation goal.

Creative interest is a prerequisite for people to develop creative and innovative consciousness in engaging in creative activities, and people have to make an intrinsic convergent choice of the goals achieved by innovation. Therefore, when cultivating innovative interest in young students, it is important to stimulate and protect students' curiosity and desire for knowledge, while strengthening their knowledge structure, as well as their correct outlook on life, high moral values, and sense of social responsibility. Creative thinking is the top priority when developing students' sense of innovation [3]. Innovative thinking is the thinking process of abandoning traditional stereotypical thinking, daring to question authority and original methods, and using a new way of thinking to develop original and novel solutions to problems through research and reasoning.

1.2. Instructional Design. Instructional design, also known as instructional systems design, aims to facilitate learning by systematically arranging instructional processes and resources to create a variety of effective instructional systems. However, due to different life and research backgrounds and life experiences, researchers involved in this discipline often interpret instructional design from different perspectives, so the meanings of instructional design are not all the same, and many different understandings have been generated, as shown in Figure 1.

Through the comparative analysis of published works and articles on instructional design at home and abroad [4], it can be found that researchers have different perspectives and focuses on the definition of the concept of instructional design, which can be roughly divided into the following three aspects: firstly, the process theory, the meaning of which is that instructional design is the planning and elaboration of the whole teaching process, emphasizing the description of the teaching process rather than other aspects of instructional design. Among them, China's education scholar Professor Umeena believes that instructional design is the process of identifying teaching problems, designing teaching objectives, formulating teaching programs to solve teaching problems, trying out the programs, evaluating the trial results, and continuously improving the original programs according to the trial results [5]. Secondly, the method theory, which focuses on the purpose and meaning of instructional design, believes that instructional design is a systematic approach to study the teaching system, teaching process, and teaching plan, aiming at optimizing the teaching process, and various activities are aimed at getting the most suitable methods and these most suitable methods can enhance students' knowledge and ability. Finally, there is the technology theory, which emphasizes the need to define the meaning by tapping into the essence of instructional design, a modern teaching technique that aims to enhance the planning and rationalization of teaching and learning activities. Through the comparative analysis of these definitions, this study concludes that instructional design is a process of specific planning of teaching objectives, teaching methods, teaching process, and teaching evaluation based on theories of teaching and learning based on a systematic approach according to the training objectives, which is not only theoretical but also extremely practical and applied.

1.3. Research on Genetic Algorithm-Based Classification Algorithm. Genetic algorithms are search algorithms based on natural selection and population inheritance mechanisms that simulate the reproduction, hybridization, and mutation phenomena involved in natural selection and natural inheritance. When a problem is solved using a genetic algorithm, each possible solution to the problem is encoded as a "colored body", i.e., an individual, if the individuals form a population. Genetic algorithm is a method to search for optimal solutions by simulating the biological evolution of nature, as shown in Figure 2. It was first proposed by John Hollander of the University of Michigan and is usually used to solve optimization and search problems. Genetic algorithms belong to one of a large class of evolutionary algorithms, and similar algorithms include particle swarm algorithms, artificial fish swarm algorithms, and differential evolution algorithms. Similar to other evolutionary algorithms, genetic algorithms encode the problem into different individuals, transforming the original problem and forming a population of many individuals. There are many ways of encoding, such as binary encoding, real encoding, Gray code encoding, and symbolic encoding. After determining the individual coding, we also need to design different adaptation value functions according to different problems and measure the advantages and disadvantages of different individuals by calculating the adaptation value of each individual. After determining the individual coding method and the adaptation value function, the basic operation flow of the genetic algorithm and the related introduction are as follows. (1) Initialization: initialize the population. (2) Individual evaluation: calculate the fitness value of individuals in the

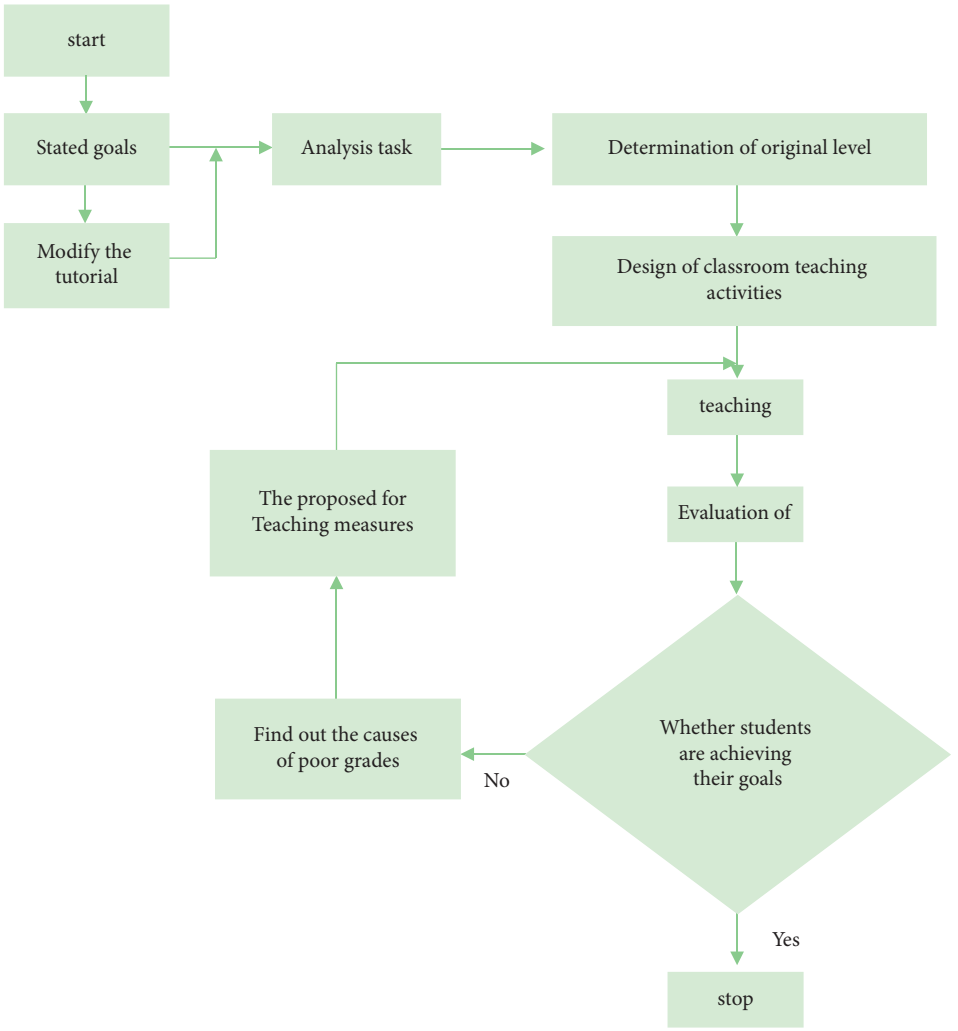


Figure 1: Instructional design pattern diagram.

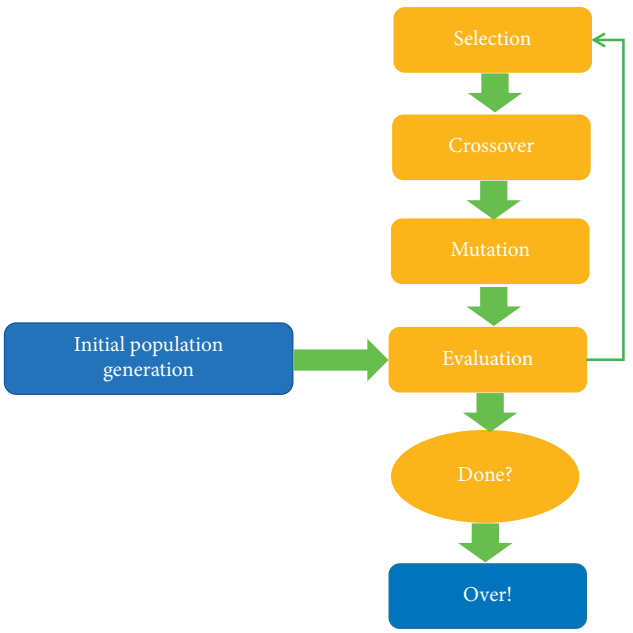


Figure 2: Genetic algorithm working principle.

population based on the fitness value function. (3) Selection operation: the selection operator is used to act on the population. The selection operator mimics the principles of survival of the fittest and survival of the fittest in nature's biological evolution and can be used to determine which individuals in the population will be retained for the next generation or to determine which individuals will undergo crossover and mutation operations. The design of selection operators is based on individual fitness values and is commonly used in roulette wheel algorithms, fitness scaling methods, and local selection methods.

2. State of the Art

2.1. Algorithm Visualization Teaching Design. The algorithm visualization basic element development library is located at the bottom of the AI algorithm visualization design architecture [6]. The basic element development library is mainly a collection of functions with high reusability, which mainly designs functions for some basic visualization elements that are used frequently and designs API call interfaces for the intermediate processing layer to call. In the algorithm

visualization design, specification 1 requires the use of simple, common, and easy-to-understand basic graphical elements for the design of algorithm visualization. The algorithm visualization basic element development library is based on this guideline for some common basic graphical elements for function design package and visualization development library internal design as shown in Figure 3.

The library of basic elements for algorithmic visualization consists of three modules: Visual Object module, Visual Effects module, and Visual Events module, as shown in Figure 4. The Visual Object module focuses on the design of some common visualization elements, such as lines, circles, rectangles, rings, text, and other basic visualization elements. The Visual Effects module contains the design of some basic visual change effects, such as moving, connecting, highlighting, setting text, deleting, etc. The Visual Events module mainly deals with the effects of basic visual elements listening to the addition and deletion of events.

2.2. Research on Teachers' Instructional Design. Relevant foreign studies have divided instructional design into five levels [7]. Each of these levels includes goal setting, information sources, and standards. The annual design and semester-level design are done by the state and schools, and the unit design, week design, and classroom-level instructional design are done by teachers themselves as shown in Figure 5.

In instructional design, teachers have a dual identity as instructional designers on the one hand and pedagogical practitioners on the other [8]. While the primary role of the teacher is that of an instructional designer, it cannot be ignored that the teacher is also a pedagogical practitioner and an expert in the subject matter of teaching. This study focused on the design of teachers' unit educational activity levels and the design of specific educational activity levels.

Because of these multiple roles, teachers' instructional design activities have the following characteristics: compared with the instructional design of full-time instructional designers, teachers' instructional design activities have higher relevance and flexibility. Teachers have a stronger sense of efficacy in instructional design than full-time instructional designers. Teachers' understanding of instructional design is more practical and comprehensive than that of full-time instructional designers.

2.3. Problems in Early Childhood Literature Education Activities. The main function of early childhood literature education should be to focus on the cultivation of young children's aesthetics, but research has found that many kindergarten literature education has some problems. According to Jimbo [9], "the main value of literary works depends on the literary charm of the works, which is the carrier to derive the functions of moral education and intellectual education, but kindergarten literature education for young children is biased towards moral education and intellectual education, ignoring the value of aesthetic education and neglecting to let young children feel the beauty of the works . . ." The value of aesthetic education is as follows. 1. Aesthetic education can expand students' intellectual horizons and develop their intelligence and creative spirit. 2. It has the educational function of purifying the mind, cultivating sentiment, and improving moral character. 3. It can promote the development of students' physical fitness and has the value of improving the health and artistry of physical beauty. 4. It helps students to establish the viewpoint of labor and the formation of skills and has the value of technical aesthetics. She believes that knowledge education and moral education in literature education are indispensable, but the essential function of literature education is not education [10]. In Ren Jimin's "Current Misconceptions in Early Childhood Literature Appreciation Education," it is argued that current early childhood literature education has not received sufficient attention, and it is believed that the main misconceptions in kindergarten literature education include ignoring the subject position of young children's appreciation, belittling the cultivation of young children's aesthetic perception, ignoring the cultivation of young children's aesthetic emotions, and not helping young children to establish a correct aesthetic attitude. There is a belief that kindergarten literature education focuses on knowledge and moral education but does not highlight literature emotional education and aesthetic education [11].

3. Methodology

3.1. Research Framework Based on GE-ELM Algorithm

3.1.1. GE-ELM Algorithm Framework. In GE-ELM, we first need to encode the random parameters in the ELM to optimize it using the evolutionary framework of the GA algorithm [12]. For an ELM network with N hidden layer nodes, we encode the random parameters in this way as follows:

$$o_i = t + \varepsilon_i, \tag{1}$$

where mouth is the individual in the GA algorithm, and % and play are the corresponding random parameters of the ELM with an initial range of [−1, 1].

The smaller the training error of the network and the smaller the network weight parametrization, the better the generalization ability of the network. We ranked the different individuals by their numerical parametric size and selected the subset of networks with smaller network weight parameters for integration, as in Figure 6.

It was suggested that using a simple averaging method for integration rather than taking different weights for each integrated individual has the advantage of avoiding the overfitting problem [13]. Therefore, in GE-ELM, we simply average the predictions of each selected ELM network to obtain the final experimental results. In solving the classification problem, the category with the highest number of votes is selected as the category to which the sample belongs. For example, when using the ith ELM network to predict a sample, the samples all have a vector v with the same dimension and number of classes. If the ith ELM network predicts that the sample belongs to the k-th category, the k-th element of the vector vi is set to 1; otherwise, it is set to

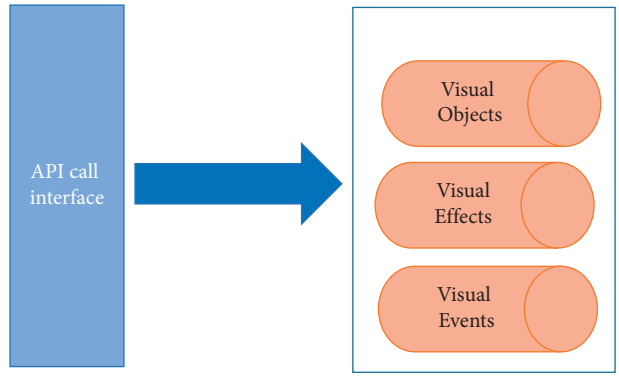


Figure 3: Design of algorithm visualization basic element development library.

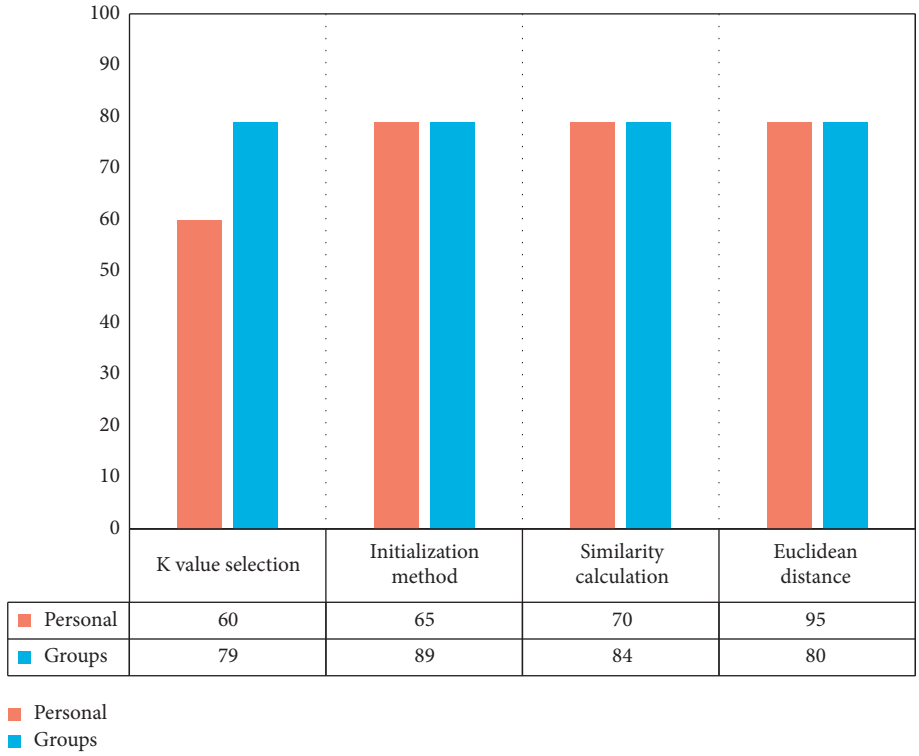


Figure 4: Individual versus group learning.

O. After all the ELM networks have predicted a sample, the corresponding decision vector V for that sample is

$$V_e = \sum_{i=1}^{M} V_i. \tag{2}$$

3.1.2. Three-Tier Architecture. The three-tier/multitier distributed computing architecture has undoubtedly become the dominant model for today's enterprise applications [14]. Any software system can be divided into three layers at the application logic level, from top to bottom: representation layer or user interface layer (UIL), business logic layer (BLL), and data access layer (DAL), as shown in Figure 7.

(1) The representation layer provides the (UI) of the application [15]. The main function is to receive and return user requests on the client side and only display the data processing results, not the specific data processing. The representation layer of most applications is constructed from forms, and the representation layer is the only part of the application that is visible to the user. The representation layer consists of a series of page forms, each of which contains a variety of fields for collecting user input and displaying output from the lower layers.

(2) The BLL is in the middle of the DAL and the UIL, also called the middle layer, and is where the user's business requests at the representation layer are handled and the requested data operations are sent to

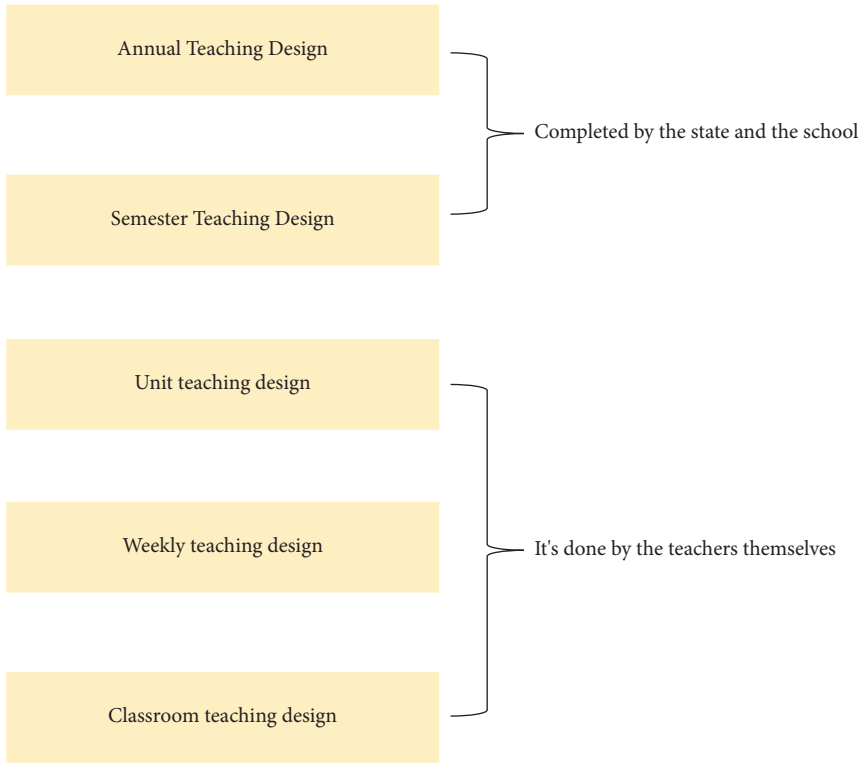


Figure 5: The level of foreign teaching design.

the data access layer. It must protect the integrity of the data in the application by implementing business rules. If the DAL is the building block, the logic layer is the construction of those blocks.

(3) The DAL is the layer that operates on the raw data (database or text files). This layer involves a variety of database access technologies and has one main function. One is to pass the raw data from the database to the BLL, specifically to provide data services for the business logic layer and the representation layer; the other is to parse the operation requests from the business logic layer and convert them into specific data operation commands to pass to the database to complete the execution of query, insert, modify, store, delete, and other operations on the raw data.

3.2. System Database Design. The personalized teaching PCAI platform system needs to store basic static information of teachers and students, as well as information related to the operation of the workflow process [16]. The main database tables in the system include teacher information table, student information table, learning activity data table, learning resource data table, role definition data table, and member definition data table. The specific design is as follows.

(1) Teacher information data table: it mainly stores the basic information of the teachers in the process of online personalized teaching, and students will know the teachers through these data. The specific design is shown in Table 1.

(2) Student information data table: it is mainly to store the information data of the student participants in the process of personalized teaching on the Internet, through which the basic information of students can be obtained. The specific design is shown in Table 2.

(3) Learning activity data table: it records the basic information and dynamic information of learning activities related to the network personalized teaching, including the participants, interactive information content, personalized teaching resources content, and other fields. The specific design is shown in Table 3.

(4) Learning resources data table: it records the learning contents assigned to different students, the specific learning contents are built in XML format documents, and the records in the learning resources data table indicate the participant objects assigned to the different contents. The specific data table structure is shown in Table 4.

3.3. Design of the Adaptation Algorithm. The prototype of the adaptive web-based teaching system (shown in Figure 8) can be divided into three layers: concept layer, relation layer, and user view layer.

The conceptual layer is the physical layer used to store "ideas" [17]. The act of learning is the perception of ideas, which may contain very simple concepts, or they may be

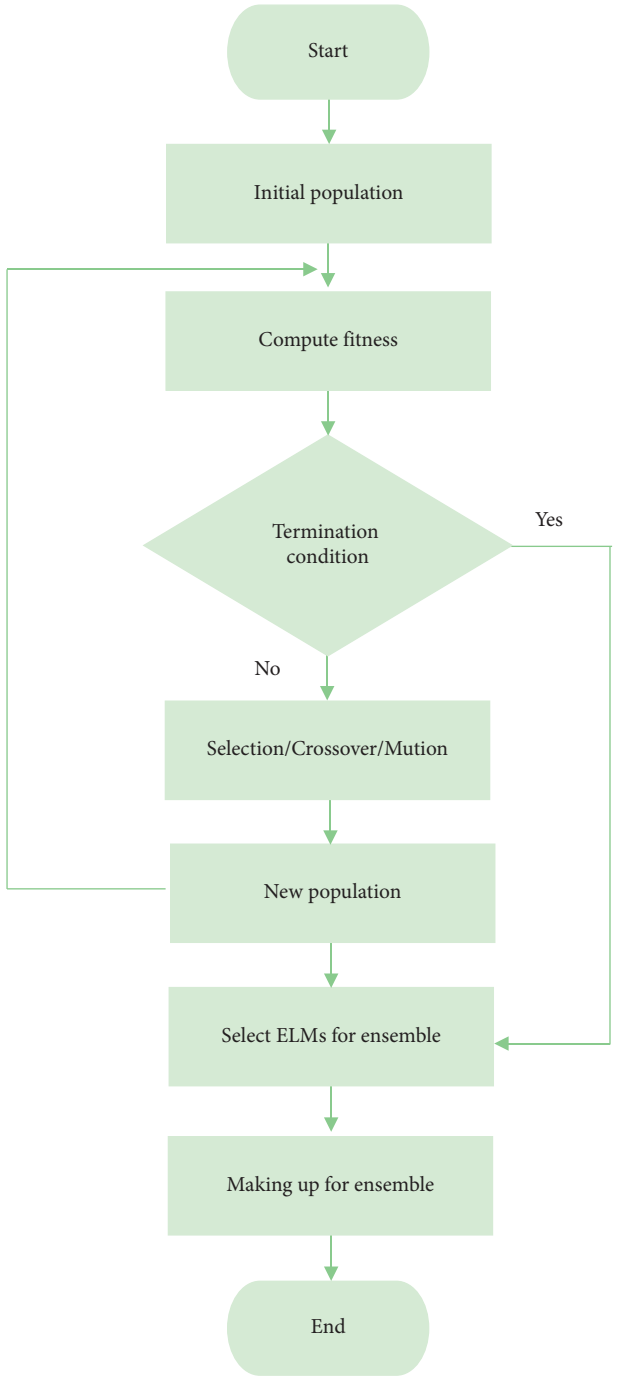


Figure 6: Algorithm block diagram of GE-ELM.

compound ideas by organizing and applying multiple ideas. The relational layer is defined as the causal relationship in a Bayesian network. The preconditions of the idea are used to define who is the parent node, and the content of the conditional probability table is also the joint probability distribution of each random variable in the Bayesian network. In this context, units of knowledge and compound ideas seem conceptually similar, but the difference is one of "need"; e.g., for elementary school students, addition, subtraction, multiplication, and division would be separated into four ideas, but for secondary school students, these four ideas might be combined into a unit of knowledge called a quadratic operation. Appropriate choices can make the generic learning paths simpler, and from a Bayesian network perspective, a simpler network structure is more efficient in terms of computational processing. The relational layer is used to describe the relationship between concepts. The desired concept or composite concept is extracted from the concept layer and defined as a knowledge unit by adding a layer to produce a common learning path. In the user view layer, the generic learning paths generated in the second layer are compared with the learner's user profile file, and then adaptive learning paths are generated for different learners [18].

3.4. Teaching Aid System Foreground. (1) Competition counseling: the administrator can not only release the competition news of related software competitions around the world but also release the competition-related counseling resources for students to download. The competition tutoring module also includes the release of information about related club activities. (2) Java platform: upload teaching materials of Java-related courses, such as Java course, JSP course, and JavaEE course, for students to learn online. (3) Database platform: upload the materials of database direction courses, where the database is usually SQL server course or Oracle course teaching resources for students to learn online [19]. (4) Online question: after students successfully log in to the teaching support system, they can select the designated instructor and ask questions they encounter in the learning process. After the instructor logs into the system, he/she can see the questions sent by students to him/her and answer them online. Net platform and database courses are uploaded in the format of SWF files which cannot be downloaded or copied. At the same time, the system has a search function, so students can search for the resources they need according to their needs. The frontend user case diagram is shown in Figure 9. (5) Learning forum: the most important feature of the teaching aid system is the interaction between teachers and students and peers. Therefore, in the learning forums, the moderators of each forum are full-time instructors. The foreground of the learning forum includes user login management, user registration management, post management, and other functions.

3.5. Classical Measurement Analysis. Performance analysis is an analysis of the mean score and score dispersion of an exam. The mean score is the most commonly used concentration measure. The arithmetic mean is the most commonly used and is usually expressed as a.

$$\overline{a} = \frac{a1 + a2 + \cdots + an}{n}, \tag{3}$$

where $a1$, $a2$, ..., all denote the scores of n students in a particular test and a is the arithmetic mean of the test. The variance and standard deviation are the most used, and the larger the standard deviation, the greater the dispersion of

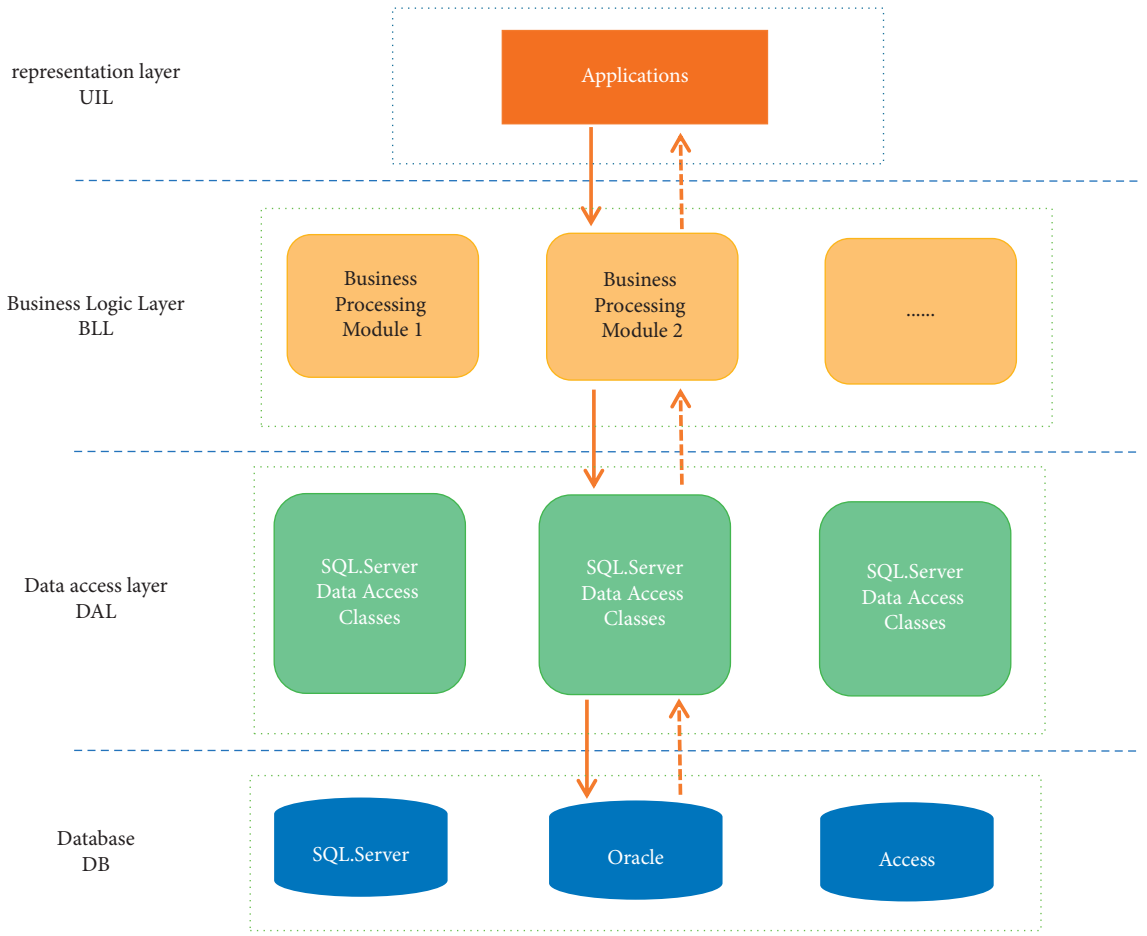


Figure 7: Three-tier architecture.

Table 1: Teacher information data sheet.

The serial number	The field names	The field type	The length of the field	The name of the field
1	ID	int	8	Teacher ID no.
2	Name	nChar	10	The name
3	Birthday	Date time	8	Birthday
4	Sex	nChar	4	Gender
5	Profession	nChar	50	Professional
6	Level	nChar	10	Job title
7	Educational	nChar	10	Level of education

Table 2: Student information data sheet.

The serial number	The field names	The field type	The length of the field	The name of the field
1	ID	int	8	Student ID no.
2	Name	nChar	10	The name
3	Birthday	Date time	8	Birthday
4	Sex	nChar	4	Gender
5	Profession	nChar	50	Professional
6	InSchool	Date time	8	Admission date

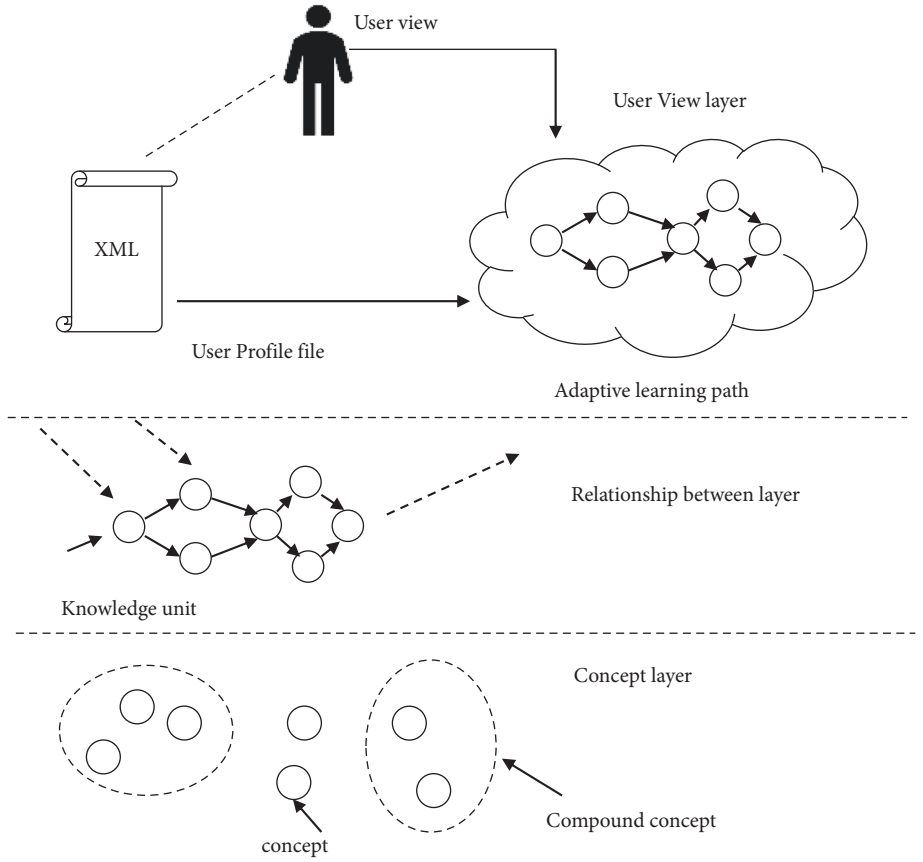


Figure 8: Schematic diagram of adaptive network teaching system prototype.

Table 3: Learning activity data sheet.

Serial number	Field name	Field type	Field length	Remarks
1	ID	int	8	Learning activity ID
2	Attends ID	nChar	100	Participant number
3	Messages	int	8	Interaction information ID
4	Teach resource	int	8	Personalized teaching resources ID
5	Time node	Date time	8	Time nodes

Table 4: Learning resources data sheet.

Serial number	Field name	Field type	Field length	Remarks
1	ID	int	8	Learning resource ID
2	Level	int	8	Resource level
3	Profession	nClar	16	Areas of expertise
4	Attendes ID	int	8	Participant ID
5	Update time	Date time	8	Update time
6	File ID	int	8	Study material index

the scores. If there are n students with scores $a1, a2, \ldots,$ all, a is their mean score, and $S2$ represents the variance, then

$$S^2 = \frac{1}{n}\sum_{i+1}^{n}(a_1 - \overline{a})^2. \quad (4)$$

The standard deviation obtained by squaring the variance is

$$S = \sqrt{\frac{1}{n}\sum_{i+1}^{n}(a_1 - \overline{a})^2}. \quad (5)$$

In addition to the analysis of test scores, it also includes the analysis of the difficulty of the whole test thesis or test questions. Difficulty analysis: the difficulty of a test question

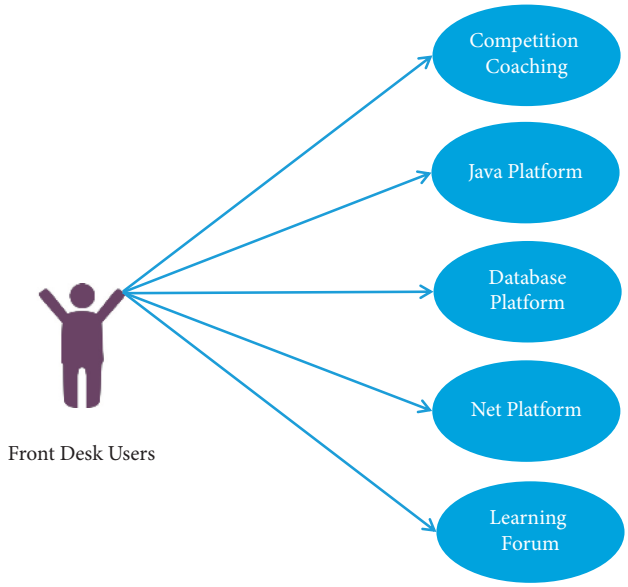


Figure 9: Frontend user example diagram.

is an indicator of how easy it is for candidates to answer the question. The difficulty value of the test question is expressed by the examinee's loss rate of the test question. The higher the loss rate, the greater the difficulty. The commonly used method to determine the difficulty of test questions is to use the following formula:

$$d_i = 1 - \frac{\overline{p_i}}{m_i}. \tag{6}$$

4. Result Analysis and Discussion

4.1. Experimental Results Analysis of MVSC Algorithm and Comparison Algorithm. In this subsection, we give the performance of different single-view and multiview algorithms on the above four data, and in Table 5 we give the relevant experimental results based on the foot evaluation criteria, including the mean and standard deviation. By analyzing the correlation results in Table 5, we can draw the following conclusions.

In the SVM-based single-view algorithm, the experimental results of SVM AU, which uses all viewpoint data as the training set, are more accurate in all four datasets than the SVM algorithm (SVM TYPE x), which is trained using only one viewpoint data information. The training dataset of SVM ALL contains richer information than that of a single perspective data, which indicates that the classification accuracy of the model can be improved by using richer information. When comparing SVM AU with the multiview algorithm, also using all viewpoint data, we found that the multiview algorithm can obtain better experimental results, which also indicates that effective fusion of viewpoint features can further improve the model performance. For example, in the Nus.wIDE.OBJEcT dataset, the best result achieved by the single-view algorithm is 0.187 ± 0.018, while the lowest experimental result among all multiview learning algorithms is 0.190 ± 0.019, which is slightly higher than that achieved by the single-view SVM AU algorithm, while MVSC achieves the highest experimental precision of 0.309 ± 0.019 in this dataset. Experimental precision of 0.309 ± 0.008 is much higher than the experimental results obtained with the SVM All algorithm.

4.2. Systematic Teaching Effect Analysis. The early childhood thinking education system provides a set of software based on modern digital technology and inductive touch technology for the teaching of young children's innovative education, integrating a variety of teaching elements of teaching interaction, experience, entertainment, and education. Teaching materials are placed in the experience table mode, and children participate in games through touch and induction, fully mobilizing their learning interest and initiative in contact with physical teaching tools and cognitive animation images. It has a significant pedagogical and educational effect on children's perception, observation ability, memory level, imagination, numerical comparison, classification, matching, sorting, judgment, reasoning, etc., as well as the formation of concepts of foot power, shape, number, color, plane and three-dimension, space, and correspondence, which encourage children to observe and experience the world independently, positively, and happily in multiple levels. In summary, this system has many positive effects for both young children and their parents, as shown in Figure 10.

(1) The early childhood thinking education system can stimulate the desire of young children to explore actively. The games in the early childhood thinking education system are some images that are very suitable for kindergarten-age children, such as common fruits and bright colors, which meet the age characteristics of kindergarten children aged 3–6 and are very stimulating to young children's senses. The computer system, on the other hand, is composed of a number of games, which are the most important way for children under 6 years old to receive information, and these games are played with children's favorite anime images as the main characters, which fully stimulate children's desire and behavior of active exploration and positive thinking while mobilizing their multiple senses and create a relaxed and pleasant mood and atmosphere for the activity process of children.

(2) The Early Childhood Thinking Education System can increase children's methods of inquiry. The goal of early childhood education is for children to master the concept of simple numbers; learn to add and subtract within 10 operations; master geometric figures, bodies, time, space, and other knowledge; develop calculation and projection skills; and develop mathematical thinking. The main starting point of the game is the concepts of shape, number, plane and three dimensions, space, and correspondence, which coincides with the development goals

Table 5: Experimental results of MVSC algorithm and comparison algorithm.

Methods	NUS-WIDE	Scene	MSRC-v1	Digit
SVM (Type1)	0.161 ± 0.016	0.830 ± 0.018	0.786 ± 0.026	0.964 ± 0.023
SVM (Type2)	0.152 ± 0.018	0.743 ± 0.015	0.774 ± 0.022	0.764 ± 0.021
SVM (Type3)	0.144 ± 0.020	0.665 ± 0.017	0.794 ± 0.021	0.958 ± 0.023
SVM (Type4)	0.153 ± 0.019	0.581 ± 0.019	0.798 ± 0.019	0.798 ± 0.026

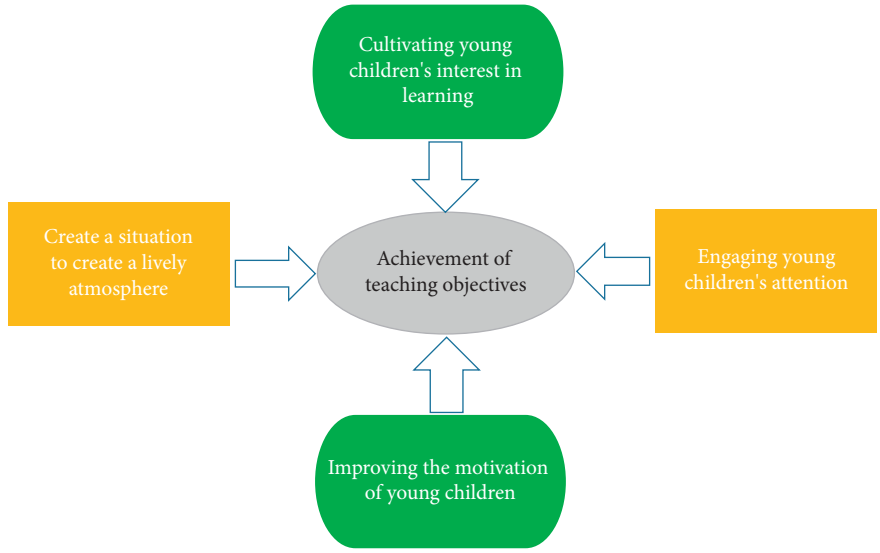


Figure 10: Program for the development of young children's sense of innovation.

of kindergarten science. In the form of games, it can be divided into tabletop games, computer games, and touchpad games, so that children have to use different ways in order to complete the game, so in the activity, children can get more and more ways to explore the problem.

(3) The early childhood thinking education system can enhance children's sense of accomplishment in problem solving. The various games in the system are divided into three levels, different levels are adapted to different developmental levels of children, and the cloud storage included in the system can analyze and archive each operation of children. This happens so that instructors and parents can more clearly understand the development trend of children and choose the level of difficulty to adapt to, in order for children to be able, after a certain amount of thinking, to solve problems and get the sense of accomplishment of exploring the world and solving their doubts.

4.3. Teaching Strategies on Developing a Sense of Innovation

4.3.1. Treat the Results of Students' Thinking Well. In the daily teaching process, the teacher's attitude will largely affect the students' emotions after their innovation [20]. It just does not accurately represent reality, and knowledge can be a summary and generalization of daily experience, which does not mean that knowledge is the truth. Knowledge is not static, but it changes with the progress of society. If teachers are not willing to listen to students' different opinions and suggestions, then this behavior will greatly frustrate students' motivation to think independently and inhibit the development of creative thinking. When a teacher is faced with a student's wrong question, he or she should analyze the reasonableness of such thinking and not simply dismiss it or even punish the student.

4.3.2. Strengthen Thinking Training and Stimulate Innovation. The specific meaning of trying to find different ways of thinking is that there are open questions that do not have fixed answers, so that we can think in many different directions in response to the question. In order to achieve the goal of developing innovative thinking, one can try to train students to think about the problem from different levels and not always be limited by the inherent patterns of thinking. The goal of innovative thinking will also eventually agree at some level with the rest of the inherent thinking, but its main manifestations are oppositional [20]. Conducting open-ended teaching can lead children to overcome their inherent thinking patterns, look at problems from different perspectives, think and analyze from both sides of things, and thus get different views. This way of teaching is conducive to promoting the development of children's innovative thinking, allowing children to further sublimate their understanding of knowledge, enhancing students' enjoyment of learning and fostering innovative thinking.

4.4. Exploring the Design of Algorithm Visualization Development Library. In the process of designing the data structure visualization library, a comprehensive consideration of the problem should be made, in which JVDSCL is mainly an extension of the original data structure class based on the Java collection library, and at the same time, the corresponding more complex data structure is added in the process: the most common is the tree diagram. In JVDSCL process, the visual data structure is constructed to realize the visualization of the data structure, and this visual data structure is also based on the operation of the original data structure class in the Java collection library, in addition to adding some visual properties and providing the visualization interface. Each data structure has multiple display modes, which requires developers to choose organically, and in JVDSCL, there are multiple layout methods for each data structure to lay out.

In addition, in the layout design, the key issue about the visualization of data structures is the layout of graphics, which has a very close relationship with the researchers' understanding of the effect of data structures and algorithms. The most important in JVDSCL is the linear layout method and the graph layout method, and the implementation of the algorithm is different for each different layout. The basic algorithm framework of the linear layout method is to obtain the number of elements of data and to calculate the size of the layout based on the displayed size and the number of data elements.

5. Conclusion

Computer multimedia technology in early childhood teaching is welcomed and favored by teachers, which is a new trend of early childhood teaching reform. The scientific and effective use of computer multimedia technology can help stimulate children's interest in learning and mobilize their enthusiasm for participation; help improve children's understanding and enrich their knowledge reserves; and help cultivate children's comprehensive ability and promote their all-round development. Therefore, the effective application of computer multimedia technology in the teaching of early childhood teachers has become a necessity. In order to give full play to the advantages of computer multimedia technology, teachers should start from the following three aspects. Firstly, use computer multimedia technology to create a situation to quickly focus the attention of young children; secondly, make full use of computer multimedia technology to do high-quality courseware to play the role of half the effort; and finally, use the combination of computer multimedia technology and traditional technology to have a good effect on the strengths and weaknesses of the common role.

In conclusion, multimedia technology for kindergarten teaching is a new teaching tool highlighted in the curriculum reform, which is very attractive and infectious to young children and can effectively promote the cognitive and emotional development of young children. Further, kindergarten teachers in teaching practice should strive to develop, explore, and study how to use multimedia technology appropriately.

Data Availability

The labeled dataset used to support the findings of this study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This work was supported by Jeonju University.

References

[1] R. V. Rao, V. J. Savsani, and D. P. Vakharia, "Teaching–learning-based optimization: a novel method for constrained mechanical design optimization problems," *Computer-Aided Design*, vol. 43, no. 3, pp. 303–315, 2011.

[2] Fan Xiu, "he cultivation and enhancement of young children's language skills," *Academic Weekly*, no. 35, pp. 1–3, 2018.

[3] Y. Gao, "Exploring the practical teaching strategy of the course "Design and guidance of kindergarten education activities" for preschool education majors," *Talent*, vol. 10, no. 32, pp. 54–56, 2020.

[4] I. Y. Kazu and A. Is, "An investigation about actualization levels of learning 0utcomes in early chi ldhood," *Curriculum Journal*, vol. 6, no. 03, pp. 23–26, 2018.

[5] Li Mo Yi, "The dilemma and breakthrough of teachers' teaching concept change under the perspective of embodied cognition," *Educational Theory Practice*, vol. 39, no. 10, pp. 53–57, 2019.

[6] A. Caramazza, S. Anzellotti, L. Strnad, and A. Lingnau, "Embodied cognition and mirror neurons: a critical assessment," *Annual Review of Neuroscience*, vol. 48, no. 37, pp. 1–15, 2020.

[7] Su Wang, "Building a new ecology of STEM education," *Digital teaching in primary and secondary schools*, vol. 56, no. 09, pp. 4–7, 2018.

[8] M. Zhang, W. Wang, and L. Yuan, "Research on the activity design of kindergarten STEAM education," *Modern distance education*, no. 04, pp. 76–80, 2018.

[9] Jimbo, "Cultivation of students' innovative consciousness and ability in elementary school mathematics teaching," *Academic Weekly*, no. 19, pp. 48-49, 2022.

[10] A. Ioannou and E. Makridou, "Exploring the potentials of educational robotics in the development of computational thinking: a summary of current research and practical proposal for future work," *Education and Information Technologies*, vol. 23, no. 6, pp. 2531–2544, 2018.

[11] X. Zhang and X. Wang, "A review of research on gray wolf optimization algorithms," *Computer Science*, vol. 46, no. 03, pp. 30–38, 2019.

[12] W. John, *Santrock.Perkembangan anak edisi kesebelas jilid 1*, Penerbit Erlangga, no. 14, , pp. 55–60, Jakarta Raya, Indonesia, 2019.

[13] R. Fogarty, "Ten ways to integrate curriculum[J]," *Educational Leadership*, vol. 49, no. 2, pp. 61–65, 2018.

[14] P. Tarair, "Sub jec t ma t ter and re lated p edago g ica l know ledge in teach eredu cat ion," *T each in g and Teacher Educa tion*, vol. 114, no. 4, pp. 99–110, 2018.

[15] Z. Miao and D. Reynolds, *The Effectiveness of Mathematics Teaching in Primary Schools*, pp. 20–35, Taylor & Francis, UK, 2018.

[16] B. Moseley, "Pre-service early childhood educators'perceptions of math-mediated language," *Early Education & Development*, vol. 16, no. 3, pp. 385–398, 2005.

[17] J. Posner, D. J. Hellerstein, I. Gat et al., "Antidepressants normalize the default mode network in patients with dysthymia," *JAMA Psychiatry*, vol. 70, no. 4, p. 373, 2019.

[18] F. Fauth and J. González-Martínez, "Trainee perceptions of instructional design in continuous online training and learning transfer," *Educational Research International*, vol. 2021, Article ID 3121559, 12 pages, 2021.

[19] X. Bing, "A new genetic algorithm application in evaluating chorus course," *TELKOMNIKA Indonesian Journal of Electrical Engineering*, vol. 11, no. 8, pp. 4517–4522, 2020.

[20] Anderson-Cook and M. Christine, "Practical genetic algorithms," *Publications of the American Statistical Association*, vol. 100, no. 471, p. 1099, 2021.

[21] F. Fauth and J. González-Martínez, "Trainee Perceptions of Instructional Design in Continuous Online Training and Learning Transfer," *Education Research International*, vol. 2021, Article ID 3121559, 12 pages, 2021.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 8155902, 9 pages
https://doi.org/10.1155/2022/8155902

Research Article

Application of Random Trees Model in Online Learning Perspective in Evaluating Learners' Behavioral Engagement

Meiping Wu[1] **and Tao Tang**[2]

[1]*School of Stomatology, Guangzhou Health Science College, Guangzhou, Guangdong 510925, China*
[2]*College of Innovation and Entrepreneurship Education, Guangzhou Health Science College, Guangzhou, Guangdong 510925, China*

Correspondence should be addressed to Tao Tang; 2015110003@gzws.edu.cn

Received 28 April 2022; Revised 23 June 2022; Accepted 8 July 2022; Published 28 August 2022

Academic Editor: Wen Zhou

Under digital technology, the vigorous development of online education has also encountered challenges of different degrees, such as the high dropout rate of learners, the low completion rate of courses, and the loss of users. Learning engagement has not yet formed an effective assessment system. Based on an exploration of the core of learning activity engagement, this research evaluates the state of learning activity engagement utilizing learners' adaptive adjustment processes of information exchange activities and a random trees model. A combined classifier is a random tree. Random trees are a combined classifier. Its main idea is to build multiple relatively independent decision tree classifiers based on two random processes, and then obtain the final prediction results by voting all decision trees. The traditional random trees model is improved by weighted calculation and aggregation calculation. After experimental analysis, it can be found that the highest can reach more than 80%, which proves that the improvement of the weighted value has a good reflection on the random trees model, and the accuracy rate is increased by 65.2% after the weighted improvement. Overall, the performance of the improved random trees model is improved by 67.3%.

1. Introduction

Based on the gradual transformation of IT and the continuous application of mega data processing technology in the field of education, more and more online learning platforms have been applied in practical teaching [1]. The online instructional platform has a variety of instructional resources, and a variety of learning support service tools and supports the development of a variety of instructional modes, which can meet the various teaching and learning needs of teaching stakeholders [2]. Online learning provides on-the-job personnel with the opportunity to further study and improve the quality of the labor force. It is of great significance to solve the current situation of a large labor force but low ability quality in China [3]. Compared with the traditional instructional form, online learning is a new learning mode developed under the network environment. With the help of the abundant and shared instructional resources on the network, it breaks through the limitation of time and place of traditional teaching, and provides a virtual and interactive learning environment for teachers and students, students and students [4]. With the continuous innovation of IT in the field of education, traditional education methods can no longer meet the learning needs of learners [5]. In recent years, the gradual transformation of educational informatization has changed people's learning methods, learning thinking, and learning cognition. Online learning has been widely recognized by all sectors of society and has become an indispensable learning method in our study and life.

Throughout the current Internet + teaching practice, an effective assessment system has not been formed, especially the integration of assessment indicators and front-line teaching scenarios is not enough [6, 7]. Therefore, there is an urgent need to design a new assessment method for the teaching scene of IT, and adopt an index system with both

reliability and validity to consider the learning state [8]. These learning activities are often unconscious and scattered, and the underlying rules and underlying structures between behaviors are not significant, but they can better reflect the subtle and complex logical relationship in learning than explicit learning activities and can reflect the truest thinking and learning situation of students, which is difficult for teachers or other assessment mechanisms to capture [9]. Select the characteristic dimension of learning activity analysis, and build a corresponding index system for learning activity characteristics and behavior indicators through online learning activity performance and the implementation process of key behavior analysis technologies, to discover and measure learners' engagement, motivation, and interaction [10]. Therefore, it is necessary to supervise the learning process of learners, predict the learning development trend of learners in time, take appropriate intervention measures for different learning effects, and give learners targeted help, guidance, or encouragement so that learners can constantly correct the learning route in the learning process.

The random trees algorithm is an excellent classification algorithm, which belongs to a typical combination classifier algorithm. It was first put forward by Professor Leo Breiman, an academician of the American Academy of Sciences in 2001. The basic classifier model of the random trees model is the classification regression tree model. In order to make the decision tree model in the random trees model different, two "random" processes are adopted in the process of building the random trees model [11] learning activity analysis is more and more widely used in education [12]. The traditional education data is single and one-sided, and cannot objectively present all the learning activities of learners. The online instructional platform comprehensively records the learning results data, learning methods, platform usage characteristics, and other learning activities of learners. The comprehensiveness of the online instructional platform data It is extremely important to analyze the learning activity of learners [13]. From the perspective of learner development and instructional mode reform, the research on learning activity analysis can guide teachers to provide personalized guidance to learners, bring new ideas to educational researchers to optimize instructional mode, and also bring new enlightenment to the construction of personalized learning and adaptive system [14]. However, there are still some shortcomings in the above research, so this study puts forward some innovations on this basis:

① In view of the shortcomings of the random trees algorithm, For example, there is no very reasonable method to specify the size of random trees when the decision tree is generated. Too large or too small a model will affect the final decision result of the model. This study proposes a random trees model composed of weighted decision trees. According to the different generalization abilities of a single decision tree, the decision weight of the decision tree in the process is calculated to improve the overall prediction accuracy of the model.

② Model optimization of random trees. By analyzing a single classifier in random trees, their similarity is calculated. Through the clustering method, the classifiers with large differences are extracted and integrated to make more fair and effective decisions. The results of various measurement methods are analyzed through experiments, and some further improvement schemes are put forward.

2. Related Work

Ferreira et al. proposed the concept identification of weak learning algorithms and strong learning algorithms, and their equivalence problem, that is, whether it is possible to upgrade weak learning algorithms to strong learning algorithms [15]. Wang et al. believe that parallel development on the spark platform has several very important benefits: first, the spark has a unified API, so it is very easy to develop applications; Second, the spark can perform different operations on the same data, and these different operations can be combined to obtain higher efficiency; Third, spark usually operates in memory and has high efficiency [16]. Patil and Deore put forward a circular data analysis model, which includes seven parts: data collection, storage, data cleaning, integration, data analysis, data presentation and visualization, and corresponding behaviors. He summarized the sources of data into two platforms, namely a learning system and a learning management system [17]. Tafesse and Wien used the clustering method in the data mining method to perform cluster analysis on the learner behavior data in 612 courses to extract the learner behavior characteristics [18]. The research of Min and Kim shows that the online learning assessment system is the key and core of online learning, so it is urgent to build a reasonable and perfect online learning assessment system and make a fair assessment through the collection and analysis of learners' learning activity [19]. Rajabalee et al. put forward the theory of "granular learning activity", which is used to discover the granular learning activity pattern of learners' learning interaction with an intelligent tutoring system, manage the uncertainty of learning activity, and cluster the N-gram model into a hierarchical structure by using rough set-based map particles, which can be used to predict learners' learning activity in intelligent tutoring system [20]. Koehler and Meech believe that the current domestic research on the relationship between teacher support, learning burnout, and learning motivation is relatively in-depth. The findings indicate that teacher support is adversely connected to students' levels of learning fatigue, and that professional assistance from instructors can increase students' learning in an online learning environment. The level of interaction and perspective is turned to research on teacher support strategies, but the majority of them are aimed at early childhood and young children, and there is relatively little research on the relationship between teacher support and learning activity engagement in the online learning environment [21]. This research results show that the overall goal of data mining is to find hidden useful information from complex data sets and use this useful information to create greater value. The

task of data mining is to automatically or semi-automatically extract previously unknown interesting patterns from a large amount of data, such as data records, exception records, and dependencies [22]. Willans et al. proposed a technology similar to Boosting, Bagging. Breiman emphasizes that the stability of the learning algorithm in integration has a great influence on the final result. For unstable algorithms, such as neural networks and decision trees, it can improve the accuracy of prediction. But it has no obvious effect on the stable learning algorithm, and sometimes even reduces the prediction accuracy [23]. Cahn and Anna believe that random trees are a nonlinear combination classifier. It uses random sampling with replacement to extract training samples and feature sets. After training, many weak classifiers are obtained, and a large number of weak classifiers (decision trees) are combined into random The forest classifier, obtains the final prediction result by means of [24]. Hooshyar and Yang sorted out three indicators affecting academic achievement: academic factors, demographic factors, and cultural and social factors. Therefore, we summarized the prediction indicators adopted from the relevant research on actual data prediction [25]. Yang believes that the core and connotation include three aspects: the object of learning analysis refers to the data generated by teaching stakeholders in the process of teaching and learning, and the focus of learning analytics is to analyze the data by using correlation analysis methods. The goal of learning analytics is to discover learning rules, predict learning effects, evaluate the learning process and optimize teaching effects [26]. Green et al. based on the rough set theory put forward an algorithm for attribute reduction using discriminative function. Knowledge of key personality characteristics, revealing the objective relationship between personality characteristics and learning strategies, and reducing the amount of data [27].

Based on the research of the above-related work, this study determines the positive role of the random trees model in the field of learner behavior investment assessment, constructs a random trees model optimized by algorithm, makes an in-depth analysis and research on the acquired and collected data using big data algorithm analysis, makes more effective use of data, and excavates the valuable knowledge hidden behind the data, Find and find out the potential problems in the assessment of learners' behavior investment that affect online learning.

3. Methodology

3.1. Construction of Random Forest Model. Learning refers to the process of a series of activities produced by the learning subject by obtaining a certain learning effect in the process of life learning activity comes with learning. In traditional learning, learning activity refers to the behavior that learners interact with learners, teachers, and teaching resources in the classroom environment. Such learning activities can only be recorded through teacher observation, video storage, and questionnaire. Behavioral science is a science that cooperates in the fields of psychology, sociology, and economics. It mainly studies human behavior or human aggregate behavior by using the experimental and observation methods of natural science. Based on the mainstream psychological point of view, learning activity can be divided into two kinds: explicit learning activity and implicit learning activity. Explicit behaviors are learning activities that can be directly observed, such as reading, taking notes, etc., while implicit learning activities cannot be directly observed behaviors, such as thinking, awareness, analytical ability, etc. Different educators have different emphases on understanding learning activities. Educational assessment has specific guiding and management functions.

Educational assessment is not only a guide for teaching management, teachers' teaching content, methods and learners' learning, but also restricts and promotes learning. Management function refers to the constraint effect and ability of learners to achieve the ultimate goal by regulating, controlling and standardizing learners' behavior. Learning activities refer to the sum of a series of behaviors that learners perform according to their individual learning needs when logging on to the online platform. Therefore, the learning activities may include logging into the learning platform, accessing a certain resource or module, replying to others, etc. Each learning activity forms a learning activity flow. Considering each learning activity as a system, it includes activity subject, activity object, activity operation, activity environment and activity result. The duration of each learning activity and the time interval for entering the next learning activity will vary according to different personal habits and motives. The analysis of a single online learning activity is shown in Figure 1.

At this time, for the convenience of statistics, the duration of a single learning activity is recorded as H, and the start time and end time are recorded as h_1, h_2 respectively; the time interval between two consecutive learning activities is recorded as $T\prime$, the end time of the previous activity and the start time of the next one They are recorded as h_1', h_2' respectively. Therefore, the duration of a single learning activity H, the time interval of two consecutive learning activities $H\prime$, the average learning duration h, and the average interval of learning activities $h\prime$ are as follows:

$$\begin{aligned} H &= h_1 - h_2, \\ H' &= h_1 - h_2, \\ h &= \frac{\sum_{i=1}^{n} H_i}{n}, \\ h\prime &= \frac{\sum_{i=1}^{n} H_i}{n}. \end{aligned} \tag{1}$$

From the research on the composition of online learning activity system and the existing online learning activity assessment index system, it can be seen that although the establishment of the existing online learning activity assessment index system has been deeply studied in theory, these theories can not better serve the specific online learning activity analysis and assessment objectives. The following Table 1 shows the relevant indicators of learning activity level.

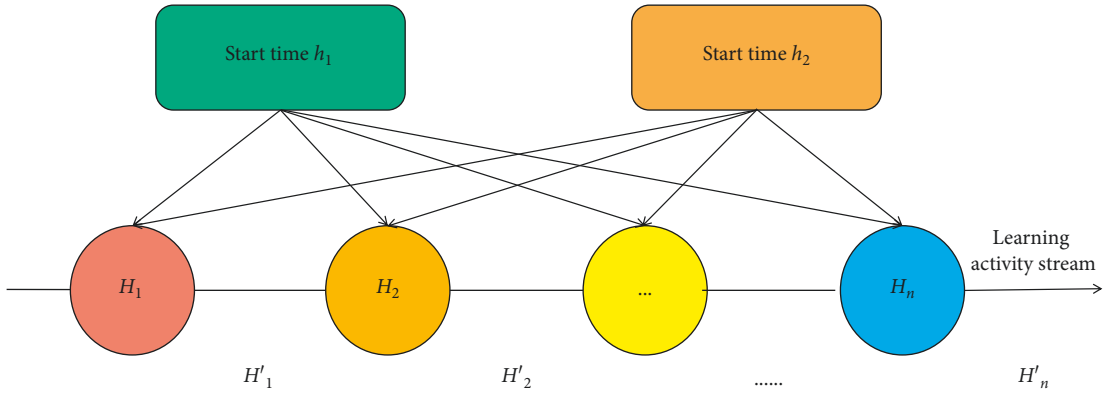


Figure 1: Time interval analysis of online learning activities.

Therefore, based on the existing online learning activity model, combined with specific online learning activity analysis and assessment indicators, this study formulates online learning activity models for different analysis and assessment objectives, as shown in Figure 2.

The whole online learning activity model includes four layers. The learning activity description is used to clearly describe various specific online learning activities. The third layer is the online learning activity classification system. Different from the previous hierarchical classification models, the wood model is a parallel classification model that analyzes and evaluates the learning activity. Each type of learning activity includes both lower-level online learning activities, It also includes a high-level online learning activity model. Each type of online learning activity serves a specific online learning activity analysis and assessment goal. The top level is the goal of online learning activity analysis and assessment. In terms of teaching, the viewpoint of the constructivism model is that learning is not a process of passively accepting knowledge, but that learners selectively construct new knowledge or things acquired into their own knowledge system according to their own cognitive structure. Teachers' duty is no longer simply to impart knowledge to learners, but to guide them to acquire learning experiences. Therefore, constructive learning theory has shifted from an objectivist knowledge dissemination model to an active learner model.

Each behavior activity is a systematic process in which the behavior subject interacts with the behavior object, operates, and produces some results in a certain learning place and time [28]. Similar to the online learning activity description model, the online learning activity classification should also be guided by the analysis and assessment goal. Although the hierarchical classification system based on the level of information processing can better reflect the changes in learners' cognitive level when implementing learning activity, it can not directly serve the analysis and assessment.

3.2. Application of Stochastic Senli Model in Assessment. The random trees model is used for data prediction. All decision trees make predictions and determine the final prediction result of the model along the way. However, there are still some problems in practical application, such as the classification of small data sets and low dimensional data sets may not get good results. Because in the process of repeated random selection, there are few examples to choose from, which will produce a large number of repeated choices, which may make the most effective choice unable to show advantages. Figure 3 shows the basic construction of the random trees model.

Random trees are a combined classifiers composed of multiple meta-classifiers, each of which is relatively independent. The process of model result prediction is that each meta-classifier predicts the result separately and gives the statistical results of all decision trees. Process, for the combined classifier $\{h_1(x), h_2(x), \ldots, h_k(x)\}$, there is an input vector x, and the model workflow is shown in Figure 4.

When the input data is, each meta-classifier predicts the results relatively independently. After obtaining the prediction results of all meta classifiers, the random trees model obtains the overall prediction results of the model through predetermined rules. Generally, for the classification problem, the prediction result given by the meta-classifier is a specified classification result, and the random trees make statistics on all the classification results, giving the one with the largest number as the final prediction result; For the regression problem, random trees is generally the final prediction result by calculating the average of the prediction results given by all meta-classifications.

3.3. Partial Optimization of Algorithm Using Stochastic Forest Model. Since in the process of building the random trees model, the construction of the decision tree and the OOB estimation of the decision tree can be completed serially. While the construction of the random trees model is completed, each decision tree obtains a corresponding OOB assessment value, so as to allocate the weight of the corresponding decision tree. For the decision tree $h(x)$, its weighted value is defined as poob, which is expressed as:

$$POOB = \alpha \times \frac{S_+}{S}. \tag{2}$$

Among them, S_+ is the data assessment of the decision tree using OOB data, and the correct number of samples for

Table 1: Relevant indicators of learning activity level.

Hierarchy	Name	Describe
1	Operational behavior layer	Actions related to online learning activity
2	Cognitive collaborative behavior layer	Learning cognition and communication between individuals
3	Problem-solving layer	Problem-solving, planning

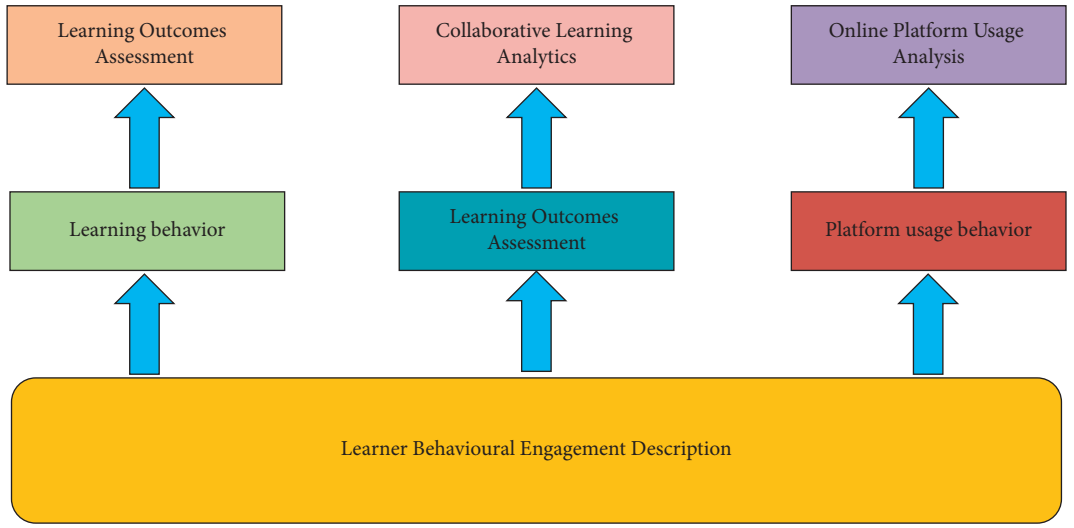


Figure 2: Goal-oriented online learning activity model.

assessment, S is the total number of samples participating in the OOB assessment of the decision tree, and α is the parameter adjustment coefficient. Since the random trees model $\{h_1(x), h_2(x), \ldots, h_k(x)\}$ obtains the OOB assessment accuracy $\{p_1, p_2, \ldots, p_k\}$ of each decision tree in the actual calculation, the assessment result of the final model can be expressed as:

$$\max\left\{c|c_i = \sum_{k}^{i=1} POOB_j I\left(h_j(x) = I_i\right), l_i \in C, j = 1, 2, 3, \ldots, k\right\}, \tag{3}$$

where C is the set of all category labels, I_i is the C category label in the set i, and $I(h(x) = I_i)$ represents the explicit function. When the assessment result of the decision tree $h(x)$ is category label I_i, the explicit function is equal to 1, otherwise it is equal to 0. p_j is the weighted value of the j th decision tree in the process, c_i is the weighted result obtained by the i th class label, and the final assessment result of the model is the one with the largest total weighted value obtained by each class label.

Since there are many variables, when measuring the correlation between variables, it is necessary to quote the correlation coefficient as the basis for judging the linear correlation between two variables. The correlation coefficient is one of the important indicators to judge the correlation degree between variables. Let variables x, y count data sets $x\{x_1, x_2, \ldots, x_k\}, y\{y_1, y_2, \ldots, y_k\}$ respectively, then the correlation coefficient x, y between variables r can be expressed as

$$r = \frac{\sum_{i=1}^{k}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{k}(x_i - \overline{x})^2 \sum_{i=1}^{k}(y_i - \overline{y})^2}}. \tag{4}$$

In the above formula, $\overline{x}, \overline{y}$ is the average value of the statistical data of the variable x, y, respectively. It should be noted that the value of the correlation coefficient is distributed in the range of - 1 to +1, i.e. $|r| \le 1$. When $r > 0$, it means that the two variables are positively correlated. On the contrary, when $r < 0$, it means that the two variables show a negative correlation. When the variable correlation coefficient is $|r| = 1$, it means that the two variables show absolute correlation. When $r = 0$, it means that there is no correlation between the two variables. As k increases, the results of the correlation coefficient r will be more accurate.

Generally, the relationship between two decision trees is analyzed, and the classification result of P_k is represented by $h_k(x)$, which is generally expressed as

$$h_k(x) = P_k = \begin{cases} 1, h_k(x) = Y, \\ 0, h_k(x) \ne Y. \end{cases} \tag{5}$$

The relationship between the results of two decision trees h_i, h_j classification samples k can be expressed as

$$P_{i,k,j} = \begin{cases} P^a_{i,k,j}, P_i = 1, P_j = 1, \\ P^b_{i,k,j}, P_i = 1, P_j = 0, \\ P^c_{i,k,j}, P_i = 0, P_j = 1, \\ P^d_{i,k,j}, P_i = 0, P_j = 1, \end{cases} \tag{6}$$

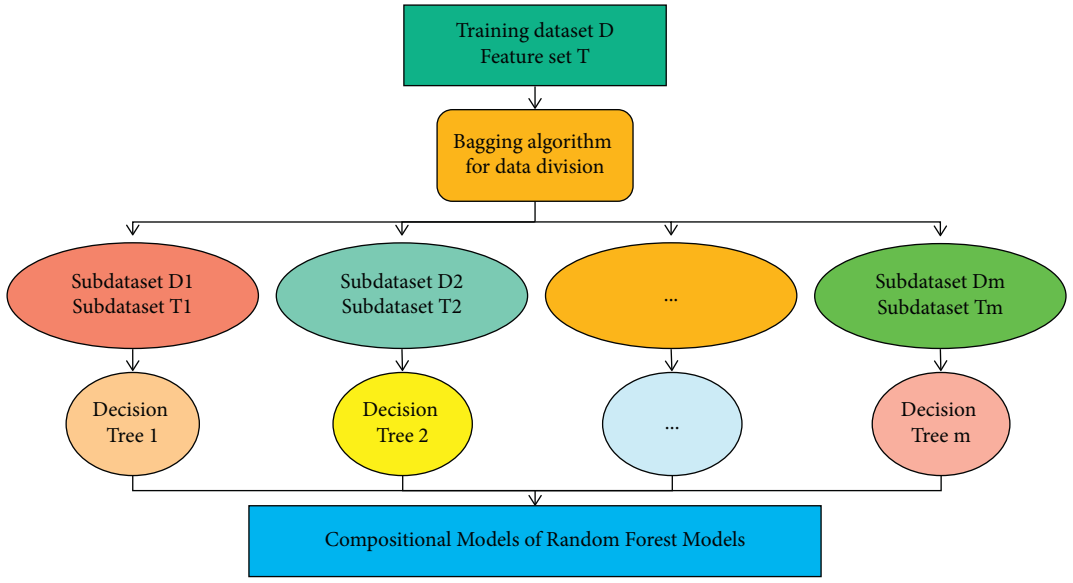


Figure 3: Basic construction diagram of the random trees model.

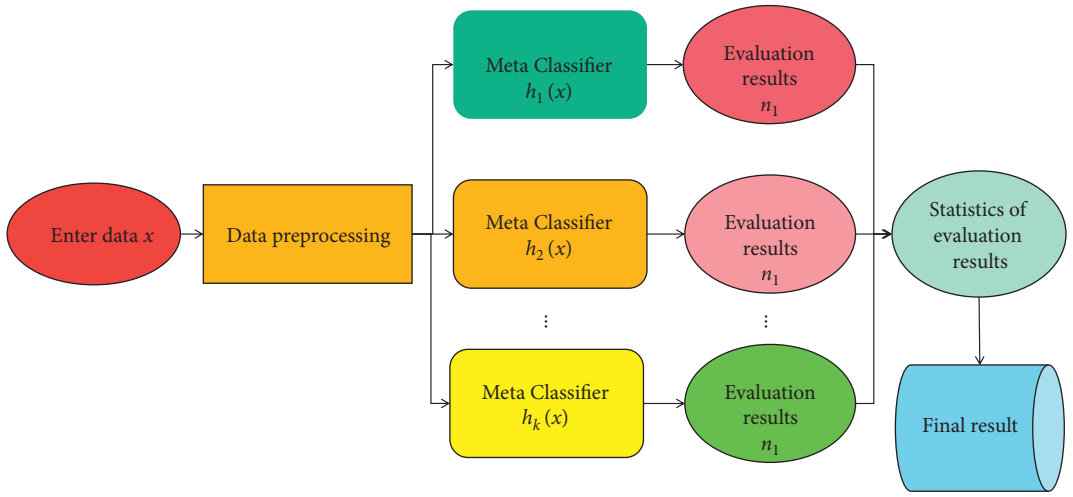


Figure 4: The basic workflow of the random trees model.

where a represents the number of samples that h_i, h_j can correctly classify in the whole data set as follows:

$$a = \sum_{k=1}^{N} I\left(P_{i,k,j}^{a}\right). \tag{7}$$

Clustering is dividing the set into several subsets according to the similarity between samples, and the samples in each subset have a high degree of internal similarity. Our purpose is to reveal the relationship between classification trees through clustering, so as to select more targeted classification tree individuals more effectively. As N increases, the results of the number of samples that can be correctly classified in the whole data set a will be more accurate.

4. Results, Analysis, and Discussion

Based on the above research, this study proposes the application of learner behavioral engagement assessment based on the random trees model, in order to verify that the random trees model has an actual effect on the assessment of learner behavioral engagement. Therefore, in order to verify the scientificity, accuracy and feasibility of the improved random trees model, this study will make an experimental analysis from five important parameter dimensions: the assessment accuracy of different decision trees, the assessment accuracy of different characteristic decision trees, the comparison of running time on different data sets, the performance improvement of the improved random trees model and the correlation strength, and analyze the applicability of the improved random trees model to the assessment of learners' behavior engagement. Three data sample sets a, B, and C are set as experimental samples for the assessment accuracy of different decision trees, the assessment accuracy of decision trees with different characteristics, and the comparison of running time on different data sets. The

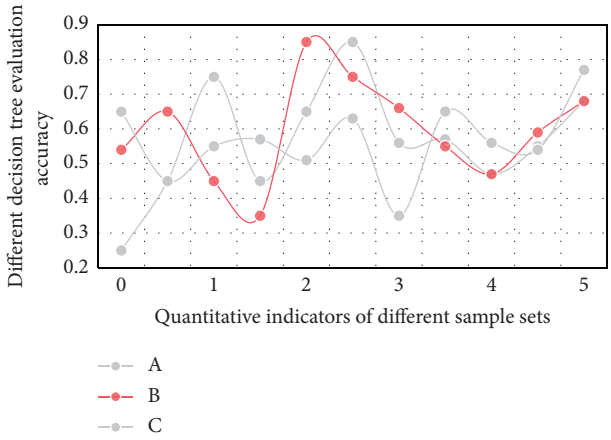


Figure 5: Assessment accuracy analysis of different decision trees.

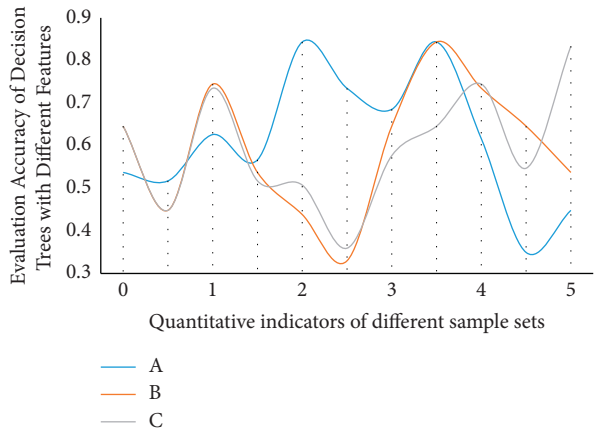


Figure 6: Assessment accuracy analysis of decision trees with different features.

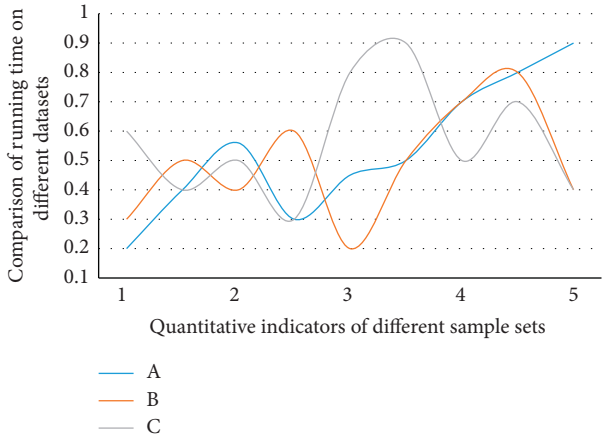


Figure 7: Analysis of running time comparisons on different datasets.

data diagram of the analysis method is shown in Figures 5, 6, and 7 below.

The above figure clearly reflects the overall trend of the assessment results on different decision trees and decision trees with different characteristics. You can basically figure it out. As a result, by focusing on the feature vector in the assessment of learner behavioral input, you can grasp the subject. The maximum in the figure above can reach more than 80%, demonstrating that the improvement of the weighted value is a good embodiment of the random trees model, and the accuracy is enhanced by 65.2 percent after the weighted improvement. To differentiate the differences, the volatility of three separate melodic data sets is within a suitable range because the three data sets largely follow the same trend in the range of 1–3. However, after 3, samples a, B, and C show significant changes, which is due to the different number of interference items in different sets. For the relationship between the number of interference items, $C > a > b$, which is also directly reflected in the fluctuation range in the range of 3–4. However, with the increase in sample size, the three tend to the same trend under the action of aggregation. It can be seen that the embedding of the aggregation algorithm is of great help to the calculation improvement of the random trees model. The random number sample sets Q1 and Q2 are set below as experimental samples for the improvement of the performance of the improved random trees model and the strength of the correlation. The specific experimental analysis diagrams are shown in Figures 8 and 9.

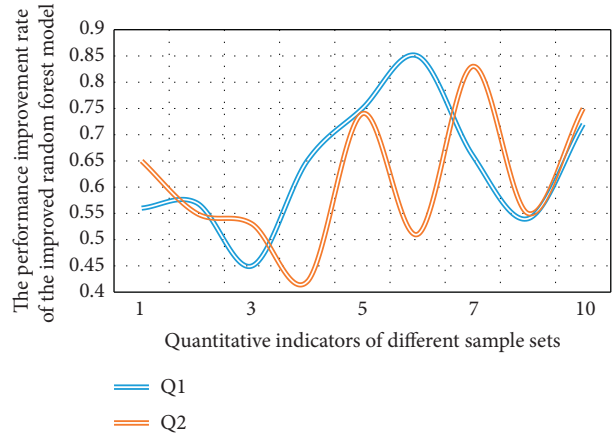


Figure 8: Analysis of the performance improvement of the improved random trees model.

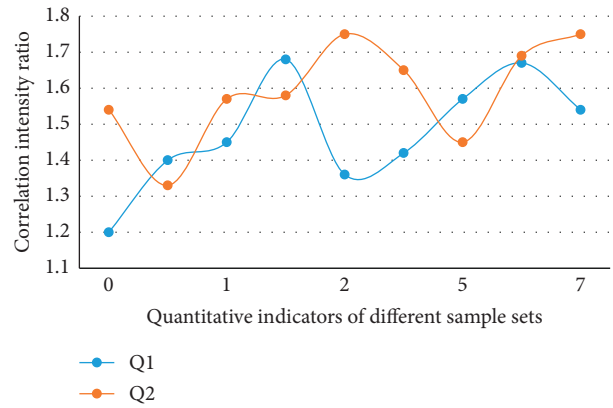


Figure 9: Analysis of correlation strength.

It can be seen from the above figure that the performance of the improved random trees model is significantly improved, which is well reflected in the overall assessment. In the range of 1–5, the performance improvement is slow. This is due to the small initial samples and the insufficient number of decision trees, which cannot achieve the overall operation effect. After accumulating enough data, the performance will increase rapidly, which is well reflected in 5–7. Overall, the performance of the improved random trees model is improved by 67.3%. For the analysis of the correlation strength, this study mainly studies the correlation between the samples, because the stronger the correlation, the higher the correlation ratio between each other. For assessment, the correlation is well expressed. This means that the accuracy of the assessment is guaranteed. Therefore, this is extremely important. In the experiment, the calculation of the model is basically stable, and the proportion of correlation is basically maintained above 1.2, which also means that the model has good control over the correlation.

5. Conclusions

Based on the study of learning activity analysis and learning theory, this study puts forward the overall framework of online learning activity analysis, and on this basis, analyzes the elements of online learning activity analysis, studies the key technologies in the analysis, realizes the scene application of online learning activity analysis, and draws a conclusion. Online learning breaks the limitations of time and place but also separates learners and teachers. It is difficult for teachers to observe learners' learning process and learning activity as intuitively as traditional teaching, so as to timely discover the problems encountered by learners difficult and give prompt guidance. Due to its excellent performance in reducing generalization error of classification systems and simplifying classifier design, the random trees algorithm has become a research hotspot of common concern to researchers in many fields and technicians in application fields. As a combination classifier, the random trees model gives the final prediction results by all decision trees in the data prediction stage. For the learner, the analysis results directly present the learners knowledge mastery level report and the learning state of the process, so as to realize the level diagnosis of the learner and determine whether he can enter the next stage of learning. Through the experimental analysis, it can be found that the maximum can reach more than 80%, which proves that the improvement of the weighted value is a good embodiment of the random trees model, and the accuracy is improved by 65.2%. Overall, the performance of the improved random trees model is improved by 67.3%.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The author declares no competing interests.

Acknowledgments

This research was supported by Bureau of Education of Guangzhou Municipality (No. KP202272).

References

[1] N. Ranasinghe, "Relationship between learner engagement and performance based on the user behavioral factors in E-learning environments," *International Journal of Engineering and Technical Research*, vol. 9, no. 12, p. 485, 2020.

[2] R. Bheim, T. Urdan, M. Knogler, and T. Seidel, "Student hand-raising as an indicator of behavioral engagement and its role in classroom learning," *Contemporary Educational Psychology*, vol. 62, no. 1, Article ID 101894, 2020.

[3] Y. Zhao, J. Da, and J. Yan, "Detecting health misinformation in online health communities: incorporating behavioral features into machine learning based approaches," *Information Processing & Management*, vol. 58, no. 1, Article ID 102390, 2021.

[4] V. M. Sunkara and R. R. Kurra, "An analysis of learner satisfaction and needs on E-learning systems[J]," *International Journal of Computational Intelligence Research*, vol. 13, no. 3, pp. 433–444, 2017.

[5] Y. Yin, H. Yuan, and B. Zhang, "Dynamic behavioral assessment model based on Hebb learning rule," *Neural Computing & Applications*, vol. 28, no. S1, pp. 245–257, 2017.

[6] I. E. Haddioui, "Study of learner behavior and learning styles on the adaptive learning management system manhali: results and analysis according to gender and academic performance [J]," *Journal of Software*, vol. 12, no. 4, pp. 212–226, 2017.

[7] P. Silitonga, B. E. Dewi, A. Bustamam, and H. S. A. Ash, "Evaluation of dengue model performances developed using artificial neural network and random forest classifiers," *Procedia Computer Science*, vol. 179, no. 2, pp. 135–143, 2021.

[8] H. M. Lai, P. J. Hsieh, L. Uden, and C. H. Yang, "A multilevel investigation of factors influencing university students' behavioral engagement in flipped classrooms," *Computers & Education*, vol. 175, no. 4, Article ID 104318, 2021.

[9] H. Huang, C. Lin, and D. Cai, "Enhancing the learning effect of virtual reality 3D modeling: a new model of learner's design collaboration and a comparison of its field system usability," *Universal Access in the Information Society*, vol. 20, no. 3, pp. 429–440, 2020.

[10] K. Nugroho, "Javanese gender speech recognition based on machine learning using random forest and neural network," *SISFORMA*, vol. 6, no. 2, p. 50, 2020.

[11] B. Thomas and J. Chandra, "Random forest application on cognitive level classification of E-learning content," *International Journal of Electrical and Computer Engineering*, vol. 10, no. 4, p. 4372, 2020.

[12] R. D. Mahande and J. D. Malago, "An E-learning acceptance assessment through UTAUT model in a postgraduate program," *Journal of Educators Online*, vol. 16, no. 2, pp. 1–10, 2019.

[13] F. A. Dwiyanto, H. Elmunsyah, and Y. Yoto, "Indonesian online learning system evaluation framework based on UTAUT 2.0," *Bulletin of Social Informatics Theory and Application*, vol. 4, no. 2, pp. 83–90, 2020.

[14] P. S. Varma and V. Anand, "Random trees learning based indoor localization as an IoT service for smart buildings," *Wireless Personal Communications*, vol. 117, no. 3, pp. 1–19, 2021.

[15] L. G. Ferreira, J. L. V. Barbosa, J. C. Gluz, V. K. Matter, and D. N. F. Barbosa, "Using learner group profiles for content recommendation in ubiquitous environments," *International Journal of Information and Communication Technology Education*, vol. 16, no. 4, pp. 1–19, 2020.

[16] H. E. Wang, M. C. Lee, M. H. Wu, and P. Shen, "Influencing overseas Chinese by tweets: text-images as the key tactic of Chinese propaganda," *Journal of Computational Social Science*, vol. 3, no. 2, pp. 1–18, 2020.

[17] V. S. Patil and P. J. Deore, "Semantic image retrieval using random forest-based AdaBoost learning," *International Journal of Intelligent Information and Database Systems*, vol. 12, no. 3, p. 229, 2019.

[18] W. Tafesse and A. Wien, "Using message strategy to drive consumer behavioral engagement on social media," *Journal of Consumer Marketing*, vol. 35, no. 3, pp. 241–253, 2018.

[19] K. K. Min and S. M. Kim, "Dynamic learner engagement in a wiki-enhanced writing course," *Journal of Computing in Higher Education*, vol. 32, no. 3, pp. 1–25, 2020.

[20] B. Y. Rajabalee, M. I. Santally, and F. Rennie, "Learner satisfaction, engagement and performances in an online module: implications for institutional e-learning policy," *E-Learning and Digital Media*, vol. 17, no. 1, pp. 1–20, 2020.

[21] A. A. Koehler and S. Meech, "Ungrading learner participation in a student-centered learning experience," *TechTrends*, vol. 66, no. 1, pp. 78–89, 2021.

[22] L. T. Le, "A real game-changer in ESL classroom? Boosting Vietnamese learner engagement with gamification," *CALL-EJ*, vol. 21, no. 1, pp. 198–212, 2021.

[23] F. Willans, A. Fonolahi, R. Buadromo, T. Bryce, R. Prasad, and S. Kumari, "Fostering and evaluating learner engagement with academic literacy support: making the most of Moodle," *Journal of University Teaching and Learning Practice*, vol. 16, no. 4, pp. 54–70, 2019.

[24] A. Cahn, "Behavioral changes and learning differences in students registered in online versus in-seat general education nutrition classes," *Journal of Nutrition Education and Behavior*, vol. 49, no. 7, pp. 61-62, 2017.

[25] D. Hooshyar and Y. Yang, "Predicting course grade through comprehensive modelling of students' learning behavioral pattern," *Complexity*, vol. 2021, no. 1, pp. 1–12, Article ID 7463631, 2021.

[26] J. M. Yang, "A study on the profile Analysis of learning behavioral patterns of students at local universities - focused on the case of A university," *The Korean Association of General Education*, vol. 14, no. 4, pp. 213–224, 2020.

[27] A. L. Green, S. Ferrante, T. L. Boaz, K. Kutash, and B. W. Reece, "Evaluation of the spark child mentoring program: a social and emotional learning curriculum for elementary school students," *Journal of Primary Prevention*, vol. 42, no. 5, pp. 531–547, 2021.

[28] X. Liao, C. Chen, Y. Wang, M. Cui, and C. Liu, "Identification of power quality disturbances based on sample entropy and weighted optimization random forest," *Journal of Physics: Conference Series*, vol. 1486, no. 6, Article ID 062018, 2020.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 5850967, 12 pages
https://doi.org/10.1155/2022/5850967

Research Article

The Model of Ceramic Surface Image Based on 3D Printing Technology

Hui Yu,[1] Enze Chen,[2] Yao Chen,[2] and Zhenyu Qi[3]

[1]*Department of Arts, Nanchang University, Nanchang 330000, China*
[2]*Department of Ceramic Arts, College of Music and Arts, Dankook University, Yongin-si 16890, China*
[3]*Department of Art and Design, Hubei University of Technology, Wuhan 4300068, China*

Correspondence should be addressed to Enze Chen; sqqm@jou.edu.cn

Received 16 May 2022; Revised 20 June 2022; Accepted 23 June 2022; Published 30 July 2022

Academic Editor: Wen Zhou

With the rapid development of the new manufacturing industry, 3D printing technology continues to make new technological breakthroughs, and new works emerge in the manufacturing, medical, construction, military, and other application fields. However, for ceramic materials, there are still many problems to be solved in 3D printing. In this study, a dual-scale lightweight interactive model based on lofted surface and periodic parameter curve embedding is proposed for ceramic 3D printing. Users can model and manufacture lofted surfaces with small-scale geometric textures. For the two closed curves entered by the user, the intermediate section sampling points are generated by interpolation between them, and the shape of the current surface is adjusted under ceramic 3D printing manufacturing constraints such as no support and path non-interference. complete large-scale surface modeling based on lofted surfaces. Then the straight line path between the sampling points is replaced by a periodic curve path, and the small-scale geometric texture modeling is completed by adjusting the period and amplitude of the curve function. Finally, each section sampling point is spirally connected layer by layer and directly generats a single continuous printing path and manufacture. The experimental results show that the tool provides users with sufficient modeling space and high efficiency of model generation and effectively generates G-code files with textured lofted surfaces that can directly print ceramic 3D. It can also avoid the collision between printer nozzles and printing models and can be directly used in 3D printing and manufacturing based on clay materials.

1. Introduction

3D printing (also known as material added manufacturing) technology appeared in the mid-1990s. With the rapid development of various science and technology, 3D printing technology has also improved. In the fields of manufacturing, medical, construction, and military applications, new technological breakthroughs and new products have emerged [1]. Experts in many fields generally believe that 3D printing technology will profoundly change the future society and will be the development direction of manufacturing informatization and intelligence in the future. At the same time, some industrial product manufacturing enterprises and traditional handicraft workshops are gradually losing competitiveness and meeting the bottleneck of development due to the influence of industrial manufacturing and processing technology on product form [2]. Through the analysis of some innovative application cases of 3D printing technology at home and abroad, the author summarizes several development trends of product forms based on 3D printing technology in the future, combines the Internet business thinking and product customization trend, and concludes that some industrial manufacturing enterprises and handicraft workshops are in the bottleneck. The conclusion of customized products based on 3D printing technology should be actively developed, which can provide ideas and references for the development of enterprises.

Predecessors have done some work on the flow analysis of the single screw extrusion process, but most of them are realized by commercial numerical calculation software, such as fluent and POLYFLOW. In essence, such software realizes the calculation and analysis by solving the differential equations to

obtain the solution of the Navier Stokes equation. When solving the fluid with complex rheological characteristics, the calculation process is complex and easy to diverge. LBM is used to replace the traditional finite element method to analyze the flow of ceramic slurry in the screw groove, which ensures the stability of the numerical simulation process.

2. State of the Art

2.1. The Development of 3D Printing Technology. 3D printing technology is a rapid stereo-forming technology based on a digital model [3]. It is a technology that makes printing materials layer by layer and then forms solid shapes through data processing. Unlike the traditional manufacturing process for material reduction, 3D printing technology is formed by adding and forming layer by layer. This is also known as additive manufacturing. Since the first commercial 3D printer was published in the 1980s, 3D printing has been developing rapidly in the fields of printing materials, printing forming principle, and application [4].

Ceramic material is one of the three solid materials with excellent characteristics such as high hardness, high strength, high-temperature resistance, low density, good chemical stability, and corrosion resistance. 3D printing materials include photosensitive resin composite, polymer powder, paraffin powder, ceramic powder, fuse line, FDM ceramic, wood plastic composite, and FDM support material.

The principle of a 3D printer is similar to that of ordinary printers in daily life. However, ordinary printers use paper ink as raw materials in the two-dimensional plane to print. While the raw materials used by 3D printers are metal, plastic, ceramics, fibers, and other materials as printing materials. Through the calculation and analysis of digital models, the data is imported into 3D printers. The printer will stack the raw materials layer by layer according to the path completed by calculation, and finally form a three-dimensional solid shape after continuous stacking one layer by one.

printed by hot melt deposition technology is solidified by cooling, and the shape printed by liquid deposition technology is cured by drying. SLS is formed and solidified by laser heating, ultraviolet irradiation, adhesive bonding, etc. Under the control of data calculation, the laser beam fused the single layer of the powder with precise coordinates, and then sintered selectively to form the solid shape. The photo-curing molding (SLA) uses UV light to precisely irradiate the photosensitive resin to make the photosensitive resin solidify. It can be cured by moving vertically to the second layer for irradiation curing, and then forming a solid shape after the irradiation curing layer by layer. And the layer solid manufacturing (lom > uses a computer-controlled laser to cut the thin film, paper, and other sheet materials accurately and form the solid shape by layer bonding between each layer [6].

With the continuous development of science and technology, the application field of 3D printing technology is also expanding. It is not only the processing of simple parts but also has many applications in the fields of national defense science and technology, aerospace, medicine, housing construction, automobile, electronics, food, clothing, etc. In 2014, ten 3D printing buildings appeared in Shanghai. In 2016, the first space in orbit 3D printer was developed by the Chinese Academy of Sciences. In 2019, the spinal cord scaffold which imitated the structure of the central nervous system was successfully made by 3D printing technology [7].

2.1.1. It Can Be Applied in Many Fields. When using 3D printing services to process products, we can obtain very fast speed. Therefore, 3D printing technology has received great attention in all walks of life, which has promoted the rapid development of this technology and has been widely used in consumer electronics, automobiles, aerospace, medical treatment, military industry, geographic information, art design, and other fields. At the same time, 3D printing can also be combined with metal castings and extended to many industrial fields.

2.1.2. Be Able to Concretize Conscious Products. In terms of the development trend of academic ideas, 3D printing services have not been widely used. Technology is developing from the past shape manufacturing to the integration of material organization structure and shape structure design and manufacturing. R&D personnel are trying to realize controllable manufacturing from micro-organization to macrostructure, so they can make conscious products more specific so that people can quickly understand them.

2.1.3. Shorten the Development Cycle of New Products. The use of a 3D printing service can quickly turn the design drawings into real models, so as to intuitively analyze and understand the deficiencies in the design structure. Therefore, it plays a positive role in promoting product innovation and shortening the development cycle of new products.

When obtaining products through 3D printing services, there is no need to prepare any molds, cutting tools, or tooling fixtures. 3D printing equipment can directly accept product design data and quickly manufacture samples, molds, and prototypes of new products. Therefore, the 3D printing service not only has a wide range of application fields but also can greatly shorten the development cycle of new products.

2.2. The Historical Development of 3D Printing Technology. In 1883, chuck hill, an American scientist, invented the technology of photo-curing 3D printing.

In 1886 chuck Hill established a 3D systems company, and launched the first commercial 3D printer, which promoted 3D printing technology.

Scott Crum and Lisa Crum jointly invented the melt deposition forming technology (FDM) in 1888 and established STRATASYS company to promote related business.

In 1995, the United States took the lead in developing 3D printers [8].

In 2005, the first 3D printer, spectrum 2510, developed by the z-crop company in the United States, was successfully developed to print high-definition and multi-color shapes.

In 2011, the world's first 3D printing aircraft was successfully developed [9].

Scottish scientists used 3D printing technology to create the first human liver tissue in 2012.

In 2018, human beings first printed biological organs in space using biological 3D printing technology.

Since the early 1990s, the research on additive manufacturing technology has been launched with the support of government funds from Tsinghua University, Central China University of Science and Technology, and the Research Institute of West Jiaotong University. Shaanxi Hengtong Intelligent Machine Co., Ltd. (Xi'an Jiaotong University), Shanghai Liantai Technology Co., Ltd.: light curing rapid prototyping (SLA), Wuhan Binhu electromechanical Co., Ltd. (Huazhong University of Science and Technology), Beijing Longyuan automatic molding system Co., Ltd.: powder laser sintering rapid prototyping (SLS), Tsinghua University: melt deposition rapid prototyping (FDM), Northwest University of Technology Beijing University of Aeronautics and Astronautics: laser cladding equipment (lens) Huazhong University of science and technology, South China University of Technology, Nanjing University of Aeronautics and Astronautics: metal powder laser melting (SLM) after 2011, the number of enterprises engaged in SLA, SLM, FDM, DLP, lens, and other processes has increased year by year. At present, the domestic additive manufacturing system can meet the production needs of conventional materials and processes. In 2019, the national output value of 3D printing was 10 billion yuan, and in the first three quarters of 2020, the national output value was 10 billion yuan. In 2019, Aikang medical and platinum were listed; In 2020, Maipu medical will be listed. In general, compared with the development history of foreign companies for more than 30 years, domestic 3D printing equipment started late. Although rapid progress has been made in a short time, it needs to be further improved in terms of equipment operation stability and product quality. It is still a distance from the goal of domestic substitution for import and agency to self-sale. However, with the continuous expansion of downstream application fields, domestic manufacturers are expected to achieve breakthroughs in subdivided fields.

2.3. 3D Printing Technology for Ceramic Product Forming. As a new rapid prototyping technology, 3D printing technology constructs the digital model in space in the direction of layer-by-layer printing. With the rapid development of 3D printing technology, there are also a lot of printable materials. The common materials are resin, metal, rubber, cement, paper, ceramics, etc., as chemically stable materials that have been used in 3D printing for a long time. Unlike the traditional ceramic manufacturing process, the traditional ceramic products are mostly formed by the relationship between humans and mud. This way often needs to have. 3D ceramic printing is designed by using a computer model scheme, and then the model is processed by slicing software, which becomes a kind of data that can be recognized by the printer, and finally imported into the printer for printing and presentation. Such a series of treatments change the relationship between man and mud into the relationship between man and number. Now, 3D printing technology can be used in ceramic molding, mainly including 3D printing of liquid deposition ceramic and ceramic powder printing. Indirect molding is to select the 3D printing technology of photosensitive resin, 3D printing technology of hot melt plastic, printing technology of paper material, etc., to turn the gypsum mold and then use the mold to assist in the molding of ceramic [10].

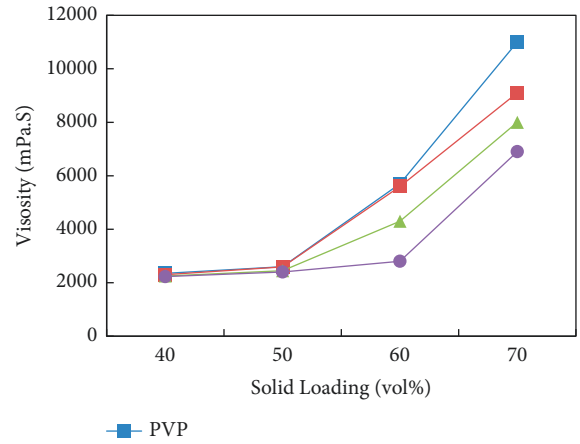


Figure 1: Viscosity of ceramics with different dispersants.

With the development of 3D printing technology and its wide application in various fields, 3D printing for ceramic materials has attracted more and more researchers' attention. Ceramics have low density, high-temperature resistance and corrosion resistance, high mechanical strength and hardness, and good chemical stability. It is suitable for aerospace, biomedical, chemical, electronic, and mechanical fields. Compared with traditional ceramic manufacturing technology, 3D printing-based ceramic manufacturing efficiency is high and the process is simple, especially in the generation of complex geometric structures or high precision models. Many materials can be used in the 3D printing of ceramics, such as concrete, engineering ceramics, and bioceramics. However, clay materials are widely used in buildings and infrastructure. Figure 1 shows the ceramic viscosity under different dispersant conditions. When different dispersants are used and the proportions of dispersants are different, ceramic materials can exhibit significantly different viscosities. This expands the application scope and field of clay materials to a certain extent.

Figures 2 and 3 show the effects of milling time and dispersant content on the viscosity of the ceramic slurry, respectively. Analysis of these performance maps shows that the ceramic materials required for 3D printing are not only easy to obtain but also can obtain different properties under different conditions, which is a good 3D printing material. The effect of ball milling time on the viscosity of the ceramic slurry is given in Figure 2. With the increase in time, the components of the ceramic slurry are more dispersed and the viscosity decreases with time. When a certain time threshold is reached, the viscosity increases due to the repolymerization of the slurry components.

Ceramic clay materials are cheap and easy to obtain. Nowadays, the desktop-level 3D printer is becoming more and more popular. Users can easily take materials from the

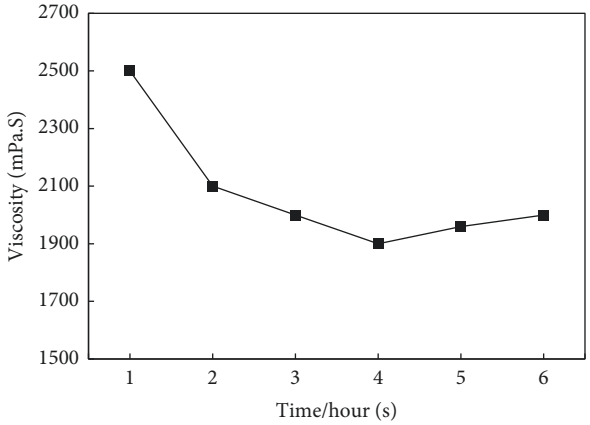


Figure 2: The effect of ball milling time on the viscosity of ceramic materials.

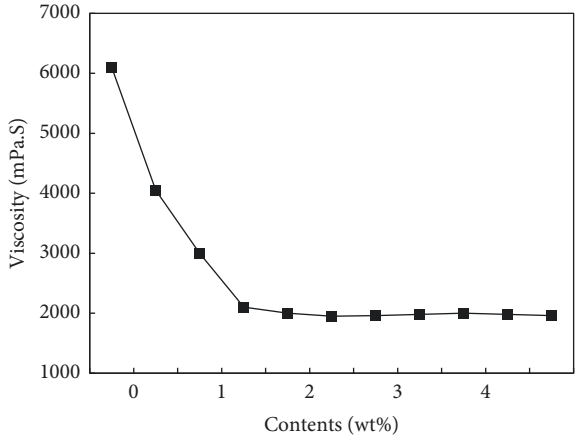


Figure 3: Effect of dispersant content on the viscosity of ceramic materials.

local area and make their own ceramic models to meet the needs of individuals. As a green and reusable printing material, unlike the thermoplastic materials used in general 3D printing processes, such as fused deposition modeling (FDM), ceramic clay materials will remain relatively soft throughout the printing process, and will not solidify rapidly after deposition [11]. If there is a free space for the moving nozzle between different printing areas, the formed part and nozzle will be deformed or damaged due to the adhesion of clay. Therefore, the design of ceramic material printing path requires that the model must be completed by a single continuous printing path. Because the removal of ceramic 3D printing support structure will cause some damage to the surface of the model, so the optimization of the model to the structure without support printing can improve the printing quality. In this study, the extrusion 3D printing technology based on ceramic material is adopted. When the height difference of the same layer in the z-axis direction exceeds the length of the printer nozzle, the printer nozzle will collide with the model being printed, which will cause the model to fail to print. Therefore, the corresponding printing constraints should be considered in modeling to avoid this situation. The rapid development of 3D printing technology makes it possible for users to customize their models. However, users usually need to create models with the help of professional CAD modeling software, and then generate paths based on existing slicing software. Modeling is very complex for ordinary users, and it can not guarantee the model without the support and no interference in the printing process, and can not meet the single continuity of generating print path. Based on Lofting technology and periodic parameter curve embedding, this study proposes a two-scale interactive modeling and manufacturing method for 3D printing of ceramics. In the modeling process, the model is supported and the printing process is automatically corrected without reconstruction of the discrete grid expression of the model [12]. After the model type is confirmed, a single continuous printing path is generated and the G-code file directly used for printing is output. The double-scale modeling proposed in this study (see Figure 4) is to generate lofting surface by user input control curve to realize large-scale geometry, and realize small-scale geometric texture based on periodic parameter curve. Manufacturing constraints are guaranteed by an automatic local correction in interactive design lofting surface. The experimental results show that the interactive modeling and manufacturing tool proposed in this study has simple operation and high G-code file generation efficiency; Compared with the existing slicing software, the tool supports model support free printing, meets the unique printing path, single continuity, and collision-free constraints of ceramic 3D printing, and improves the printing quality of physical model [13].

3. Methodology

3.1. Application of LBM in Herschel Bulkley Fluid. The raw materials for preparing ceramic slurry include pentaerythritol triacrylate and benzene couple as organic solvents. After mixing, lead lanthanum zirconate titanate powder (PLZT) is evenly added. At the same time, high-speed stirring helps the powder dissolve rapidly, and finally, a standby slurry with a solid content of 68.6% is obtained. After the slurry is prepared, its viscosity needs to be tested to obtain its rheological equation to prepare for subsequent numerical simulation analysis. Here, it is planned to use a rotary viscometer (model: rheolab MC1) to measure the viscosity of the mixed fluid. The results show that the slurry shows obvious non-Newtonian characteristics of shear thinning. According to the fitting results of MATLAB software, the rheological equation of the slurry tends to the type of Herschel Bulkley fluid.

The schematic diagram of the 3D printing ceramic forming process is shown in Figure 5. The alumina ceramic slurry is printed and formed by ceramic 3D printing technology. After that, the light-cured alumina ceramic slurry with the optimal dispersant and alumina slurry powder was printed layer by layer by a self-developed DLP type ceramic 3D printer.

LBM describes the motion process of fluid particles by solving the equation of equilibrium, which is a specific evolution equation

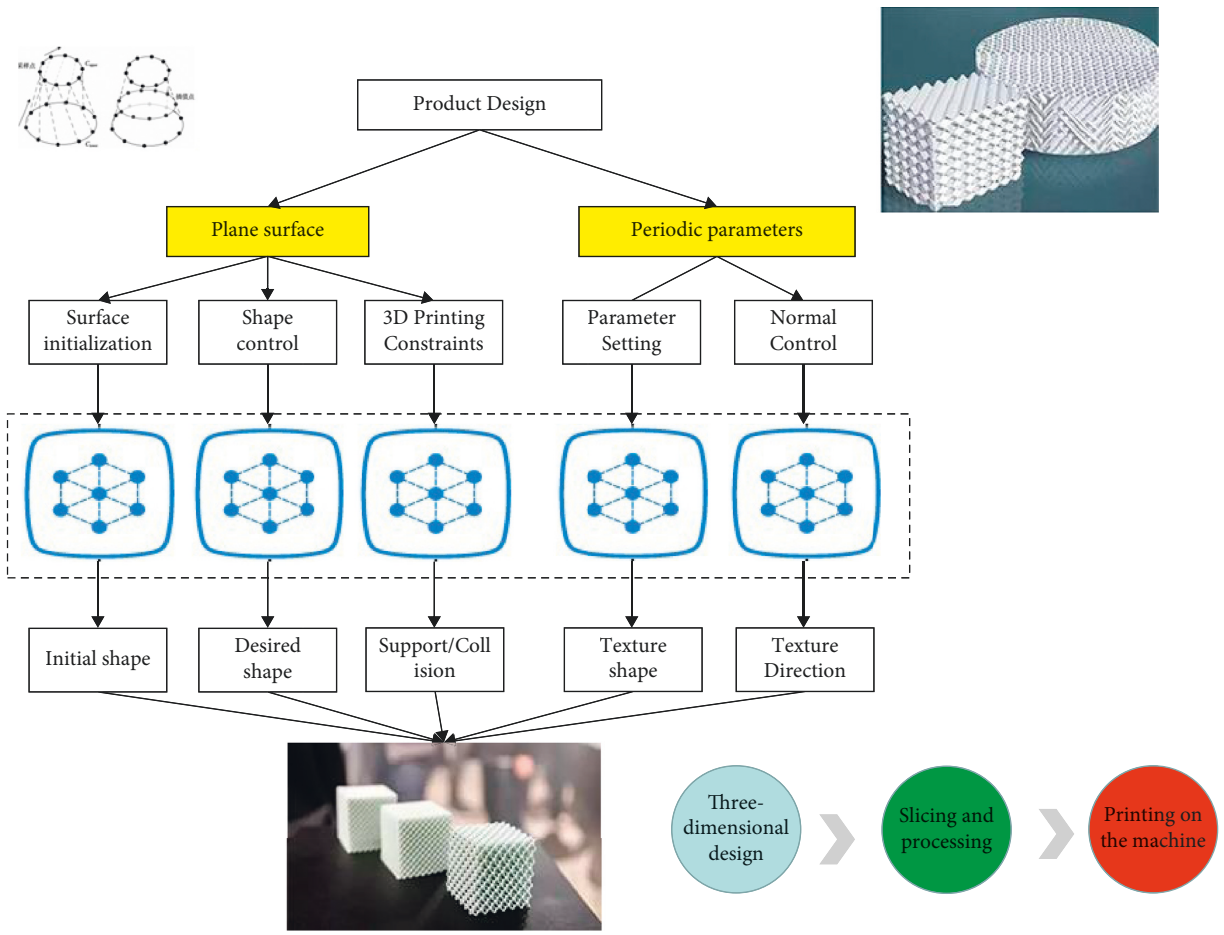


Figure 4: 3D ceramic printing scheme designed in this study.

$$f_i(r + e_i\delta t, t + \delta t) = -\frac{1}{\tau}[f_i(r,t) - f_i^{eq}(r,t)], \tag{1}$$

where τ-The relaxation time and velocity vector EI can be obtained by:

$$\begin{cases} (0,0), & i = 0, \\ c\left(\cos\dfrac{i-1}{2}\pi,\ \sin\dfrac{i-1}{2}\pi\right), & i = 1,2,3,4, \\ \sqrt{2}\,c\left(\cos\dfrac{2i-9}{4}\pi,\ \sin\dfrac{2i-9}{4}\pi\right), & i = 5,6,7,8. \end{cases} \tag{2}$$

The lattice speed c depends on the step size of the grid δX and time step δt. The specific relationship is $C = \delta x/\delta t$。. Generally, both are taken as 1, and C is also 1. The equilibrium equation is mainly affected by density ρ. The specific relationship between the influence of velocity u is as follows:

$$f_i^{eq} = \omega_i\rho\left[1 + \frac{e_i \cdot u}{c_s^2} + \frac{(e_i \cdot u)^2}{2c_s^4} - \frac{u^2}{2c_s^2}\right]. \tag{3}$$

According to the formula, we can see that due to the influence of the fluid equilibrium state, when the density of the fluid is greater, the speed of the fluid motion is slower; when the speed is greater, the density of the fluid will decrease. For the D2Q9 model, the sound velocity CS = $c/3$, and weight parameter ω, the specific form of I is shown in the formula

$$\omega_i = \begin{cases} \dfrac{4}{9}, & i = 0, \\ \dfrac{1}{9}, & i = 1,2,3,4, \\ \dfrac{1}{36}, & i = 5,6,7,8. \end{cases} \tag{4}$$

According to the distribution function, the macro expressions of velocity, density, and pressure are, respectively,

$$\begin{aligned} \rho &= \sum_i f_i^{eq}, \\ \rho u &= \sum_i e_i f_i^{eq}, \\ P &= \rho c_s^2. \end{aligned} \tag{5}$$

According to the isotropic constraints, we can get the following:

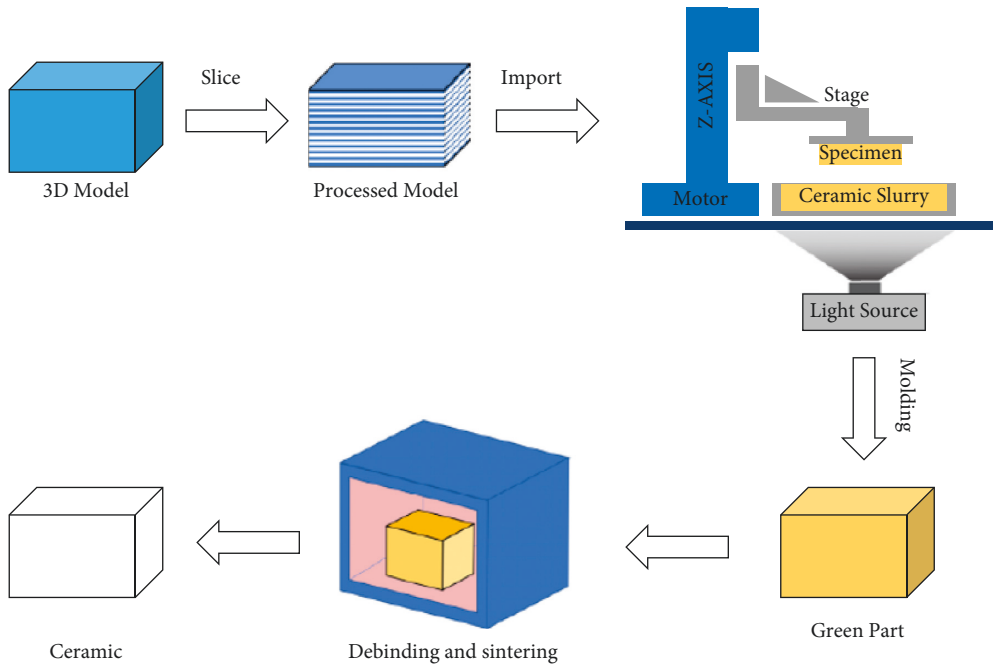


Figure 5: Schematic diagram of the process of 3D printing ceramic molding.

$$\sum_i f_i^{eq} e_{ix} e_{iy} = \rho u_x u_y + P\delta_{xy} = \rho u_x u_y + \frac{1}{3}\rho\delta_{xy}, \tag{6}$$

where δXY is the croceck function. Based on Chapman Enskog, the distribution function and momentum tensor can be extended to:

$$f_i \approx f_i^{eq} + \varepsilon f_i^{(1)} + \varepsilon^2 f_i^{(2)}, \quad \prod_{xy} \approx \prod_{xy}^{(0)} + \prod_{xy}^{(1)}. \tag{7}$$

By solving the primary moment of velocity, the momentum tensor of equilibrium state π XY (0) and the momentum tensor of non-equilibrium state π XY are solved.

(1) It can be calculated by the following formula

$$\prod_{xy}^{(0)} \sum_i e_{ix} e_{iy} f_i^{eq} = P\delta_{xy} + \rho u_x u_y, \prod_{xy}^{(1)} \sum_i e_{ix} e_{iy} \left(1 - \frac{1}{2\tau}\right) f_i^{(1)}. \tag{8}$$

For non-Newtonian fluids such as Herschel Bulkley fluid, the formula for the strain rate tensor s_{xy} is as follows:

$$S_{xy} = -\frac{1}{2\rho\tau e_s^2} \sum_i e_{ix} e_{iy} f_i^{(1)}. \tag{9}$$

The relationship between dynamic viscosity relaxation time τ and density ρ is:

$$\mu = \rho\nu = \frac{(2\tau - 1)\rho}{6}. \tag{10}$$

3.2. Flow Simulation in the Extrusion Process of Slurry Direct Writing. Path planning is a basic problem in 3D printing. At present, there has been a lot of work on this problem. The commonly used path planning algorithms include zig-zag scanning algorithm, contour parallel line algorithm, space-filling curve algorithm, and so on. Due to the angle between the model surface and the printing direction in the process of 3D printing, the zig-zag scanning algorithm is easy to produce underfill or overfill errors, which will affect the printing accuracy. The contour parallel line algorithm avoids the problem of printing accuracy by calculating a series of equidistant lines parallel to the contour. However, when the shape is complex, there will be too many empty strokes between parallel contour lines. The space-filling curve has attracted more attention because of its continuity, such as the continuous Fermat curve filling algorithm.

The two-scale modeling tool proposed in this study carries out large-scale parametric design through lofting and obtains the basic geometry of the object It can reduce the amount of surface data and ensure the continuity of the surface.

Take section Y-Z as the analysis surface. According to the actual rotation, it can be seen that the speed should only be set on the upper surface and the speed direction is parallel to the Z axis. The speed in the remaining three directions is set to 0. According to Table 1, the width and depth of the screw groove are all 4 mm, and the lattice number is 120 in numerical simulation × 120, the speed of screw $n = 45$ r/min. As

Table 1: Formulation of photosensitive resin paste.

Reagent	PEG	ACMO	PPTTA	TPO	HQ	Findan orange G	BYK
Mass fraction	30	28	37.99	1	1	0.01	2

LBM is a dimensionless method, dimension conversion is needed when the actual simulation analysis is carried out. Here, Reynolds number Re is used as the criterion number, and then the conversion process can be realized by combining similar criteria. The streamlined diagram can be obtained by numerical analysis. The upper side of the cross-section flow area is the inner wall of the outer cylinder of the screw, and the left and right sides are respectively two wall surfaces of the screw groove, and the lower side corresponds to the outer wall of the screw rod core. The center of the flow field is near (2 mm, 2.7 mm). From the position, it is closer to the inner wall of the outer cylinder of the screw rod, and there is bidirectional flow in the depth direction of the screw groove. The whole flow is carried out in circulation. There is no obvious flow in the lower left and right corners. In the later optimization of the structure, the angle between the screw edge and the rod core can be increased rather than the current vertical welding.

The distribution of velocity component V in different directions is given respectively. The comparison is made when the depth of different screw grooves and width of the slot is taken. Combining the two figures, it can be found that the velocity component V is basically 0 in the middle of the channel. As it approaches the edge of the screw, the speed changes gradually. Due to the different depth of the spiral groove, the velocity component V is also significantly different. The maximum value of V appears in the center of the flow field and is smaller when it is close to the boundary.

The distribution of velocity component u in different directions is given, respectively. The comparison is made between the different depths of the screw groove and the width of the slot. Combining the two graphs, it can be found that the velocity component u is close to 0 near the wall of the screw edge. When the velocity is gradually away, the velocity changes gradually, and the corresponding velocity is different with different groove depths, The closer the inner wall of the outer cylinder of the screw, the greater the velocity component U.

The concept of slurry direct writing molding technology was first proposed by Cesarano et al. This technology carries out the pre-design of graphics through computer-aided manufacturing, and the computer controls the movement of the slurry conveying device installed on the z-axis on the X-Y platform to obtain the required graphics. After the first layer is formed, the z-axis rises to an appropriate height, and the structure of the first layer is formed on the basis of the first layer. Through repeated superposition and the addition of materials, a fine three-dimensional structure is finally obtained. Slurry direct writing technology appeared earlier and began to be called robocasting. It was not included in the category of 3D printing until recent years. Therefore, it is called a new 3D printing technology.

In the traditional slurry direct writing process, the extrusion part adopts the needle barrel structure, which realizes the extrusion movement in the form of pump pressure. In addition to this extrusion method, screw extrusion, as an effective transportation extrusion method, is widely used in food processing, polymer materials, and mechanical fields. It is proposed to use screw extrusion to replace the common needle barrel structure.

As an effective transportation extrusion method, screw extrusion is widely used in food processing, polymer materials, and mechanical fields. Domain screw extrusion is plastic. It carries out solid transportation, compaction, melting, shear mixing, and extrusion of a plastic through external power transmission and heat transfer of external heating elements. The needle cylinder structure realizes extrusion movement in the form of pump pressure.

Aiming at the 3D printing technology of slurry direct writing ceramic, a screw structure instead of a needle barrel extrusion structure is proposed [14]. The formula of photosensitive resin paste is shown in Table 1. LBM is used to replace the traditional finite element method. The flow of ceramic slurry in the screw groove is analyzed, which ensures the stability of the numerical simulation process. The following conclusions can be obtained: (1) It is found by viscosity test and the ceramic slurry involved belongs to a typical shear thinning non-Newtonian fluid. (2) Through the rational application of LBM, the numerical solution is successfully obtained, which further widens the effective application of LB in the field of engineering application; (3) According to the obtained figure, the flow of ceramic slurry in the cross-section presents the characteristics of circulation, and the streamline diagram can be used to judge the effective flow area of ceramic slurry in the screw groove, and there is no obvious flow in the left and right lower corners of the cross-section; (4) In order to enhance the flow of ceramic slurry, the rotating speed can be appropriately increased and the groove width of the screw can be widened [15].

After mapping the two closed contour curves Cupper and Clower entered by the user to the $z = H$ plane and $z = 0$ plane in the world coordinate system, calculate the leftmost and rightmost endpoints of the two curves in the x-axis direction, respectively, and align Cupper and Clower based on the midpoint of the endpoint line. Please note that this tool not only supports users to draw contours directly based on spline curves but also supports users to load images with curves. The system will automatically extract continuous pixels in the image and generate contour curves. The large-scale modeling process of this study is as follows: based on the lofting technology, the interpolation operation is carried out between Cupper and Clower to generate multiple intermediate sections [16], and then the control line is used to adjust the current surface shape. For the model with support, because removing the support after printing will damage the

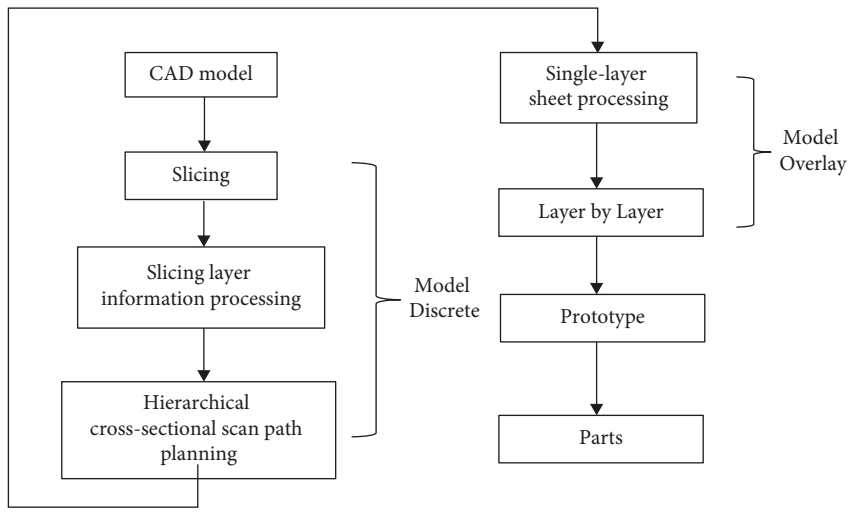


Figure 6: 3D printing workflow.

Table 2: Printing parameters.

Brightness	Delaminating thickness	Exposure inch same (s)	Base layer monolayer exposure time (s)	Light intensity
65	25 um	2	15	20

surface of the model, in order to ensure support-free printing, it is necessary to correct the model without support to ensure that the model will not have an area with too large inclination. At the same time, in order to avoid the collision between the printer nozzle and the printing model, the height difference between the highest point and the lowest point of the model on the same printing layer shall not exceed the length of the printer nozzle. See Table 2 for printing parameters. (Algorithm 1)

3.3. Ceramic 3D Printing Manufacturing Constraints. First, the suspension structure of the part is identified and segmented; then the three-dimensional model of the suspension structure is transformed by spatial rotation; afterward, the rotating structure is sliced; and then the slicing code is rotated reversely to the original position. Finally the transformed code is coupled. This method has the advantages of low algorithm complexity, high integration, and strong expansibility. It has universal applicability in the fields of biological 3D printing, light curing 3D printing, and so on.

In this study, an extruded ceramic 3D printer based on clay is used. In view of the particularity of clay materials, three manufacturing constraints are mainly considered in the modeling process (1) Support free constraint in the ceramic 3D printing process. For the part of the model whose inclination is greater than the threshold, if the support structure is not added, it is easy to collapse in the printing process [17]. Therefore, this study proposes a support-free algorithm, which realizes support-free printing by locally adjusting the inclination of the model, avoids the damage to the model surface caused by removing the support, and improves the printing quality of the model. (2) Collision-free constraint between printer nozzle and model. Ceramic 3D printing requires that the maximum height difference of each layer of the printing path in the z-axis direction should not exceed the length of the printer nozzle, otherwise there will be a collision between the printing model and the printer nozzle, resulting in printing failure. In this study, the height difference threshold is set in the horizontal control line adjustment to ensure that the height difference of each layer in the printing path is not greater than the length of the printer nozzle [18]. (3) Single continuous print path constraint. Clay is a fluid material with strong viscosity. When there is an empty stroke of moving the nozzle in the process of model printing, the strong adhesion between the newly extruded clay and the previously printed model will lead to model deformation and even printing failure [19].

We carried out the inclination test experiment, with inclination angles of 45°, 50°, and 55°, respectively. It can be seen that when the layer thickness is 0.25 mm, the physical quality of the printed models under the three dip angles is good. After measurement, the error between the actual physical dip angles of the three models and the original digital model is small and can be ignored. However, when the layer thickness is 1.0 mm, the upper half of the model has obvious outward convex deformation under the inclination of 50°, while the upper half of the model collapses under the inclination of 55°, and the actual physical model under the inclination of 45° is similar to the original digital model. To sum up, 45° inclination can ensure the reliable printing of the model, so this study takes 45° as the maximum safety angle threshold of the model relative to the vertical direction, as shown in Table 3.

3.4. Small Scale Modeling Based on Periodic Parameter Curve. Lofting surface generation based on large-scale modeling can only control the shape of the model microscopically, and

Input: Upper top surface contour curve cupper, lower bottom surface contour curve Clower, model height H
Output: G-code file that can be used for 3D printing of ceramics.
Step 1. Make equidistant sampling on Cupper and Clower to generate the same number of sampling point sets Cupper and Clower, and establish one-to-one correspondence based on the drawing order
Step 2. Linear interpolation is made between Cupper and Clower to generate sampling points in the middle section
Step 3. Under the constraint of ceramic 3D printing manufacturing, adjust the control line and recalculate the coordinates of sampling points on the current surface
Step 4. Select the periodic curve to be embedded into the horizontal and vertical directions in the current parameter space, and adjust the curve period and amplitude to generate geometric texture
Step 5. The sampling points on each section are connected layer by layer in a spiral way to generate a printing path
Step 6. Generate G-code files that can be used for 3D printing of ceramics (see Figure 6).

Algorithm 1: Two-scale lofting surface modeling algorithm.

Table 3: Analysis and comparison of advantages and disadvantages of 3D printing materials.

Material name	Advantages	Shortcomings
ABS PLASTICS	(1) It has excellent mechanical properties and excellent pullout strength	(1) Printing a large area of products is easy to raise
	(2) Easier to remove support	(2) The platform needs to be heated to $80^{\circ}C \leq 120^{\circ}C$
PLA PLASTIC	(1) Biodegradable materials, environmental protection (2) The printing product has a high gloss (3) Good liquidity, printing is not easy to crack (4) It is not easy to print a large area of products (5) The printing process has no odor	(1) It is not easy to remove support (2) The impact resistance is relatively low

can not generate a model with rich geometric details. Therefore, this study controls the shape of the model by embedding various periodic parameter curves in the current surface parameter space. In this study, the directions of any two corresponding points in Cupper and Clower and the interpolation points between them are abstracted as y direction, and the directions of points located in the same section layer are abstracted as X direction. Select the periodic parameter curve in the X direction and Y direction respectively for embedding, that is, the connecting line between two points in these two directions is replaced by the periodic parameter curve. From left to right, the three models are embedding triangular wave curve in X direction, embedding triangular wave curve in Y direction, and embedding triangular wave curve in two directions at the same time, and multiplying the function values of the two directions. By adjusting the period of the periodic parameter curve (the number of sampling points in a period) and the amplitude of the curve, rich and detailed geometric textures can be generated on the surface of the model in this study, the amplitude direction is the normal direction of the surface [20].

For models with rich geometric details, the geometric texture is usually used for modeling. Bhat et al. proposed a sample-based geometric texture synthesis method, established the corresponding relationship between the sample model and the target model through training, and migrated the sample geometric texture to the target model according to the direction field given by the user.

Without considering small-scale modeling, embedding periodic curves directly on Cupper and Clower, and generating base note based on lofting, then adjusting the vertical direction control line to further adjust the shape of the model, the generated model can also present a certain scale geometric texture feature. The cupper and follower of the model are petal curves with the shape of the lower left corner. However, the texture generation based on this method depends on the manual adjustment of control lines, the more fine the texture adjustment is, the more complex the texture adjustment is, and the consistency of curve period and amplitude cannot be guaranteed. The periodic curves embedded in the top and bottom surfaces are the same as those. After large-scale modeling, triangle wave functions with periods of 10 and 2 and amplitude of 2 are embedded in the transverse and vertical directions respectively. It is obvious that the resulting geometric texture is more abundant and detailed than the large-scale modeling based on the sample placement.

In this study, three periodic curves, sinusoidal function wave, triangle wave, and square wave are provided for the user to choose. In this study, the sampling points on the contour line of the periodic curve to be inserted are discretely expressed as the value of independent variables.

A periodic function is a function whose value can be repeated after a certain period on any independent variable. For the function $y = f(x)$, if there is a constant t that is not zero, so that $f(x + T) = f(x)$ is true when x takes every value in the definition field, then the function $y = f(x)$ is called a periodic function, and the constant t that is not zero is called the period of the function.

Table 4: Data of different model.

Model name	Area (cm^2)	Mass (g)	Specific surface area (cm^2/g)	Results of the program
Lattice structure	332.72	10.32	32.24	Better
Cellular structure	312.33	19.68	15.87	General

Table 5: Formulation of ceramic slurry.

Material	Content (wt. %)	Content (vol. %)
Si_1N_4 powder	56.0	30.2
Yttium-aluminium-ganmen owder	6.2	2.3
Distilled water	24.9	42.8
Ethylene glycol	4.4	6.8
Dispersant (polyacrylic and carboxylic acid)	0.2	0.3
Ethanol	7.2	15.7
Lmsorganic binder	0.7	1.1
Deflocculant	0.4	0.8

Table 6: 3D printing method classification and comparison.

3D Printing technique	Strategy	Relative cost	Production time	Advantages	Disadvantages
Extrusion	Ceramic paste with polymer binder and plasticizer	Low—moderate	Slow	Straightforward process. Flexible in porous scaffolds or dense structures	Limited resolution
Binder jetting	Ceramic powder bed and polymer binder	Moderate -high	Moderate/ fast	Great for larger, porous ceramic structures. Requires few sacrificial materials	Challenging for very dense ceramics
Material jetting	Ceramic-suspended droplets on substrate	Low—moderate	Slow/ moderate	Beneficial for small models. Creates smooth surfaces	Difficult for large models
	Ceramic powder bed with laser	High	Fast	Flexible in porous scaffolds or dense structures	Distortion and warping leading to microcracks
Vat photopolymerization	Ceramic dispersed in photosensitive resin	Moderate	Moderate/ fast	Precise. Creates smooth surfaces	Requires extensive post-processing

$$f(t) = A\sin\left(\frac{2\pi t}{T}\right)$$
$$f(t) = A\left(\frac{4}{T}\left(t - \frac{2}{T}\left[\frac{2t}{T} + \frac{1}{2}\right]\right)(-1)^{[2t/T+1/2]}\right) \quad (11)$$
$$f(t) = A\text{sign}\left(\sin\left(\frac{2\pi t}{T}\right)\right).$$

4. Result Analysis and Discussion

Rapid and effective data processing can effectively improve the accuracy and strength of formed parts and the manufacturing efficiency of the equipment. (1) The analysis and processing technology of STL files in ASCII plain code and binary format, and the realization of core functions by Java programming language; (2) Based on STL file visualization, the topological relationship of common edges between two triangular patches, the support algorithm based on the topological relationship of triangular patch coordinate points and triangular patch meshing, and the advantages of feature region method and discrete identification method are combined to realize the generation of the support structure of STL 3D model from any perspective, And the time of support generation is greatly shortened, as shown in Table 4.

The algorithm is implemented by c++. The operating environment is 4 core intel core i5 CPU, 2.5 GHz main frequency, and 8 GB memory. Using the ceramic 3D printer cerambot plus print model, the printer has a shaping size of 180 mm (width) × 190 mm (deep). The minimum thickness is 0.25 mm, the maximum layer thickness is 1.0 mm, and the line width is 3.0 mm. The length of the nozzle of the ceramic 3D printer used in this experiment is 30.0 mm. The 3D printing technology of ceramic is based on the direct writing technology of fluid slurry. The technology makes the model at room temperature. This tool provides the user with an interactive interface, which can directly set the actual physical height of the model and the actual physical size corresponding to the current canvas edge length. In the process of 3D printing file generation, the sampling points and interpolation points on the top, bottom, and middle section layer are taken as the moving positions of printer nozzles; Then calculate the moving speed and extrusion amount of the printer nozzle at each position, and connect all points in spiral way layer by layer to generate the final

printing path and model G-code file, and the corresponding physical printing results. In this study, the method of Zhong and others is used in calculating the extrusion amount of clay. In order to ensure the single continuity of the printing path, for the model with a height difference in Z direction, this study calculates and adjusts the extrusion amount of ceramsite in real-time according to the distance change of Z direction of the sampling point, realizes the printing path with variable layer thickness, ensures the consistency of material volume per unit height of the path, and eliminates the step effect on the surface of the model Chen et al. In modeling and printing thin-walled shell, in order to minimize the step effect in the printing process, a modeling printing method combining multi-axis 3D printing technology and variable thickness surface slice technology is proposed. The work also generates a printing path with variable layer thickness, but it needs to be realized by multi-axis 3D printing technology. In this study, three groups of curves are drawn for the experiment. The results of sintering are printed according to the model. For the model generated by large-scale modeling based on lofting and the model with the texture generated based on the small-scale modeling, the printing time of the latter is 10–20 s longer than that of the former. Tables 5 and 6 analyze and compare the advantages and disadvantages of 3D printing materials to facilitate the selection of printing materials. The model and other models with texture are consistent in size and sampling point number.

5. Conclusion

In this study, a two-scale user interactive modeling and manufacturing tool based on Lofting surface is proposed for 3D printing of ceramics. The user can model and manufacture lofting surfaces with small-scale geometric textures. The print file can ensure a single continuous and unsupported print path, and avoid the collision between the printer nozzle and the print model. The experimental results show that the tool has high freedom and high efficiency, and the generated print file can be directly used in the ceramic model manufacturing of a 3D printer based on ceramic clay.

However, the method does not consider the influence of gravity in the modeling process. When the amplitude of the periodic function is too large, the drooping of the print path and even the collapse of the model may occur, which results in the difference between the physical model actually printed and the digital model presented in modeling. In addition, because the model with inclination exceeding the threshold can be optimized without support, it is impossible to model and manufacture the model with a larger inclination angle, and also can not model and manufacture the model with the height difference in Z direction greater than the length of printer nozzle. Finally, the volume of the ceramic 3D printing clay model will shrink by 10%–20% after sintering at high temperature. Hence, it can be explored in the future if the actual physical manufacturing results of the model can be predicted and the compensation optimization can be carried out in the future.

Data Availability

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

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

This work was supported by Nanchang University, Dankook University, and Hubei University of Technology.

References

[1] Z. Chen, Z. Li, J. Li et al., "3D printing of ceramics: a review," *Journal of the European Ceramic Society*, vol. 39, no. 4, pp. 661–687, 2019.

[2] M. Schwentenwein and J. Homa, "Additive manufacturing of dense alumina ceramics," *International Journal of Applied Ceramic Technology*, vol. 12, no. 1, pp. 1–7, 2015.

[3] C. F. Revelo and H. A. Colorado, "3D printing of kaolinite clay ceramics using the Direct Ink Writing (DIW) technique," *Ceramics International*, vol. 44, no. 5, pp. 5673–5682, 2018.

[4] S. C. Park and B. K. Choi, "Tool-path planning for direction-parallel area milling," *Computer-Aided Design*, vol. 32, no. 1, pp. 17–25, 2000.

[5] Y. Yang, H. T. Loh, J. Y. H. Fuh, and Y G. Wang, "Equidistant path generation for improving scanning efficiency in layered manufacturing," *Rapid Prototyping Journal*, vol. 8, no. 1, pp. 30–37, 2002.

[6] X. Zhai and F. Chen, "3D printing path planning of fractal models," *Journal of Computer-Aided Design & Computer Graphics*, vol. 30, no. 6, p. 1123, 2018 (in Chinese).

[7] H. Zhao, F. Gu, Q. X. Huang et al., "Connected Fermat spirals for layered fabrication," *ACM Transactions on Graphics*, vol. 35, no. 4, pp. 1–10, 2016.

[8] J. Hergel, K. Hinz, S. Lefebvre, and B. Thomaszewski, "Extrusion-based ceramics printing with strictly-continuous deposition," *ACM Transactions on Graphics*, vol. 38, no. 6, pp. 1–11, 2019.

[9] F. Zhong, W. Liu, Y. Zhou, X. Yan, Y. Wan, and L. Lu, "Ceramic 3D printed sweeping surfaces," *Computers & Graphics*, vol. 90, pp. 108–115, 2020.

[10] S. Schaefer, J. Warren, and D. Zorin, "Lofting Curve Networks Using Subdivision surfaces[C]," in *Proceedings of the Eurographics/ACM SIGGRAPH Symposium on Geometry Processing*, pp. 103–114, ACM Press, New York, USA, July 2004.

[11] N. Engleitner and B. Jüttler, "Lofting with patchwork B-splines," *Advanced Methods for Geometric Modeling and Numerical Simulation*, Springer, Nora Engleitner, Bert Jüttler, pp. 77–98, 2019.

[12] N. Engleitner and B. Jüttler, "Patchwork B-spline refinement," *Computer-Aided Design*, vol. 90, pp. 168–179, 2017.

[13] A. Usumezbas, R. Fabbri, and B. B. Kimia, "The surfacing of multiview 3D drawings via lofting and occlusion reasoning [C]," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pp. 4560–4569, IEEE Computer Society Press, Honolulu, HI, USA, July 2017.

[14] C. Y. Deng, J. Huang, and Y. L. Yang, "Interactive modeling of lofted shapes from a single image," *Computational Visual Media*, vol. 6, no. 3, pp. 279–289, 2020.

[15] P. Bhat, S. Ingram, and G. Turk, "Geometric texture synthesis by example[C]," in *Proceedings of the Eurographics/ACM SIGGRAPH Symposium on Geometry Processing*, pp. 41–44, ACM Press, New York, USA, July 2004.

[16] J. Dumas, A. Lu, S. Lefebvre, and C. WuDick, "By-example synthesis of structurally sound patterns," *ACM Transactions on Graphics*, vol. 34, no. 4, pp. 1–12, 2015.

[17] C. Torres, T. Campbell, N. Kumar, and E. Paulos, "Haptic Print: Designing Feel Aesthetics for Digital fabrication[C]," in *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology*, pp. 583–591, ACM Press, New York, USA, November 2015.

[18] H. Takahashi and H. Miyashita, "Expressive fused deposition modeling by controlling extruder height and extrusion amount[C]," in *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pp. 5065–5074, ACM Press, New York, USA, May 2017.

[19] R. Suzuki, T. Yeh, K. Yatani, and M. D. Gross, "Autocomplete Textures for 3D Printing," 2020.

[20] B. Gürsoy, "From control to uncertainty in 3D printing withclay[C]," in *Proceedings of the 36th International Conference on Education and Research in Computer Aided Architectural Design in Europe*, pp. 21–30, eCAADe Press, 2018.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 9662074, 11 pages
https://doi.org/10.1155/2022/9662074

Research Article

Improvement of English Classroom Teaching Effect Based on Real-Time Supervision of Student Status

Ping Yin

School of Foreign Language Studies, Shandong Jiaotong University, Jinan 250000, Shandong, China

Correspondence should be addressed to Ping Yin; 209076@sdjtu.edu.cn

Received 12 May 2022; Revised 9 June 2022; Accepted 20 June 2022; Published 12 July 2022

Academic Editor: Wen Zhou

For English courses, the interaction between teachers and students in the classroom teaching process has a crucial impact on the improvement of classroom teaching effects, and through real-time supervision of students' classroom learning status, students' learning dynamics and learning effects can be grasped in time. For this reason, this paper proposes a learning state semisupervised learning method and real-time state monitoring system based on a clustering algorithm and a self-training SVM classification algorithm. At the same time, combined with the reform of English classroom teaching, the teaching effect can be improved to the greatest extent through the supervision of students' learning state. The experimental results show that monitoring the primary school English classroom teaching quality subject and providing skill training can help the primary school English classroom teaching quality subject predict the possible situation in the monitoring and prepare in advance in terms of thinking and skill teaching. Schools can urge primary school English classroom teaching quality monitoring subjects to have basic monitoring knowledge literacy, monitoring ability literacy, and monitoring moral literacy through primary school English classroom teaching quality monitoring knowledge training, skill training, and moral training. On the basis, the main body of primary school English classroom teaching quality monitoring can give full play to the role of the main body of monitoring when it organizes and implements monitoring. It is proved that real-time supervision of students' status can effectively improve the effect of English classroom teaching.

1. Introduction

As China's education continues to deepen, the new curriculum adapts to the new needs of the traditional curriculum and curriculum. As part of the revision of the new curriculum, it is possible to gradually establish the important role of students in the curriculum by gradually changing the presentation standards of the curriculum. Education is thus motivating and encouraging students to learn [1]. Let the students' learning process in class and after class change into a knowledge exploration process in which students constantly ask questions and teachers help students solve problems. At the same time, select appropriate teaching methods for different course learning contents, so as to make students' learning activities richer and personalized. In this process, the real-time supervision of students' learning state is directly related to the improvement of classroom teaching effect, and it is also an important content of classroom management [2]. The classroom management under the new curriculum reform is to let teachers use modern educational ideas to continuously optimize the content and result system of classroom teaching, maximize the enthusiasm and initiative of students in classroom learning, give full play to the role of classroom teaching time, and complete the objectives and tasks of classroom teaching more efficiently and with higher quality [3]. Therefore, the key and main purpose of classroom management is to gradually improve the quality, effect, and efficiency of teachers' classroom teaching. Classroom teaching without classroom management is impossible. Classroom management must supervise students' learning state in real time and master students' learning state in time. Therefore, this paper focuses on how to better improve the effect of English classroom teaching by combining semisupervised learning method and real-time state detection system [4].

2. Literature Review

Dharmawati believes that the definition of "teaching quality" is influenced by the concept of education and can be divided into static concept and dynamic concept. Some scholars define this concept as static and define teaching quality as the sum of all characteristics that can be used to distinguish whether it meets the specified "target." It is owned by both the teaching process and the teaching effect [5]. Phoeun and Sengsri believe that the definition of this concept reflects its dynamics and that teaching quality is the overall structure of talent training specifications, an inexhaustible development system, a general effect of school education and teaching management, and a dynamic generation process of continuous development [6]. Kurdi and Archambault believe that since this study will expand to "primary school English classroom teaching quality" on the basis of "teaching quality," the definition of this concept by previous scholars is conducive to increasing the reliability of the concept of primary school English classroom teaching quality monitoring sorted out by the author [7].

Alsahli believes that, due to the lack of research on English teaching quality monitoring in primary school, no completely relevant research results have been found. However, the author believes that English teaching quality monitoring in college and English classroom teaching quality monitoring in primary school have disciplinary commonality, so he tries to seek reference from the research results of English teaching quality monitoring in colleges and universities [8]. Ekstedt et al. believe that English, as an important part of college education, has received great attention in recent years. Some scholars have proposed to build a people-oriented teaching process quality monitoring system by establishing a college English teaching resource monitoring system and a teaching process monitoring system. It is proposed that the establishment of a scientific student quality evaluation system and the realization of teaching evaluation activities must be multiangle, the teachers' teaching evaluation consciousness and theoretical level must be improved, and the members of the evaluation team should carefully design the form of praise teaching activities [9]. Saienko and Chugai call for the establishment of a good English language college management system by establishing a quality English language program based on good English, good English teaching, and teaching English, that is, quality assurance, good English language inspections record work performance, rewards, and penalties. These strategies and procedures for improving English language proficiency management in colleges are important in this study for developing strategies to improve English language arts management to be good in elementary schools [10].

Jitjumnong and Suksakulchai believe that total quality management is an important theoretical basis for teaching quality monitoring. It is a way to manage long-term success based on performance, total participation, customer satisfaction, and benefits for all members of the organization and people. It was started by General Electric of the United States, and other industrialized nations have entered a new phase in the development of efficient management systems, including the implementation of sound management systems and improvements of their own qualities and characteristics [11]. Payant and Bell believe that total quality management refers to a quality management method for an organization to continuously improve product quality, mobilize all personnel to comprehensively use modern scientific management technology to conduct the whole process and comprehensive and systematic management of various factors affecting quality, and finally ensure that the products provided satisfy consumers [12]. Pan believes that emphasizing the overall situation and systematic viewpoint is a prominent feature of the total quality management system, which requires that the product quality should not only satisfy users, but also be conducive to the overall development of society [13].

3. Semisupervised Learning Algorithm

3.1. Semisupervised Learning and Clustering Algorithm. Semisupervised learning algorithm combines the learning concepts of supervised algorithm and unsupervised algorithm, as shown in Figure 1. Generally processed data sets are as follows:

$$X = \{(x_1, y_1), (x_2, y_2), \ldots, (x_l, y_l), x_{l+1}, \ldots, x_n\}, \quad x_i \in R^D, y_i \in \{1, 2, \ldots, c\}. \tag{1}$$

It includes the first i labeled samples and the last $n - l$ unlabeled samples. Its purpose is to label unlabeled samples by finding reliable internal structure information in labeled samples and then train a better classifier or regression system through the expanded labeled sample training set. The learning process is shown in Figure 2.

In the traditional classification algorithm, the classification process mainly follows the labeled information of training samples to establish the classification model, while the semisupervised classification algorithm pays more attention to the global structure implied in a large number of unlabeled samples to optimize the classifier. Previously, unlabeled samples were difficult to introduce into learning algorithms (such as feedforward neural network) until someone explained the value of unlabeled samples and integrated semisupervised algorithm into classification algorithm to mine the structure information of the whole sample from unlabeled samples and avoid the classification model falling into local minimum. Then it is proved that unlabeled samples can affect the performance of the classifier in the classification process [14], as shown in Figure 3.

Self-training: as a semisupervised learning algorithm with more research, this algorithm first uses a small number of labeled samples to train the classifier, then uses the classifier to predict the unlabeled samples, adds the high confidence results to the training samples, and then repeatedly trains the classifier. In fact, the classifier uses its own prediction results to improve itself. At present, it has been

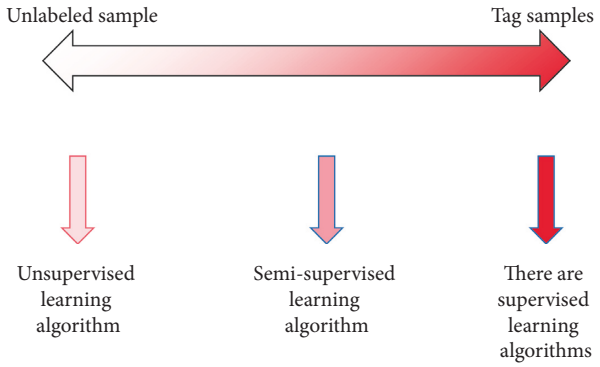


Figure 1: Schematic diagram of semisupervised learning algorithm.

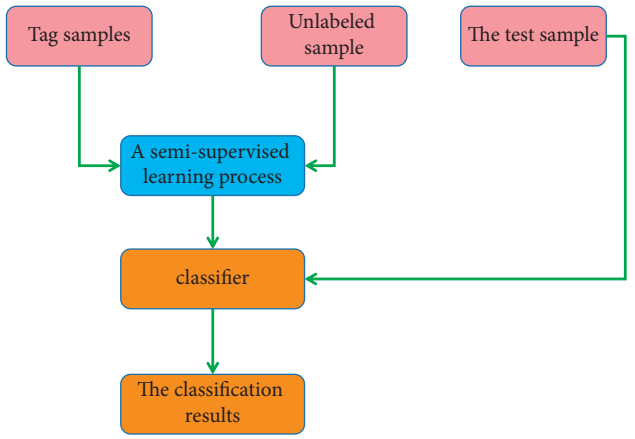


Figure 2: Process of semisupervised learning algorithm.

applied in natural language processing, word sense disambiguation, image recognition, and other fields.

3.2. Semisupervised Learning Algorithm Based on SVM. Advantages of SVM algorithm are as follows:

(1) It can solve the classification and regression problems of high-dimensional features.

(2) The final result of the model does not need to depend on the entire sample, but only on the support vector.

(3) There are well-researched kernel techniques that can be used to deal with linearly inseparable problems.

(4) The sample size is moderately small and has a good effect, with a little generalization ability and robustness.

For the traditional SVM optimization problem, the training set contains i samples:

$$(x_i, y_i), i = 1, \ldots, l, \tag{2}$$

where $x_i \in R^n$ and the classification hyperplane constructed by SVM is $wx + b = 0$. Through transformation, the problem can be transformed into an original optimization problem:

$$\begin{aligned} &\min_{w,b,\eta} C \sum_{i=1}^{l} \eta_i + \frac{1}{2}\|w\|^2, \\ &s.t. y_i (w \cdot x_i - b) + \eta_i \geq 1, \\ &\eta_i \geq 0, i = 1, \ldots, l. \end{aligned} \tag{3}$$

Add unmarked data at this time:

$$x_j, j = l + 1, \ldots, l + k. \tag{4}$$

The semisupervised SVM optimization problem can be described as follows:

$$\begin{aligned} &\min_{w,b,\eta,\xi,z} C\left[\sum_{i=1}^{l} \eta_i + \sum_{j=l+1}^{l+k} \min\left(\xi_i, z_j\right)\right] + \|w\|, \\ &s.t. y_i (w \cdot x_i - b) + \eta_i \geq 1, \eta_i \geq 0, i = 1, \ldots, l; \\ &w \cdot x_i - b + \xi_j \geq 1, \xi_j \geq 0, j = l + 1, ..., l + k; \\ &-(w \cdot x_i - b) + z_j \geq 1, z_j \geq 0. \end{aligned} \tag{5}$$

The second and third inequalities constrain the class of 1 and −1, respectively. The objective function represents the minimum value of computational error classification, and the programming problem can be solved by integer programming.

$$\begin{aligned} &\min_{w,b,\eta,\xi,z} C\left[\sum_{i=1}^{l} \eta_i + \sum_{j=l+1}^{l+k} \min\left(\xi_i, z_j\right)\right] + \|w\|, \\ &s.t. y_i (w \cdot x_i - b) + \eta_i \geq 1, \eta_i \geq 0, i = 1, \ldots, l; \\ &w \cdot x_i - b + \xi_j + M\left(1 - d_j\right) \geq 1, \xi_j \geq 0, j = l + 1, \ldots, l + k; \\ &-(w \cdot x_i - b) + z_j + M d_j \geq 1, z_j \geq 0; d_j = \{0, 1\}. \end{aligned} \tag{6}$$

The problem with this method is that the amount of calculation will increase rapidly with the increase of unlabeled samples. Therefore, some researchers have transformed the original nonlinear programming optimization problem into iterative optimization problem through each iteration of linear programming, but the effect is limited.

3.3. Semisupervised SVM Classification Algorithm Based on Collaborative Training

3.3.1. Standard Cooperative Training Algorithm. Specifically, the training set meets the following two conditions: (1) Each attribute set contains enough information to establish the structural model of the system; that is, each attribute set can train a strong learner independently, and the learner itself has high generalization ability; (2) when a tag is given, each attribute set condition is independent of another attribute set, which is often difficult to achieve in the actual process [15]. Then, in the process of collaborative training, each classifier screens several unlabeled samples with high prediction confidence and adds them to another tag set to provide update conditions for each other. The specific steps of the algorithm are shown in Figure 4.

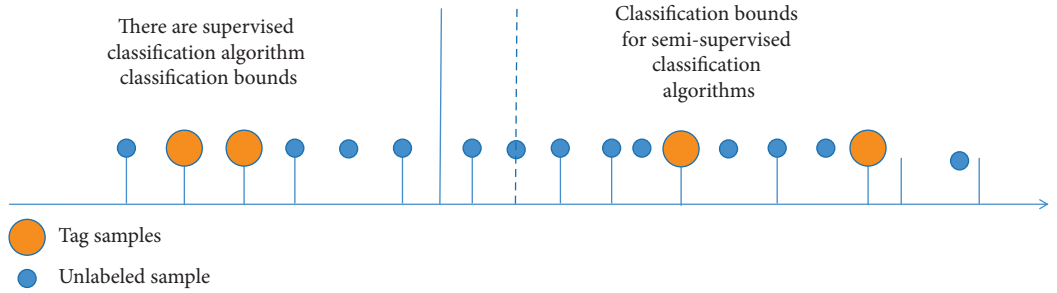


Figure 3: Effect of unlabeled samples.

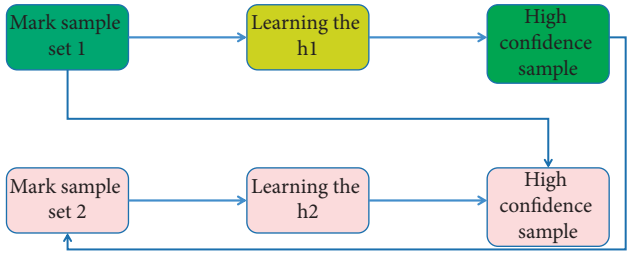


Figure 4: Standard cooperative training algorithm.

This algorithm has attracted the attention of many researchers since it was proposed. However, in practical problems, it is often difficult to directly obtain two fully redundant views from the original data. In this algorithm, unlabeled samples are classified by two different SVM classifiers, and the samples with high classification reliability are added to the labeled samples, so as to expand the labeled sample size.

3.3.2. Semisupervised Support Vector Machine Classification Algorithm. The main purpose of the SVM classifier is to prepare the low-dimensional data model to enter the high-dimensional feature model according to some nonlinear relationship and assume that it still can be divided into separate models in the high-section space. The distribution problem is solved by the distribution of the small area and then the high area [16]. The topology of SVM is shown in Figure 5. n is the input data dimension, K is the kernel function, and n is the number of support vectors.

Given a dataset:

$$\{x_i, y_i | i = 1, 2, \ldots, N\}. \tag{7}$$

$x_i \in R^d$ is the difference of the individual, $y_i \in \{+1, -1\}$ is the difference of the individual (data set), and N is the magnitude of the training pattern. When dividing binary classification problems linearly, the following model can be used to define hyperplane $f(x) = 0$ to divide data:

$$f(x) = \sum_{i=1}^{N} w \cdot x_i + b = 0, \tag{8}$$

where w is the weight matrix and b is the bias factor, N is the training sample size. The following constraints are then used to determine the location of the classification hyperplane:

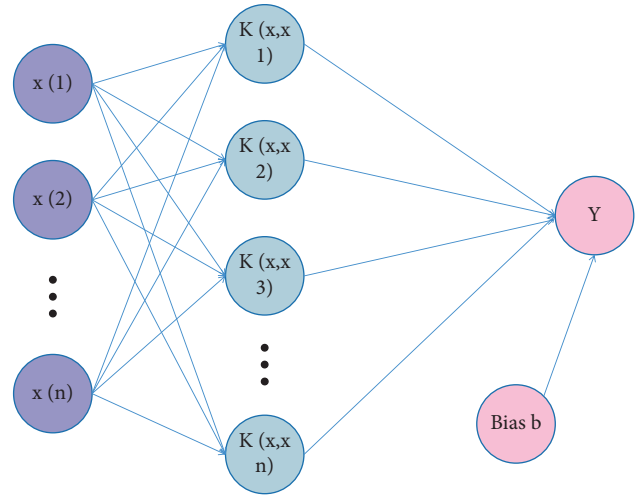


Figure 5: Topology of SVM.

$$y_i (w \cdot x_i + b) \geq 1, i = 1, 2, \ldots, N. \tag{9}$$

The positive relaxation variable ξ_i is defined to calculate the distance between the boundary and the misclassification vector x_i, w is the weight matrix, and the b is the bias factor. Then the optimal classification hyperplane can be obtained through the following optimization problems:

$$\min \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{l} \xi_i, i = 1, 2, \ldots, N,$$
$$s.t. \begin{cases} (w \cdot x_i - b) \geq 1 - \xi_i, \\ \xi_i \geq 0. \end{cases} \tag{10}$$

Here, C is the offense. By including the negative Lagrange multiplier α_i, the above model can be converted to a quadratic optimization rule, which can be defined as follows:

$$\max L(\alpha) = \sum_{i=1}^{N} \alpha_i - \frac{1}{2}\sum_{i,j=1}^{N} \alpha_i \alpha_j y_i y_j K(x_i, x_j),$$
$$s.t. \sum_{i,j=1}^{N} \alpha_i y_j = 0, 0 \leq \alpha_i \leq C, i = 1, 2, \ldots, N. \tag{11}$$

For linear classification problems,

$$K(x \cdot x_i) = x \cdot x_i. \tag{12}$$

The training sample with nonzero weight α_i is called support vector, so the decision function of SVM is defined as follows:

$$f(x) = \text{sign}\left(\sum_{i=1}^{N} \alpha_i y_i K(x \cdot x_i) + b\right). \quad (13)$$

The advantage of using kernel function is that the kernel function replaces the spatial internal multiplication of a high-dimensional function, which drastically reduces the number and complexity of calculations. Classical kernel functions include linear kernel functions, polynomial kernel functions, Gaussian radial basic kernel functions, and S-shaped kernel functions. Each kernel function has its own unique characteristics [17]. The Gaussian radial root function (RBF) used in this form is widely used in parametric computing due to its excellent effect and strength. RBF format is as follows:

$$K(x \cdot x_i) = \exp\left(-\gamma \left\| x - x_i \right\|^2\right), \quad (14)$$

where

$$\gamma = \frac{1}{2}\sigma^2. \quad (15)$$

σ is the width parameter in RBF. According to the experience of previous researchers, the main content of SVM design is to select the appropriate kernel function and kernel parameters. However, some researchers believe that the key factors affecting the performance of SVM compared to the mode of action of the tablets are the nontablets and the penalties C. Thus then, it is necessary to select the model that fits the specific model of SVM. Take advantage of SVM. In this chapter, two different SVM classifiers are defined using different values. It is able to calculate the constraints of an SVM classifier by the genetic algorithm and determine the value of the measure according to the specified parameters.

In the implementation of the algorithm, we must ensure that h_1 and h_2 are two different classifiers; otherwise the collaborative algorithm will be transformed into a self-training algorithm, which will lead to the two classifiers having the same misclassification result for the same sample, and this result will deteriorate with the iteration, and the subsequent classifier will be updated. Therefore, in this paper, according to the characteristics of SVM, we adjust the parameters of two SVM classifiers to obtain the difference between classifiers. In h_1, we use the default parameter value, and in h_2, we use genetic algorithm to optimize the parameter value. As mentioned above, the parameters in SVM have a very important impact on the performance of the learner, so we can think that we have selected two different learners by selecting two different parameters.

For the classification reliability problem, it is intuitively believed that if the two classifiers trained by L have the same prediction results for the same unlabeled sample, the result will have higher classification reliability. Therefore, this labeled result can be added to L to expand the training labeled sample set [15].

4. Design of Real-Time Condition Monitoring System

4.1. Platform Software. The system developed is a real-time condition monitoring system for track circuit. It is an application based on C/S architecture. An important feature of the application is that it can provide users with an easy-to-use user environment. In addition, it requires developers to write programs in a development environment with friendly interface, easy operation, and easy understanding. Based on the above considerations, C++ Builder 5.0 is selected. C++ Builder provides powerful database application development functions and database auxiliary tools. Through these components, you can access large databases such as Oracle and SQL server. Using these component tools, developers can quickly and with high quality develop applications based on C/S architecture. And there are more than twenty kinds of components on the Internet component board of C++ Builder. Users can use them to create almost all common Internet applications.

4.2. Overall System Architecture

4.2.1. Software Structure. The overall software structure of the system is shown in Figure 6.

As can be seen from Figure 6, the monitoring system carries out real-time data communication with each board of the lower computer through the serial bus. On the one hand, it receives the real-time data transmitted by the lower computer; on the other hand, the upper computer application program can send instructions to the lower computer to change the working state and mode of the lower computer. At the same time, the real-time data information collected by the upper computer application and the relevant information of the application itself are stored in the database server, and users can query, update, and delete this information.

4.2.2. System Software Function Module Diagram. The division of functional modules is an important part of system design. Its key task is to divide a system into several subsystems according to the objective requirements of function or logic. After the division, each subsystem can be independent as far as possible and has universality in some aspects, in order to expand and modify the system in the future. Its functional modules are shown in Figure 7.

4.3. Design and Key Technology of Each Functional Module of the System

4.3.1. Communication Module. The communication mode between the system and the lower computer acquisition device is serial communication. Serial communication is that data is transmitted bit by bit through a transmission line. The advantages of serial communication are long transmission distance and strong anti-interference ability. Serial communication can be divided into three transmission modes according to the direction of data flow: simplex, half-duplex,

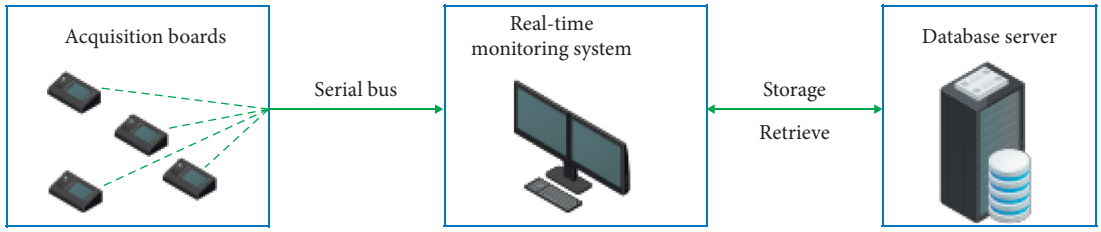


Figure 6: Overall software structure of the system.

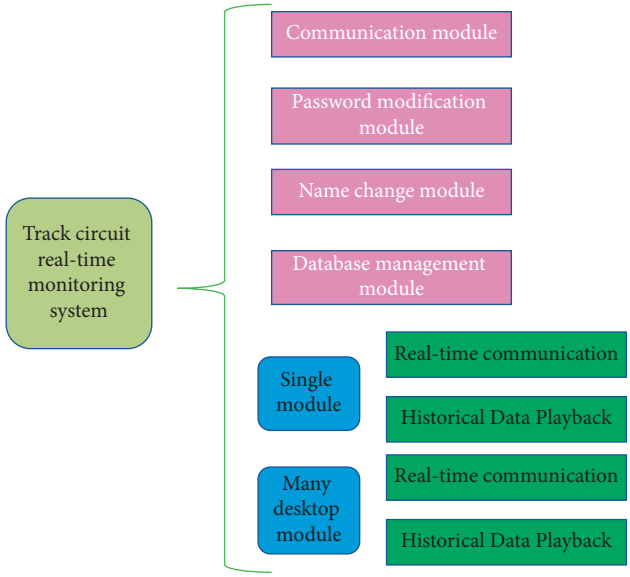


Figure 7: System software function module diagram.

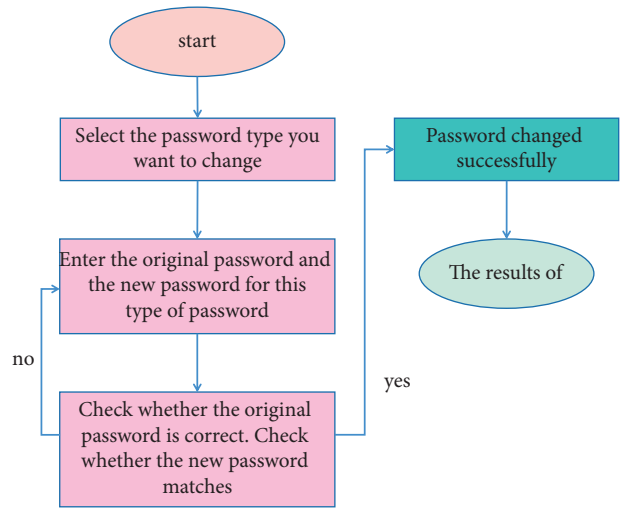


Figure 8: Password management flowchart.

and full duplex. Simplex data transmission is one-way. One party is fixed as the sending end and the other is fixed as the receiving end. Half-duplex communication uses a transmission line, which can send and receive data but can not send and receive data at the same time. At any time, only one party can send data and the other party can receive data. The main function of the communication module is to set various communication parameters of the serial port to adjust the communication state. These parameters include port number, baud rate, data bit, and checksum stop bit [18].

4.3.2. Password Management Module. Because the system has strict requirements for operation, in order to prevent improper operation caused by users who are not authorized or have low access to some functions of the system, when users use some functions of the system, they need to enter a password, and the system will verify whether the user's permission is legal. The system divides user passwords into three levels. They are debugging password, maintenance engineer password, and exit password. The debug password level is the highest and the exit password level is the lowest. For example, threshold setting requires the highest level of permission, while the lowest level of permission can be used when exiting the system. The password management flowchart is shown in Figure 8.

4.3.3. Name Management Module. In order to enable users to modify the display mode of the lower computer name in the system according to different usage habits and in different environments, it is necessary to modify and manage the lower computer name. The flowchart of this module is shown in Figure 9.

4.3.4. Database Management Module. Database management module is a platform to realize these functions. Its function is mainly divided into two parts: first, delete and update the expired and worthless single machine/multimachine historical data information saved in the database; second, when single machine/multimachine historical data is played back, the required historical data information is retrieved through the platform. The flowchart of this module is shown in Figure 10.

4.3.5. Single Machine, Multimachine Mode, Real-Time Communication. When storing data files, in order to reduce the capacity size of data files, the system uses data file compression to save. In this way, the capacity of data files saved in the local hard disk is very small and will not occupy too much local hard disk space [19]. The real-time communication flowchart of single machine/multimachine mode is shown in Figure 11.

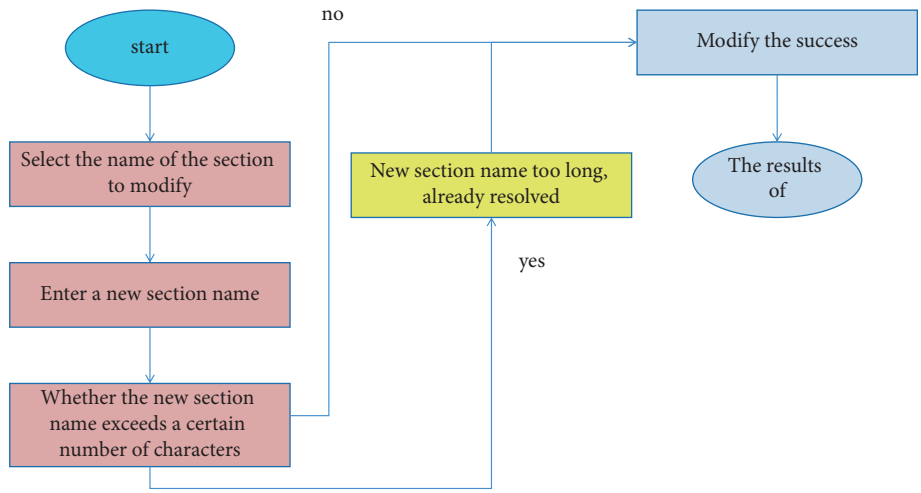


Figure 9: Name management flowchart.

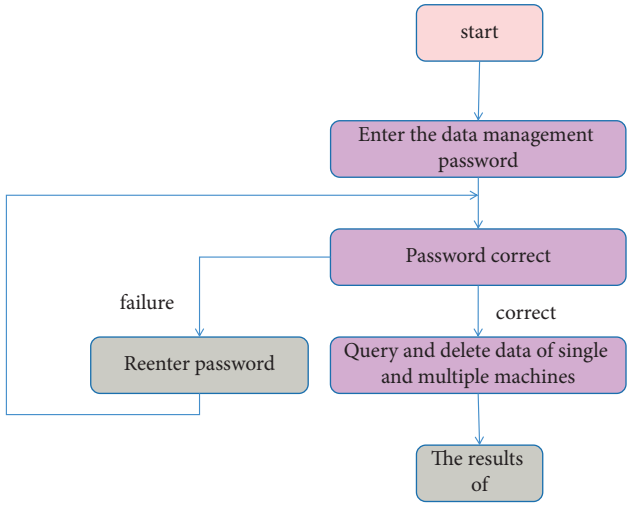


Figure 10: Flowchart of database management.

4.3.6. Single Machine, Multimachine Mode, and Historical Data Playback. Since the single machine/multimachine mode uses compression to save the historical data file when saving real-time data, the contents of the file cannot be read directly. Therefore, when selecting the historical data file for playback, the system decompresses the selected data file to generate a temporary file and restore it to the original readable state, so that the system can read the contents of the file for data playback. When the user selects the next history file to open, or when the user exits the module, the temporary file will be deleted [20]. The flowchart of single machine/multimachine mode historical data playback is shown in Figure 12.

The user selects the historical data to be played back in two ways. In the standalone mode, the data content will be displayed in the oscilloscope after successful selection. The historical data playback of multimachine mode is divided into two parts. One is the historical data playback of the overall status of multiple machines; the other is to select a specific section to view the data of the section.

Through the construction of quality culture, every employee of the school can understand the connotation of quality and form a certain quality responsibility and quality ethics, so that every person participating in quality monitoring can restrict their own quality behavior. Through the construction of quality culture, the quality foundation of quality monitoring participants can be improved. Therefore, first of all, the school should strengthen the construction of "quality culture," so as to make the school environment form an atmosphere of paying attention to quality and better understand quality monitoring in the edification of this atmosphere. On this basis, the school organizes and implements the quality monitoring of primary school English classroom teaching, which can be carried out in such an atmosphere with better background support. The next step is to promote good governance in English elementary schools. The banner not only allows the display of banners and posters, but also supports the administration of English language education in elementary schools. All participants in the effective management of English language instruction will have a better understanding of this, reducing the negative understanding of the topics and objects of management. English schools are good and develop a good understanding of the environment [21]. The word "control" often makes people feel bad, so the objects of control are not understood and felt high and lead to good management. In order to avoid such a decision and make a better impact, which is the real goal of "performance management." Within the framework of the mission of "Quality Assurance in Primary English," the curriculum and materials of management formed a "United Front" to ensure the quality of the original English.

The content of overseeing English language proficiency in elementary school should remain in the general curriculum of elementary school English language teacher classes, and key words that affect English proficiency in elementary school should be gradually subdivided into elementary school concepts. Good English language management: The concept of "whole process" of all formal management is combined with the standards or stages of the process of

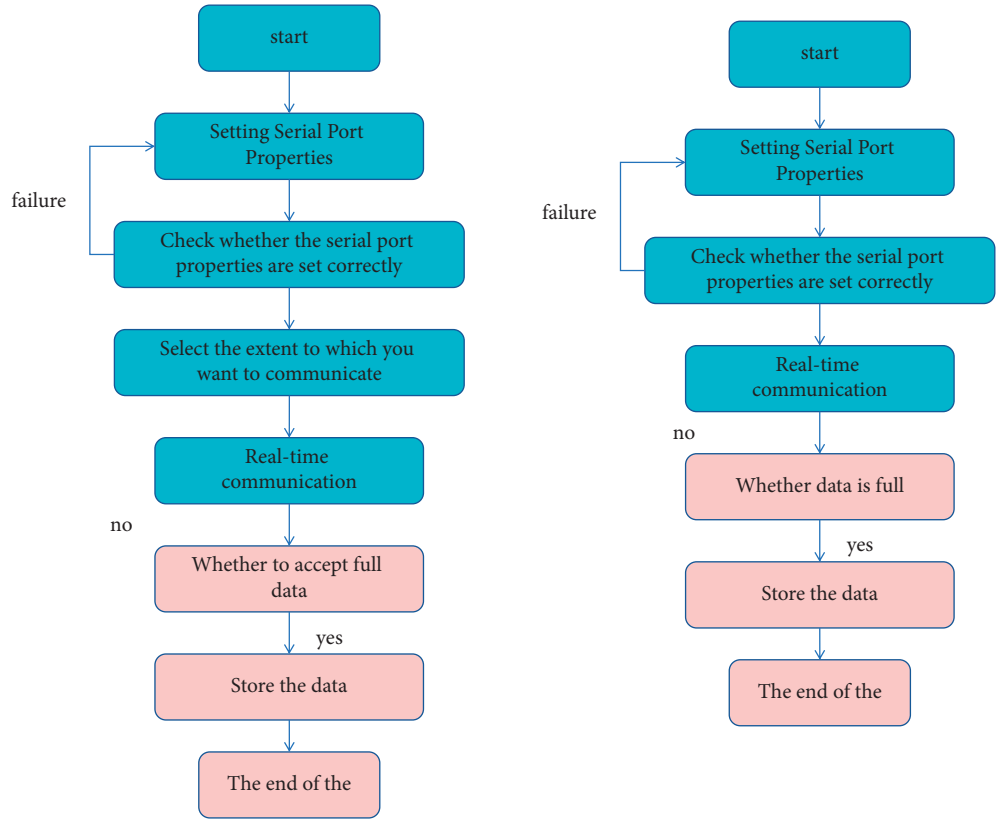


Figure 11: Single machine/multimachine mode real-time communication flowchart.

teaching English in elementary school, as shown in Tables 1 and 2.

The purpose of dismantling the monitoring content in stages is to make the monitoring subject no longer feel the classroom as a whole by feeling aimlessly in the information collection link, and the elements settled in each stage are more targeted. In addition, it should be explained that the knowledge literacy, ability literacy, and moral literacy of primary school English teachers can be subdivided. Here is only a reference monitoring content framework. Formulating the monitoring content throughout the "whole process" of primary school English classroom can well improve the monitoring content of primary school English classroom and reduce the problems caused by incomplete monitoring content [22].

By implementing a number of specialized trainings on key concepts of performance management in English language elementary schools, we will be able to eliminate the risk of recognizing the importance of maintaining college English proficiency and gain a full understanding of the concept of care in our hearts. In addition, training skills to monitor the good governance of the elementary school English will help to predict the situation that will occur in the management of good governance at elementary school English and prepare their thoughts and skills in advance. From the first English language school to a comprehensive English language center for intellectual property, vocational training, and ethics training, the school provides a comprehensive English language arts supervision program, to excel in elementary school, promoting academic achievement and ethical supervision. By ensuring that the supervisors have achieved these positive characteristics, a good performance management class for the English primary school can play a full role in management and administration [23].

A single monitoring means will lead to the problems found in the monitoring process which is not comprehensive enough, so we need to choose the primary school English classroom teaching quality monitoring means from multiple perspectives to find problems from multiple perspectives to make up for the shortcomings of each monitoring means. The convenience and efficiency of the "Internet +" model are increasingly recognized by the society, so the "Internet + primary school English classroom quality monitoring" will produce "online" monitoring means, and the application of this means can improve the efficiency of primary school English classroom teaching quality monitoring and will greatly improve the level of modern education and teaching in schools. Therefore, schools need to look at the cost of investment in "online" monitoring technology from a long-term perspective and consider the development of education in the future. In addition, the application of self-evaluation monitoring means is relatively weak compared with evaluation monitoring and mutual evaluation monitoring, and self-evaluation monitoring means can help primary school English teachers form self-monitoring and improve their awareness of ensuring quality. Therefore, it is necessary to strengthen the use of self-evaluation monitoring

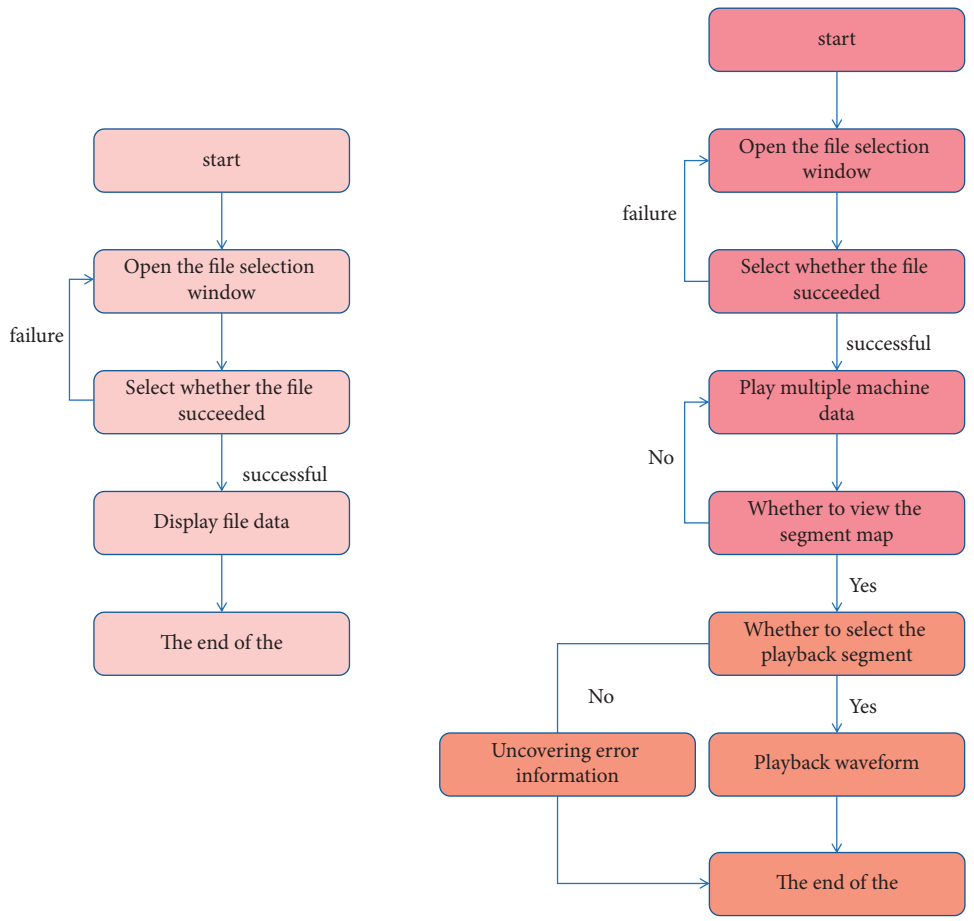


Figure 12: Single machine/multimachine historical data playback flowchart.

Table 1: Reference frame A of "whole process" monitoring content of English classroom teaching quality in primary school.

		Warm up and lead in	Presentation	Practice and consolidation	Production and homework
Primary school English teachers	Knowledge literacy Ability literacy Truth literacy				
Student	Degree of participation Degree of concentration				

Table 2: Reference frame B for "whole process" monitoring content of English classroom teaching quality in primary school.

		Before reading/before listening	While reading/while listening	After reading/after listening
Primary school English teachers	Knowledge literacy Ability literacy Truth literacy			
Student	Degree of participation Degree of concentration			

means in primary school English classroom monitoring quality monitoring.

5. Conclusion

"Quality Assurance of English Language Teaching" should be changed to "Quality Assurance in English Language Teaching and Strengthening the Effectiveness of English Language Teaching." Second, engage English elementary school teachers in the development of assessment standards, including the specific concept of teaching English in elementary school. It will improve the management content of the first English language education, which reaches all levels of the "whole process" of basic English. Specialized training will be provided to elementary English classes to teach classroom management skills to gain knowledge of classroom management. An organization will be set up to oversee English language classes in elementary schools in order to work with "responsible leaders." Sixth, provide tools to monitor the quality of English language instruction and strengthen the use of "online" monitoring and self-assessment. Specify the operational time of the link to monitor the quality of basic English instruction and to conduct a strict writing process for the link to be tested.

The primary school English classroom teaching quality monitoring link is mainly composed of classroom information collection link, evaluation link, feedback link, and regulation link. In order to ensure the quality of each monitoring link and avoid the neglect of the monitoring link, it is necessary to divide the labor of each link, and at least two people participate in one link. In the information collection link, because the monitoring content involves the "whole process," the number of monitoring subjects can be appropriately increased as needed. Every subject participating in the information collection link should participate in the evaluation link. Both written feedback and face-to-face communication feedback in the feedback link should be fed back to the teaching teacher. The regulation link is essentially the beginning of a new round of monitoring, which requires the personnel who participated in the information collection link and those who did not participate in the previous round of monitoring to be responsible together, so as to ensure that the teaching teachers implement the feedback and consciously improve the teaching. In addition, the monitoring link needs to make a strict and mature written regulation on the specific requirements and taboos of each link, so as to take this as the minimum behavior standard for the monitoring subject to implement the monitoring in each monitoring link and standardize the monitoring behavior.

Schools can, through the primary school English classroom teaching quality control knowledge training, skills training, and moral training, promote primary school English classroom teaching quality monitoring where subject has basic monitoring knowledge literacy, monitoring ability literacy, monitoring moral quality, on the basis of the basic quality of primary school English classroom teaching quality monitoring subject in the organization and implementation of monitoring to give full play to the role of the monitoring main body. It proves that the real-time supervision of students' status can effectively improve the effect of English classroom teaching.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work was supported by China Transportation Education Research Association 2020-2022 Transportation Education Scientific Research Project (JTYB20-176).

References

[1] J. V. D. Meer, J. Skalicky, H. Speed, and D. G. Young, "Focusing on the development of the whole student: an international comparative study of the percei4ed benefits of peer leadership in higher education," *Open Journal of Social Sciences*, vol. 10, no. 3, p. 22, 2022.

[2] P. Arslan, "Classroom teachers' opinions concerning the evaluation of student-related services at elementary schools in respect of the best interest of the child," *Social Sciences Studies Journal*, vol. 6, no. 55, pp. 341–350, 2020.

[3] Q. Chen and D. Ou, "The effects of classroom reverberation time and traffic noise on English listening comprehension of Chinese university students," *Applied Acoustics*, vol. 179, no. 4, Article ID 108082, 2021.

[4] P. C Saravana and Dr. H Deepa, "Perception of higher secondary students about technology supported learning in English classroom," *International Journal of Psychosocial Rehabilitation*, vol. 24, no. 2, pp. 1443–1447, 2020.

[5] D. Dharmawati, "An analysis of students' learning independence in learning English for computer using google classroom," *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, vol. 4, no. 2, pp. 1635–1642, 2021.

[6] M. Phoeun and S Sengsri, "The effect of a flipped classroom with communicative language teaching approach on undergraduate students' English speaking ability," *International Journal of Instruction*, vol. 14, no. 3, pp. 1025–1042, 2021.

[7] V. Kurdi and I. Archambault, "Self-perceptions and engagement in low-socioeconomic elementary school students: the moderating effects of immigration status and anxiety," *School Mental Health*, vol. 12, no. 2, pp. 400–416, 2020.

[8] F. S. Alsahli, "Efl students' perception of classroom assessment environment in translation courses," *International Journal of English Linguistics*, vol. 10, no. 1, p. 255, 2019.

[9] M. Ekstedt, M. Lindblad, and A. Lfmark, "Nursing students' perception of the clinical learning environment and supervision in relation to two different supervision models – a comparative cross-sectional study," *BMC Nursing*, vol. 18, no. 1, pp. 1–12, 2019.

[10] N. Saienko and O. Chugai, "Quarantine: teaching English from home with google classroom, classtime and quizlet,"

Revista Romaneasca pentru Educatie Multidimensionala, vol. 12, pp. 151–156, 2020.

[11] K. Jitjumnong and S. Suksakulchai, "Comparison study of student's learning achievement between the flip classroom with and without group management," *International Journal of Information and Education Technology*, vol. 9, no. 12, pp. 904–908, 2019.

[12] C. Payant and P. Bell, "Very easy, it's an English class, therefore they should not rely on a French text":English language teachers' beliefs regarding l1 use for literacy instruction," *Language Teaching for Young Learners*, vol. 4, no. 1, pp. 143–170, 2022.

[13] C. Pan, "Ncov–based considerations on online- English teaching and traditional classroom-English teaching in China," *IRA International Journal of Education and Multidisciplinary Studies*, vol. 16, no. 2, p. 96, 2020.

[14] S. H. Jensen, J. Weile, R. Aagaard et al., "Remote real-time supervision via tele-ultrasound in focused cardiac ultrasound: a single-blinded cluster randomized controlled trial," *Acta Anaesthesiologica Scandinavica*, vol. 63, no. 3, pp. 403–409, 2019.

[15] J. D. Hernandez, E. S. Cespedes, D. A. Gutierrez, D. Sanchez-Londono, and L. Fumagalli, "Human-computer-machine interaction for the supervision of flexible manufacturing systems: a case study," *IFAC-PapersOnLine*, vol. 53, no. 2, pp. 10550–10555, 2020.

[16] V. Rahimimovaghar and M. R. Rasouli, "Published validated study and restricted supervision are two confounding factors in implementation of c-spine rule," *BMJ*, vol. 339, no. 44, p. 729, 2021.

[17] J. Liu, P. Wang, F. Zha, W. Guo, and L. Sun, "A strong tracking mixed-degree cubature kalman filter method and its application in a quadruped robot," *Sensors*, vol. 20, no. 8, p. 2251, 2020.

[18] K. Bi and Y. Bi, "Research on real time monitoring of operation status of large data platform for energy conservation supervision based on computer," *Journal of Physics: Conference Series*, vol. 1744, no. 2, Article ID 022052, 2021.

[19] L. Chen, S. Wu, and Q. Zhao, "Design and realization of the supervision system for the harmless treatment of building waste based on lca," *IOP Conference Series: Earth and Environmental Science*, vol. 836, no. 1, Article ID 012013, 2021.

[20] K. Ishwarya and A. A. Nithya, "Performance-enhanced real-time lifestyle tracking model based on human activity recognition (pert-har) model through smartphones," *The Journal of Supercomputing*, vol. 78, no. 4, pp. 5241–5268, 2021.

[21] A. T. Purnomo, D. B. Lin, T. Adiprabowo, and W. F. Hendria, "Non-contact monitoring and classification of breathing pattern for the supervision of people infected by covid-19," *Sensors*, vol. 21, no. 9, p. 3172, 2021.

[22] A. Zeaiter, E. Videcoq, and M. Fénot, "Determination of electric motor losses and critical temperatures through an inverse approach," *Electrical Engineering*, vol. 103, no. 1, pp. 621–631, 2020.

[23] L. C. Moreira, W. D. Li, X. Lu, and M. E. Fitzpatrick, "Supervision controller for real-time surface quality assurance in cnc machining using artificial intelligence," *Computers & Industrial Engineering*, vol. 127, pp. 158–168, 2019.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 8343909, 12 pages
https://doi.org/10.1155/2022/8343909

Research Article

English Online Teaching Resource Processing Based on Intelligent Cloud Computing Technology

Wenjuan Zhang

Xinyang Vocational and Technical College, Xinyang 464000, China

Correspondence should be addressed to Wenjuan Zhang; zhangwenjuan@xyvtc.edu.cn

Received 29 April 2022; Revised 13 June 2022; Accepted 24 June 2022; Published 8 July 2022

Academic Editor: Wen Zhou

In order to improve the processing effect of English online teaching resources, this paper improves the efficiency of resource processing by building an intelligent cloud system. Aiming at the problem of insufficient acquisition of traditional teaching resources, this paper adopts the intelligent data acquisition method and proposes an English resource mining method based on crawler technology. Moreover, in view of the difficulty of English semantic recognition, this paper proposes a method for calculating weights of feature items weighted by mixed factors on the basis of traditional algorithms and constructs a system model based on the characteristics of online English teaching. In addition, in order to explore the system effect, the model proposed in this paper is verified by clustering experiments. Through the experimental research, it can be seen that the English online teaching resource processing system has a good effect in the processing of English teaching resources.

1. Introduction

At present, the pace of informatization construction in colleges and universities is also accelerating. Moreover, major colleges and universities have established their own campus networks to realize the connection with the Internet, which has laid a good hardware foundation for the development of computer-assisted classroom English teaching, distance English teaching, network English teaching, and building a lifelong learning system.

According to the scientific citation analysis theory, the interconnected data between documents contains rich and useful information, and web structure mining mainly derives information and knowledge from the web organizational structure and link relationships. Due to the complexity of the structure, the common search engine only regards the web as a collection of flat documents and ignores its structure information. Mining the structure of pages and web structure can be used to guide the classification and clustering of pages. Besides, hyperlinks, as an important feature of hypertext documents, provide valuable information for web information acquisition. Recently, web retrieval algorithms based on hyperlink analysis, such as PageRank, have greatly improved the retrieval accuracy compared with the word-based methods used by traditional search engines. Generally speaking, hyperlinks in web documents contain two kinds of information. First of all, they provide users with navigation information for browsing the web, just like the commonly used navigation bar is used to guide visitors to jump between pages. Secondly, the hyperlinks in the page are often the document author's recommendation for a certain document, and the recommended target document often has similar content and is recognized by the author. The latter forms the basis of link analysis. That is, the importance of a certain document is determined not by the content of the document but by the number of times it is linked (or referenced) by other documents. In web retrieval, in addition to the number of links by other documents, the quality of the linked source document is also a reference factor for evaluating the quality of the linked document. Documents linked or recommended by high-quality documents tend to be more authoritative. This method of link analysis of web pages is called web structure mining. Compared with the query result ranking algorithm based on word frequency statistics used by traditional search engines, the advantage of the algorithm based

on hyperlink analysis is that it provides an objective and less cheating web resource evaluation method (some web documents are used to trick traditional search engines by adding invisible strings). Therefore, link analysis algorithms are currently used in the ranking of documents in search engines.

Web log mining can automatically and quickly discover the browsing patterns of network users, such as frequently accessed paths, frequently accessed page groups, and user clustering [1]. Based on the recognition of user browsing patterns, one method is to manually improve the site structure according to these patterns, so as to facilitate the browsing of users. Another more effective and more automated method is to allow the site to dynamically adjust and customize the site structure and page content automatically according to the current user's browsing mode and provide personalized services according to the user's behavioral characteristics. Data preprocessing and log mining algorithms are the key technologies in web log mining [2]. The result of data preprocessing as the input of mining algorithm directly affects the quality of mining, and the selection and improvement of mining algorithm are an important factor to ensure the success of mining. Therefore, the research on web log mining technology focuses on these two aspects [3]. Web usage mining techniques can generally be applied to two fields: when used to analyze access logs of web servers, adaptive websites can be designed using the service model obtained from mining, and [4] when applied to a single user, by analyzing user access history to discover useful user access patterns. Because the data objects processed in web usage mining are usually the user's access history or the server's access log, the content represented by the data objects cannot be known, so the results obtained are generally rough. However, because this method is relatively mature and simpler to implement than content mining, it has also been widely used in personalized systems [5].

In today's era, a large amount of information is pouring in, which has also caused a lot of inconvenience to people's lives. The most troublesome thing for users is that they need to slowly select the information that is useful to them from the massive information; at the same time, for the disseminators of information, they hope that the information they publish or generate will be discovered by the vast number of information acquirers, so that being able to stand out has also become a difficult thing to do. acquirers [6]. Since then, it has become an important tool to solve these problems brought by the Internet. The recommendation system needs to understand the user's habits, and then the channel to understand the user's habits is to analyze the user's purchase, browsing, and other historical records to obtain the user's preferences, thereby proactively recommending information to users that they are interested in or need. There are two popular recommendation systems now: one is to send web links to users by analyzing their preferences [7]; the other is to directly recommend products to users on an e-commerce platform. This kind of recommendation can also be called an e-commerce personalized recommendation system. People are more inclined to personalized recommendation, because the personalized recommendation system can greatly improve the service efficiency and service quality of the website, and users will be very efficient when browsing [8]. Therefore, personalized customization can attract more users and enhance the stickiness of existing users. But any kind of recommendation system is composed of 3 parts, including the front page displayed in front of the user, the background log, and the recommendation algorithm. The background logs and recommendation algorithm users are invisible. The front page is directly facing the user and interacts with the user [9]. Background logs are used to record and store various historical behaviors of users. The recommendation algorithm generates recommendation results by analyzing the user's historical behavior logs and then performing a series of calculations. Finally, the recommendation result is returned to the front page to display to the user [10].

Literature [11] proposed the learning theory in the era of digital network learning. Relevance learning theory mainly focuses on four questions and specifically answers the questions: What is learning in the era of digital network learning? Why learn? How to learn? Where do you learn from? First of all, learning in the era of digital network learning is a dynamic, open, and continuous process. Learning is the process of connecting information sources or knowledge nodes, that is, the connection of learning networks [12]. Secondly, the purpose of learning is to obtain knowledge absorption and innovation by establishing organic connections between knowledge nodes; the core skill of learning is to be able to discover or connect different fields, viewpoints, and concepts. Again, both formal and nonformal learning are ways of learning, but future learning is closely linked to work activities, mainly achieved in practical activities, personal networks, or task completion. Finally, learning is based on technology-supported learning, and knowledge is developed dynamically and diversely, so it is more important to know where there are massive information resources than to have them [13].

Reference [14] defines the characteristics of learning with chaos, complexity, continuity, cocreation, specialization of connection, and stability of continuous expectation. Literature [15] mainly studies E-learning. In the process of designing learning resources, the authors began to pay attention to the development of relationalism theory and discussed the connotation of relationalism, the connotation of connected knowledge, and the relationship between learning network and connected knowledge. Relationship is discussed. Literature [16], on the basis of summarizing the characteristics and development dilemmas of the business English subject, proposes the principles of building a business English subject system based on the perspective of relational learning theory (i.e., the principles of overall development, inclusiveness, integration and innovation, and cultivating characteristics). The conception of constructing a business English subject system (i.e., the construction of a multitheoretical system and the construction of an online learning environment) is proposed. Literature [17], based on the analysis of the problems existing in the current college English autonomous learning of college students, discusses the new characteristics of college English autonomous

learning under the guidance of the relevant learning theory and summarizes college students' English autonomy in the era of digital network learning. Based on the guidance of constructivist learning theory and connectivity learning theory, [18] constructed a ubiquitous learning resource sharing platform for "three-duo" college English quality courses of "multimodal resources, multiterminal access, and multichannel interaction." And in practice, it breaks through the dilemma of lack of situational context in college English language schools and effectively alleviates the contradiction of insufficient college English learning resources.

The main contribution of this paper is as follows: in the process of English resource processing, the traditional algorithm ignores semantic mining. This paper considers the appearance semantics and frequency of words from two perspectives and proposes a mixed factor weighted feature item weight calculation method to improve text similarity. It can improve the accuracy of degree calculation and promote the processing efficiency of English online teaching resources.

From the above analysis, it can be seen that the current processing of English online teaching resources is mostly carried out through data mining at that time. By analyzing the literature research on the simple structure of the network, it can be found that the topology map has obvious convergence, that is, web pages with similar themes converge. Page theme groups, and this kind of grouping between pages, is called a network community. This makes the web pages on the Internet naturally form various types of link structures, each link structure is called a network community, and its member pages are basically related to a certain topic. This feature of the online community makes it very relevant to its internal topics and is easy to crawl. However, there may be relatively few links due to thematic differences between different online communities. This will reduce the crawling rate of the theme crawler, and the strategy of the theme crawler to traverse the tunnel and crawl the web page information efficiently has become one of the focuses of crawler research in recent years.

The main innovation of this paper is to process English online teaching resources by improving the crawler technology. By analyzing the VSM web page classification algorithm, the VSM web page classification algorithm is improved from three aspects: feature extraction, eigenvalue calculation, and class core vocabulary generation. In this paper, considering the semantics of the appearance of words, a method for calculating the weights of feature items weighted by mixed factors is proposed, which improves the accuracy of text similarity calculation.

This paper combines intelligent cloud computing technology to construct an English online resource processing system to improve the efficiency of English online resource processing and combines crawler technology to conduct data mining to create resources suitable for English teaching and improve the effect of English online teaching.

2. Cloud Computing-Based Crawler Technology

2.1. Key Technologies of Theme Crawler. The description of the crawling target by the topic crawler can be divided into three types: based on the characteristics of the target web page, based on the target data pattern, and based on the domain concept.

The objects crawled, stored, and indexed by crawlers based on the characteristics of target web pages are generally websites or web pages. According to the method of obtaining seed samples, it can be divided into the following:

(1) The first is to predetermine the initial crawling seed sample

(2) The second is to predetermine web page categories and seed samples corresponding to the categories

(3) The third is to determine the crawling target samples through user behavior, which is divided into crawling samples that display annotations during user browsing, and access patterns and related samples obtained through user log mining.

The crawler based on the target data pattern is aimed at the data on the web page, and the crawled data generally conforms to a certain pattern or can be transformed or mapped into the target data pattern. Another way of description is to establish target domain ontology, which is used to analyze the importance of different features in a topic from a semantic perspective.

When calculating the PageRank value of a certain web page, all backlinks should be considered. The calculation formula of the PageRank value of a certain page p is shown in the following equation:

$$PR(p) = (1 - d) + d * \sum_{v \in B(p)} \frac{PR(v)}{N_v}. \tag{1}$$

v represents the web page, P represents the page of the website, and the crawler data mining can be carried out in combination with the corresponding parameters. In the above formula, N_v represents the number of forward links of web page v; $B(u)$ represents the set of web pages with links directly pointing to page p; PR (p) represents the PageRank value of page p; $PR(v)$ means that web page v evenly distributes its PageRank value to its forward links; d is a damping constant factor, usually 0.85. In reality, it is impossible for Internet users to randomly jump to completely irrelevant pages when browsing Internet pages, and it is impossible to completely follow the links in the current page. Therefore, d actually represents the probability that the user follows the web page link to browse without generating random jumps. In order to ensure that the calculation results are always converged, a damping coefficient d is added. Although the PageRank algorithm considers both the existence of Sink web pages and the randomness of user access behaviors, it still ignores the relevance of most user access links and query topics and the purposeful factors in query.

The Hits algorithm calculates its Authority value and Hub value for each page that has been visited and then uses this to determine the order of link visits. The Authority and Hub values of page p are $A[p]$ and $H[P]$, respectively, and the Authority and Hub values are calculated according to the following formula:

$$\begin{cases} A[p] = \sum_{q:(q,p)\in E} H[q], \\ H[p] = \sum_{q:(q,p)\in F} A[q]. \end{cases} \tag{2}$$

In the formula, E is the set of all pages pointing to page p, and F is the set of pages pointed to by links in page p.

We utilize web page and topic relevance for fuzzy scoring. The relevance scores of extracted links are mainly affected by three factors, namely, link text information, link context information, and inheritance to parent nodes. The calculation of the correlation in the Shark-Search algorithm uses VSM (vector space model) and takes a real number between 0 and 1. The score of a single link in the linked list is calculated by the following formula:

$$\begin{aligned} \text{Potentialscordur}\gamma = {} & \gamma * \text{inheritedur} + (1-\gamma) \\ & * \text{neighborhod}(\text{url})\,(\gamma < 1). \end{aligned} \tag{3}$$

When the parent node topic is related, the relevance score inherited from the parent node inherited (child (url)) is calculated by the similarity between the topic q and the parent node web page according to the following formula:

$$\text{inherited}\left(\text{child}(\text{ur}\delta) = \begin{cases} \delta^* \text{sim}(q, \text{current}(\text{url})), \text{sim}(q, \text{current}(\text{url})) < 0, & (\delta < 1), \\ \delta^* \text{inherited}(\text{current}(\text{url})), & \text{otherwise.} \end{cases}\right. \tag{4}$$

Among them, δ is the attenuation factor.

According to formula (5), the similarity between the topic q and the link text information sim (q, anchor (context (url))) can be obtained by simply calculating the similarity score of the link text. The score of the neighbor link neighborhood (url) and the context and text content of the link text are calculated as shown in formula (6).

$$\begin{aligned} &\text{anchor}(\text{context}(\text{url})) \\ &= \begin{cases} 1, & \text{anchor}(\text{url}) > 0, \\ \text{sim}(q, \text{anchor}(\text{text})), & \text{otherwise}, \end{cases} \end{aligned} \tag{5}$$

$$\begin{aligned} &\text{neighborhood}(\text{url}) \\ &= \beta * \text{anchor}(\text{url}) + (1-\beta) \\ &\quad * \text{anchor}(\text{context}(\text{url}))\,(\beta < 1). \end{aligned} \tag{6}$$

The crawling depth d of the Shark-Search algorithm is prespecified by the user. In one algorithm, the user needs to preset 4 parameter values: d, γ, δ, and β.

The topic-related pages on the Internet have obvious convergence; that is, web pages of the same type converge into page groups. There is a structure called Web Community in the network. That is, web pages on the Internet naturally form various link structures, and each link structure is called a network community, and the member pages in it are roughly related to a certain topic. This feature of the online community makes it very relevant to its internal topics and is easy to crawl. However, there may be relatively few links between different online communities due to differences in topics. The network community and network tunnel existing on the network are shown in Figure 1.

In the link relationship of each web page in Figure 1, we can see that when the theme crawler completes crawling all theme-related pages of an online community A, it enters the theme-independent link path and then enters other online communities B, because the linked pages are multiple. The topic is not related to the page, so it may be pruned on a certain link path, so there is a possibility that the network community B cannot be reached. This reduces the crawling rate of the theme crawler. A lot of topic-related resources are left out. Another situation is that the link relationship between two online communities is one-way; that is, an online community A contains a page that links to online community B, and online community B does not have a link to online community A. Particularly, web pages of affiliation in the network are a typical example of this situation. For example, the lower-level department webpages of some administrative departments have links to the higher-level departments, and most of the upper-level departments will not link to the huge lower-level department websites. In the case of one-way links, according to the principle of branch reduction of the crawling trajectory of the theme crawler, the possibility of loss of web page information of lower-level departments will increase. The unrelated links between related pages are called "network tunnels."

The space vector model is an algebraic model of correlation, applied to information filtering, information extraction, indexing, and evaluation. In this model, the document is regarded as a multidimensional vector space formed by keywords, and the set of index words is usually the phrases that appear at least once in the document. When searching, the input search term is also converted into a vector similar to the document. This model assumes that the degree of correlation between the document and the search term can be obtained by comparing the cosine angle deviation between the document and the search term.

The central idea of this model is that text information basically contains some keywords to express or reveal the content-independent attributes of the text, each independent attribute can be regarded as a dimension of the concept space, and these independent attributes are called text feature items. Text can be represented as a collection of these feature items, namely, $D = \{t_1, w_1; t_2, w_2; \cdots; t_n, w_n\}$.

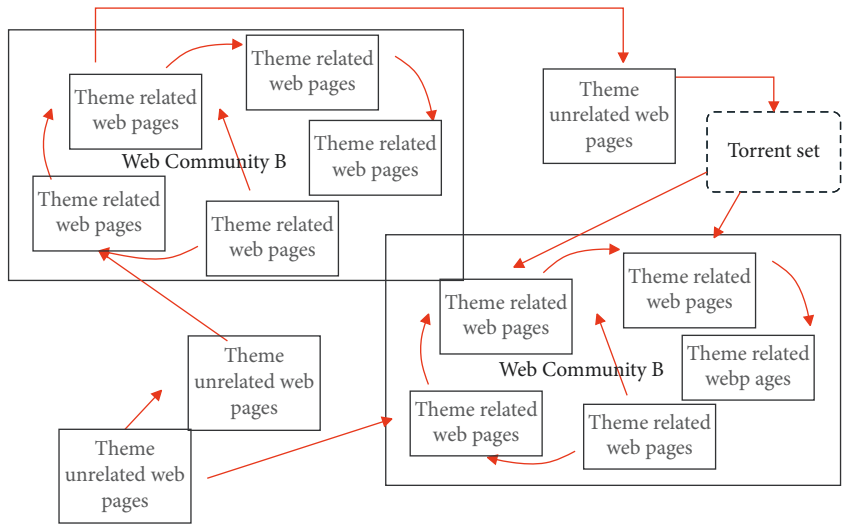


Figure 1: Web Community and network tunnel.

Among them, t_i is the feature word, and w_i is the weight of the feature word. In this way, the realization of the text information representation is transformed into the representation of the space vector. The cosine similarity can be used to measure the similarity between them. When calculating the similarity between two target vectors, the larger the cosine value, the higher the text similarity. The cosine similarity calculation formula is shown as follows:

$$\mathrm{sim}\left(D_i, D_j\right) = \frac{\sum_{k=1}^{n}\left(w_{k,i} \times w_{k,j}\right)}{\sqrt{\sum_{k=1}^{n} w_{k,i}^2} \times \sqrt{\sum_{k=1}^{n} w_{k,j}^2}}. \tag{7}$$

Through the abovementioned vector space model, text data is transformed into structured data that can be processed by computers, and the similarity between two documents is transformed into the similarity between two vectors. Usually, it is easier to calculate the cosine between the included angle vectors than to directly calculate the included angle. The cosine of zero means that the search term vector is perpendicular to the document vector; that is, there is no match; that is, the document does not contain this search term. However, VSM also has shortcomings. It regards text as a set of feature items for similarity calculation, which simplifies the calculation and ignores some important information.

Currently, the main weight calculation methods are as follows:

(1) Square root function: $w_i(d) = \sqrt{tf_i(d)}$

(2) Logarithmic function: $w_i(d) = \log(tf_i(d) + 1)$

(3) Boolean function: $w_i(d) = \begin{cases} 1, & tf_i(d) \geq 1, \\ 0, & tf_i(d) = 0, \end{cases}$

(4) TF-IDF function: $w_i(d) = t_i(d) * \log(N/n_i)$.

2.2. Improvement of VSM Web Page Classification Algorithm. Generally, general texts contain a large number of words, and these words have different effects on text classification. If all vocabulary is used for calculation, it will cause a large amount of calculation. The so-called feature extraction is to select those items with a large degree of discrimination of the text as the features of the text for classification. This can not only reduce the amount of computation but also improve the effect of classification. There are many methods for text feature extraction, and the commonly used are document frequency, information gain, mutual information, CHI, expected cross entropy, text evidence weight, odds ratio, feature selection method based on word coverage, etc. In the literature, these methods are compared. In this paper, the improved mutual information feature extraction method proposed in the literature is selected. The mutual information definitions of terms and categories are shown in the following formula:

$$\mathrm{RMI}\left(T, C_i\right) = \log\left[\frac{P(T|C_i)}{P(T)}\right]\frac{1}{R(t)}. \tag{8}$$

The value of the correction factor is shown in the following formula:

$$R(i) = \frac{N(i)}{\sum N(j)}. \tag{9}$$

The first 200 words with large mutual information between terms and categories are selected as text features.

The position weight is set to σ_t and its value is shown in the following formula:

$$\sigma_t = \begin{cases} 0.8, & \text{if } t \text{ in title}, \\ 0.6, & \text{if } t \text{ in head of paragraph}, \\ 0.4, & \text{if } t \text{ in end of paragraph}. \end{cases} \tag{10}$$

S_t is the number of times the word appears in the corresponding position, and the word weight calculation formula with the position weight added is shown as follows:

$$\mathrm{weight}_i(d) = \mathrm{weight}_i(d) * \frac{\sum s_{t_i} * \sigma_{t_i}}{\sum s_{t_i}}. \tag{11}$$

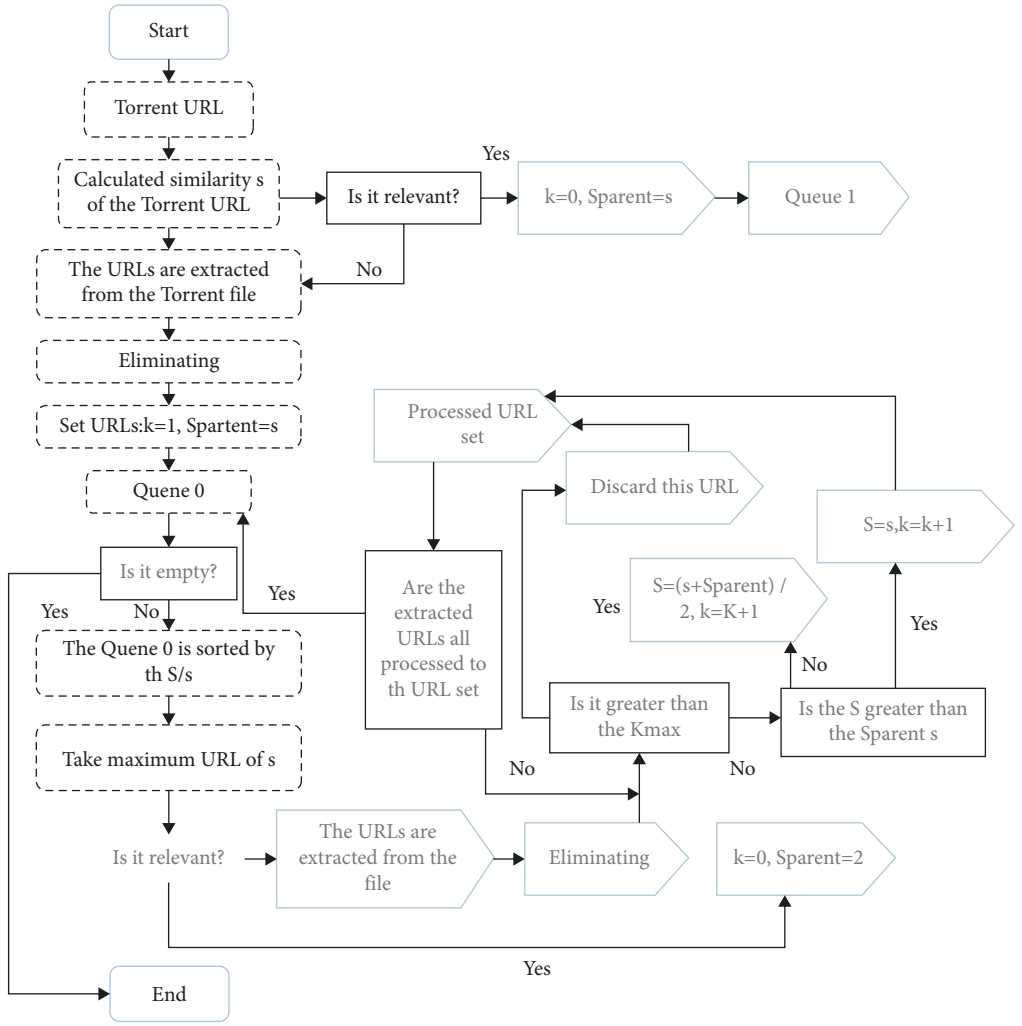


Figure 2: Crawler crossing tunnel algorithm based on dynamic adjustment theme.

Long words should have higher weight. In this way, after taking the Chinese idea into account, we calculate the weight of the vocabulary according to the following formula:

$$\text{weight}_i(d) = \frac{a}{a+1}\text{weight}_i(d). \tag{12}$$

In the formula, a represents the length of the vocabulary t_i.

The total number of times the word t_i appears in the text d is S_i, that is, the word frequency $t_f(t_i, d)$, and the total number of times the word t_j appears in the text d is S_j, that is, the word frequency $t_f(t_j, d)$. The cooccurrence frequency of the word t_i and the word t_j is recorded as S_{ij} (the count of nonrepetition in the sentence), and it can be known that $S_{ij} = S_{ji}$.

$$\begin{aligned} P_{ij} &= \frac{S_{ij}}{S_{ii} + S_{jj} - S_{ij}} \\ &= \frac{S_{ii}}{S_i + S_j - S_{ij}}. \end{aligned} \tag{13}$$

Among them, P_{ij} is the cooccurrence frequency of words t_i and t_j. Furthermore, it can be seen that $P_{ij} = p_{jj}$, $p_{ii} = 1$.

Finally, in a text, we can get a cooccurrence probability matrix between words in a word space, which is a symmetric matrix with n rows and n columns, which represents the number of text feature items.

$$P_{n\times n} = \left[p_{ij}\right]. \tag{14}$$

When using this matrix to modify the weight (t_i, d), the weight of the characteristic item t_i is modified as

$$w_i(d) = \sum_{j=1}^{n} pi_j \times w_i(d). \tag{15}$$

After processing in this way, words that often modify other words or are modified by other words have a high probability of cooccurrence, and the weight of words with a high probability of cooccurrence is strengthened. Words with high cooccurrence probability are generally more important words, reflecting the theme of the text. Also, not only the weight of the word but also the weight of the word it

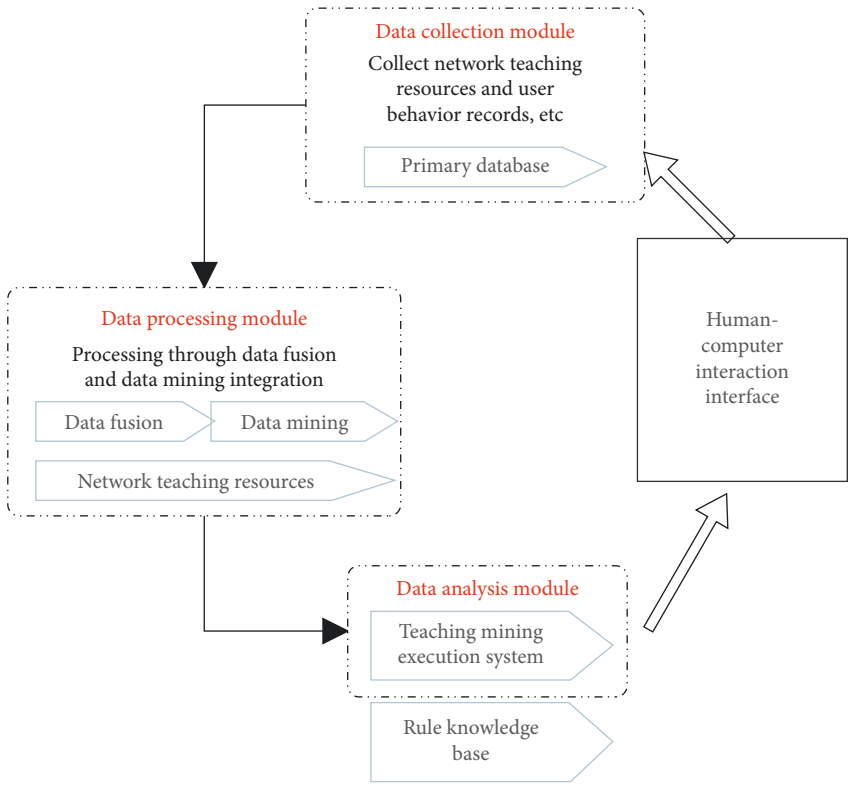


Figure 3: Model framework of network English teaching resource system based on data fusion and data mining.

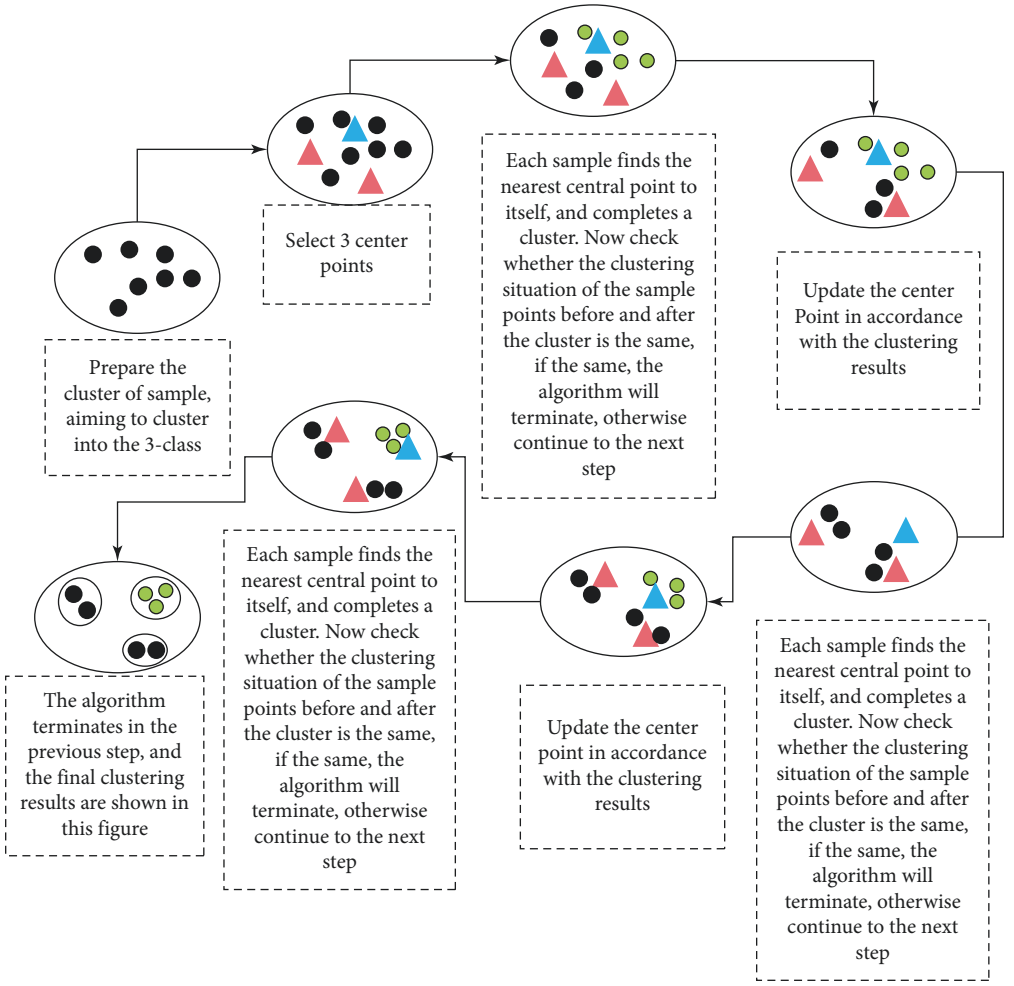


Figure 4: Clustering algorithm process.

wants to associate should be strengthened. The text features obtained in this way can summarize the text content, conform to people's thinking habits, and reflect the semantic information of the text.

The steps of the improved classification algorithm in this paper are as follows:

Step 1: the algorithm trains the core vocabulary group. Since each text category is a specific field set by people, the text of this category is a description of the category. Concept words of this class will appear repeatedly in the text of that class. For example, words such as programs, viruses, and drivers appear in computer texts higher than other categories. In the subject crawler research of this paper, the search information is mainly analyzed and extracted, and the class core vocabulary group Class Words $(D_j) = \{w_1, w_2, \ldots, w_m\}$ related to the search information is generated.

Step 2: the algorithm classifies the text D_i and extracts the core vocabulary Core Words $D_i = \{w_1, w_2, \ldots, w_m\}$; then the influence of Core Words D_i on the text D_i belonging to the core vocabulary group of D_j is $V(D_i, D_j)$. The calculation formula is shown as follows:

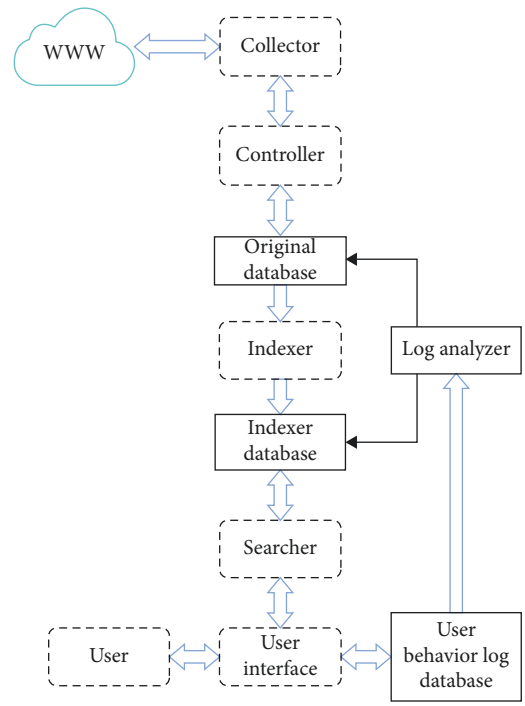


Figure 5: The architecture of the search engine for English teaching resources.

$$V(D_i, D_j) = \frac{\sum_{i=0, w_i \in D_i}^{n} \text{weigh}(w_i) + \sum_{i,j=,i \neq j, w_j, w_j \in D_i}^{n} \text{weigh}(w_i) \times \text{weigh}(w_j)}{\sum_{i=0}^{n} \text{weigh}(w_i) + \sum_{i,j=,i \neq j}^{n} \text{weigh}(w_i) \times w_{ij}(w_j)}. \quad (16)$$

Among them, weight (w) is the weight of w, and this paper uses the weight of the feature item weighted by the mixed factor for calculation.

Step 3: the influence value obtained above is weighted and combined with the cosine angle of the traditional VSM, and the final score is obtained as follows:

$$\text{SCORE}(D_i, D_j) = \alpha \times V(D_i, D_j) + \beta \times \text{sim}(D_i, D_j). \quad (17)$$

Among them, α, β is the weight, $\alpha + \beta = 1$.

Next, we will apply this algorithm to the subject crawl out of the tunnel algorithm.

2.3. The Design of the Crawler Crossing Tunnel Algorithm Based on Dynamically Adjusting Themes. The traditional idea of tunnel technology is a heuristic global optimal algorithm. When a crawler using tunnel technology encounters an irrelevant web page, it does not stop immediately but continues to explore K steps forward on this path, and the size of K is manually set. This allows spiders to jump from one Web Community to another, even though there is no link between the two Web Communities. If the distance between the two Web Communities is not large, it is possible to improve the crawling rate of the web page. However, this way of manually setting the K value is inflexible, and resources are wasted in vain when the distance between Web Communities is slightly larger or larger.

The idea of dynamically adjusting the crawler to pass through the tunnel is as follows: when the topic crawler enters the tunnel from a Web Community, the crawled pages that are not related to the topic use the above improved VSM text classification algorithm to calculate the topic similarity. After that, according to the similarity of the text, according to the idea of "Better Parents Have Better Children," the genetic factors of the parents are considered to judge the similarity of the theme. At the same time, the number of steps K to be advanced is dynamically judged according to the similarity prediction value, so that the K value is flexibly set to cross the tunnel. This eliminates the defect that the fixed K value is too large or too small. This paper proposes a crawler traversal tunnel algorithm based on dynamically adjusting themes.

The algorithm steps are as follows:

Step 1: according to the search topic, the algorithm trains two sample sets of topic-related and topic-independent offline training.

Step 2: the algorithm calculates the topic relevance s of the seed URL, extracts the URL links of the seed document D, and calculates the relevance s of the topic of the document D corresponding to these URLs and

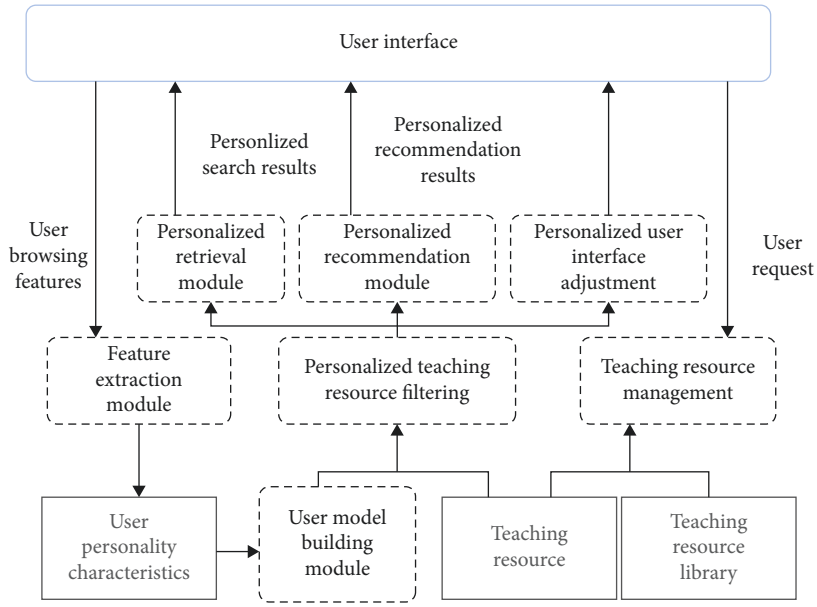


Figure 6: Retrieval model structure.

sets its parent $S_{\text{parent}} = s$, and the path $K = 0$ enters the crawling queue Queue0.

Step 3: the algorithm sorts the URLs in Queue0 according to the size of the relevance s. If Queue0 is not empty, the algorithm extracts the most relevant URL1 and judges its type according to the offline training sample set.

Step 4: if the document corresponding to the URL is a subject-related document,

(1) the URL enters the Queue1 queue
(2) the algorithm extracts the URLs of this article D and "eliminates duplicates"
(3) the algorithm calculates the topic relevance s of the extracted URLs one by one and sets its $K = 0$. If the document corresponding to the URL is a topic-irrelevant document, the algorithm determines whether the $K1$ of the URL is less than $K_{\max}$. If it is greater than Kmax and greater than the critical relevance value scritical, the K value is cleared to 0, and if it is less than the critical relevance value, the URL is discarded.

If it is less than $K_{\max}$, the algorithm judges whether it is greater than the minimum subject similarity $s_{\min}$. If it is less than $s_{\min}$, the URL will be discarded; otherwise, the size of its relevance s_1 and the parent's parent will be determined first.

If the correlation value s_1 is less than the parent's correlation value apparent, then according to "Better Parents Have Better Children," consider the genetic factors of its parents. If the correlation value s_1 is greater than or equal to the parent correlation value apparent, it is set to the correlation degree of s_1. The calculation formula is shown in formulas (18) and (19).

$$s = \begin{cases} \dfrac{s_1 + s_{\text{parent}}}{2}, & \left(K < K_{\max}, s_1 < s_{\text{parent}}\right), \\ s_1, & \left(K < K_{\max}, s_1 >= s_{\text{parent}}\right), \end{cases} \tag{18}$$

$$K = K_{\text{parent}} + 1\left(K_1 < K_{\max}\right), \tag{19}$$

Step 5: the algorithm determines whether the crawling queue Queue0 is empty. If it is not empty, the algorithm goes to Step 3, and if it is empty, the algorithm ends. The algorithm flowchart is shown in Figure 2.

3. English Online Teaching Resource Processing Model Based on Intelligent Cloud Computing Technology

This paper constructs a network English teaching resource system model based on data fusion and data mining. The model is mainly divided into four parts: human-computer interaction interface, data collection module, data processing module, and data analysis module. The model frame is shown in Figure 3.

We set a resource to be the sample points to be clustered, and the goal is to cluster the sample points into three categories. For each point, the algorithm calculates the center point that is closest to itself among all the center points, which can be defined as the same cluster. After one iteration, the center point of each cluster class is recalculated, and then the center point closest to itself is found again for each point. In this way, the loop continues until the cluster class of the two iterations before and after no longer changes. The algorithm process is shown in Figure 4.

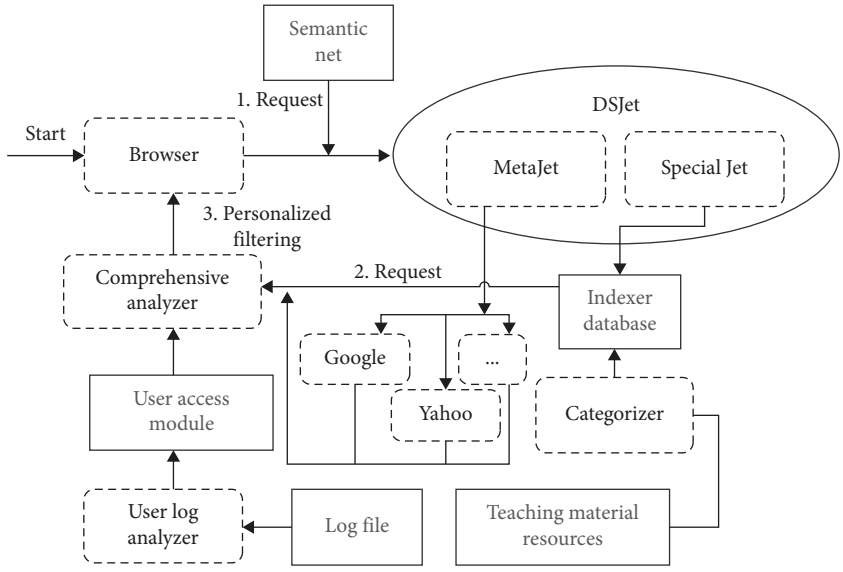


Figure 7: English teaching resource processing plan.

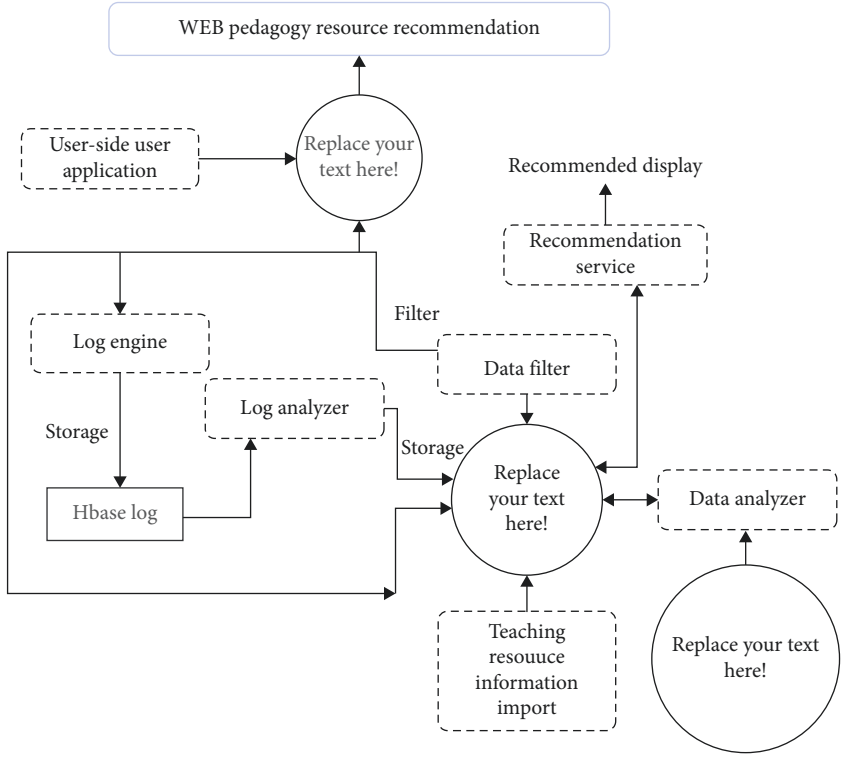


Figure 8: Schematic diagram of personalized English teaching resource recommendation system.

The block diagram of this system is shown in Figure 5, which is mainly composed of key parts such as collector, controller, original database of English teaching resources, indexer, retriever, and user interface.

According to the user's personalized interest characteristics, the English teaching resources are filtered to help the user quickly and accurately retrieve and recommend the English teaching resources he is interested in in the massive network English teaching resource database system. The structure is shown in Figure 6.

This system is mainly composed of four parts: user interface part, search engine part, database part, and user access mode personalized interface part (equivalent to four agent systems). The index user interface section incorporates the relevant feedback principle. The English teaching resource processing plan is shown in Figure 7.

The search engine part fully combines the advantages of professional search engines and metasearch engines and can better meet the needs of users in terms of precision and recall.

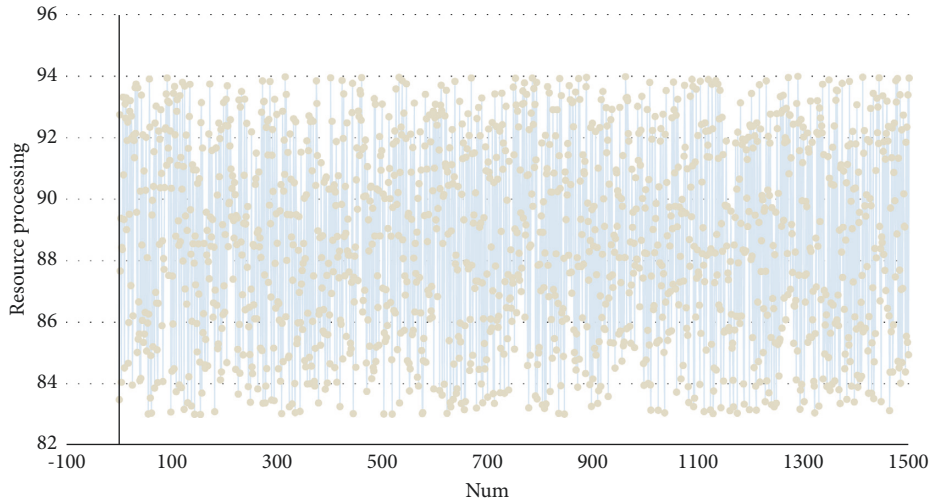


Figure 9: Clustering effect of English online teaching resource processing system based on intelligent cloud computing technology.

The schematic diagram of the complete personalized English teaching resource recommendation system is shown in Figure 8.

Through the clustering method, the effect of the English online teaching resource processing system based on intelligent cloud computing technology proposed in this paper is evaluated, and the obtained clustering results are shown in Figure 9.

From the above clustering results, the English online teaching resource processing system based on intelligent cloud computing technology proposed in this paper has a good effect in English teaching resource processing and can effectively improve the efficiency of English online teaching.

4. Conclusion

While doing a good job in the construction of hardware facilities, many colleges and universities have successively invested a lot of human, material, and financial resources in various ways to build a comprehensive English teaching resource library. These English teaching resources are currently mainly integrated and centrally stored and managed through the English teaching resource library and are provided to teachers and students in the form of portal websites. However, information from many aspects shows that the effect of these English teaching resources in English teaching practice is not ideal, and they have not fully played their due role in terms of the depth and breadth of application. This paper combines intelligent cloud computing technology to build an English online resource processing system to improve the efficiency of English online resource processing and combines crawler technology to perform data mining. From the clustering results, the English online teaching resource processing system based on intelligent cloud computing technology proposed in this paper has a good effect in the processing of English teaching resources and can effectively improve the efficiency of English online teaching.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This study is sponsored by Xinyang Vocational and Technical College.

References

[1] Z. Sun, M. Anbarasan, and D. J. C. I. PraveenKumar, "Design of online intelligent English teaching platform based on artificial intelligence techniques," *Computational Intelligence*, vol. 37, no. 3, pp. 1166–1180, 2021.

[2] H. Kim, "The efficacy of Zoom technology as an educational tool for English reading comprehension achievement in EFL classroom," *International Journal of Advanced Culture Technology*, vol. 8, no. 3, pp. 198–205, 2020.

[3] A. E. P. Atmojo and A. Nugroho, "EFL classes must go online! Teaching activities and challenges during COVID-19 pandemic in Indonesia," *Register Journal*, vol. 13, no. 1, pp. 49–76, 2020.

[4] A. Yuliansyah and M. Ayu, "The implementation of project-based assignment in online learning during covid-19," *Journal of English Language Teaching and Learning*, vol. 2, no. 1, pp. 32–38, 2021.

[5] S. Liu and J. Wang, "Ice and snow talent training based on construction and analysis of artificial intelligence education informatization teaching model," *Journal of Intelligent and Fuzzy Systems*, vol. 40, no. 2, pp. 3421–3431, 2021.

[6] E. Apriani and J. Hidayah, "The ICT used by the English lecturers for non English study program students at STAIN curup," *Vision: Journal of Language and Foreign Language Learning*, vol. 8, no. 01, pp. 26–37, 2019.

[7] R. G. Jones, "Second language writing online: an update," *Language, Learning and Technology*, vol. 22, no. 1, pp. 1–15, 2018.
[8] P. P. Paredes, C. O. Guillamón, and P. A. Jiménez, "Language teachers' perceptions on the use of OER language processing technologies in MALL," *Computer Assisted Language Learning*, vol. 31, no. 5-6, pp. 522–545, 2018.
[9] Y. Bin and D. Mandal, "English teaching practice based on artificial intelligence technology," *Journal of Intelligent and Fuzzy Systems*, vol. 37, no. 3, pp. 3381–3391, 2019.
[10] R. W. Todd, "Teachers' perceptions of the shift from the classroom to online teaching," *International Journal of TESOL Studies*, vol. 2, no. 2, pp. 4–16, 2020.
[11] M. A. AlGhamdi, "Arabic learners' preferences for instagram English lessons," *English Language Teaching*, vol. 11, no. 8, pp. 103–110, 2018.
[12] Z. Xu and Y. Shi, "Application of constructivist theory in flipped classroom - take college English teaching as a case study," *Theory and Practice in Language Studies*, vol. 8, no. 7, pp. 880–887, 2018.
[13] G. A. Toto and P. Limone, "Motivation, stress and impact of online teaching on Italian teachers during COVID-19," *Computers*, vol. 10, no. 6, pp. 75–94, 2021.
[14] C. M. yue, L. Dan, and W. Jun, "A study of college English culture intelligence-aided teaching system and teaching pattern," *English Language Teaching*, vol. 13, no. 3, pp. 77–83, 2020.
[15] Y. Rinantanti, S. Z. B. Tahir, and A. Suriaman, "The impact of EFL senior high school teachers' performance in papua, Indonesia toward the students' English learning achievement," *Asian EFL Journal*, vol. 23, no. 3.3, pp. 431–447, 2019.
[16] R. Shadiev and M. Yang, "Review of studies on technology-enhanced language learning and teaching," *Sustainability*, vol. 12, no. 2, pp. 524–532, 2020.
[17] M. A. S. Khasawneh, "An electronic Training Program on Developing the Written Expression Skills among a Sample of foreign language learners EFL who are at-risk for Learning disabilities during the emerging Covid-19," *Academy of Social Science Journal*, vol. 7, no. 10, pp. 1974–1982, 2021.
[18] N. Hollenstein, J. Rotsztejn, M. Troendle, A. Pedroni, C. Zhang, and N. Langer, "ZuCo, a simultaneous EEG and eye-tracking resource for natural sentence reading," *Scientific Data*, vol. 5, no. 1, pp. 180291–180313, 2018.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 5920268, 9 pages
https://doi.org/10.1155/2022/5920268

Research Article

An Assistant Teaching System of English Creative Writing Based on Semantic Mining

Yu Zhang

Xinyang Vocational and Technical College, Xinyang 464000, China

Correspondence should be addressed to Yu Zhang; zhangyu@xyvtc.edu.cn

Received 13 May 2022; Revised 6 June 2022; Accepted 21 June 2022; Published 8 July 2022

Academic Editor: Wen Zhou

To enhance students' English writing ability, English creative writing has become a common course offered by colleges and universities. English reference is an indispensable tool for creative English writing. How to choose appropriate English references is an important guarantee to complete good work. Therefore, this paper proposes a Deep Semantic Mining-based Recommendation (DSMR) algorithm for English writing reference selection and recommendation to assist the completion of high-quality English creative writing works. The model can extract user features and document attributes more accurately by deeply mining semantic information of literature content and user needs, so as to achieve more accurate recommendations. First, the Bidirectional Encoder Representation from Transformers (BERT) pretraining model is adopted to process literature content and user requirement documents. Through in-depth mining of user characteristics and literature attributes, the problems of data sparsity and cold start of items are effectively alleviated. Then, the forward long short-term memory (LSTM) network was used to focus on the changes in user preferences over time, resulting in more accurate recommendations. The experimental results show that the use of heterogeneous information can significantly improve the recommendation performance, and the additional use of user attribute information can also improve the recommendation performance. Compared with other benchmark models, the recommendation quality of this model is greatly improved.

1. Introduction

English creative writing is a common course offered by colleges and universities. It uses English as a writing method to express users' thoughts and emotions. In the process of writing, users need to read many excellent English works, so it is important to choose appropriate English references. How to meet the writing needs of different users and provide accurate and personalized references and recommendations for each user in a large number of references is the key of this paper.

The amount of data is exploding, leading to information overload and making it difficult for users to find what they are interested in. To improve user experience, the recommendation system has been applied to music, film, advertising, and other recommended scenes [1, 2]. The Collaborative filtering (CF) based recommendation system is widely used because it can effectively capture user preferences and is easy to implement in a variety of scenarios without feature extraction in a content-based recommendation system. However, CF-based recommendations have problems of data sparsity and cold start [3]. To solve these problems, a hybrid recommendation system is put forward. It leverages multiple recommendation techniques to overcome the limitations of a single recommendation approach, exploring various types of supporting information, such as item attributes, item reviews, and the user's social network.

At first, researchers tried to use comment text in topic modeling [4], which achieved higher prediction accuracy than the model using only score data. However, this approach only focuses on thematic clues and ignores semantic content. Comments are usually expressed as word bags and context information is ignored [5], thus limiting the further improvement of prediction accuracy. In recent years, many studies have begun to combine deep learning with review text, and many excellent algorithms have been proposed. This results in a more accurate recommendation than the

topic-based modeling approach. Literature [6] connects multiple comments into a long document and uses Convolutional Neural Network (CNN) to learn useful features from the comment text. However, document-based modeling indiscriminately connects all comments to the same document without distinguishing the different importance of different comments, which is not conducive to extracting effective features [7]. Therefore, researchers began to use review-based modeling for each comment separately, and finally aggregating the features of each comment into a general feature. Literature [8] is based on review modeling and uses attention mechanism to distinguish the importance of different reviews, which achieves higher recommendation accuracy than the model based on document modeling.

To sum up, we note the limitations of much of the current work. (1) It is still a lot of models using CNN to extract the characteristics of users and items in the review, can capture the local characteristics, for a long sequence of text feature extraction, it effectively to a certain extent, limits the accuracy of recommendation. (2) Based on the comment model, much of the work does not take into account the changes in users' interests and preferences over time [9], but rather the same views from the past. (3) None of the excellent models mentioned above that use review text to improve recommendation accuracy emphasizes the use of article description documents as well as the use of review text. Item description documents contain a comprehensive introduction of item attributes, which plays an important role in alleviating the cold start of items. (4) For training data, existing methods do not consider the large difference in the number of different points. The scores of 4 and 5 are a large proportion. The training results are unfair to the data with low scores, which is easy to cause overfitting and poor robustness of the model.

For solving the problems, the article propose a recommendation model based on deep semantic mining, and design an English creative writing-assisted teaching system based on this model. This paper mainly completed the following work.

(1) Use the pretrained BERT [10] model (Bert_base_uncase) to process the comment text instead of CNN. It overcomes the weakness that CNN can only extract local features, can more accurately capture the semantic meaning of words in different contexts, and measure the contribution of different comments to user characteristics. In addition, the forward long short term memory (LSTM) model was used to learn the user's interest transfer over time, which improved the recommendation accuracy. Many models have a Recurrent Neural Network (RNN) to process data. But for our model, the semantic information has been learned by BERT, and we only expect LSTM to learn the change in user interest over time. Since only existing comments can affect future comments, future comments cannot affect existing comments, and backward LSTM is not effective in the transfer of learning interest and will only increase the complexity of the model, so we do not adopt it.

(2) Introduce English literature description documents and user demand description documents into the model. This can help us better describe the features of English literature and improve the accuracy of prediction. In addition, when new English literature lacks comments, English literature description documents can alleviate the problem of the cold start of English literature.

(3) For the experimental data, we randomly sampled the comment data of the five score values from 1 to 5 as 1 : 1 : 1 : 1 : 1 to ensure that the data amount of each score value is equal, so as to reduce the overfitting combination and improve the robustness of the model.

(4) Comparative experiments on datasets show that, compared with other models, our recommendation model DSMR based on deep semantic mining has high prediction scoring accuracy and significantly improved recommendation performance.

The main objective of this research paper is to assist users in creative writing in English by providing accurate and personalized reference recommendations for each user among a large number of references. To achieve that goal, this paper mainly does the following work. First, we extract the semantic information of literature content and user requirements and extract user features and literature attribute features more accurately. Second, we use BERT pretraining model to process the document content and user requirements, deep mining user features and document attributes, and solve the problem of data sparsity and item cold start. Third, the forward LSTM is used to focus on the changes of user preferences over time to make the recommendations more accurate.

This model has the following advantages.

(1) English literature description and user demand are used as reference data for the recommendation model to improve the recommendation quality.

(2) Equalize the comment data with different scores to improve the robustness of the model.

This paper mainly consists of five parts, including the first introduction, the second state of the art, the third methodology, the fourth experiment and analysis, and the fifth conclusion.

2. State of the Art

In recent years, the success of deep learning in fields has brought the recommendation community to notice this powerful tool. Scholars began to explore the use of deep learning methods to improve some of the weaknesses of the current recommendation system, such as sparse data, cold start, poor scalability, and other problems [11]. Data sparsity refers to that under the condition of huge data volume and sparse data, first of all, it is difficult to find the existence of the nearest neighbour user set, and second, the cost of computing the similarity is also high. At the same time,

information is often lost, leading to the reduction of the recommendation effect. A cold start is when a project first appears, and there is absolutely no user review of it in detail, so there is no way to predict ratings and recommendations for the project. At the same time, the accuracy of new items is poor because users have few comments when they appear. The reason for poor scalability is that as the number of users and items in the recommendation system continues to increase, the amount of computation of the collaborative filtering recommendation algorithm will also increase, leading to the gradual decline of system performance and thus affecting user experience. In particular, the emergence of CNN and RNN has achieved great success in many Natural Language Processing (NLP) tasks. Therefore, people began to try to use deep learning methods, such as DeepCoNN and D-ATTN [12], etc., to mine user preferences and characteristics of products in review texts, so as to directly apply them to predict scores. DeepCoNN consists of two parallel neural networks based on CNN, learning the implicit representation of users and objects respectively. By connecting the two parts at the top of the network to learn the interaction, the effectiveness of the comment text in alleviating the sparse problem is proved.

The key of the attention mechanism [13] is to learn a weight to mark the degree of importance, which has been widely used in natural language processing since it was proposed. The most advanced results have been achieved in machine translation, reading comprehension, speech recognition, and other fields [14]. Therefore, the attention mechanism attracted the attention of the recommendation field and began to be used in review-based recommendation algorithms [15]. Literature [16] uses attentional mechanisms to learn the usefulness of different reviews, better model users and items, predict item ratings, and generate explanations. Different from the attention mechanism at D-ATTN word level, the attention mechanism at the comment level is adopted in literature [17]. Literature [18] puts forward a new learning scheme based on Pointers, which enables users to carry out deep text interactions with objects and achieves good results.

The development of NLP has greatly promoted the application of review text in the field of recommendation. The pretraining language model [19] has developed rapidly since it was proposed, producing many excellent methods, such as features-based ELMo [20] and fine-tuning-based Open AI GPT [21]. However, these language models are one-way in nature, limiting the ability of pretrained representation. Therefore, literature [22] proposed a bidirectional pretraining model BERT, which uses an Encoder in the transformer to read the whole text at one time, so that the model can learn based on both sides of words, so as to grasp the meaning of words expressed in sentences more accurately. Therefore, BERT has a natural bidirectional and strong generalization ability, which provides a good foundation for downstream tasks.

Data preprocessing technology [23] is to process data information in advance, so as to improve the accuracy of data mining. For example, in keyword retrieval, data preprocessing can sort the information resources in the database to improve retrieval accuracy and efficiency. The technology generally goes through data review, data screening, data sorting, etc., to achieve the effect of enhancing the efficiency of data information processing. The working principle of preprocessing technology generally includes data cleaning, integration, transformation, reduction and other technical processing to improve the accuracy of data retrieval in the later period. Data cleaning is carried out by filling missing values, identifying outliers, and correcting inconsistencies in data. Data integration needs to consider many problems, such as redundancy. The commonly used redundancy analysis methods include Pearson product distance coefficient, Chi-square test, numerical attribute covariance, and so on. Data transformation transforms data into a form suitable for learning, including data smoothing, aggregation, generalization, normalization, etc. The data reduction technique is used to obtain the reduced representation of the dataset, which greatly reduces the size of the dataset from dimension to quantity while approaching the integrity of the original data.

3. Methodology

3.1. Overall Framework of Auxiliary Teaching System. Figure 1 is the overall structure of the English creative writing assistant teaching system. The system consists of the bottom database module, the middle recommendation algorithm module, and the top user demand module. The database stores literature characteristic data and user demand data. Recommendation algorithm for English literature recommendation based on semantic mining. The user requirements module is used for front-end interaction. Its running process is shown in Figure 2.

3.2. DSMR Model

3.2.1. Model Framework. Every User of English creative writing will browse many English references and comment on many English references, so we can use reviews as an indication of user preference. But for the user, the description of the reference is just as important. Because users only choose to browse the reference and see the comments received by the reference if they are attracted by its description. In addition, for a new English reference, there is little or no browsing and evaluation, and the reference description provides rich information on literature attributes, which helps to solve the problem of reference cold start. Many models, when using text for modeling, only make use of the comment text and do not pay attention to the reference description document. We thought this would lose some important information, so we added the reference descriptions to the model to get more accurate predictions.

DSMR uses the BERT pretraining model to process text data and distinguish the importance of different reviews, thus helping us to more accurately predict a user's rating of an English reference. The structure of the DSMR model is shown in Figure 3. The model is divided into two parallel parts. One is the user module and the other is the documentation module. In the User module, enter description

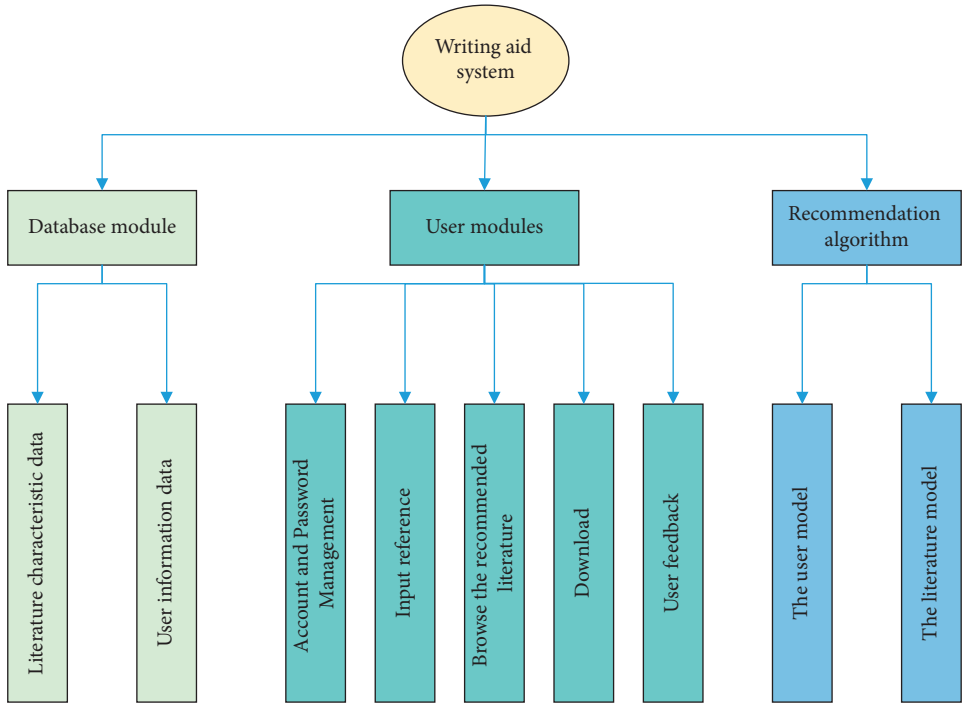


Figure 1: The overall structure of the English creative writing assistant teaching system.

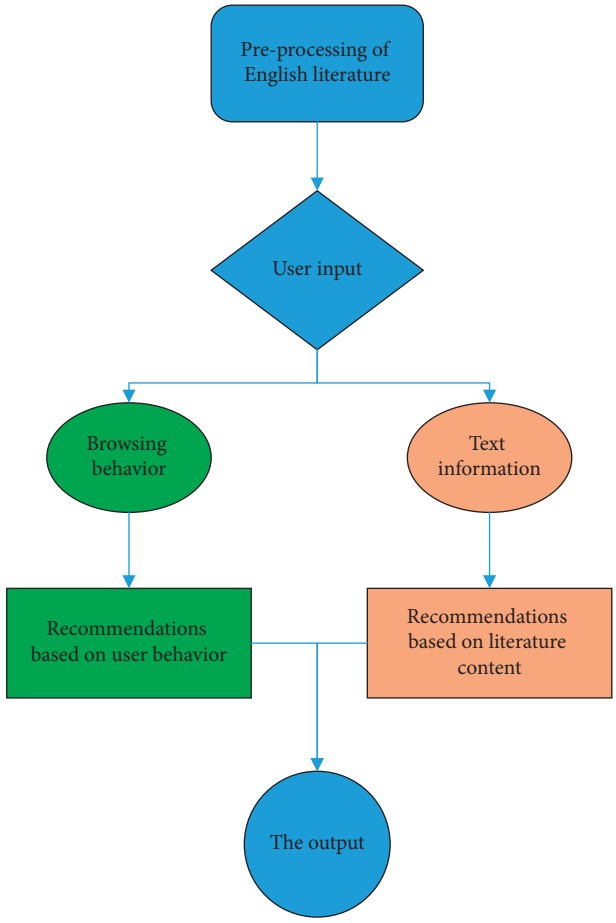


Figure 2: Operation process of English creative writing assistant teaching system.

documents for all references reviewed for that user and all comments received for each reference. In the literature module, enter all comments received for this reference and a description of this reference. Finally, the results of the two modules are dotted to get the user's prediction score of the reference. Since the user module is similar to the literature module in structure, this paper takes the user module as an example to introduce our model in detail.

3.2.2. Implementation Details

(1) Encoder. For a user u, all English references he has reviewed are represented by $\hat{\mathbf{X}}_{px}\,(x = 1, 2, \ldots, t)$. Pass $\hat{\mathbf{X}}_{px}$ into the Item_encoder module. The specific structure of Item_encoder is shown in the left box in Figure 4. Where $\oplus$ means the sum. In the Item_encoder module, the description document D_x of the document $\hat{\mathbf{X}}_{px}$ and all comment $\hat{\mathbf{R}}_{xy}\,(y = 1, 2, \ldots, w)$ received by document $\hat{\mathbf{X}}_{px}$ are passed into BERT. Our comparison model uses CNN for comment text processing and can only establish short-distance dependence on input sequences. However, self-attention in the transformer can process variable length information sequences by dynamically generating weights of different connections, which can realize parallelization and improve training speed.

The word vector representation of the reference description document D_x was obtained after BERT pretraining. BERT (Bidirectional Encoder Representations from Transformers) is a language representation model. Its main model structure is a stack of transformer's encoder. It is a 2-stage framework for pretraining, and for fine-tuning on each

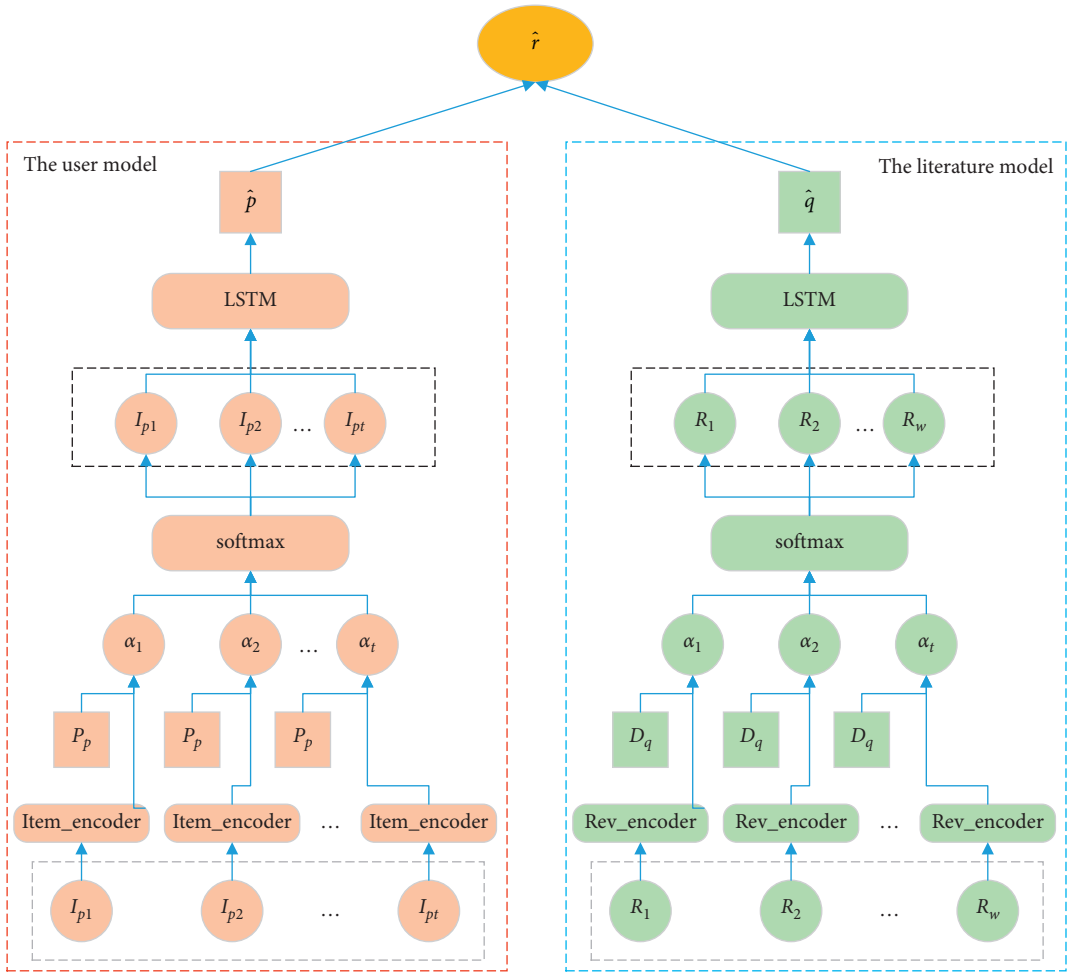


Figure 3: DSMR model overall framework.

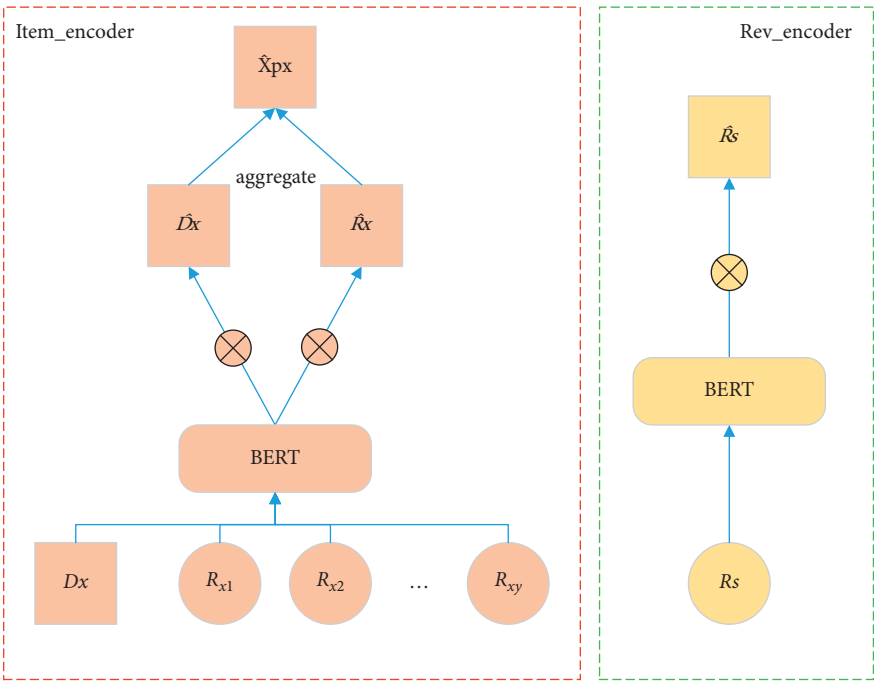


Figure 4: The coding section.

specific task. $\widehat{D}_x$ is obtained by adding the vectors of each word. The implicit representation of each comment was obtained after BERT pretraining. The sum of the implicit representations yields $\widehat{R}_x$. The literature embedding vector $\widehat{X}_{px}$ is obtained by combining $\widehat{D}_x$ and $\widehat{R}_x$. $\widehat{X}_{px}$ describes the characteristics of reference x. The formula is as follows:

$$\begin{aligned}\widehat{D}_x &= BERT\left(D_x\right),\\ \widehat{R}_x &= sum\left(BERT\left(R_{x1}, R_{x2}, \cdots, R_{xw}\right)\right),\\ \widehat{X}_{px} &= \widehat{D}_x \odot \widehat{R}_x,\end{aligned} \tag{1}$$

where, $\odot$ represents the splicing of two vectors.

For reference q, all comments received by it are represented by Rs $(s = 1, 2, \ldots, w)$. Comments are implicitly expressed as $\widehat{R}_s$ after passing through BERT model, as shown in rev_encoder on the right side of Figure 4.

(2) LSTM. We use word embedding to represent user ID as a user embedding vector $P_p\,(p = 1, 2, \ldots, d)$, d is the total number of users. Mapping P_p to the same space as the literature embedding vector $\widehat{X}_{px}$ for dot product operation, the correlation degree α_x between user p and literature x features is obtained. The higher the value of α_x is, the higher the correlation degree is, and the more interested users are in the literature.

$$\alpha_x = P_p \cdot \widehat{X}_{px}, x = 1, 2, \cdots, t, \tag{2}$$

$\alpha_x\,(x = 1, 2, \cdots, t)$ was normalized by Softmax, and the normalized α_x was multiplied by $\widehat{X}_{px}$ to obtain the contribution degree of each literature to user characteristics. Finally, $\widehat{X}_{px}$ is sent into LSTM to learn user interest transfer over time, and the output vector $\widehat{p}$ of the user model is obtained. Softmax is a normalized exponential function. It is an extended application of the binary classification function sigmoid to multi-classification, to present the results of multi-classification in the form of probabilities.

$$\widehat{p} = LSTM\left(softmax\left(\alpha_x\right) \cdot \widehat{X}_{px}\right), x = 1, 2, \cdots, t. \tag{3}$$

Similarly, we represent the description document of literature q as Dq, and map Dq to the same space with the review embedding vector $\widehat{R}_s$ to obtain the output vector $\widehat{q}$ of the literature model.

(3) Score Prediction. The final prediction score $\widehat{r}$ is obtained by the dot product of the user model's output vector $\widehat{p}$ with the literature model's output vector $\widehat{q}$.

$$\widehat{r} = \widehat{p} \cdot \widehat{q}. \tag{4}$$

(4) Model Learning. The goal of DSMR model is actually to improve the accuracy of score prediction, which is equivalent to a regression problem. For regression problems, the most commonly used objective function is the squared loss function. In the training set sample W, the predicted score of user p for reference x is $\widehat{r}_{px}$ and the real score is r_{px}, so the objective function can be expressed as:

$$L = \sum_{p,x \in W} \left(\widehat{r}_{px} - r_{px}\right)^2. \tag{5}$$

Our task is to minimize the target function. We choose Adam optimization algorithm to optimize the objective function because Adam uses momentum and adaptive learning rate to accelerate the convergence speed, which is suitable for problems with large data volume and only requires a small amount of memory.

4. Result Analysis and Discussion

4.1. The Data Set. To better evaluate the model proposed in this paper, a dataset containing interactive and user-assisted information is necessary. This paper collects 600 English novels from the website as an experimental dataset, which includes 10,020 anonymous ratings (value range from 1 to 5) generated by 6,020 users on about 600 English novels. The user attribute information includes age level, gender, grade and major.

In the process of processing the dataset, we consider that although there are 5 scores ranging from 1 to 5, 5 and 4 still account for the majority of the scores. Almost all the models that have been proposed do not take this situation into account. We don't think this is fair to a score of 1 or 2. It overfits the training results. In this way, the data of each score value in the dataset are of equal amount, and the results are more objective and the model is more robust. The extraction results are shown in Table 1.

4.2. Comparison Model. The proposed DMSR is compared with the recommended model in the following literature, and the hyper-parameter settings of the comparison model are the same as those in the original text, except as specifically indicated. Table 2 shows the comparison algorithm.

4.3. Experimental Settings. The BERT pretraining model used by us has an initial learning rate of 0.01 for Bert_base_uncase, Review-DSMR, and DSMR models trained by Google, and then the NoamOpt optimizer is used for dynamic adjustment. The loss rate is set to [0.05, 0.1, 0.3, 0.5], the batch size is set to [3, 5, 8, 16, 32], and the number of potential factors is set to [32, 64, 128, 256].

The ratio of the training set, validation set, and test set was 3 : 1 : 1. Each experiment was repeated 3 times and the average performance value was taken.

Models were evaluated in two experimental scenarios: (1) in the click-through rate (CTR) prediction, trained models were used to predict each interaction in the test set, followed by Precision, Recall, and F1 to evaluate the CTR prediction. (2) in Top@K recommendation, the trained model is used to select K items with the highest predicted click probability for each user in the test set, and then select Precision@K, Recall@K and F1@K to evaluate the recommendation set, where $K = 1, 2, 5, 10, 20, 50, 100$.

4.4. Evaluation Indicators. In CTR prediction, AUC, Precision and compromise accuracy, and recall rate score (F1)

Table 1: Dataset preprocessing results.

Score	Comment number	Number of English novels	The number of users
1	5000	40	200
2	5000	40	200
3	5000	40	200
4	5000	40	200
5	5000	40	200

Table 2: The comparison algorithms.

Number	Algorithm	Theory	Operation principle
1	Literature [24]	Matrix decomposition	The rating matrix is used as input, the inner product of the low-rank matrix of users and items is used to represent the rating, and the objective function is minimized by the alternate least squares (ALS) technique
2	Literature [25]	Probability matrix decomposition	Only score data is used for collaborative filtering, and Gaussian distribution is introduced to model the underlying factors of users and items
3	Literature [26]	Parallel neural network	An additional sharing layer on top of the two neural networks connects the two parallel networks so that the learned user and project potential factors can interactively predict ratings. This model proves that the sparsity problem can be effectively alleviated by using comment text

are used as evaluation indexes. In Top@K recommendation, Precision, Recall and compromised accuracy and Recall score (F1) are used as evaluation indexes. AUC considers the sorting quality of samples, which is closely related to the sorting error. Their calculation formula is as follows:

$$\begin{aligned} \text{AUC} &= \frac{\sum_{x\in U}\text{rank}_x - (|U| * (|U|+1)/2)}{|U| * |T|}, \\ \text{Precison} &= \frac{\sum_{p\in P}|R(p)\cap N(p)|}{\sum_{p\in P}|R(p)|}, \\ \text{Recall} &= \frac{\sum_{p\in P}|R(p)\cap N(p)|}{\sum_{p\in P}|N(p)|}, \\ F1 &= \frac{2 * \text{Recall} * \text{Precison}}{\text{Recall} + \text{Precison}}. \end{aligned} \tag{6}$$

where, $R(p)$ is the recommendation list made to users based on their behaviours in the training set, and $N(p)$ is the behaviour list of users in the test set. Rank is the sample sort position, and it starts at 1. $|U|$ is positive sample number, $|T|$ is negative sample number. When $|U| > |T|$, $1 \geq \text{AUC} > 0.5$. $|U| = |T|$, $\text{AUC} = 0.5$. $|U| < |T|$, $0 \leq \text{AUC} < 0.5$.

4.5. Results and Analysis. This section describes the comparison results between the different models and the proposed model (DMSR) in this paper. Table 3 and Figure 5 show the prediction results of CTR of the model.

As can be seen from Table 3 and Figure 5, the proposed model has achieved good performance in all indicators of CTR. Compared with the best-performing model literature [25], the proposed model improved by 1.52% on AUC, 1.82% on Precision, and 1.88% on F1. Compared with the reference [24], the proposed model improves 2.41% in AUC, 2.84% in Precision and 2.9% in F1. Compared with reference [26], the proposed model improves 1.84% in AUC, 2.23% in Precision, and 2.33% in F1. The model in this paper achieves better recommendation results mainly for the following reasons.

Table 3: AUC, precision and F1 results predicted by CTR.

Models	AUC	Precision	F1
Literature [24]	0.8926	0.8137	0.8161
Literature [25]	0.9015	0.8239	0.8263
Literature [26]	0.8983	0.8198	0.8218
Proposed (DMSR)	0.9167	0.8421	0.8451

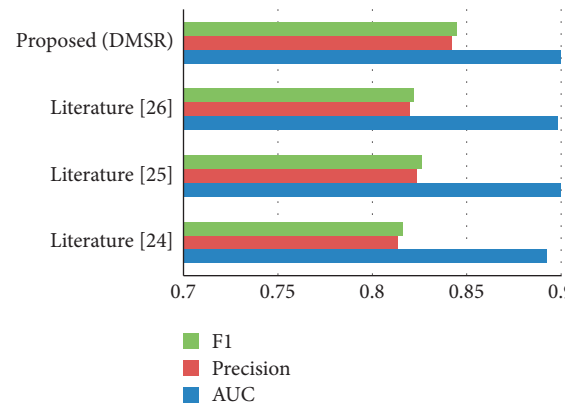


Figure 5: Results of AUC, precision and F1.

(1) The model proposed in this paper adopts BERT pretraining model to process the document content and user requirement documents. It digs into user characteristics and document attributes, effectively alleviates the problem of sparse data, and improves the accuracy of recommendations.

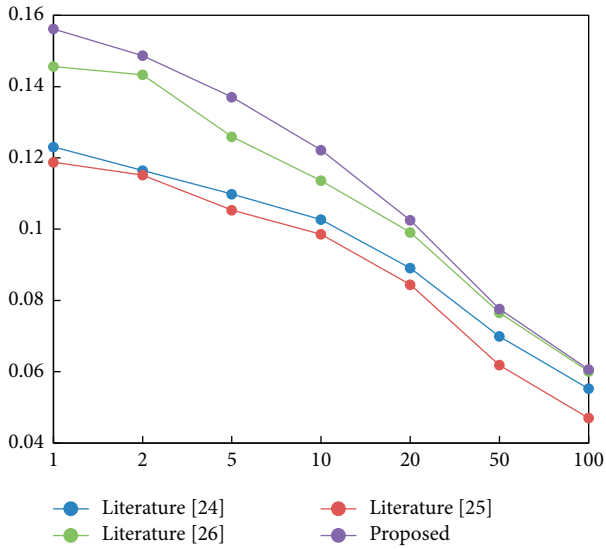


Figure 6: Accuracy in Top@K.

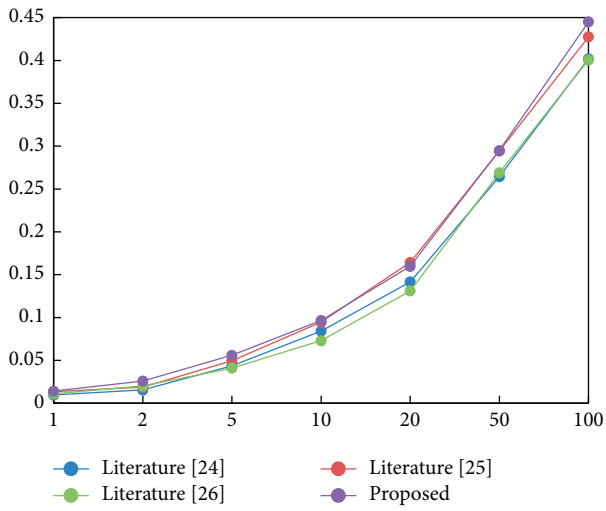


Figure 7: Recall in Top@K.

(2) The model uses forward LSTM to pay attention to the changes in user preferences over time, thus generating more accurate recommendations.

Figures 6–8 show the accuracy rate, recall rate, and F1 line graph recommended by Top@K respectively. As you can see from these figures, the proposed model also achieves good performance on Precison@K, Recall@K, and F1@K. When $K = 10$, reference [26] showed the best performance in accuracy, and the proposed model improved by 7.09% compared with it. Literature [25] has the best performance in recall rate and F1. The proposed model has a 2.68% improvement in recall rate and a 12.88% improvement in F1. Compared with the reference [24], the proposed model improved 18.63% in accuracy, 0.69% in recall rate, and 12.52% in F1.

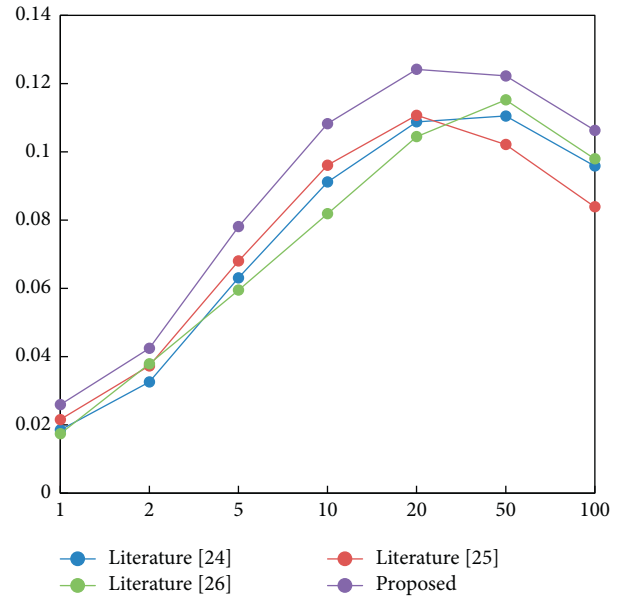


Figure 8: F1 in Top@K.

In CTR prediction and top-K recommendation, the proposed model achieved good performance in all indicators. In the comparison model, reference [24] performed well in CTR recommendation scenarios, but not in top-K recommendation scenarios. The proposed model does well in both recommended scenarios. This is because reference [24], reference [25], reference [26,] and the proposed model all combine rich heterogeneous information in English literature. However, reference [24], reference [25] and reference [26] only integrate the auxiliary information and its relationship to the content of the literature. Only the proposed model combines their respective auxiliary information and its relationship at both the user end and the literature end. There are two potential reasons for the performance improvement of the proposed model in this paper: the first reason is the use of more information sources. The second reason is the use of structured descriptions to model heterogeneous information. The proposed model shows that it is feasible to fuse auxiliary information of users on the user side and auxiliary information of documents on the document side. The use of heterogeneous information can significantly improve the recommendation performance, and the additional use of user attribute information can also improve the recommendation performance.

5. Conclusion

There are two problems in the traditional collaborative filtering recommendation algorithm: cold start and personalized recommendation. This paper conducts in-depth research on these two problems and obtains the optimized experimental results after the improved scheme through relevant experiments. Based on the literature content and user needs, this paper proposes a deep semantic mining recommendation model DSMR, which can predict the score

more accurately. It uses BERT pretraining model to learn the accurate semantics of words in context information. LSTM is also used to learn the internal relationship between contents, explore the change of user preferences over time, and introduce literature content documents to alleviate the problem of cold start. Experimental results show that the improved algorithm in this paper can optimize the cold start and personalized recommendation problems of the recommendation algorithm, so as to improve the data processing ability in the big data environment and give users a better user experience.

For future studies, we will focus on the recommended interpretability issues. The interpretability of recommendation is also an important aspect to improve the effect of recommendation. Persuasive and appropriate reasons for recommendation will improve the trust of users. How to use review text to generate recommendation reasons is a promising research direction in the future.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] M. Aivazoglou, A. O. Roussos, D. Margaris, C. Vassilakis, S. Loannidis, and J. Polakis, "A fine-grained social network recommender system," *Social Network Analysis and Mining*, vol. 10, no. 1, pp. 1–18, 2020.

[2] H. Tahmasebi, R. Ravanmehr, and R. Mohamadrezaei, "Social movie recommender system based on deep autoencoder network using Twitter data," *Neural Computing & Applications*, vol. 33, no. 5, pp. 1607–1623, 2021.

[3] T. Anwar, V. Uma, M. Hussain, and M. Pantula, "Collaborative filtering and kNN based recommendation to overcome cold start and sparsity issues: a comparative analysis," *Multimedia Tools and Applications*, pp. 1–19, 2022.

[4] T. R. Hannigan, R. F. J. Haans, K. Vakili et al., "Topic modeling in management research: rendering new theory from textual data," *The Academy of Management Annals*, vol. 13, no. 2, pp. 586–632, 2019.

[5] L. Yue, W. Chen, X. Li, W. Zuo, and M. Yin, "A survey of sentiment analysis in social media," *Knowledge and Information Systems*, vol. 60, no. 2, pp. 617–663, 2019.

[6] U. D. Gandhi, P. Malarvizhi Kumar, G. Chandra Babu, and G. Karthick, "Sentiment analysis on twitter data by using convolutional neural network (CNN) and long short term memory (LSTM)," *Wireless Personal Communications*, pp. 1–10, 2021.

[7] J. Devezas and S. Nunes, "A review of graph-based models for entity-oriented search," *SN Computer Science*, vol. 2, no. 6, pp. 1–36, 2021.

[8] S. Xing, Q. Liu, X. Wang, X. Zhao, and T. Li, "A hierarchical attention model for rating prediction by leveraging user and product reviews," *Neurocomputing*, vol. 332, pp. 417–427, 2019.

[9] C. Gao, W. Lei, X. He, M. de Rijke, and T.-S. Chua, "Advances and challenges in conversational recommender systems: a survey," *AI Open*, vol. 2, pp. 100–126, 2021.

[10] J. Carrión and V. Serrano, "Revisión sistemática de literatura: características y funcionamiento respecto a los modelos BERT y SQuAD," *CEDAMAZ*, vol. 11, no. 1, pp. 79–86, 2021.

[11] A. Da'u and N. Salim, "Recommendation system based on deep learning methods: a systematic review and new directions," *Artificial Intelligence Review*, vol. 53, no. 4, pp. 2709–2748, 2020.

[12] Z. Y. Khan, Z. Niu, and S. Sandiwarno, "Deep learning techniques for rating prediction: a survey of the state-of-the-art," *Artificial Intelligence Review*, vol. 54, no. 1, pp. 95–135, 2021.

[13] Z. Niu, G. Zhong, and H. Yu, "A review on the attention mechanism of deep learning," *Neurocomputing*, vol. 452, pp. 48–62, 2021.

[14] L. N. Vieira, M. O'Hagan, and C. O'Sullivan, "Understanding the societal impacts of machine translation: a critical review of the literature on medical and legal use cases," *Information, Communication & Society*, vol. 24, no. 11, pp. 1515–1532, 2021.

[15] Y. Du, L. Wang, Z. Peng, and W. Guo, "Review-based hierarchical attention cooperative neural networks for recommendation," *Neurocomputing*, vol. 447, pp. 38–47, 2021.

[16] H. Liu, Y. Wang, Q. Peng et al., "Hybrid neural recommendation with joint deep representation learning of ratings and reviews," *Neurocomputing*, vol. 374, pp. 77–85, 2020.

[17] A. Da'u and N. Salim, "Sentiment-aware deep recommender system with neural attention networks," *IEEE Access*, vol. 7, pp. 45472–45484, 2019.

[18] J. Li, A. Sun, J. Han, and C. Li, "A survey on deep learning for named entity recognition," *IEEE Transactions on Knowledge and Data Engineering*, vol. 34, no. 1, pp. 50–70, 2020.

[19] Y. Cui, W. Che, T. Liu, B. Qin, and Z. Yang, "Pre-training with whole word masking for Chinese BERT," *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, vol. 29, pp. 3504–3514, 2021.

[20] Y. Qiao, X. Zhu, and H. Gong, "BERT-Kcr: prediction of lysine crotonylation sites by a transfer learning method with pre-trained BERT models," *Bioinformatics*, vol. 38, no. 3, pp. 648–654, 2022.

[21] M. Zhang and J. Li, "A commentary of GPT-3 in MIT technology review 2021," *Fundamental Research*, vol. 1, no. 6, pp. 831–833, 2021.

[22] J. Hou, X. Li, H. Yao, H. Sun, T. Mai, and R. Zhu, "BERT-based Chinese relation extraction for public security," *IEEE Access*, vol. 8, pp. 132367–132375, 2020.

[23] S. Rajeswari and K. Suthendran, "C5.0: advanced Decision Tree (ADT) classification model for agricultural data analysis on cloud," *Computers and Electronics in Agriculture*, vol. 156, pp. 530–539, 2019.

[24] N. Singh, L. Ma, H. Yang, and E. Solomonik, "Comparison of accuracy and scalability of gauss--Newton and alternating least squares for CANDECOMC/PARAFAC decomposition," *SIAM Journal on Scientific Computing*, vol. 43, no. 4, pp. C290–C311, 2021.

[25] C. Feng, J. Liang, P. Song, and Z. Wang, "A fusion collaborative filtering method for sparse data in recommender systems," *Information Sciences*, vol. 521, pp. 365–379, 2020.

[26] C. E. Lawson, J. M. Martí, T. Radivojevic et al., "Machine learning for metabolic engineering: a review," *Metabolic Engineering*, vol. 63, pp. 34–60, 2021.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 6542300, 10 pages
https://doi.org/10.1155/2022/6542300

Research Article

Achievement Prediction of English Majors Based on Analytic Hierarchy Process and Genetic Algorithm

Guannan Li[1] and Wenyu Gao[2]

[1]*Department of Foreign Languages, Hebei Normal University, HuiHua College, Hebei 050000, China*
[2]*School of Foreign Languages, Jiangsu Commercial Vocational College, Nantong 226019, China*

Correspondence should be addressed to Wenyu Gao; 2014089@jsbc.edu.cn

Received 16 April 2022; Revised 24 May 2022; Accepted 30 May 2022; Published 7 July 2022

Academic Editor: Wen Zhou

The prediction and analysis of student achievement aim to realize personalized guidance for students and improve student achievement and teacher's teaching achievement. Student achievement is affected by many factors such as family environment, learning conditions, and individual performance. Traditional prediction methods often ignore that different factors have different effects on the same student's score, and different students have different effects on the same factor, so the model constructed cannot realize personalized analysis and guidance for students. Therefore, this paper proposes a prediction model based on the analytic hierarchy process and genetic algorithm. Firstly, according to the relationship among different levels, the analytic hierarchy process (AHP) model is established. Then, a k-means clustering algorithm is used to process the experimental data. Secondly, in order to get rid of the negative impact of the randomness of the initial threshold and weight on model prediction accuracy, which leads to the prediction result falling into a local minimum, a genetic algorithm is proposed to find the optimal initial threshold and weight of model first. Finally, a prediction model based on the BP neural network is established to predict students' scores, which proves that the prediction effect is good. The experiment was conducted with English major students in a university as the research object. Experimental results show that compared with traditional data mining methods, the proposed method has better prediction accuracy.

1. Introduction

Education is the foundation of a nation and the foundation of a strong nation. With the rapid development of Internet technology, it becomes more convenient and fast to collect education-related data. The analysis, mining, and application of education big data are an important demand and inevitable trend [1]. Student achievement prediction, also known as student academic achievement prediction, refers to the use of students' relevant information to predict their future academic performance. It includes course scores, comprehensive scores at the end of the semester, and whether there is a risk of dropping out. With the help of student achievement prediction technology, teachers can have a clear insight into students' learning status and quality, carry out differentiated teaching based on this, meet students' personalized learning needs, and truly achieve the goal of "promoting learning through evaluation." The prediction technology of students' scores is also helpful for colleges and universities to carry out academic early warning, especially to establish dynamic early warning mechanism according to the real-time prediction results of students' scores, so as to timely find the students who may not be able to finish their studies normally, guide them out of trouble, and successfully achieve the goal of talent training. Therefore, no matter from the perspective of improving teaching effect or strengthening student management, student achievement prediction technology has important research value and practical significance [2].

In recent years, the prediction of student achievement has been widely concerned by scholars at home and abroad, and a series of fruitful research work studies has emerged.

Most of the early studies focused on pedagogy and psychology, trying to explore the key factors affecting students' academic performance, such as personality composition, learning motivation, family environment, etc. [3]. This kind of research is mainly based on the self-assessment reports provided by some students, which has great defects in sample size and timeliness, and the conclusions are also susceptible to the influence of the subjective consciousness of the interviewed individuals. In some studies, students' performance information in the learning process is used to predict students' final grades [4], such as attendance, homework completion, and stage test scores. Because there is a strong correlation between the performance information of the course learning process and the final score, the obtained model can often achieve better predictive performance [5]. However, such research can be carried out after the course is carried out for some time, so it is impossible to predict students' learning performance at the initial stage of the course, leading to a certain lag in the predicted results.

At present, the prediction and analysis of student achievement and the research on the key influencing factors have attracted the attention of scholars at home and abroad. In terms of student performance prediction, literature [6] selected several typical learning behavior characteristics from many behavioral characteristics of MOOC learners. And use the selected characteristics to predict whether learners can successfully complete the learning task and obtain the certificate to find out the potential serious learners. Literature [7] selects 8 important attributes by calculating the information gain rate of each attribute characteristic from 18 attributes that affect students' performance, and uses the selected 8 important attributes to construct a decision tree to predict students' performance. In terms of the mining of influencing factors of students' scores, literature [8] conducted a study on the scores of 300 students in an Indian university and found that students' scores were greatly affected by such factors as home address, annual family income, mother's education, living habits, and students' historical scores. Literature [9] proposed that students' sociodemographic characteristics (such as race, gender, and economic status) and academic characteristics (such as school type and school performance) are closely related to their academic performance. Although the above work has made a good performance, but there are still two problems. (1) Only considers the current work has the characteristics of the selected influence on student achievement and ignores the influence of the selected features. (2) The current work assumes that the key factor to the influence degree of all the students is the same, ignoring the students' individual differences. In fact, different factors have different effects on the same student's score, and different students have different effects on the same factor.

Educational data mining aims to discover the internal connections and rules hidden in massive educational data and provide some help for students' learning, teachers' teaching, and the management of education managers [10]. Student achievement prediction can help teachers timely and effectively intervene and guide students' learning process, such as identifying students at risk so as to provide timely intervention measures. In addition, it can also be used in the online evaluation, cognitive diagnosis, student portrait construction, and recommendation system, which has important research significance and application value.

With the rise of data mining technology, a large number of data mining methods have been applied to the study of student achievement prediction. Existing research methods can be divided into two categories: one is to regard prediction problems as regression or classification problems. Data mining models such as linear regression [11], decision tree [12], support vector machine [13], deep neural network [14], and Bayesian network [15] are used in the literature [16]. On the other hand, the student prediction problem is likened to the user evaluation problem in the recommendation system, and the technology in the recommendation field is borrowed to solve the problem, including collaborative filtering, matrix factorization (MF) [17], and other methods. Compared with regression-based methods, recommendation-based methods are more widely used because of their higher prediction accuracy and interpretability.

However, recommendation-based approaches tend to perform poorly in the absence of historical data. Because this kind of method mainly relies on the historical record of students' scores to mine the similarity of courses, and then predicts the results. Therefore, when the number of history courses is small, additional information must be used to help accurately depict the similarity between courses. These background information are usually miscellaneous, have high requirements for data sources, and have limited mining of knowledge information. So far, there is no research that relies on knowledge information to predict students' performance. In view of this, this paper proposes a student achievement prediction model based on the analytic hierarchy Process and genetic algorithm.

The innovations and contributions of this paper are listed as follows:

(1) According to the relationship among different levels, the analytic hierarchy process model is established, and then the k-means clustering algorithm is used to process the experimental data

(2) Genetic algorithm is proposed to find the optimal initial threshold and weight of the model first

(3) A prediction model based on the BP neural network is established to predict students' scores

This paper consists of five main parts: the first part is the introduction, the second part is state of the art, the third part is a methodology, the fourth part is result analysis and discussion, and the fifth part is the conclusion.

2. State of the Art

Taking English major students in a university as the research object, this paper conducts a questionnaire survey on their academic performance. The design of the questionnaire was carried out in accordance with the principles of clear theme, reasonable structure, easy to understand,

appropriate control of the length of the questionnaire, convenient data verification, sorting, and statistics.

A questionnaire survey is conducted on the influencing factors of English major students' scores, which is divided into three levels, namely, individual, school, and family. The corresponding specific influencing factors are set in each layer with different numbers. The questions set in this questionnaire are mainly as follows

The influencing factors at the individual layer mainly include gender, class acceptance, taking notes or not, course interest, the length of study after class, and own health status

The influencing factors at the school layer mainly include the academic atmosphere of the school, teaching mode of teachers, faculty, and equipment resource sharing

The influencing factors of the family layer mainly include the education level of parents, family environment relationship, and family economic level

The questionnaire is mainly investigated from three aspects, each of which contains specific factors affecting English major students' scores. There are 13 question factors in total. A total of 202 questionnaires were collected for this survey, and 18 invalid papers were screened out after statistics and collation of the data in the later stage. Finally, 184 pieces of data could be used as data sources for this survey. Reliability and validity tests of the questionnaire data showed good performance.

3. Methodology

3.1. Establishment of the Hierarchy of Influencing Factors of English Major Scores. The influencing factors of English major scores can be divided into three levels: target layer A, criterion layer B_i, and subcriterion layer C_y. The target layer is the influencing factor of English major students' performance. The criterion layer is divided into three factors, namely, the influence factors of individual, school, and family on English major students' performance. The three criteria layers are decomposed into more subcriteria layers, for example, the individual layer considers gender, class acceptance, taking notes or not in class, interest in English, etc. The school layer considers the teaching mode of teachers, the academic atmosphere of the school, equipment resource sharing, and the faculty. At the family layer, the education level of parents, family economic level, and family environment relationship (see Table 1).

The factors in the criterion layer have an effect on the factors of the upper layer, and all the factors in the subcriterion layer have an effect on the target layer, but for the upper layer, only the factors belonging to the upper layer have an effect, but each factor in the subcriterion layer is independent of each other and does not affect each other.

3.2. Consistency Test and Hierarchical Single Ordering of Judgment Matrix. Through the analysis of English major student performance influence factors, namely, the five criteria layer individual, class, school, family, and society, and the corresponding criterion layer of the factor analysis, respectively, established principles of the target layer, layer of criterion of the judgment matrix, by using mathematical software Matlab to calculate the maximum eigenvalue and eigenvector of a judgment matrix. The feature vectors are normalized, and finally, the consistency test is done.

Table 1: Hierarchy table of factors influencing English major students' scores.

Target layer A	Criterion layer B_x	Subcriteria layer C_y
An influencing factor of English majors' achievement	B_1 individual factors	C_1 gender
		C_2 class acceptance
		C_3 take notes or not
		C_4 own health status
		C_5 course interest
		C_6 length of study after class
	B_2 school factors	C_7 academic atmosphere of the school
		C_8 teaching mode of teachers
		C_9 faculty
		C_{10} equipment resource sharing
	B_3 family factors	C_{11} education level of parents
		C_{12} family environment relationship
		C_{13} family economic level

(1) Judgment matrix A-B_x:

$$A - B_x = \begin{vmatrix} 1 & 3 & 4 & 6 & 5 \\ \frac{1}{4} & \frac{1}{3} & 1 & 4 & 2 \\ \frac{1}{6} & \frac{1}{5} & \frac{1}{4} & 1 & \frac{1}{2} \end{vmatrix}. \quad (1)$$

The maximum eigenvalue of the matrix λ Max = 5.1984, and its corresponding eigenvector is $M_1 = (0.8388, 0.2332, 0.0856)^T$.

The corresponding weight can be obtained by the normalization of M_1:

$M_A = (0.4769, 0.1326, 0.0487)^T$.

Consistency test: the indicators of consistency test are as follows:

$$CX_1 = \frac{\lambda_{\max} - t}{t - 1} = \frac{0.1984}{4} = 0.0496, \quad t = 5. \quad (2)$$

The average consistency index is

$$RX_1 = 1.12,$$

$$\mathrm{CR}_1 = \frac{CX_1}{RX_1} = \frac{0.0496}{1.12} = 0.0443 < 0.1. \quad (3)$$

If the consistency ratio $CR1 < 0.1$, the matrix A-B_x passes the consistency test. It shows that the matrix A-B_x is reasonably constructed without secondary construction.

According to the normalized weight M_A, it can be seen that the eigenvalue 0.0487 is the smallest; that is, family factors have the least influence on the scores of English majors. The characteristic value of 0.4769 is the largest; that is, personal factors have the greatest influence on the scores of English majors.

(2) Judgment matrix B_1-C_y:

$$B_1 - C_y = \begin{bmatrix} 1 & \frac{1}{3} & \frac{1}{6} & \frac{1}{5} & \frac{1}{7} & \frac{1}{5} & \frac{1}{4} \\ 3 & 1 & \frac{1}{2} & \frac{1}{3} & \frac{1}{5} & \frac{1}{3} & \frac{1}{3} \\ 6 & 2 & 1 & \frac{1}{2} & \frac{1}{3} & 1 & \frac{1}{4} \\ 5 & 3 & 2 & 1 & \frac{1}{2} & 1 & 1 \\ 7 & 5 & 3 & 2 & 1 & \frac{1}{3} & 1 \\ 5 & 3 & 1 & 1 & 3 & 1 & 2 \end{bmatrix}. \quad (4)$$

It can be concluded from the above matrix that when λ Max = 7.6323, $M_2 = (0.0692, 0.1356, 0.2595, 0.3829, 0.5017, 0.5683)^T$.

After normalization, the resulting vector is as follows: $M_{B_1} = (0.0294, 0.0576, 0.1103, 0.1627, 0.2132, 0.2416)^T$; then, the consistency test index is obtained.

$$\begin{aligned} CX_2 &= \frac{\lambda_{\max} - t}{t-1} = \frac{0.6323}{6} = 0.1054, \quad t = 7, \\ RX_2 &= 1.36, \\ \mathrm{CR}_2 &= \frac{CX_2}{RX_2} = \frac{0.1054}{1.36} = 0.0775 < 0.1. \end{aligned} \quad (5)$$

If the consistency ratio $\mathrm{CR}_2 < 0.1$, the matrix B_1-C_y passes the consistency test, indicating that the matrix B_1-C_y is reasonably constructed and no secondary construction is required.

According to the normalized weight M_{B1}, it can be seen that the eigenvalue 0.0294 is the smallest; that is, gender factors have the least influence on the scores of English majors. The characteristic value of 0.2416 is the largest; that is, the length of study after class has the greatest impact on the scores of English majors. The second factor is course interest with a weight of 0.2132, and their health status also plays an important role in English major students' performance.

(3) Judgment matrix B_2-C_y:

$$B_2 - C_y = \begin{bmatrix} 1 & 3 & 4 & 6 & 6 & 6 & 7 \\ \frac{1}{4} & 1 & 1 & 3 & 2 & 2 & 2 \\ \frac{1}{6} & \frac{1}{2} & \frac{1}{2} & 1 & 1 & 1 & 1 \\ \frac{1}{7} & \frac{1}{3} & \frac{1}{2} & \frac{1}{2} & 1 & 1 & 1 \end{bmatrix}. \quad (6)$$

It can be concluded from the above matrix that when λ Max = 7.1067, $M_3 = (-0.8703, -0.2807, -0.1357, -0.1159)^T$.

After normalization, the resulting vector is $M_{B2} = (0.4387, 0.1415, 0.0684, 0.0584)^T$.

Then, the consistency test index is obtained as follows:

$$\begin{aligned} CX_3 &= \frac{\lambda_{\max} - t}{t-1} = \frac{0.1067}{6} = 0.0178, \quad t = 7, \\ RX_3 &= 1.36, \\ \mathrm{CR}_3 &= \frac{CX_3}{RX_3} = \frac{0.0178}{1.36} = 0.0131 < 0.1. \end{aligned} \quad (7)$$

If the consistency ratio $\mathrm{CR}_3 < 0.1$, the matrix B_2-C_y passes the consistency test. It shows that the structure of matrix B_2-C_y is reasonable and no secondary structure is needed.

According to the aforementioned normalized weight M_{B2}, it can be known that $0.0584 < 0.0684 < 0.1415 < 0.4387$.

Therefore, it can be seen that the academic atmosphere of the school has the greatest weight, followed by the teaching mode of the teacher, followed by the faculty, and the equipment and resources of the school have the lowest impact on the scores of English majors.

(4) Judgment matrix B_3-C_y:

$$B_3 - C_y = \begin{bmatrix} 1 & 2 & 3 \\ \frac{1}{3} & 1 & 2 \\ \frac{1}{2} & 2 & 1 \end{bmatrix}. \quad (8)$$

From the above matrix, it can be concluded that when λ Max = 3.0889, $M_4 = (0.8500, 0.4287, 0.3061)^T$.

After normalization, the resulting vector is $M_{B3} = (0.5363, 0.2705, 0.1931)^T$. Then, the consistency test index is obtained as follows:

$$CX_4 = \frac{\lambda_{\max} - t}{t-1} = \frac{0.0889}{2} = 0.0445, \quad t = 3. \quad (9)$$

The average consistency index is

$$\begin{aligned} RX_4 &= 0.58, \\ \mathrm{CR}_4 &= \frac{\mathrm{CI}_4}{\mathrm{RI}_4} = \frac{0.0445}{0.58} = 0.0767 < 0.1 \end{aligned} \quad (10)$$

Table 2: Composite weight table of influencing factors of English major scores.

Target layer A	Criterion layer B_x	Weight M_A	Subcriteria layer C_y	Weight M_B	Weight M_C
An influencing factor of English majors' achievement	B_1 individual factors	0.4769	C_1 gender	0.0294	0.0241
			C_2 class acceptance	0.0576	0.0476
			C_3 take notes or not	0.1103	0.1105
			C_4 own health status	0.1627	0.1065
			C_5 course interest	0.2132	0.1144
	B_2 school factors	0.1326	C_6 length of study after class	0.2416	0.2012
			C_7 academic atmosphere of the school	0.1549	0.0271
			C_8 teaching mode of teachers	0.1415	0.0162
			C_9 faculty	0.0684	0.012
			C_{10} equipment resource sharing	0.0584	0.0471
	B_3 family factors	0.0487	C_{11} education level of parents	0.5363	0.0143
			C_{12} family environment relationship	0.2705	0.013
			C_{13} family economic level	0.1931	0.0121

If the consistency ratio $CR_4 < 0.1$, the matrix B_3-C_Y passes the consistency test. It shows that the structure of matrix B_3-C_Y is reasonable and no secondary structure is needed.

According to the normalized weight M_{B3} above, the eigenvalue is $0.1931 < 0.2705 < 0.5363$.

It can be seen that at the family layer, parents' educational level has the highest impact on the scores of English major schools, followed by family environment relationship, while family economic level has a low impact on the scores of English major academic schools. Therefore, parents' educational level is also particularly important, which has a greater impact on students' academic performance.

Because the weight ranking of a single layer is relatively simple, it is not possible to comprehensively analyze the influencing factors of college students' higher mathematics academic performance. Therefore, it is necessary to intuitively understand the influence of various factors on English major students' performance through hierarchical overall ranking.

3.3. Hierarchical Total Ranking and Its Consistency Test. The pair comparison matrix is constructed, and the maximum eigenvalue and corresponding eigenvector of the matrix are obtained by Matlab. The eigenvector is normalized, and then the weight M is obtained. M_A is the weight of the criteria layer to the target layer, that is, the influence factors of English major students' scores. M_B is the weight of the subcriteria layer to its corresponding criteria layer. M_C is the weight of all subcriteria layers to the target layer. The synthetic weight of all factors at all levels to the scores of English majors was calculated, and the total ranking of all levels was carried out. The CR value of each matrix is less than 0.1, and the consistency test is passed. Table 2 shows the results of composite weight after the hierarchical total ordering.

It is found that the weight value of the length of study after the class is the highest. The weight value of the academic atmosphere of the school in the school layer is the highest. The weight value of parents' education level is the highest at the family layer.

3.4. BP Neural Network Algorithm. Due to the uncertainty of subjective factors, this paper only considers the influence of objective factors when building the prediction model. To effectively predict the real school English professional level of academic performance, according to the theory of the BP neural network model, select five parameters to build a neural network algorithm model, namely: spare time learning time p, curriculum interest, school academic atmosphere q, a teacher teaching model w, and parents education level x, as shown in Figure 1. In Figure 1, there are 5 input nodes in the model input layer, which are the 5 parameters selected above to participate in model prediction.

3.5. Data Cluster Analysis. According to the original data samples, the data of each dimension has its own change interval and unit; that is, the data of each dimension are data of different attributes. Therefore, in order to improve data quality and accuracy, it is very important to define data in the same interval and minimize the impact of data repetition and redundancy on model calculation while maintaining the original data relationship unchanged during model training. The methods of data clustering are divided into hard clustering and flexible partitioning. In this section, the k-means clustering algorithm in the hard clustering method is selected to preprocess experimental sample data. The original data set I with t objects was divided into K clusters to minimize the distance between each data point and the cluster center. In other words, the cluster analysis was completed and the overall redundancy

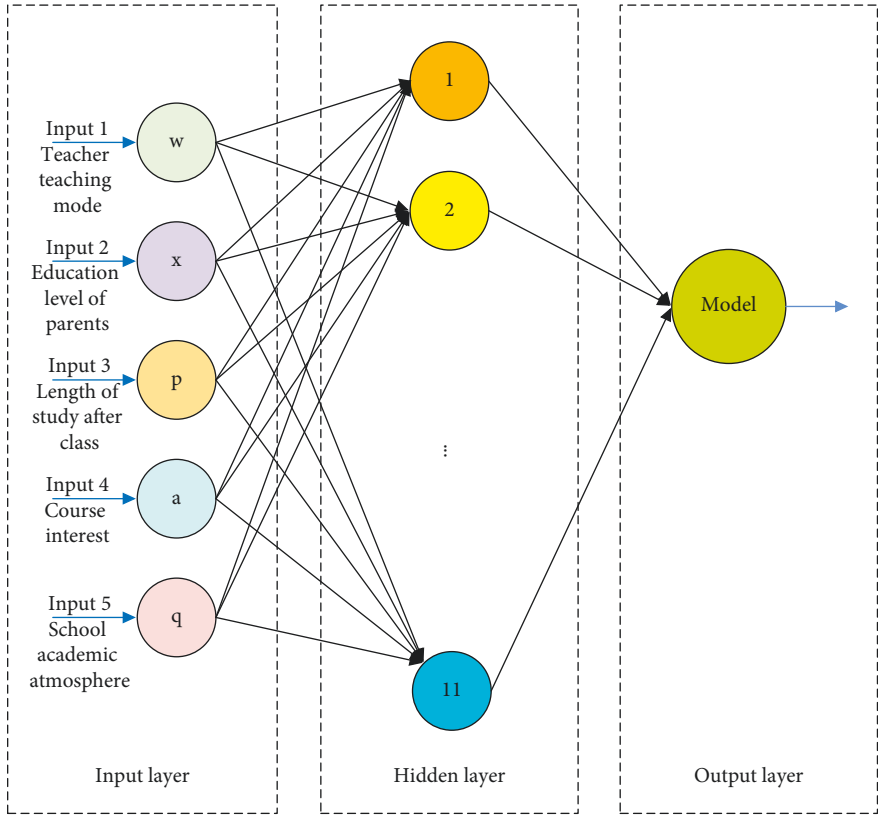


Figure 1: Schematic diagram of the BP neural network model.

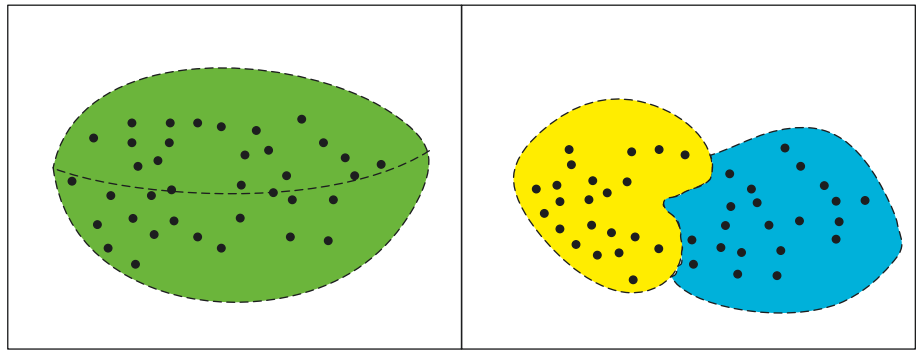


Figure 2: Schematic diagram of K-means clustering algorithm.

was reduced. The steps of this method to analyze indoor environmental data are as follows:

Step 1: initialize the K cluster center:

$$w_1^{(1)}, w_2^{(1)}, \ldots, w_k. \tag{11}$$

Step 2: allocate t data to the cluster set with the least square Euclidean distance from the cluster center, that is, complete the nearest neighbor cluster center. The classification principles are as follows:

$$S_x^{(n)} = \left\{ i_u : \left\| i_u - w_x^{(n)} \right\|^2 \le \left\| i_u - w_y^{(n)} \right\|^2 \forall y, \quad 1 \le y \le z. \right\} \tag{12}$$

Step 3: calculate the new sample center of the cluster set assigned to the node, as shown below.

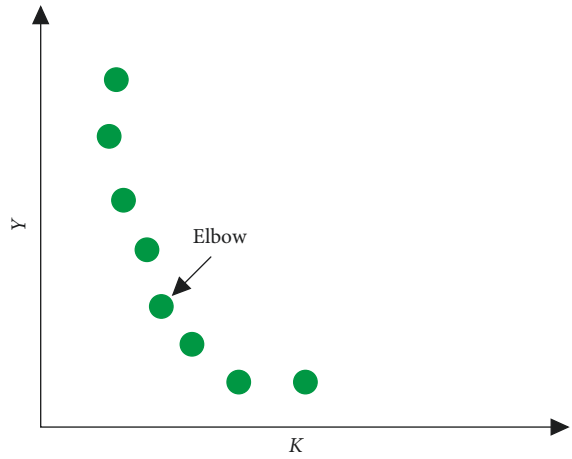


Figure 3: Schematic diagram of Elbow algorithm.

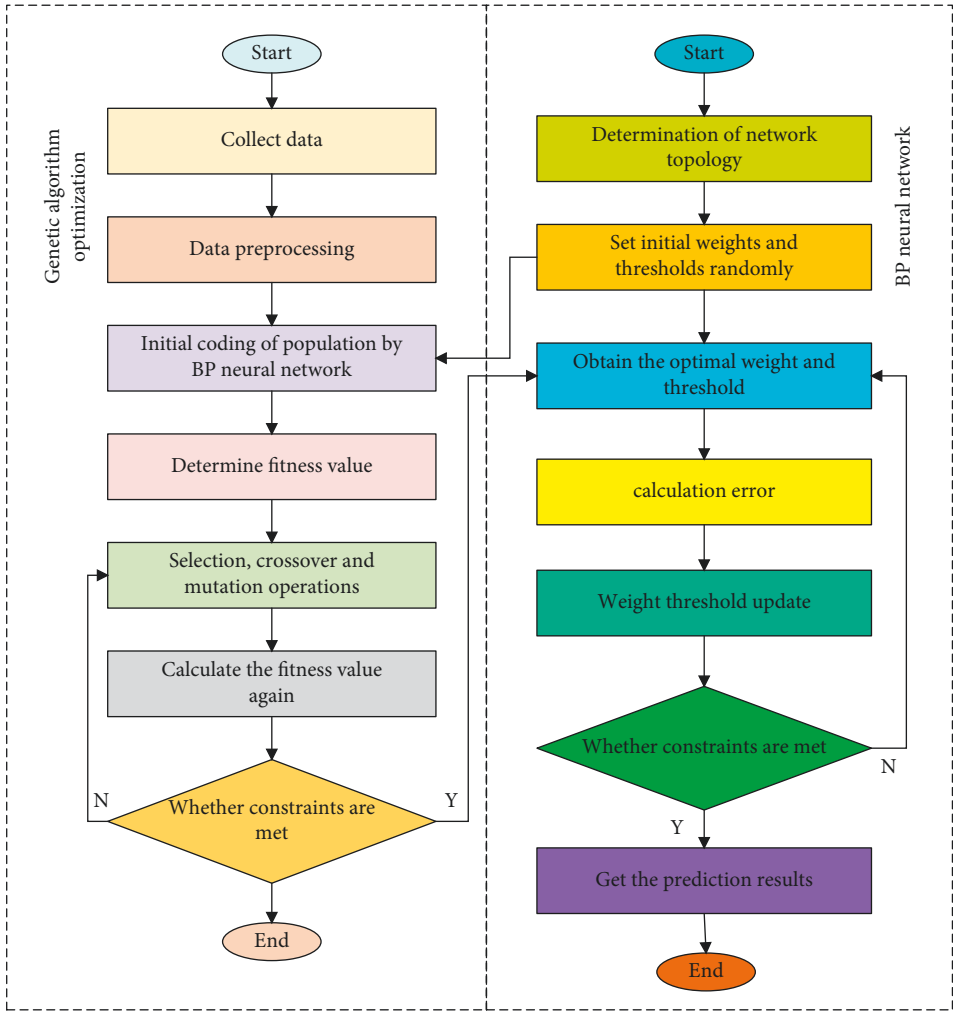


Figure 4: Flow chart of genetic algorithm optimizing BP neural network.

$$w_y^{(n+1)} = \frac{1}{\left|S_x^{(n)}\right|} \sum i_y \in S_x^{(n)} i_y. \quad (13)$$

Step 4: run steps 2 and 3 iteratively alternately until the clustering center does not change or reaches a certain number of iterations, as shown in Figure 2.

In the face of a large number of experimental data, it is difficult to determine the number of clustering K. In this paper, the Elbow method in the K value evaluation algorithm is used to determine it.

In the K-means clustering algorithm, the optimization objective is as follows:

$$Y\left(c^{(1)}, c^{(2)}, \ldots, c^{(w)}, \mu_1, \mu_2, \cdots, \mu_k\right) = \frac{1}{w} \sum_1^w \left(\left\| i^{(x)} - \mu_{c(w)} \right\|\right). \quad (14)$$

where $c^{(x)}$ is the corresponding subscript of the cluster center closest to $i^{(x)}$. μ_k is the clustering center. The optimization objective Y is the sum of the distance from each sample to the cluster center and also represents the clustering error. The smaller the Y value is, the smaller the clustering error is, and the better the clustering effect is.

When the K value is different, the Y value is also different. According to the idea of the elbow algorithm, the classification effect is the best when the value of K is the inflection point of the optimization objective function curve, see Figure 3.

In summary, the k-means algorithm was used to cluster the initial samples, the Y-cost function was used to evaluate the clustering effect, and the optimal K value was determined by the Elbow algorithm. The results show that there is an inflection point when $K = 5{,}928$; that is, there are 5,928 clustering centers.

3.6. Data Standardization Processing. After clustering, each variable is more dependent on its own specific unit property and change interval. In order to avoid this situation, after data clustering, this section conducts standardized data processing. That is, the clustering data is processed again, the weight of the same attribute is assigned, and mapped to the same change interval (0, 1). In this way, the data set quality can be improved again, which is more conducive to modeling, training, and analysis of data in the later period.

Table 3: Parameter table of genetic algorithm improving BP neural network model.

	Parameter category	Parameter value preset
1	Individual length of genetic algorithm	Lenchrom = 10
2	Number of genetic evolution	Maxgen = 90
3	Population size	Sizepop = 15
4	Crossover rate	Pcross = 0.5
5	Variation rate	pmutation = 0.1
6	Maximum number of iterations of neural network	net.trainParam.epochs = 90
7	Training and learning rate of neural network	net.trainParam.lr = 0.2
8	Allowable error range of neural network	net.trainParam.goal = 0.0005

Table 4: Raw data overview.

Basic data information	Mock exam 1 scores	Mock exam 2 scores	Mock exam 3 scores	Mock exam 4 scores	Final scores
The minimum	59	215	159.8	87.5	106
The quantile	328	306	307.5	321	313
The median	373	345.5	342.5	366.5	351.5
The mean	273	348.5	348.4	368	353.4
On the quantile	416.5	384	348.5	412	393
The maximum	550	528.5	535.5	575	522.5

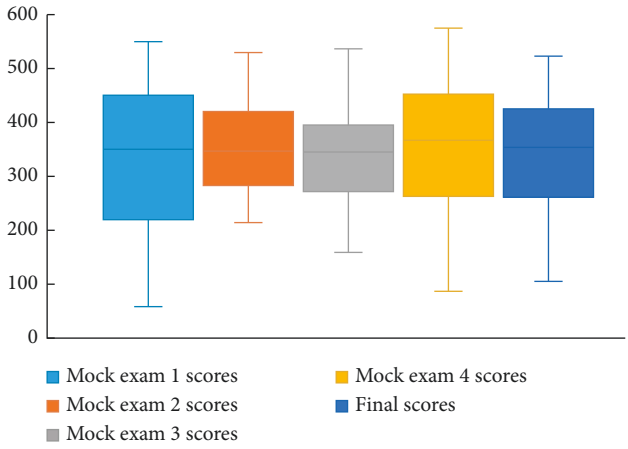


Figure 5: Boxplot of the original variable.

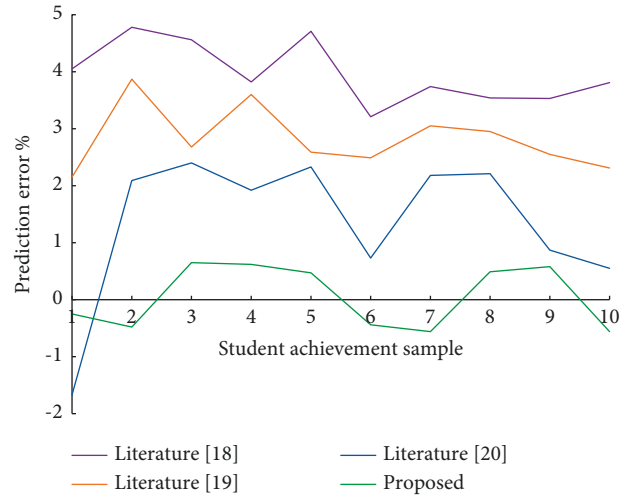


Figure 6: Comparison of prediction errors of various models.

3.7. BP Neural Network Model Training and Prediction Analysis. In order to solve the problems caused by the defects of the BP neural network mentioned above, this paper considers a genetic algorithm to directly use the fitness function as search information. The search process is not constrained by the continuity of a function and has good global search ability, which can overcome the problem that the BP neural network easily falls into the local minimum and find the optimal value of the BP neural network quickly and accurately. Therefore, the genetic algorithm is adopted to optimize the BP neural network first and strive to improve the accuracy of the prediction model, so as to realize an accurate grasp of the scores of English majors. The optimization process is shown in Figure 4.

Taking the initial threshold and weight of the BP neural network as the initial population, the MATLAB GA toolbox is used to optimize it. Parameter settings of the genetic algorithm optimization model are shown in Table 3.

4. Result Analysis and Discussion

Some factors in the above analytic hierarchy process modeling are obtained by calculating the synthetic weight of all factors at all levels to the scores of English majors in a certain university and making a total ranking of all levels. The empirical analysis data came from the results of four mock exams scores and the final exam score of English majors in this university, with a sample size of 669 and a data dimension of 669×5. The source of students in the school is medium level in the province, and the college entrance examination scores have been relatively stable for many years. The data are real and reliable and have strong representativeness. Table 4 provides an overview of the raw data. It can be clearly seen from Table 4 that the mean value of $X1$ is 273, and the mean value of the other three mock exams and the final exam is about 350. The median of the

Table 5: Comparison results of average relative errors of various models.

Prediction model	Test sample 1 (%)	Test sample 1 (%)	Test sample 1 (%)	Average relative error (%)
Literature [18]	15.63	16.81	5.56	12.67
Literature [19]	2.90	7.50	18.37	9.59
Literature [20]	17.44	0.11	14.01	10.28
Proposed	4.21	7.93	7.40	6.51

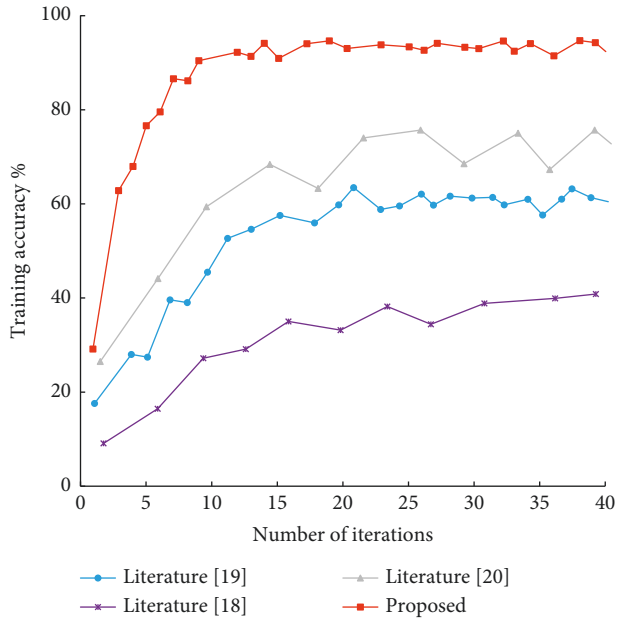


Figure 7: Training accuracy curve of each model.

five variables is around 360, their maximum value is around 540, and their variance is stable around 75. Furthermore, it was observed from the boxplot (see Figure 5) that the range of predicted variables and the final exam score data were basically the same, as well as the variance, so there was no need to standardize the variables during modeling.

Figure 6 shows the prediction results of 10 sample scores randomly selected from English majors in a university in [18], [19], [20], and the proposed model.

The smaller the average relative error is, the higher the accuracy of the model is and the better the prediction performance is. As can be seen from Table 5, among the four prediction models, the average relative error of the model in this paper is the smallest, which is 6.51%. This shows that the prediction results of the model are more consistent with the real value. Thus, the model in this paper can eliminate redundancy between data. The main reason is that genetic algorithm automatic parameter optimization can make support vector machines have better performance, so the prediction result is better.

This section also explores the influence of iteration times on the prediction accuracy of the model. As shown in Figure 7, the training accuracy of the algorithm in this paper tends to be stable after about 10 cycles of iteration, and the model begins to converge.

5. Conclusion

Student achievement prediction is a research hotspot in the field of educational data mining in recent years and is also one of the important objectives of learning analytics. In view of the problem that the influence degree of different factors on the same student's score is not considered in the current relevant research, and the influence degree of different students by the same factor is also different, this paper proposes a student's score prediction model based on AHP and genetic algorithm. Firstly, a questionnaire survey was conducted on the factors influencing English major students' scores. According to the relationship between different levels, an analytic hierarchy process model was established, and then the k-means clustering algorithm was used to process the experimental data. Finally, BP neural network algorithm improved by the genetic algorithm is used to predict students' grades, and more accurate and reliable prediction data are obtained. The prediction results of English majors in a university proved to be effective. Experimental results show that compared with traditional data mining methods, the proposed method has better prediction accuracy. The prediction accuracy of the model needs to be further improved. Because there are many subjective and objective factors affecting students' scores, it is necessary to carefully screen and extract levels, so as to predict students' scores more accurately.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work was supported by (1): A Research on the Effective Cultivation of English Majors' Comprehensive Capacities from the Perspective of the Multimodality Teaching Design Based on POA 2020YYJG069 and (2) Research on the Way to Improve the Effectiveness of Cross-Cultural Communication Virtual Experiment Teaching Based on Network Platform (2021-R-92296) issued by Institute of modern Educational Technology, Jiangsu Academy of Educational Science, which were funded by National and Regional Institute, Nantong University, and Jiangsu Federation of Social Science.

References

[1] C. Romero and S. Ventura, "Educational data mining and learning analytics: an updated survey," *WIREs Data Mining and Knowledge Discovery*, vol. 10, no. 3, Article ID e1355, 2020.

[2] Y. C. Yeh, O. M. Kwok, H. Y. Chien, N. W. Sweany, E. Baek, and W. A. McIntosh, "How college students' achievement goal Orientations predict their expected online learning outcome: the mediation roles of self-regulated learning strategies and supportive online learning behaviors," *Online Learning*, vol. 23, no. 4, pp. 23–41, 2019.

[3] O. H. T. Lu, A. Y. Q. Huang, J. C. H. Huang, A. J. Q. Lin, H. Ogata, and S. J. H. Yang, "Applying learning analytics for the early prediction of Students' academic performance in blended learning," *Journal of Educational Technology & Society*, vol. 21, no. 2, pp. 220–232, 2018.

[4] M. Saqr, U. Fors, and M. Tedre, "How the study of online collaborative learning can guide teachers and predict students' performance in a medical course," *BMC Medical Education*, vol. 18, no. 1, pp. 1–14, 2018.

[5] A. Abu Saa, M. Al-Emran, and K. Shaalan, "Factors affecting students' performance in higher education: a systematic review of predictive data mining techniques," *Technology, Knowledge and Learning*, vol. 24, no. 4, pp. 567–598, 2019.

[6] C. H. Yu, J. Wu, and A. C. Liu, "Predicting learning outcomes with MOOC clickstreams," *Education Sciences*, vol. 9, no. 2, p. 104, 2019.

[7] M. Zaffar, K. S. Savita, M. A. Hashmani, and S. S. H. Rizvi, "A study of feature selection algorithms for predicting students academic performance," *International Journal of Advanced Computer Science and Applications*, vol. 9, no. 5, pp. 541–549, 2018.

[8] R. Naylor, "Key factors influencing psychological distress in university students: the effects of tertiary entrance scores," *Studies in Higher Education*, vol. 47, no. 3, pp. 630–642, 2022.

[9] K. U. Lazarus, "Socio-demographic factors affecting Reading comprehension achievement among secondary school students with learning Disabilities in Ibadan, Nigeria," *IAFOR Journal of Education*, vol. 8, no. 1, pp. 145–158, 2020.

[10] Y. K. Salal, S. M. Abdullaev, and M. Kumar, "Educational data mining: student achievement prediction in academic," *International Journal of Engineering and Advanced Technology*, vol. 8, no. 4C, pp. 54–59, 2019.

[11] S. M. Ayyoubzadeh, S. M. Ayyoubzadeh, H. Zahedi, M. Ahmadi, and S. Niakan Kalhori, "Predicting COVID-19 Incidence through analysis of Google trends data in Iran: data mining and deep learning Pilot study," *JMIR public health and surveillance*, vol. 6, no. 2, Article ID e18828, 2020.

[12] H. H. Patel and P. Prajapati, "Study and analysis of decision tree based classification algorithms," *International Journal of Computer Science and Engineering*, vol. 6, no. 10, pp. 74–78, 2018.

[13] M. Mohammady, H. R. Pourghasemi, and M. Amiri, "Assessment of land subsidence susceptibility in Semnan plain (Iran): a comparison of support vector machine and weights of evidence data mining algorithms," *Natural Hazards*, vol. 99, no. 2, pp. 951–971, 2019.

[14] B. K. Francis and S. S. Babu, "Predicting academic performance of students using a hybrid data mining approach," *Journal of Medical Systems*, vol. 43, no. 6, p. 162, 2019.

[15] S. Hussain, N. Abdulaziz Dahan, F. M. Ba-Alwi, and N. Ribata, "Educational data mining and analysis of students' academic performance using WEKA," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 9, no. 2, p. 447, 2018.

[16] A. V. Manjarres, L. G. M. Sandoval, and M. S. Suárez, "Data mining techniques applied in educational environments: literature review," *Digital Education Review*, vol. 33, pp. 235–266, 2018.

[17] I. Fernández-Tobías, I. Cantador, P. Tomeo, V. W. Anelli, and T. Di Noia, "Addressing the user cold start with cross-domain collaborative filtering: exploiting item metadata in matrix factorization," *User Modeling and User-Adapted Interaction*, vol. 29, no. 2, pp. 443–486, 2019.

[18] S. U. Damuluri, K. Islam, P. Ahmadi, and N. S Qureshi, "Analyzing Navigational data and predicting student Grades using support vector machine," *Emerging Science Journal*, vol. 4, no. 4, pp. 243–252, 2020.

[19] S. Sahoo, M. Mohanty, and S. Sabut, "Automated ECG beat classification using DWT and Hilbert transform-based PCA-SVM classifier," *International Journal of Biomedical Engineering and Technology*, vol. 32, no. 3, p. 287, 2020.

[20] Y. Cao, K. Yin, C. Zhou, and B. Ahmed, "Establishment of landslide groundwater level prediction model based on GA-SVM and influencing factor analysis," *Sensors*, vol. 20, no. 3, p. 845, 2020.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 7116171, 12 pages
https://doi.org/10.1155/2022/7116171

Research Article

Teaching Effect Evaluation Mechanism of English MOOC Combined with LS-SEM Intelligent System

Jing Liu

Basic Teaching Department, Shangqiu Institute of Technology, Shangqiu 476000, China

Correspondence should be addressed to Jing Liu; 161849037@masu.edu.cn

Received 13 April 2022; Revised 8 June 2022; Accepted 17 June 2022; Published 7 July 2022

Academic Editor: Wen Zhou

In order to improve the effect of English teaching, this article analyzes the MOOC teaching system, constructs an evaluation mechanism combined with the LS-SEN intelligent system, and obtains an intelligent English MOOC teaching effect evaluation system. According to the actual needs of English MOOC teaching effect evaluation, this article proposes an integrated method LS-Ensem algorithm for continuous modeling from the perspective of gradient descent. At the same time, this article uses the commonly used variance function as the loss function, combined with repeated iterations to improve the running accuracy of the algorithm. In addition, this article constructs an intelligent system structure based on the actual needs of English MOOC teaching. According to the experimental research, the teaching effect evaluation mechanism of English MOOC combined with the LS-SEM intelligent system can play an important role in English MOOC teaching.

1. Introduction

College English teaching urgently needs to enrich the types of courses and improve the quality of teaching, so as to meet the diverse English learning needs of learners, and this demand is particularly prominent due to the impact of MOOCs on traditional classrooms. The themes of MOOCs involve various disciplines, and the language of instruction is mainly English, which can fully meet the diverse needs of learners in terms of professional English, academic English, and general education English. In addition, the MOOC is based on a systematic fragmented learning method and modular short videos, which not only facilitates learners to learn by topic, but also facilitates them to use fragmented time to split and watch. This will attract many students to choose to "skip classes" and go to "Amoy (mo) classes." At this time, college English teachers will lose their position of knowledge authority to a large extent, and it will be difficult for students to accept traditional teaching methods, which will lead to the danger of student loss in the classroom.

MOOCs can test the effect of college English teaching to a certain extent, and language barriers (i.e., English proficiency) are one of the main reasons that hinder learners from completing MOOCs, which will inevitably exacerbate students' understanding of the content and teaching of traditional college English courses. Dissatisfaction with quality, to a large extent, "divides" the traditional relationship of domination and dependence between teachers and students, awakening students' subjectivity. Faced with the impact of MOOCs on traditional college English teaching, colleges and universities should take advantage of MOOCs and explore a hybrid teaching model that integrates MOOCs and classroom teaching through the collaborative innovation of online MOOC education and traditional face-to-face teaching, so as to realize the structure of college English courses upgrade and improve the quality of teaching.

Teacher training, training and maturity, and other related teacher development issues are one of the key factors to realize the transformation of college English follow-up curriculum and the improvement of teaching quality. MOOCs have brought about many changes in college English education concepts, teaching concepts, teaching methods, and teaching content. While challenging the original teaching concepts and knowledge structure of college English teachers, it also breeds opportunities. Professional international MOOC courses improve their own

ESP and EAP levels, and then open more high-quality school-based college English follow-up courses to better meet learners' personalized English learning needs. Teachers can learn about English teaching methods by learning. The MOOC courses, especially the modern educational technology MOOC courses, can improve the teaching design and development ability in the information technology environment.

In order to analyze the teaching effect of English MOOCs, this article combines the LS-SEN intelligent system to construct an evaluation mechanism and obtains an intelligent English MOOC teaching effect evaluation system, which provides a theoretical reference for the subsequent improvement of the teaching effect of English MOOCs.

2. Related Work

In recent years, there have been related research studies on microteaching in the context of MOOCs, such as "how to realize the mutual penetration of English microteaching and MOOCs in colleges and universities." The research shows that MOOC teaching provides resources and materials for microteaching; MOOC teaching provides technical support for microteaching [1]. Microteaching in the context of MOOCs can help teachers to further understand and improve their classroom teaching skills, and promote their professional development. With the development of online learning, Xuetong has gradually become a common learning channel in colleges and universities. Teachers can share excellent resources to Xuetong for students to watch and learn [2]. With the help of the Xuetong platform, the effect and problems of English micro-introduction skill training are studied. With the continuous deepening and development of basic education curriculum reform, teachers pay more attention to the effectiveness of classroom teaching [3]. At the beginning of classroom teaching, classroom introduction is related to the success or failure of a class. At the same time, introduction skills are one of the top ten skills in microteaching [4]. Correct and ingenious introduction can prepare for the next teaching and help students to obtain good learning effect. However, the research on the development of teachers' teaching ability is the core part of the research on teachers' professional development. The practical knowledge of English teachers is generally relatively lacking, and the teaching ability of teachers needs to be improved urgently [4]. As one of the compulsory courses for teachers' vocational skills training in higher normal colleges and universities, microteaching just provides a broad practical platform for English teachers, making it possible for normal students to focus on solving a specific teaching behavior or conduct it under controlled conditions [5]. Through English micro-introduction skills training, teachers can further understand microteaching, which will also be a process for teachers to continuously learn, improve teaching skills, and constantly improve themselves [6].

The system provides a wealth of English learning resources. Through videos, students are guided to learn English language knowledge and have a good understanding of their own English language skills for training [7]. The self-learning system can be divided into course selection and self-study. Students can choose their own learning content, including writing, reading, and listening, according to their own interests and real learning needs. Students can choose flexibly to achieve individuality chemical learning [8]. In the self-learning system, students can design their own English learning progress and do not need to study according to the progress of traditional English teaching, so that students with different learning abilities and different learning foundations can be satisfied. Students can choose their weak points of knowledge to strengthen training, further consolidate classroom knowledge, and check and fill gaps [9].

The MOOC education platform is an online learning and education platform for teachers and students [10]. The teaching management system can play a navigational role, guide students to complete the staged learning and then conduct testing, and guide students in the selection of learning content. The supervision function of the teaching management system can better guide and restrict students, mobilize students' enthusiasm for autonomous learning, and encourage students to actively participate in the autonomous learning of the MOOC platform [11]. Teachers can use the teaching management system to grasp the online time of students, whether they complete the knowledge test on time, whether they have read the educational resources in the educational platform, etc. [12].

The evaluation feedback system in the MOOC education platform is to better supervise, regulate, and encourage students' self-learning awareness and behavior [13]. The evaluation feedback system will also provide feedback on the students' learning process, such as students' online learning time reports and students' learning process reports on the MOOC platform, which can help teachers better grasp the students' learning process [14]. The system also has a pass detection module. After students complete the learning of a certain skill, the system will pop up a pass test to assess students' English skills online [15]. There are many overall analyses, but the design of empirical research on MOOC teaching and learning, especially the overall analysis of the quality of MOOC teaching, is still extremely lacking, and there is no recognized quality evaluation index system, and even the evaluation standards are in the theoretical level [16].

3. LS-Ensem Algorithm

When traditional algorithms process teaching information, the information processing process is complex, which leads to poor system performance. In the iterative process, the LS-Ensem algorithm no longer selects complex approximation functions, but selects submodels with relaxed conditions and sets a suitable This method can effectively reduce the amount of calculation and the possibility of noise, so this article chooses the LS-Ensem algorithm as the core algorithm of the system.

The partial linear square (PLS) method is a common modeling method, which has been widely used due to its simplicity and speed. However, the PLS method is a linear

algorithm, and most of the actual objects have a certain nonlinearity more or less, which causes the models obtained by the PLS algorithm to often have inaccurate predictions. The following will select the PLS algorithm as the modeling method and explain how to use the AdaBoost.Rm method to improve its prediction accuracy. Because the traditional PILS algorithm does not consider the distribution information in the modeling process. If we want AdaBoost.Rm to be able to call it, it must be improved to model both the sample and the sample distribution.

The traditional PLS algorithm decomposes the sample set S into an input matrix $X = [x_1, \ldots, x_m]'$ and an output vector $Y = [y_1, \ldots, y_m]\prime$. Among them, $(x_i, y_i), i = 1, \ldots, m$ is a sample point in S. $W \in R^{p\times r}$ in the resulting model is a weight matrix consisting of weight vectors. However, $P \in R^{p\times r}$ and $C \in R^{1\times r}$ are the loading matrices of X and y, respectively. $b \in R^{p\times 1}$ is the parameter vector of the model.

The PLS algorithm itself does not consider the distribution information on the sample set during the execution process. In order to use the AdaBoost.Rm method to improve its accuracy, it must be improved. Therefore, the following work is to improve the PLS so that the distribution information on the sample set is also considered in the calculation process without loss of generality. We assume that the distributions $D(i), i = 1, \ldots, m$ on the sample set S are all in the form of reduced fractions, that is, $D(i) = (Dn_i/Dd_i)$. Among them, S and Dd_i are relatively prime positive integers. The least common multiple Dd of all denominators $\{Dd_1, \ldots, Dd_m\}$ is calculated. The sample points in S are replicated so that the number of sample points (x_i, y_i) is $(Dd \times (Dn_i/Dd_i))$, and the extended sample set $\widetilde{S} = \{(x_1, y_1)_1, \ldots, (x_1, y_1)_{Dd\times(Dn_1/Dd_1)}, \ldots, (x_m, y_m), \ldots, (x_m, y_m)_{Dd\times(Dn_m/Dd_m)}\}$ is obtained. A simple calculation shows that there are $Dd\sum_{i=1}^{m}(Dn_i/Dd_i) = Dd$ sample points in the extended sample set $\widetilde{S}$. And, for each sample point $(x_i, y_i), i = 1, \ldots, m$, the ratio of its number in the extended sample set $\widetilde{S}$ to the total number of samples in $\widetilde{S}$ is exactly equal to D(i). That is to say, the extended sample set $\widetilde{S}$ not only contains the same sample points as the sample set $\widetilde{S}$, but also implies the distribution information on the sample set S.

Now, the extended sample set $\widetilde{S}$ is decomposed into an input matrix $\widetilde{X}$ and an output vector $\widetilde{Y}$, and then, the traditional PLS algorithm is invoked. First, the weight vector is calculated, and the input matrix $\widetilde{X}$ and output vector $\widetilde{Y}$ are brought into the PLS algorithm:

$$\begin{aligned}\widetilde{w} &= \frac{\widetilde{X}'\widetilde{y}}{(\widetilde{y}/\widetilde{y})}\\ &= \frac{D(1)\times y_1 x_1' + \cdots + D(m)\times y_m x_m'}{D(1)\times y_1^2 + \cdots + D(m)\times y_m^2}\\ &= \frac{X'(D\cdot y)}{y'(D\cdot y)}.\end{aligned} \tag{1}$$

The symbol in the formula represents the dot product of the vector. The weight vector $\widetilde{w}$ obtained in formula (1) is normalized and recorded as $\widetilde{w} = (\widetilde{w}_1, \ldots, \widetilde{w}_p)'$. We set $t = X\widetilde{w} = [t_1, \ldots, t_m]'$ and then calculate the fractional factor $\widetilde{t}$:

$$\widetilde{t} = \widetilde{X}\widetilde{w} = \begin{pmatrix} Dd\times\dfrac{Dn_1}{Dd_1}\begin{Bmatrix}x_1\\ \vdots\\ x_1\end{Bmatrix}\\ \vdots\\ Dd\times\dfrac{Dn_m}{Dd_m}\begin{Bmatrix}x_m\\ \vdots\\ x_m\end{Bmatrix}\end{pmatrix}\left(\widetilde{w}_1, \ldots, \widetilde{w}_p\right)\prime = \begin{pmatrix} Dd\times\dfrac{Dn_1}{Dd_1}\begin{Bmatrix}t_1\\ \vdots\\ t_1\end{Bmatrix}\\ \vdots\\ Dd\times\dfrac{Dn_m}{Dd_m}\begin{Bmatrix}t_m\\ \vdots\\ t_m\end{Bmatrix}\end{pmatrix}. \tag{2}$$

Next, the load factor $\widetilde{c}$ of $\widetilde{y}$ is calculated as

$$\begin{aligned}\widetilde{c} &= \frac{\widetilde{y}\prime\widetilde{t}}{(\widetilde{t}\prime\widetilde{t})}\\ &= \frac{Dd\times(Dn_1/Dd_1)y_1t_1 + \cdots + Dd\times(Dn_m/Dd_m)y_mt_m}{Dd\times(Dn_1/Dd_1)t_1^2 + \cdots + Dd\times(Dn_m/Dd_m)t_n^2}\\ &= \frac{y\prime(D\cdot t)}{(t\prime(D\cdot t))}.\end{aligned} \tag{3}$$

In the same way, the load factor of $\widetilde{x}$ can be obtained as follows:

$$\widetilde{p} = \frac{X\prime(D\cdot t)}{(t\prime(D\cdot t))}. \tag{4}$$

For the final output model of the PL algorithm, the parameter matrix b is only related to the weight vector W and the load factors P and C.

The following continuous steady-state system modeling problem is considered. If it is assumed that data $x \in X \subset R^p$ is randomly selected according to an unknown but fixed probability distribution D, a corresponding real number $g \in R$ is assigned to each data x, so that (x, g) satisfies an unknown functional relationship $y = F^*(x) \in [-B, B]$. A sample set $S = \{(x_1, y_1), \ldots, (x_m, y_m)\}$ is given, and the goal is to select a model $\widehat{F} \in F$ in a given model set F, so that the specified loss function $L(g, F(x))$ is the smallest relative to the probability distribution D on the entire set X value, that is,

$$\widehat{F} = \arg\min_{F\in F} E_{y,x}L(y, F(x)). \tag{5}$$

The variance function is one of the most commonly used loss functions. In the following discussion, the variance function will be adopted as the loss function, that is $L(y, F(x)) = (1/2)(y - F(x))^2$. The goal then becomes to find a model F: $X\longrightarrow R$ that minimizes the following (generalization) error:

$$er_D(F) = E_{y,x}\left[\frac{1}{2}(y - F(x))^2\right]. \tag{6}$$

In order to solve the problem of minimizing the loss function in formula (5), the model function F can be regarded as the parameter of the loss function $L(g, F(x))$. The gradient descent method in numerical optimization is borrowed to perform a gradient descent search in the model set to find the model function $\widehat{F}(x) = F_T(x) = \sum_{t=0}^{T} f_t(x)$ that minimizes the loss function $L(y, F(x))$. Here, $f_0(x)$ is the initialization function, T is the number of search iterations, and $\{f_t(x)\}_1^T$ is the sequence of incremental functions obtained using the gradient descent algorithm. Among them, $f_t(x) \triangleq -\rho_t g_t(x)$ is the incremental function obtained by the t-th search, and $g_t(x) = [\partial\phi(F(x))/\partial F(x)]_{F(x)=F_{t-1}(x)} = [\partial E_y[L(y, F(x))|x]/\partial F(x)]_{F(x)=F_{t-1}(x)}$ represents the gradient direction of the loss function. We set $\phi(F) = E_{y,x}L(y, F(x)) = E_x[E_y(L(y, F(x)))|x]$ and $\phi(F(x)) = E_y[L(y, F(x))|x]$, and then, we have

$$\begin{aligned} g_t(x) &= [\partial\phi(F(x))/\partial F(x)]_{F(x)=F_{t-1}(x)} \\ &= \left[\partial E_y[L(y, F(x))|x]/\partial F(x)\right]_{F(x)=F_{t-1}(x)}. \end{aligned} \tag{7}$$

If sufficient regularity is assumed, the differential and integral operators in formula (7) can be interchanged, and we can get

$$g_t(x) = E_y\left[\frac{\partial L(y, F(x))}{\partial F(x)}|x\right]_{F(x)=F_{t-1}(x)}. \tag{8}$$

Moreover, ρ_t represents the best step size $\rho_t = \text{argmin}_\rho E_{y,x}L(y, F_{t-1}(x) - \rho g_t(x))$ for searching along the negative gradient direction, and among them, there is $F_{t-1}(x) = \sum_{i=0}^{t-1} f_i(x)$.

Since the true functional relationship $*$ and probability distribution D are unknown, it is actually impossible to directly use equation (8) to solve $\widehat{g}_t(x_i)$. However, the gradient descent direction at each sample point can be estimated from the sample set:

$$-\widehat{g}_t(x_i) = -\left[\frac{\partial L(y_i, F(x_i))}{\partial F(x_i)}\right]_{F(x)=F_{t-1}(x)}. \tag{9}$$

They must be generalized over the entire domain. By solving, we get

$$\alpha_t = \arg\min_{\alpha,\beta} \sum_{1}^{m} \left[-\widehat{g}_t(x_i) - \beta h(x_i; a)\right]^2. \tag{10}$$

The (fitting) error of the real-valued function F on the sample set $S = \{(x_1, y_1), \ldots, (x_m, y_m)\}$ is defined as

$$\widehat{er}_S(F) = \frac{1}{2}\sum_{i=1}^{m}\left(y_i - F(x_i)\right)^2. \tag{11}$$

Then, the gradient descent direction on the sample point represented by formula (9) becomes

$$\begin{aligned} -\widetilde{g}_t(x_i) &= -\left[\frac{\partial L(y_i, F(x_i))}{\partial F(x_i)}\right]_{F(x)=F_{t-1}(x)} \\ &= y_i - F_{t-1}(x_i) \end{aligned} \tag{12}$$

A new variable is introduced to represent the degree of association between any submodel $h_i(x)$ in the model set H, and the negative gradient $\{\widetilde{y}_i\}_1^m$. λ_t is defined as follows:

$$\lambda_t = \frac{\left|\sum_{i=1}^{m} h_t(x_i)\widetilde{y}_i\right|}{\sqrt{\left(\sum_{i=1}^{m}\widetilde{y}_i^2\right)}\cdot\sqrt{\left(\sum_{i=1}^{m} h_t^2(x_i)\right)}}. \tag{13}$$

Therefore, according to Cauchy's inequality, we can know $\lambda_t \in [0, 1]$. If $\widetilde{y}_i, i = 1, 2, \ldots, m$ is seen as a vector with m components, $h_t(x_i), i = 1, 2, \ldots, m$ is seen as another vector with m components. Then, when there is $\lambda_t = 1$, it means that the directions of these two vectors are completely consistent or completely opposite, that is, the submodel $h(x)$ is completely correlated with. However, when there is $\lambda_t = 0$, it means that the directions of these two vectors are completely perpendicular; that is to say, there is absolutely no relationship between the submodel $h(x)$ and y.

A parameter $\lambda_0 \in [0, 1]$ is set in the LS-Ensem algorithm and λ_0 is used to ensure that each selected submodel has a certain relationship with the gradient descent direction. Obviously, the minimum degree of correlation between the submodels and the direction of gradient descent is determined by the chosen parameter λ_0.

At the same time, the optimal search step ρ_t is referred to as the iteration coefficient ρ_t in the future, which becomes

$$\rho_t = \arg\min_{\rho} \sum_{i=1}^{m}\left(\widetilde{y}_i - \rho h_i(x_i)\right)^2. \tag{14}$$

The solution of formula (14) is actually a linear optimization problem, and the analytical solution of this problem can be obtained according to the optimization method:

$$\rho_t = \frac{\sum_{i=1}^{m} h_t(x_i)\widetilde{y}_i}{\sum_{i=1}^{m} h_t^2(x_i)}. \tag{15}$$

Then, there is

$$F_t(x) = F_{t-1}(x) + \rho_t h_t(x). \tag{16}$$

There are still certain requirements for the selection of submodels in the LS-Ensem algorithm; that is, $\lambda_t \geq \lambda_0$ needs to be satisfied.

The convergence of the LS-Ensem algorithm is analyzed. It can be proved that the LS-Ensem algorithm has the following properties in the iterative process: the fitting error of the sample decreases monotonically with the increase in the number of iterations.

Theorem 1. *In the iterative process of the LS-Ensem algorithm, if there is $\lambda_0 > 0$, the following relation holds:*

$$\lambda_t \geq \lambda_0, \forall t. \tag{17}$$

Then, the fitting error of the sample order $e\hat{r}_S(F_t)$ decreases at the rate of λ_t^2.

Proof. According to the definition of (11) and formula (16), there is

$$\begin{aligned} e\hat{r}_S(F) &= \frac{1}{2}\sum_{i=1}^{m}\left(y_i - F(x_i)\right)^2 \\ &= \frac{1}{2}\sum_{i=1}^{m}\left(y_i - F_{t-1}(x_i) - \rho_t h_t(x_i)\right)^2 \\ &= e\hat{r}_S(F_{t-1}) - \frac{2\rho_t}{2}\sum_{i=1}^{m} h_t(x_i)\tilde{y}_i + 2\sum_{i=1}^{m} h_t^2(x_i). \end{aligned} \tag{18}$$

According to formula (15), the expression of ρ_t is substituted into the above formula and referring to the definition of (11), we can get

$$\begin{aligned} e\hat{r}_S(F_t) &= e\hat{r}_S(F_{t-1}) - \frac{1}{2}\frac{\left(\sum_{i=1}^{m} h_t(x_i)\tilde{y}_i\right)^2}{\sum_{i=1}^{m} h_t^2(x_i)} \\ &= \left[1 - \frac{\left(\sum_{i=1}^{m} h_t(x_i)\tilde{y}_i\right)^2}{\left(\sum_{i=1}^{m}\tilde{y}_i^2\right)\left(\sum_{i=1}^{m} h_t^2(x_i)\right)}\right] e\hat{r}_S(F_{t-1}) \\ &= \left(1-\lambda_t^2\right) e\hat{r}_S(F_{t-1}). \end{aligned} \tag{19}$$

According to Cauchy's inequality, we can know that $\lambda_t^2 = \left(\sum_{i=1}^{m} h_t(x_i)\tilde{y}_i / \left(\sum_{i=1}^{m}\tilde{y}_i^2\right)\left(\sum_{i=1}^{m} h_t^2(x_i)\right)\right) \leq 1$, and the algorithm requires that the child obtained in each round of iteration satisfies $\lambda_t \geq \lambda_0 > 0$, so there is

$$e\hat{r}_S(F_t) = \left(1-\lambda_t^2\right) e\hat{r}_S(F_{t-1}) < e\hat{r}_S(F_{t-1}). \tag{20}$$

It can be seen from Theorem 1 that, under the given conditions, the fitting error on the samples in the LS-Ensem algorithm decreases with the increase in the number of iterations. According to this property, it can be further proved that the fitting error of the LS-Ensem algorithm to the sample can be arbitrarily small after a finite number of iterations. □

Theorem 2. *We set the sample (x, g) to satisfy some unknown bounded function relation $y = F^*(x) \in [-B, B]$. If there is $\lambda_0 > 0$ so that formula (17) holds, for any given positive real number ϵ, the fitting error of the corresponding LS-Ensem algorithm on FT does not exceed e after several iterations. Among them, $\lambda_{\min} \geq \lambda_0 > 0$ is the infimum of $\lambda_t, t = 1, 2, \ldots, T$ obtained in the iterative process:*

$$T = \left\lceil \frac{\ln\left(2\epsilon / mB^2\right)}{\ln\left(1-\lambda_{\min}^2\right)} \right\rceil. \tag{21}$$

Proof. Since there is $F_0(x) = \overline{y} = (1/m)\sum_{i=1}^{m} y_i$, there is

$$\begin{aligned} e\hat{r}_S(F_0) &= \frac{1}{2}\left[\left(y_1 - \overline{y}\right)^2 + \left(y_2 - \overline{y}\right)^2 + \cdots + \left(y_m - \overline{y}\right)^2\right] \\ &= \frac{1}{2}\left[y_1^2 + \cdots + y_m^2 + m\overline{y}^2 - 2\left(y_1 + \cdots + y_m\right)\overline{y}\right] \\ &= \frac{1}{2}\left[y_1^2 + \cdots + y_m^2 - m\overline{y}^2\right] \\ &\leq \frac{1}{2}\left(y_1^2 + \cdots + y_m^2\right) \leq \frac{m}{2}B^2. \end{aligned} \tag{22}$$

Since there is $\lambda_t \geq \lambda_0$ in each iteration, there must be an infimum $\lambda_{\min}$ that satisfies $\lambda_{\min} \geq \lambda_0 > 0$. According to Theorem 1, after t iterations, there is [17]

$$\begin{aligned} e\hat{r}_S(F_t) &< e\hat{r}_S(F_0) \cdot \left(1-\lambda_{\min}^2\right)^t \\ &\leq \frac{m}{2}B^2 \cdot \left(1-\lambda_{\min}^2\right)^t. \end{aligned} \tag{23}$$

If T is chosen such that there is $(m/2)B^2 \cdot \left(1-\lambda_{\min}^2\right)^T \leq \epsilon$, there must be $e\hat{r}_S(F_t) \leq \epsilon$. By taking the logarithm of both sides of $(m/2)B^2 \cdot \left(1-\lambda_{\min}^2\right)^T \leq \epsilon$, we can get

$$T\ln\left(1-\lambda_{\min}^2\right)^T \leq \ln\left(\frac{2\epsilon}{mB^2}\right). \tag{24}$$

Since there is $1 > \lambda_{\min} > 0$, that is, $\left(1-\lambda_{\min}^2\right) < 0$, there is

$$T \geq \frac{\ln\left(2\epsilon / mB^2\right)}{\ln\left(1-\lambda_{\min}^2\right)}. \tag{25}$$

Theorem 2 shows that under the given conditions, the LS-Ensem algorithm is convergent. It can be further proved that although the LS-Ensem algorithm minimizes the fitting error $e\hat{r}_S(F)$ for a given sample as the objective function, it still has good generalization performance. That is to say, when the number of samples and the number of iterations meet certain requirements, the model F obtained by the algorithm will make the generalization error $er_D(F_T)$ defined in (6) arbitrarily small over the entire input space. □

Theorem 3. *If it is assumed that all data $x \in X \subset R^n$ in the input space are randomly selected according to an unknown but fixed probability distribution D, each data x corresponds to a real number $y \in R$, which satisfies an unknown functional relationship $y = F^*(x) \in [-B, B]$. The optimal search step size obtained in each iteration satisfies $p \leq C$. Then, for V6 ϵ(0,1) and Ve > 0, when the number of samples satisfies*

$$\begin{aligned} m = m_L(\epsilon, \delta) &\geq \frac{C_1 K^4}{\epsilon^2}\ln\left(\frac{4}{\delta}\right) \\ &+ \frac{C_1 K^4 q}{\epsilon^2}\left\lceil\frac{C_2 K^6}{\epsilon^2}\right\rceil \ln\left(\frac{C_3 e K^7 \left\lceil C_2 K^6/\epsilon^2\right\rceil}{\epsilon^2}\right). \end{aligned} \tag{26}$$

The model F_T obtained after

$$T = \left\lceil \frac{\ln\left(\in /m\mathrm{B}^2\right)}{\ln\left(1-\lambda_{\min}^2\right)} \right\rceil. \tag{27}$$

Iterations satisfy $er_D(F_T) < \in$ with a probability not less than $1-\delta$ in the entire input space.

Proof. $\in$ and δ are given so that the sample set S contains $m = m_L(\in, \delta)$ samples. First, according to Theorem 1, after $T = \left\lceil \ln(\in /m\mathrm{B}^2)/\ln(1-\lambda_{\min}^2) \right\rceil$ iterations, the fitting error on the sample set is called $e\hat{r}_S(F_T) < \in/2$.

The sample and model F_T will be normalized below. Since the value range of $h \in H$ is $[-1, 1]$ and there is $\rho_t \le C$, we can get [18]

$$\left|F_T(x)\right| \le \left|\overline{y} + \sum_{t=1}^{T} \rho_t\right| \le |C|T + |\overline{y}|. \tag{28}$$

$y \in [-B, B]$ is in the sample, so we set

$$K = \max\left((|C|T + |\overline{y}|) + B\right). \tag{29}$$

K normalizes the sample and model F_T to get $y_i' = (1/2K)y + (1/2), F_T' = (1/2K)F_T + (1/2)$. Then, there is

$$\begin{aligned} er_D\left(F_T'\right) &= E\left(y\imath - F_T'(x)\right)^2 \\ &= \frac{1}{4K^2} er_D\left(F_T\right) \\ e\hat{r}_S\left(F_T'\right) &= \frac{1}{4K^2} e\hat{r}_S\left(F_T\right). \end{aligned} \tag{30}$$

The model set to which the model F_T belongs is represented by F, and the function set to which the processed function F_T' belongs is represented by F' [19].

Then, there is

$$\begin{aligned} &P^m\left\{\exists F_T \in F\colon \left|er_D\left(F_T\right) - e\hat{r}_S\left(F_T\right)\right| \ge \frac{\in}{2}\right\} \\ &= P^m\left\{\exists F_F' \in F\imath\colon \left|er_D\left(F_T'\right) - e\hat{r}_S\left(F_T'\right)\right| \ge \frac{\in}{8K^2}\right\} \\ &\le 4N_1\left(\frac{\in}{2^7K^2}, F\imath, 2m\right)\exp\left(-\frac{m\in^2}{2^{11}K^4}\right) \\ &\le 4N_2\left(\frac{\in}{2^7K^2}, F\imath, 2m\right)\exp\left(-\frac{m\in^2}{2^{11}K^4}\right) \\ &\le 4N_2\left(\frac{\in}{2^8K^3}, H, 2m\right)^{\left\lceil K^6 2^{16}/\in^2\right\rceil} \cdot \exp\left(-\frac{m\in^2}{2^{11}K^4}\right) \\ &\le 4\left(\frac{em4k_1K^3}{\in q}\right)^{q\left\lceil C^2K^6/\in^2\right\rceil} \cdot \exp\left(-\frac{m\in^2}{k_2K^4}\right). \end{aligned} \tag{31}$$

Among them, P^m represents the joint distribution of m independent random samples. If we want to make the above formula less than δ, that is,

$$4\left(\frac{em4k_1K^3}{\in q}\right)^{q\left\lceil C^2K^6/\in^2\right\rceil} \cdot \exp\left(-\frac{m\in^2}{k_2K^4}\right) < \delta. \tag{32}$$

Then, there should be

$$q\left\lceil \frac{C^2K^6}{\in^2} \right\rceil \ln\left(\frac{em4k_1K^3}{\in q}\right) - \left(-\frac{m\in^2}{k_2K^4}\right) < \ln\left(\frac{\delta}{4}\right). \tag{33}$$

The value of mL that makes inequality (33) true is found below. We set $b = q\left\lceil C^2K^6/\in^2\right\rceil$, $A = m_L$, and $B = (\in^2/2k_2K^4b)$. The above A and B are substituted into x and y to get, respectively:

$$\begin{aligned} \frac{m_L\in^2}{2k_2K^4b} &\ge \ln\left(m_L\right) + \ln\left(\frac{\in^2}{2k_2K^4b}\right) \\ &+ 1 \ge \ln\left(m_L\right) + \ln\left(\frac{\in^2}{2k_2K^4b}\right). \end{aligned} \tag{34}$$

Furthermore, there are

$$\frac{m_L\in^2}{2k_2K^4} \ge b \cdot \ln\left(\frac{\in^2 m_L}{2k_2K^4b}\right). \tag{35}$$

If the following inequality holds, there is

$$\frac{m_L\in^2}{2k_2K^4} \ge \ln\left(\frac{4}{\delta}\right) + b\ln\left(\frac{4k_1 2k_2 eK^7 b}{\in^3 q}\right). \tag{36}$$

Inequalities (35) and (36) are added together to get

$$\begin{aligned} \frac{m_L\in^2}{2k_2K^4} &\ge \ln\left(\frac{4}{\delta}\right) + b\ln\left(\frac{\in^2 m_L}{2k_2K^4b} \times \frac{4k_1 2k_2 eK^7 b}{\in^3 q}\right) \\ &= -\ln\left(\frac{4}{\delta}\right) + q\left\lceil \frac{C^2K^6}{\in^2} \right\rceil \ln\left(\frac{em_L4k_1K^3}{\in q}\right). \end{aligned} \tag{37}$$

This is inequality (33). $C_1 = 2k, C_3 = 4k_1 2k_2$ is substituted into inequality (36) to get

$$m_L \ge \frac{C_1K^4}{\in^2}\ln\left(\frac{4}{\delta}\right) + \frac{C_1K^4q}{\in^2}\left\lceil \frac{C^2K^6}{\in^2} \right\rceil \ln\left(\frac{C_3eK^7\left\lceil C^2K^6/\in^2\right\rceil}{\in^3}\right). \tag{38}$$

This is inequality (26). Therefore, when inequality (26) holds, there is

$$P^m\left\{\exists F_T \in F\colon \left|er_D\left(F_T\right) - e\hat{r}_S\left(F_T\right)\right| < \frac{\in}{2}\right\} \ge 1 - \delta. \tag{39}$$

Among them, there is $T = \left\lceil \ln(\in /mB^2)/\ln(1-\lambda_{\min}^2) \right\rceil$. At the same time, because of $e\hat{r}_S(F_T) \le (\in /2)$, there is

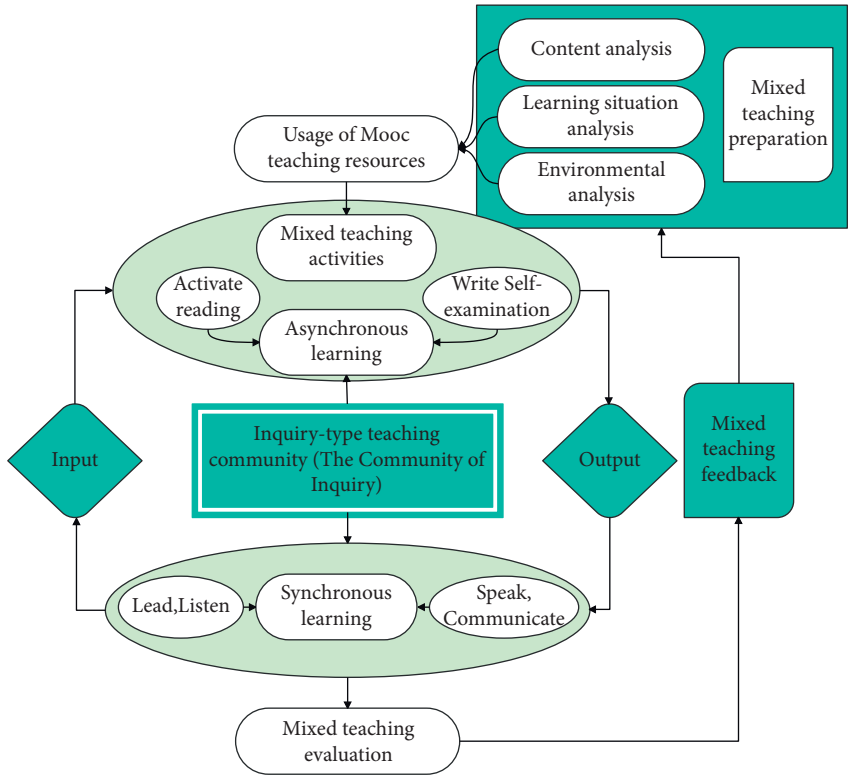


Figure 1: The blended English listening and speaking teaching model combining traditional classrooms and MOOCs.

$$P^m\left\{\exists F_T \in F: \left|er_D\left(F_T\right)\right| < \epsilon\right\} \geq 1 - \delta. \tag{40}$$

□

4. Teaching Effect Evaluation Mechanism of English MOOC Combined with LS-SEM Intelligent System

Based on the research results of the blended teaching model at home and abroad, the model in this study is divided into three stages (as shown in Figure 1): preparation, activity, and evaluation.

This article proposes a new teaching method, also known as the inverted classroom. It refers to disrupting the conventional teaching order, putting the course content after class, allowing students to learn or complete in advance according to the teaching task, and the teacher answering questions in the classroom. The flipped classroom breaks through the traditional teaching mode and allows students to learn independently through the online teaching platform. For example, before class, teachers can publish a video of class introduction on the online teaching platform, and teachers and students should discuss and analyze the questions raised by the video content, so as to promote real-time communication between teachers and students. The teaching process of the combination of flipped classroom and MOOC is shown in Figure 2:

The general introduction of the English MOOC design is shown in Figure 3. (1) Teaching method: online self-learning (microvideo, PPT, audio, and other electronic network resources) + classroom teaching (problem-based classroom discussions, reports, summaries, etc.). (2) Teaching objectives: to learn language skills through a combination of autonomy and practice, and to improve students' comprehensive English application ability. (3) Teaching content: based on the "Comprehensive Course of College English in the New Century," a college English MOOC teaching course with eight thematic units has been independently developed and designed. (4) Class schedule: a total of 40 class hours, including 2 class hours for course introduction (detailed introduction to the course, teaching calendar, teaching plan, classroom group discussion methods, and video viewing content, offline Q&A, etc.) and 32 class hours for unit theme teaching (4 class hours per unit), and 6 class hours for final review (the problems in this semester are sorted out, summarized, and the key points and difficulties are summarized). (5) Assessment method: online test + usual performance + final test.

Blended learning curriculum design can be divided into three stages: front-end analysis, activity and resource design, and teaching evaluation design. The flipped classroom teaching mode emphasizes the replanning of preclass, in-class, and after-class links and the subversion of traditional knowledge transfer and knowledge internalization. Based on this, this study designed the basic framework of the MOOC-based flipped classroom teaching model, as shown in Figure 4.

This article proposes a relatively simplified and fast online course production and presentation process. As shown in Figure 5, first, the user uploads the courseware

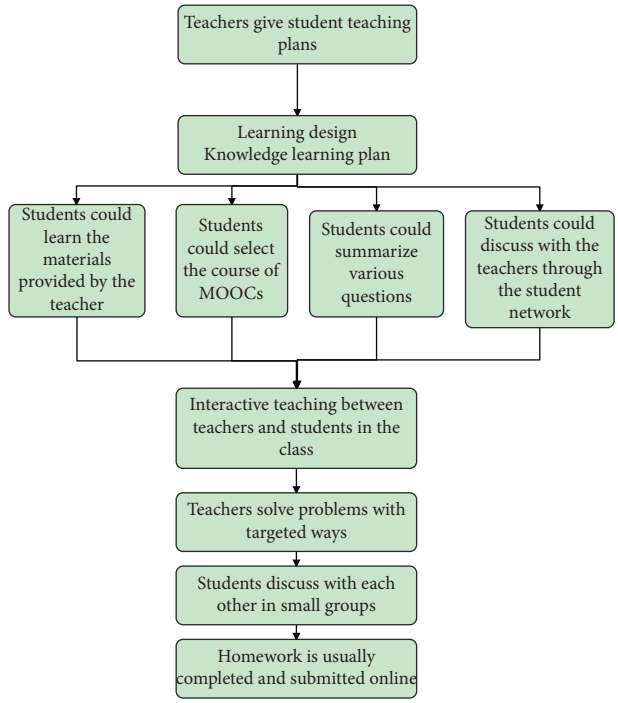


Figure 2: The intelligent teaching mode combining MOOC and flipped classroom.

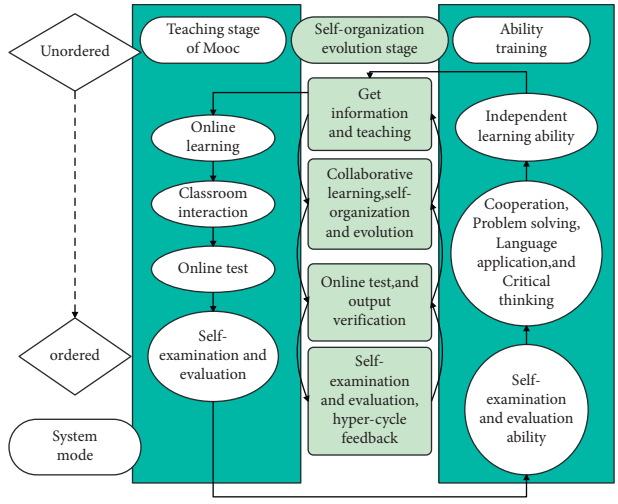


Figure 3: The strategy of self-organizing evolution of English MOOC system.

made to the server through the web-side platform, and the system automatically extracts the courseware into a picture set by calling a third-party service. After that, users can use mobile devices.

This article divides the "Qing MOOC" system into five functional modules: course management module, user management module, course playback module, course comment and evaluation module, and course production module. As shown in Figure 6, the course management module and the course production module are mainly for the user to complete the whole supply process of the course, including the uploading, saving and conversion of

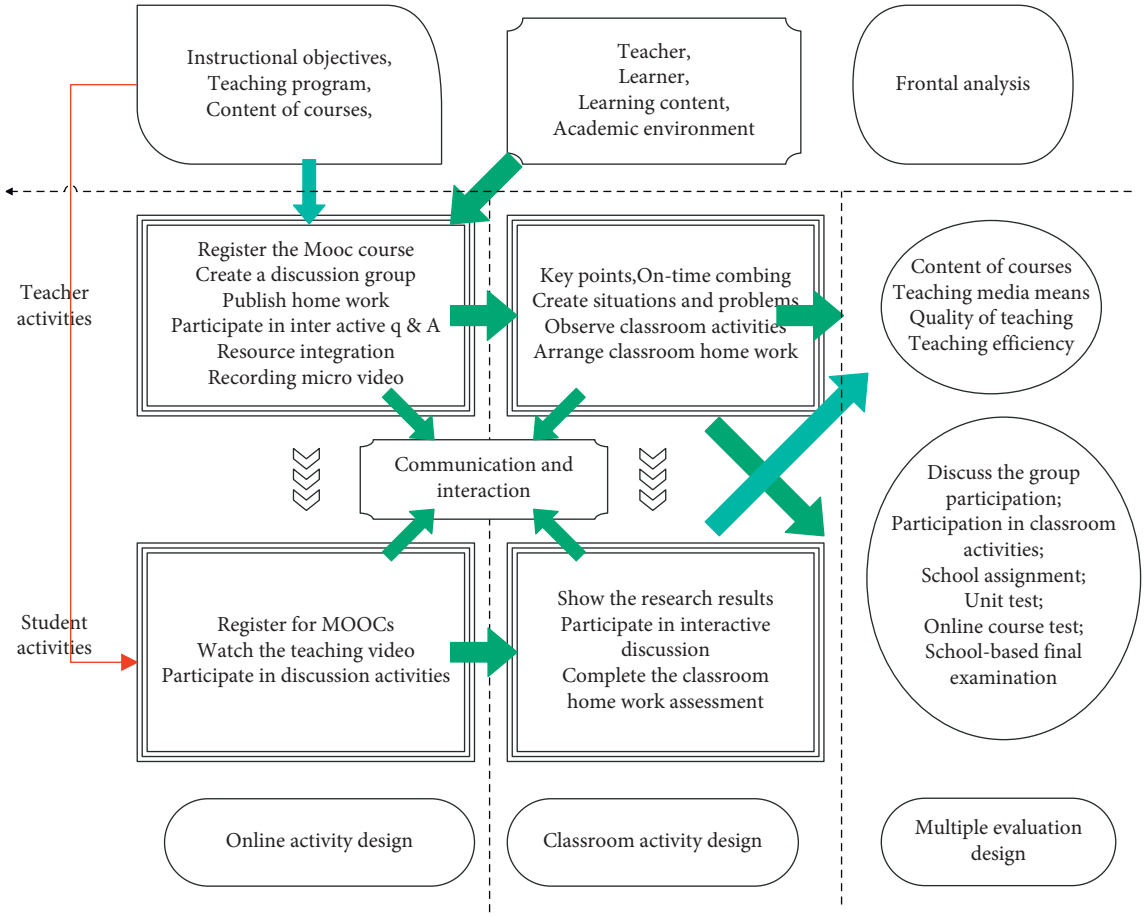


Figure 4: Framework of flipped classroom teaching mode based on MOOC.

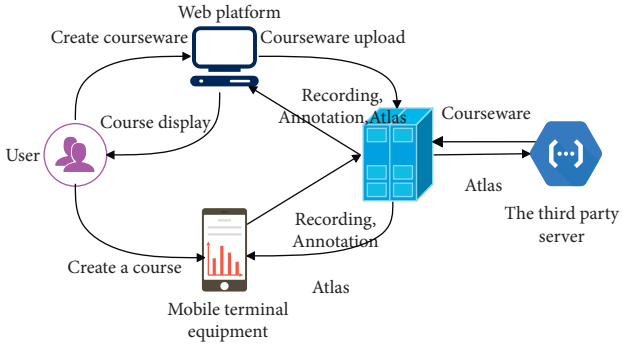


Figure 5: System course production and presentation process design.

courseware, course making, publishing, editing, deleting and classifying, and other steps.

The overall function realization process of the system is roughly shown in Figure 7.

The platform is deployed based on the Tomcat6 web server, which effectively reduces the overall deployment cost and supports load balancing technology. The platform needs to publish a large number of courses and at the same time

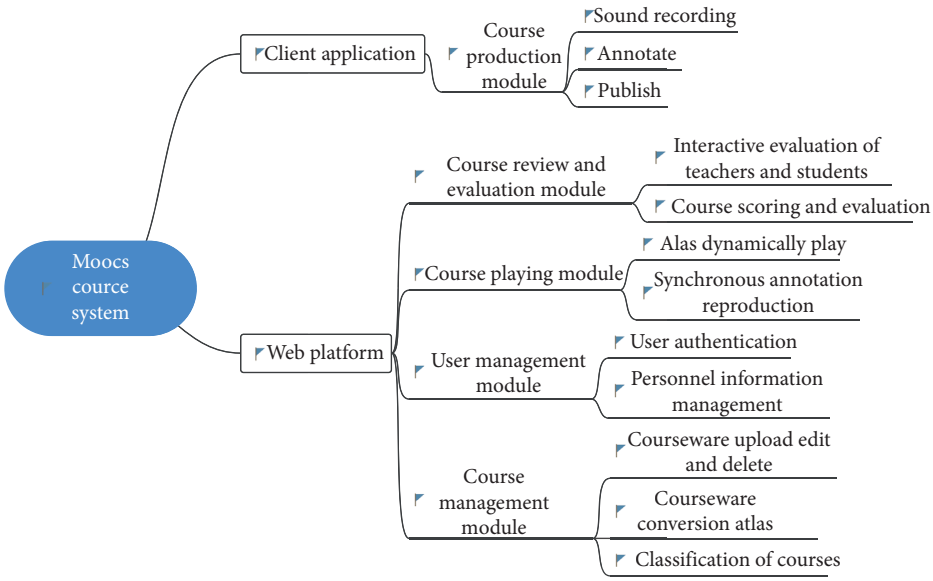


Figure 6: System functional module design diagram.

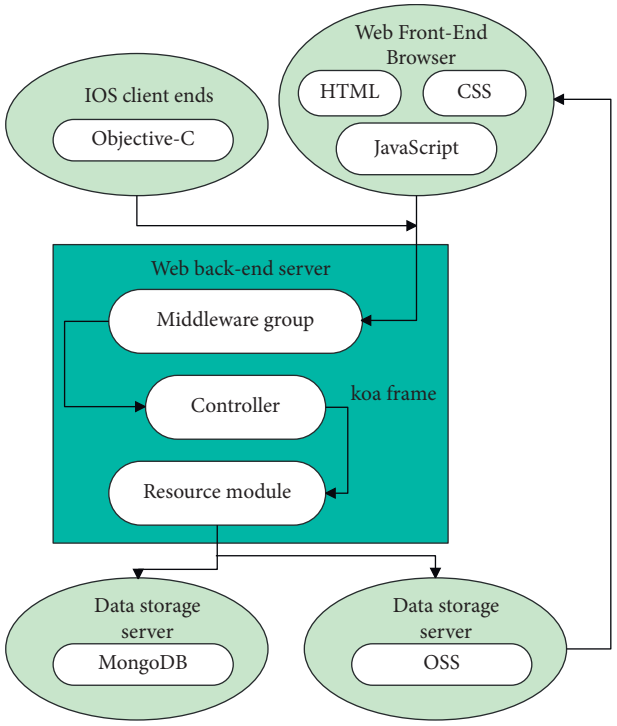


Figure 7: Schematic diagram of system data flow.

needs to support a large number of students to watch, and it is decided that the platform uses Flex4 and Red5 video server

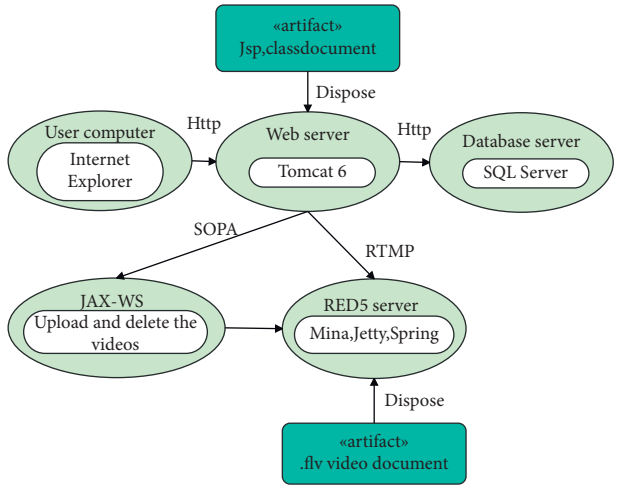


Figure 8: Architecture diagram of the MOOC platform combined with the LS-SEM intelligent system.

technology to play video files. The architecture of the platform is shown in Figure 8.

On the basis of the above research, this article combines the LS-SEM intelligent system to evaluate the effect of the English MOOC teaching constructed in this article and counts the teaching effect of the English MOOC teaching system in this paper, and obtains the evaluation results shown in Table 1 and Figure 9.

Table 1: The evaluation results of the LS-SEM intelligent system on the English MOOC teaching constructed in this article.

Num	Evaluate
1	82.85
2	78.42
3	83.99
4	88.16
5	85.96
6	81.69
7	83.31
8	81.98
9	87.63
10	78.86
11	83.73
12	82.33
13	82.66
14	86.07
15	84.78
16	80.15
17	79.16
18	82.31
19	82.17
20	83.75
21	81.90
22	84.90
23	83.97
24	81.85
25	84.92
26	87.94
27	87.44
28	84.25
29	79.42
30	82.20
31	85.84
32	88.56
33	85.57
34	80.81
35	86.20
36	84.72
37	83.30
38	87.91
39	82.09
40	79.04
41	80.41
42	78.47
43	84.29
44	87.05
45	78.80
46	85.91
47	80.79
48	85.47
49	82.55
50	81.70
51	82.00
52	85.44
53	79.65
54	85.45

From Figure 9, we can draw the evaluation results of the LS-SEM intelligent system on the English MOOC teaching constructed in this article. A total of 54 sets of simulation experiments were carried out. It can be seen from the data in the figure that the minimum evaluation score is not less than 78 points. From the perspective of traditional spinning methods, the LS-SEM intelligent system has a high improvement in the teaching effect of English MOOCs and has certain practicality.

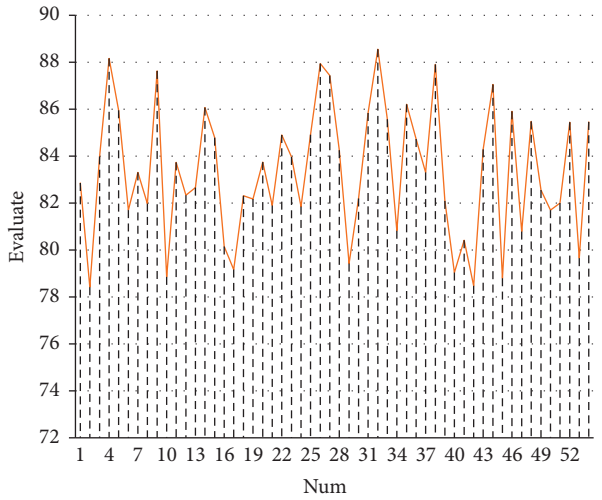


Figure 9: Statistical diagram of test results.

The above research shows that the English MOOC teaching effect evaluation mechanism combined with the LS-SEM intelligent system can play an important role in English MOOC teaching.

5. Conclusion

College English follow-up courses refer to content-based college English courses offered to students by colleges and universities after completing the teaching of the basic stage of college English, including ESP courses, subject English courses, and general education courses in college English. In recent years, the academic circles have carried out a lot of thinking and discussion on the curriculum setting and course orientation of college English follow-up courses, and the analysis of relevant learners' needs has also confirmed the necessity of carrying out follow-up course teaching in the college English stage. In order to analyze the teaching effect of English MOOC, this article constructs an evaluation mechanism based on the LS-SEN intelligent system and obtains an intelligent MOOC system. The experimental research results show that the English MOOC teaching effect evaluation mechanism combined with the LS-SEM intelligent system can play an important role in English MOOC teaching.

Data Availability

The labeled dataset used to support the findings of this study is available from the author upon request.

Conflicts of Interest

The author declares no conflicts of interest.

Acknowledgments

This work was supported by the Shangqiu Institute of Technology.

References

[1] A. S. Fatimah, S. Santiana, and Y. Saputra, "Digital comic: an innovation of using toondoo as media technology for teaching English short story," *English Review: Journal of English Education*, vol. 7, no. 2, pp. 101–108, 2019.

[2] B. Ayçiçek and T. Y. Yelken, "The effect of flipped classroom model on students' classroom engagement in teaching English," *International Journal of Instruction*, vol. 11, no. 2, pp. 385–398, 2018.

[3] N. Guzachchova, "Zoom technology as an effective tool for distance learning in teaching English to medical students," Бюллетень науки и Црактики, vol. 6, no. 5, pp. 457–460, 2020.

[4] M. S. Hadi, "The use of song in teaching English for junior high school student," *English Language in Focus (ELIF)*, vol. 1, no. 2, p. 107, 2019.

[5] A. Mahboob, "Beyond global Englishes: teaching English as a dynamic language," *RELC Journal*, vol. 49, no. 1, pp. 36–57, 2018.

[6] H. Sundari, "Classroom interaction in teaching English as foreign language at lower secondary schools in Indonesia," *Advances in Language and Literary Studies*, vol. 8, no. 6, p. 147, 2017.

[7] A. Gupta, "Principles and practices of teaching English language learners," *International Education Studies*, vol. 12, no. 7, p. 49, 2019.

[8] B. Abdelshaheed, "Using flipped learning model in teaching English language among female English majors in majmaah university," *English Language Teaching*, vol. 10, no. 11, p. 96, 2017.

[9] T. A. Ashraf, "Teaching English as a foreign language in Saudi Arabia: struggles and strategies," *International Journal of English Language Education*, vol. 6, no. 1, p. 133, 2018.

[10] O. Tarnopolsky, "Principled pragmatism, or well-grounded eclecticism: a new paradigm in teaching English as a foreign language at Ukrainian tertiary schools?" *Advanced Education*, vol. 5, no. 10, pp. 5–11, 2018.

[11] N. I. Sayakhan and D. H. Bradley, "A nursery rhymes as a vehicle for teaching English as a foreign language," *Journal of University of Raparin*, vol. 6, no. 1, pp. 44–55, 2019.

[12] D. A. W. Nurhayati, "Students' perspective on innovative teaching model using edmodo in teaching English phonology: a virtual class development," *Dinamika Ilmu*, vol. 19, no. 1, pp. 13–35, 2019.

[13] A. B. Rinekso and A. B. Muslim, "Synchronous online discussion: teaching English in higher education amidst the covid-19 pandemic," *JEE*, vol. 5, no. 2, pp. 155–162, 2020.

[14] A. S. N. Agung, "Current challenges in teaching English in least-developed region in Indonesia," *SOSHUM: Jurnal Sosial dan Humaniora*, vol. 9, no. 3, pp. 266–271, 2019.

[15] M. A. Saydaliyeva, E. B. Atamirzayeva, and F. X. Dadaboyeva, "Modern methods of teaching English in Namangan state university," *International Journal on Integrated Education*, vol. 3, no. 1, pp. 8-9, 2020.

[16] L. B. Kelly, "Preservice teachers' developing conceptions of teaching English learners," *Tesol Quarterly*, vol. 52, no. 1, pp. 110–136, 2018.

[17] A. Coşkun, "The application of lesson study in teaching English as a foreign language," *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, vol. 18, no. 1, p. 151, 2017.

[18] M. Siregar, "The use of pedagogical translation in teaching English by scientific approach," *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, vol. 2, no. 4, pp. 111–119, 2019.

[19] M. Atiquzzaman, N. Yen, and Z. Xu, *Big Data Analytics for Cyber-Physical System in Smart City*, Vol. 1117, Springer Nature, Shenyang, China, 2020.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 2604761, 9 pages
https://doi.org/10.1155/2022/2604761

Research Article

Optimization of Digital Management Path for Human Resource Performance Evaluation Based on Multiobjective Decision-Making Mathematical Model

Li Liu and Seechen Yong

Graduate School of Business, Segi University, Kota Damansara, Petaling Jaya, Selangor, Malaysia

Correspondence should be addressed to Seechen Yong; sukd1800941@segi4u.my

Received 13 April 2022; Revised 30 May 2022; Accepted 14 June 2022; Published 6 July 2022

Academic Editor: Wen Zhou

Talent is an indispensable and important factor for the development and growth of an enterprise. Therefore, human resources have become an important resource of enterprises, and performance appraisal in human resource management has also become one of the important contents of modern enterprise management. Without a set of scientific and standardized performance appraisal systems, it will make it difficult for the daily human resource performance management of enterprises to achieve the expected goals. This study analyzes the actual needs, business processes, and existing problems of an enterprise in performance management and uses the multiobjective decision-making mathematical model to obtain an optimization plan for human resources performance assessment. Finally, a digital management system for enterprise performance appraisal is designed. The main work of this study is as follows: (1) based on the work characteristics of a certain enterprise, the key indicators of enterprise performance evaluation are analyzed; (2) a multiobjective decision-making mathematical model is constructed for the optimization of human resources performance evaluation; (3) the Hungarian algorithm is used to solve the construction The mathematical model of multiobjective decision-making can obtain the optimal work arrangement. This study combines performance appraisal with practical work and uses the proposed multiobjective decision-making mathematical model to obtain the optimization results of human resources, guide practical work, and improve the efficiency of enterprise operation.

1. Introduction

At present, the competition for human resources is becoming more and more fierce, and the most important thing for enterprises to win in the competition for talents is to build a team with both ability and political integrity. In an enterprise, senior managers are responsible for decision-making, middle managers are responsible for implementation, and ordinary employees are responsible for implementation, which determines whether the strategic goals of the enterprise can be achieved. The key to personnel team building is to strengthen performance appraisal management. In order to implement corporate goals and ensure the realization of corporate business goals, many companies are promoting performance appraisal systems. Through regular performance evaluation, we can timely understand the ability and evaluation of each personnel to ensure the realization of enterprise management goals. At present, the main global performance management methods are key performance indicator (KPI) and balanced scorecard (BSC). The key performance indicator method is to decompose the strategic objectives of the organization to generate operational objectives and promote the realization of enterprise objectives through the completion of performance indicators. This method points out that the design of key performance indicators should be matched with corporate goals. BSC is to transform the goals of the enterprise into a comprehensive set of performance indicators, as a monitoring tool for the operation of the enterprise. Foreign research on performance appraisal is earlier and has been widely practiced in enterprises. However, due to the different management concepts in different regions, there are also differences in specific practices. Performance evaluation in

European and American countries focuses on the evaluation of individual behavior and qualifications. In recent years, the assessment of qualifications has also been widely used in the performance appraisal of organizations. Most scholars summarize performance management into eight aspects: the first is the proficiency in specific work.

References [1, 2] argue that performance is not a result, but it is a behavior. It includes goal-related behavior under the individual's control. Whether these behaviors are cognitive, driven, spiritual, or interpersonal is determined. Reference [3] expresses their view of performance behavior by distinguishing "behavior," performance," and "result." They see behavior as what people do when they work. Performance is behavior with measurable elements. These behaviors have a positive or negative effect on individual or organizational effectiveness. Outcomes are the states of people or things that change as a result of performance, thereby benefiting or hindering the achievement of organizational goals. Reference [4] states that behavior is a part of any definition of performance, just as results or outcomes that can theoretically be linked to behavior. Simply defining performance as either an action or an outcome is not comprehensive enough. Perspectives of performance as outcomes and processes each have their advantages and disadvantages. Compared with the performance appraisal of enterprises in western developed countries, the performance appraisal of enterprises in my country started relatively late, and it is still in its infancy. Although my country's enterprise performance appraisal system and methods have been continuously improved in recent years, with the deepening of economic and political system reforms, more and more problems have been exposed in my country's enterprise performance appraisal. The problems that are mainly reflected in are as follows: (1) the assessment system is difficult to implement. First, there is a gap with the actual requirements. The grass-roots assessment management system either copied the assessment system of the higher level or made simple modifications and did not refine and quantify it according to its own reality, which is easy to deviate from reality. Second, the assessment criteria were not refined and quantified, which affected the objectivity and fairness of the assessment. The third is that the responsibilities of different positions in the grass-roots units are different, the daily management and management work are difficult to quantify, and the assessment results cannot completely and truly reflect the performance of the unit and individual. (2) There are flaws in the performance appraisal process. First, it does not pay attention to the performance appraisal management in daily work. The second is the poor combination of performance appraisal management and inspection guidance. After the assessment, the underlying reasons behind the assessment results were not analyzed, and the grass-roots units were not promptly helped to improve measures and strengthen management. The third is that the performance appraisal method emphasizes the form rather than the actual effect. The assessment is mainly based on written materials. If the written materials are confirmed, then it is considered that the work has been carried out or carried out well. Conversely, if the written materials cannot be verified, then it will be deemed that the work has not been carried out or that the work has not been carried out well. (3) The incentive function of the assessment has not been brought into full play. First, the demonstration effect of the assessment is not obvious. Second, there is not enough attention to the further application of the assessment results.

To sum up, in order to truly reflect the scientificity and rationality of performance appraisal settings, it is necessary to put people first, optimize the appraisal system, and design a digital performance appraisal management system. The information platform is used to enhance the transparency of assessment, the entire assessment process is standardized, and supervision is strengthened. This study analyzes the actual needs, business processes, and problems of an enterprise's current performance management and uses the multiobjective decision-making mathematical model to obtain an optimization plan for human resource performance assessment. Finally, a digital management system for enterprise performance assessment is designed. The main work of this study is as follows: (1) based on the work characteristics of an enterprise, a performance appraisal system is designed to lay a solid foundation for the optimal management of human resources; (2) a multiobjective decision-making mathematical model is constructed for the optimal design of human resources performance appraisal; (3) performance appraisal is combined with actual work, using the proposed multiobjective decision-making mathematical model to get the results of human resource optimization, so as to guide practical work and improve enterprise operation efficiency.

2. Human Resource Performance Appraisal-Related Theories

2.1. Overall Structure of Performance Appraisal Digital Management Platform. The performance appraisal system is a part of the human resource management platform. Usually, the human resource management platform adopts a B/S structure. The client does not need to be installed, and the user layer, application service layer, and data service layer are reasonably distributed. Database servers and application servers are centrally deployed within the enterprise. At present, the human resource management system can not only achieve high performance, easy expansion, easy integration, high reliability, high security, etc., but also general enterprise organizational structure management, user management, user group management, role management, fine-grained authority control, workflow management, etc. The human resource management system has high performance and high reliability, so that the enterprise project team can focus on the realization of the business function of the project itself, thereby reducing development investment and resource consumption in software stability, ease of use, scalability, security, etc. The system architecture of the human resource management platform is shown in Figure 1.

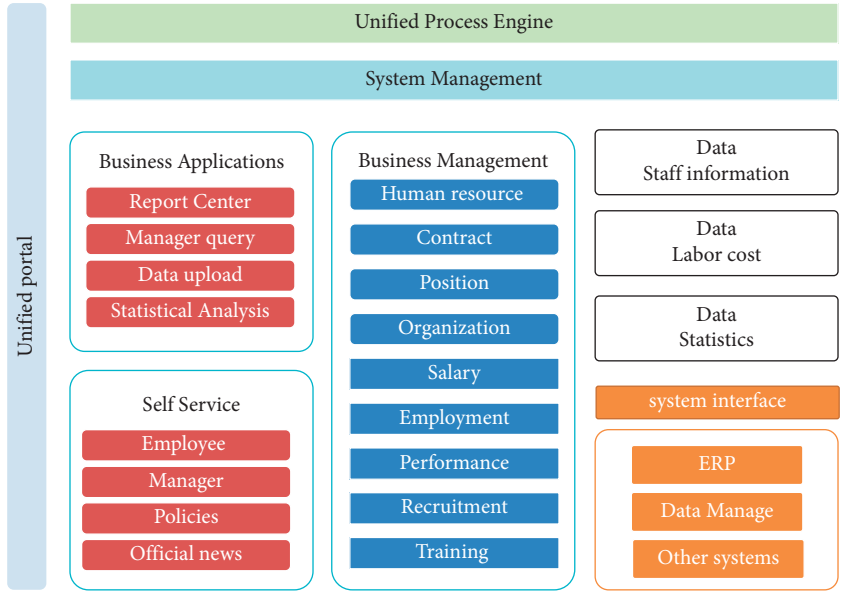


Figure 1: Architecture of the human resource management system.

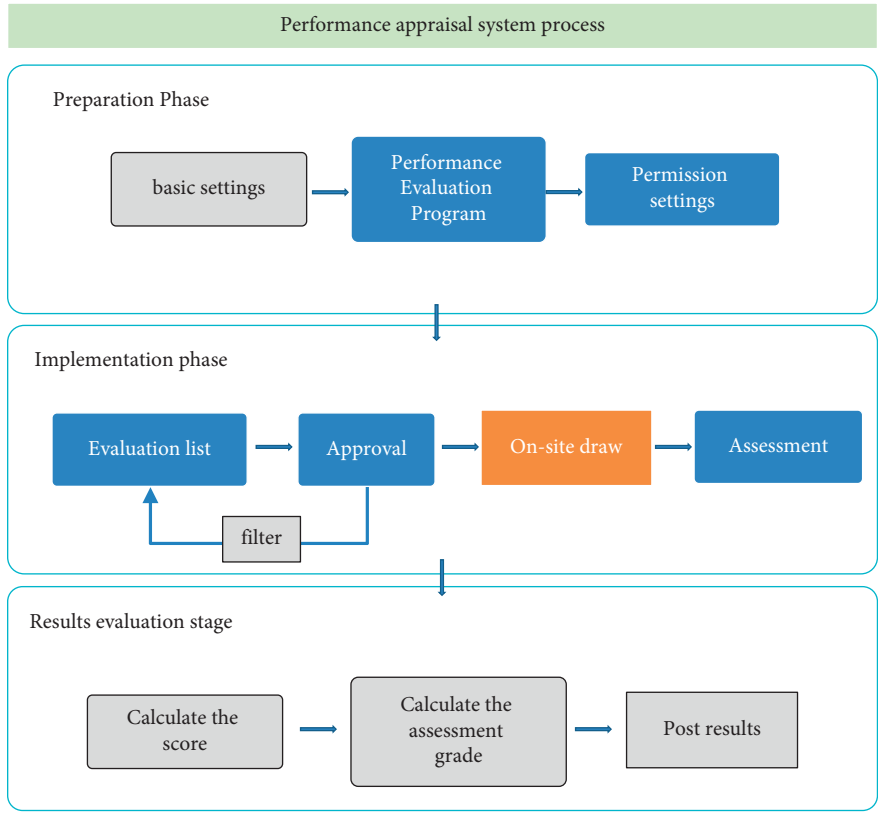


Figure 2: Performance appraisal process.

2.2. Performance Appraisal Process. The performance appraisal process is shown in Figure 2. The performance evaluation system has completed the monitoring and adjustment of performance evaluation information through three stages: preplanning, in-process control, and postevent management. Since the overall business process of managerial performance evaluation and employee performance evaluation is basically the same, differences in individual business scenarios, the management performance evaluation system process, and the employee performance evaluation

system process are combined into an overall system functional process.

3. Construction and Solution of the Multiobjective Decision-Making Mathematical Model

3.1. Model Construction. Enterprise human resources performance appraisal is not simply based on the number of completed tasks to increase performance, but it belongs to the situation of multiobjective decision-making. The traditional task assignment research is to arrange N people to complete N tasks, and each task has one and only one person to complete. It is known that the efficiency of the jth job done by the ith person is P_{ij}, where $i, j = 1, 2, \ldots, N$, and finding the optimal assignment makes the overall work efficiency the highest. However, in actual work, it is often limited by many conditions, such as working time, work effect, and work risk. Therefore, the use of multiobjective decision-making can achieve an optimal assignment in the case of considering multiple factors. There are two situations in the multiobjective decision-making assignment problem, one is that the number of people is more than the number of tasks, and the other is that the number of tasks is more than the number of people. The construction methods and calculation principles of these two models are the same. Therefore, this article describes the selection of any one of them.

Suppose that J people are arranged to complete I work, where $J > I$, each person has one and only one work, but each work can be done by one or more people. There are K targets to be considered in the process of arranging. It is known that under the kth target, the target attribute value of the jth job when the ith person does it is P^k_{ij}, where $j = 1,2,\ldots, J$; $i = 1,2,\ldots, I$; $k = 1,2,\ldots,K$. A mathematical model is constructed so that each target can get the optimal assignment scheme:

$$\max F_k = \sum_{i=1}^{I}\sum_{j=1}^{J} p_{ij}^k h_{ij}, k = 1, 2, \ldots, K, \tag{1}$$

$$s.t\begin{cases} \sum_{j=1}^{J} h_{ij} = 1, \\ \sum_{j=1}^{J}\sum_{i=1}^{I} h_{ij} = J, \\ h_{ij} = 0, 1. \end{cases} \tag{2}$$

where $h_{ij} = 1$ means assigning the ith person to do the jth job; otherwise, $h_{ij} = 0$. For the target whose value is larger, the better, the maximum value of $\max F_k$ indicates that the higher the quality of work, the higher the efficiency. For the target whose value is smaller, the better, the minimum value of $\max F_k$ indicates that the shorter the working time, the higher the efficiency. Through the above example, we transform the actual problem into a mathematical method; that is, the number of people J is 4, the number of tasks I is 3, and the number of goals K is 2, which are the time goal and the work quality goal respectively.

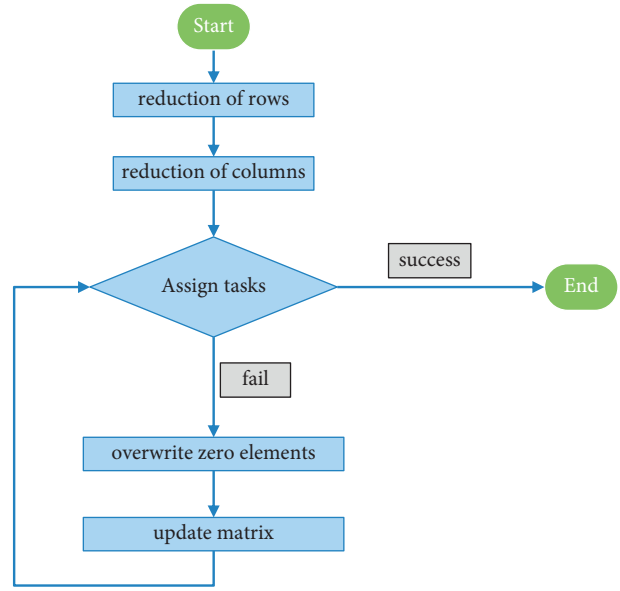


Figure 3: Flowchart of the Hungarian algorithm.

3.2. Hungarian Algorithm for Model Solution. The above problem is a typical assignment problem. There are two main methods to solve the assignment problem: one is the deterministic analytical algorithm Hungarian algorithm [5–7]. The other is the heuristic intelligent algorithm, such as genetic algorithm [8–10], simulated annealing algorithm [11–13], ant colony algorithm [14–16], and particle swarm algorithm [17–19]. The heuristic algorithm has the advantage of high speed for large-scale assignment problems, but it cannot guarantee the optimal solution, and the algorithm is relatively complex, so it is not widely used in engineering practice [20]. The Hungarian algorithm [21] has the characteristics of simple steps and can get the optimal solution without verification. The algorithm is widely used to solve small- and medium-scale assignment problems. The algorithm's theoretical foundation is that adding or deleting a constant from any row or column of the benefit matrix has no effect on the optimal allocation scheme. Figure 3 shows the algorithm's flow chart.

The following uses a simple example to illustrate the usage of the Hungarian algorithm. Suppose a company has four tasks of T1, T2, T3, and T4, which need to be assigned to four people P1, P2, P3, and P4 to complete. The remuneration they need to pay for completing the task is listed in Table 1. The problem that needs to be solved is how to allocate the task to minimize the total cost. The process of solving using the Hungarian algorithm is as follows:

The resulting payoff matrix is as follows:

$$\begin{bmatrix} 3 & 8 & 2 & 10 \\ 9 & 7 & 5 & 3 \\ 1 & 5 & 4 & 3 \\ 4 & 5 & 7 & 9 \end{bmatrix}. \tag{3}$$

Table 1: Details of the fees paid.

Personnel\tasks	T1	T2	T3	T4
P1	3	8	2	10
P2	9	7	5	3
P3	1	5	4	3
P4	4	5	7	9

Step 1. Row Reduction. Find the smallest element of each row, and subtract this smallest element from each row respectively. The transformed matrix is as follows:

$$\begin{bmatrix} 1 & 6 & 0 & 8 \\ 6 & 4 & 2 & 0 \\ 0 & 4 & 3 & 2 \\ 0 & 1 & 3 & 5 \end{bmatrix}. \tag{4}$$

Step2. Column Reduction. Find the smallest element of each column and subtract this smallest element from each column respectively:

$$\begin{bmatrix} 1 & 5 & 0 & 8 \\ 6 & 3 & 2 & 0 \\ 0 & 3 & 3 & 2 \\ 0 & 0 & 3 & 5 \end{bmatrix}. \tag{5}$$

After the above two-step transformation, each row and column of the matrix have at least one zero element. The third step is to assign tasks.

Step 3. Assigning Tasks. First, the independent zero elements need to be determined. i starts from the first row or column. If there is only one zero element in the row or column, then mark the zero element with 1, indicating that the task is assigned to the corresponding person. Each time when 1 is marked, the other zero elements in the same column of the zero element are marked as 2, indicating that this task can no longer be done by others. This is repeated until all zero elements in the coefficient matrix have been marked as 1 or 2. The resulting matrix is as follows:

$$\begin{bmatrix} 1 & 5 & 0(1) & 8 \\ 6 & 3 & 2 & 0(1) \\ 0(1) & 3 & 3 & 2 \\ 0(2) & 0(1) & 3 & 5 \end{bmatrix}. \tag{6}$$

Second, we assign tasks. The zero element marked 1 in the coefficient matrix is exactly equal to 4, which means that the optimal assignment scheme has been determined. At this time, the position of 0 (1) is recorded as 1, the other positions are recorded as 0, and then the optimal solution of the problem is obtained. The optimal solution is as follows:

$$\begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}. \tag{7}$$

As can be seen from the above matrix, task T1 is handed over to P4, task T2 is handed over to P3, task T3 is handed over to P1, and task T4 is handed over to P2. The total reward currently is as follows: $1 + 5 + 2 + 3 = 11$.

3.3. Model Solution. The Hungarian method is used in this research to tackle the above problem. The steps for solving the problem are as follows:

(1) *Complete the Benefit Matrix*. Suppose $P_{ij}^{\ k}$ is the jth job under the kth objective, which is determined by the ith person attribute value when an individual comes to do it, where $i \in [1, I]$, $j \in [1, J]$, and $k \in [1, K]$. The attribute value matrix $P_k = (P_{ij}^{\ k})_{\mathrm{IxJ}}$ under the condition of target k is composed of multiple attribute values. Then, according to the matrix P_k, the optimal fuzzy relation matrix is obtained as $U_k = (u_{ij}^{\ k})_{\mathrm{IxJ}}$. Equation (2) represents the larger the value, the better the target, and equation (3) represents the smaller the value, the better the target:

$$u_{ij} = \frac{p_{ij}^{k} - p_{k\min}}{p_{k\max} - p_{k\min}}, \tag{8}$$

$$u_{ij}^{k} = \frac{p_{k\max} - p_{ij}^{k}}{p_{k\max} - p_{k\min}}, \tag{9}$$

(i) where p_{kmax} represents the maximum value of the matrix P_k, and p_{kmin} represents the minimum value of the matrix P_k. According to the above formula, the attribute value matrix P_k is transformed into the fuzzy relation matrix $U_k = (u_{ij})_{\mathrm{IxJ}}$. Then, the weight vector is determined mainly based on the target weight vector given by experts.

(ii) In actual work, the leader will comprehensively consider the importance of the task and make a trade-off between the quality of the task and the time required. For example, this task is relatively complex and important. Obviously, the quality of the task will play an important role, and the time required for the task will be longer. Then in combination with this model, when assigning weight vectors, the quality of the task completion must be larger than the time required for the task. If the task is simple and unimportant, then obviously the opposite is done when assigning weights. First, the target weight vector $W = (w_1, w_2, \ldots, w_K)$ is given by the group leader, and then

$$u_{ij} = \sum_{k=1}^{K} w_k u_{ij}^{k}, \tag{10}$$

(i) where u_{ij} represents the relative membership degree synthesized by each attribute value after considering K targets comprehensively. In this way, (IxJ) u_{ij} is combined into a multiobjective fuzzy relation synthesis matrix as follows:

$$U = \begin{bmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{21} & u_{22} & \cdots & u_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ u_{m1} & u_{m2} & \cdots & u_{mn} \end{bmatrix} = \left(u_{ij}\right)_{I\times J}. \tag{11}$$

(i) u_{ij} represents the fuzzy comprehensive work efficiency of the ith person doing the jth job. A larger value indicates higher efficiency, so it assigns the problem's fuzzy benefit matrix to multiobjective decision-making.

(ii) The method of determining the fuzzy benefit matrix of workers is as follows: first, the attribute value of the ith person doing the jth job is determined under the target k. These attribute values need to be based on the evaluation of the professional ability and work quality of the staff in the process of work in the past, and then the comprehensive quality evaluation of the staff is converted into a hundred-point system for work assessment. The full score is 100 points. Second, according to equations (2) and (3), the fuzzy relative membership degree of the staff to complete the task under a certain goal can be calculated. Finally, the target weight vector $W = (w_1, w_2)$ is given according to the leader's requirements for the task, and the multitarget fuzzy relation matrix is obtained by equation (4).

(2) The Kuhn–Munkres algorithm solves multiobjective assignment decisions. When the number of jobs is less than the number of people, that is, $J > I$, it means that each job can be done by multiple people, and it also shows that the relationship between the number of tasks and the number of people is a one-to-many relationship. Assuming that each job is first assigned to one person, then among the remaining J-I individuals, each person can also participate in any one of the I jobs; that is, each job may be performed by at most J-I individuals. Therefore, it may be assumed that there are other J-I virtual jobs that are completely equivalent to each job, and the comprehensive benefit value of each person doing these equivalent jobs is the same. Therefore, there are $I(J$-$I)$ jobs. There are more jobs than people. This ensures that each person is assigned one and only one job, and that at most one person does each job. Suppose there are still $I(J$-$I+1)$-$J = (J$-$I)\ (I$-$1)$ employees whose overall efficiency is 0 when they do any work. Therefore, the number of people currently is equal to the number of jobs. This further ensures that each job is done by one and only one person, satisfying the requirements of traditional assignment problems. Therefore, the multiobjective assignment decision extension benefit matrix can be constructed as follows:

$$E = \left(\beta_{ij}\right)_{(I(J-I+1))\times(I(J-I+1))} = \begin{bmatrix} U & U & \cdots & U \\ 0 & 0 & \ldots & 0 \end{bmatrix}. \tag{12}$$

Row 1 in the above matrix has $(J$-$I+1)$ U. The 0 in row 2 represents a zero matrix of $I(J$-$I+1)$ row and I column. The optimal solution to the traditional assignment problem corresponding to the extended benefit matrix E by the Hungarian algorithm is $N = (n_{ij})_{K\text{x}K}$, where $K = I\text{x}(J$-$I+1)$. The solution of the multiobjective assignment problem can be determined according to the elements equal to 1 in the first J rows of $N=(n_{ij})_{K\text{x}K}$.

4. Design of the Digital Management System for Human Resource Performance Appraisal Based on Multiobjective Decision-Making Mathematical Model

4.1. Application of the Multiobjective Decision-Making Mathematical Model in Performance Appraisal. In order to optimize the enterprise human resources performance appraisal, this section uses the multiobjective decision-making model mentioned above for the actual task assignment scenario of an enterprise. Suppose a company has four workers involved in three tasks. The number of personnel J is 4, and the number of tasks I is 3. The completion of the task has two goals, namely, $K = 2$. The two goals are high-quality task completion and short task time. Then, the attribute matrix of the person is determined. It is assumed that under the kth goal, the full score of each secondary indicator is 100 points. A score between 100 and 90 is considered excellent. A score between 90 and 80 is considered good. A score between 80 and 70 is a pass, a score between 70 and 60 is a basic pass, and a score below 60 is a failure (Table 2).

The original data are determined through the above process. For the convenience of calculation, the staff attribute value is obtained by rounding the staff performance appraisal result. The attribute value matrix is as follows:

$$\begin{aligned} P_1 &= \begin{bmatrix} 80 & 75 & 90 \\ 80 & 85 & 90 \\ 90 & 85 & 75 \\ 75 & 85 & 95 \end{bmatrix}, \\ P_2 &= \begin{bmatrix} 70 & 90 & 80 \\ 60 & 70 & 80 \\ 75 & 85 & 90 \\ 90 & 80 & 70 \end{bmatrix}. \end{aligned} \tag{13}$$

Here, P_1 is the quality matrix for completing the task and P_2 is the time matrix required for the task. For the quality matrix P1, the larger the target value, the better the quality matrix P1 will be. Equation (2) is used to calculate its fuzzy relation matrix. For the time matrix P2, the smaller the target value, the better the time matrix P2 will be. The calculated results are as follows:

Table 2: Quantitative table for employee performance appraisal.

First-level indicator	Weight	Second-level indicator	Weight
Morality	0.15	Moral quality	0.2
		Political literacy	0.2
		Professional ethics	0.3
		Solidarity	0.3
Ability	0.35	Total knowledge	0.2
		Operational capacity	0.4
		Learning ability	0.3
		Coordination	0.1
Diligent	0.2	Attendance	0.3
		Work attitude	0.7
Achievement	0.3	Job completion	0.3
		Work quality	0.2
		Results of the work	0.2
		Work efficiency	0.3

$$U_1 = \begin{bmatrix} 0.25 & 0.00 & 0.75 \\ 0.25 & 0.50 & 0.75 \\ 0.75 & 0.50 & 0.00 \\ 0.00 & 0.50 & 1.00 \end{bmatrix},$$
$$U_2 = \begin{bmatrix} 0.29 & 0.86 & 0.57 \\ 0.00 & 0.29 & 0.57 \\ 0.43 & 0.71 & 1.00 \\ 0.86 & 0.57 & 0.29 \end{bmatrix}. \quad (14)$$

In this study, we take the quality of task completion as the main goal and the time required for the task as the secondary goal. If the superior leader gives the weight $W = (0.7, 0.3)$, then the result of the multiobjective fuzzy relationship synthesis matrix calculation is as follows:

$$U = \begin{bmatrix} 0.26 & 0.17 & 0.71 \\ 0.20 & 0.46 & 0.71 \\ 0.69 & 0.54 & 0.20 \\ 0.17 & 0.51 & 0.86 \end{bmatrix}. \quad (15)$$

The extended work benefit matrix for multiobjective assignment decision-making is constructed according to the multiobjective fuzzy relation synthesis matrix as follows:

$$S = \begin{bmatrix} 0.26 & 0.17 & 0.71 & 0.26 & 0.17 & 0.71 \\ 0.20 & 0.46 & 0.71 & 0.20 & 0.46 & 0.71 \\ 0.69 & 0.54 & 0.20 & 0.69 & 0.54 & 0.20 \\ 0.17 & 0.51 & 0.86 & 0.17 & 0.51 & 0.86 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$
$$S' = \begin{bmatrix} 0.60 & 0.69 & 0.14 & 0.60 & 0.69 & 0.14 \\ 0.66 & 0.40 & 0.14 & 0.66 & 0.40 & 0.14 \\ 0.17 & 0.31 & 0.66 & 0.17 & 0.31 & 0.66 \\ 0.69 & 0.34 & 0 & 0.69 & 0.34 & 0 \\ 0.86 & 0.86 & 0.86 & 0.86 & 0.86 & 0.86 \\ 0.86 & 0.86 & 0.86 & 0.86 & 0.86 & 0.86 \end{bmatrix}. \quad (16)$$

The result obtained according to the Hungarian algorithm is as follows:

$$N = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}. \quad (17)$$

From the above matrix N, the first person and the fourth person do the third job, the second person does the second job, and the third person does the first job. In accordance with such a division of labor, work efficiency can be maximized while ensuring the completion of work objectives.

4.2. Performance Appraisal System Functional Architecture. The performance appraisal designed in this study can be integrated into the large system of human resource management. The performance appraisal mainly interacts through the portal website, to realize the centralized management of application data, and the data level mainly realizes the analysis and processing of data through data sharing and process control. Setting modules such as module management, interface setting, and other tools preserve various parameters of the system. After the user logs in, according to the identity authentication, it is determined whether the user has the authority of this module through the authority of the platform. If we have permission, then the configuration information of the module from the database can be read, and the corresponding module on the interface can be displayed. The functional architecture of the performance appraisal system is listed in Figure 4.

The performance appraisal management system mainly includes the following modules: (1) basic settings module includes evaluation period, evaluation dimension, and evaluation template. (2) KPI assessment module mainly includes the KPI assessment approval relationship and KPI assessment process function. (3) Evaluation relationship module includes evaluation object grouping, evaluation subject grouping, and evaluation relationship maintenance

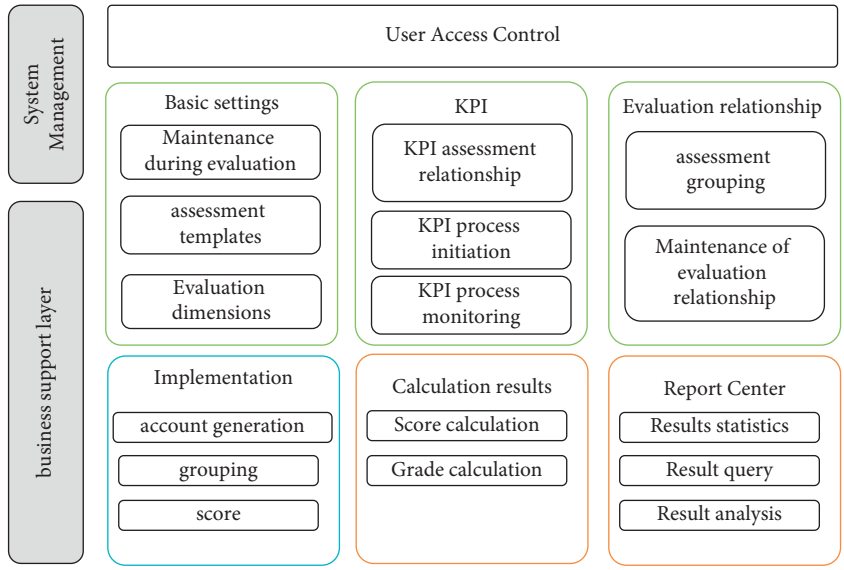


Figure 4: Functional architecture diagram of the performance appraisal system.

functions. Corresponding evaluation subjects and evaluation weights can be set according to different evaluation dimensions, different evaluation forms, different evaluation units, and different evaluation objects. (4) Evaluation implementation module mainly includes anonymous account generation, grouping, and scoring functions. After the performance administrator configures the evaluation group and the evaluation relationship, the evaluation relationship can be activated to enter the scoring state. At this time, the system will automatically generate anonymous accounts in groups. (5) Result calculation module can calculate the data collected by the performance evaluation form to obtain data, such as the number of test scores and the ranking within the group, and calculate the evaluation status of the evaluation objects by different evaluation subject groups according to the evaluation method. (6) Report center module mainly includes the functions of evaluation result statistics, query, and analysis. It supports the analysis and statistics of the evaluation results from different angles and provides reporting functions such as the traceability of the original evaluation results, the evaluation result table of each subject, and the comprehensive analysis of the evaluation results.

5. Conclusion

It is of great significance to apply the quantitative results of performance appraisal to actual work. Using scientific mathematical models, the division of labor can be further rationally optimized and the overall work efficiency can be improved. Increased productivity is a win-win situation for businesses as well as employees. Under normal circumstances, the number of tasks of a company is generally far greater than the number of employees, and the increase in the number of employees generally cannot keep up with the increase in the number of tasks. In view of this situation, it is very important for business leaders to arrange reasonable arrangements for employees and tasks. This study uses a multiobjective decision-making mathematical model to optimize performance appraisal in human resource management. This optimization method is applied to the performance appraisal digital management system. The evaluation of the employees' work in this study is entirely based on the reform of the performance appraisal system and the quantification of the appraisal results. However, there is still a lot of room for improvement in the development of human resource management. The reform of the performance appraisal system has not been taken seriously, and qualitative appraisal is still used as the evaluation result of personnel. This also makes it difficult to achieve the goal of scientific management using information tools or intelligent models.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This work was supported by the Segi University Malaysia.

References

[1] J. J. Mchenry, J. P. Campbell, and L. L. Wise, "Modeling job performance in population of jobs," *Personnel Psychology*, vol. 43, no. 2, pp. 313–575, 1990.

[2] M. C. Campion, E. D. Campion, and M. A. Campion, "Using practice employment tests to improve recruitment and personnel selection outcomes for organizations and job seekers," *Journal of Applied Psychology*, vol. 104, no. 9, pp. 1089–1102, 2019.

[3] S. J. Motowidlo and M. J. Schmit, "A theory of individual difference in task performance and contextual performance," *Human Performance*, vol. 10, no. 2, pp. 71–83, 1997.

[4] J. D. Olian and S. L. Rynes, "Making total quality work: aligning organizational processes, performance measures, and stakeholders," *Human Resource Management*, vol. 30, no. 3, pp. 303–333, 1991.

[5] A. Kume and S. G. Walker, "The utility of clusters and a Hungarian clustering algorithm," *PLoS One*, vol. 16, no. 8, pp. 1–23, 2021.

[6] S. Dias, S. Kolhe, R. Shinde, R. Chaudhari, and R. M. Wahul, "Query time optimization using Hungarian algorithm," *Lecture Notes in Electrical Engineering*, vol. 570, pp. 271–276, 2020.

[7] P. R. R. J. Stevens and A. Sciacchitano, "Application of clustering and the Hungarian algorithm to the problem of consistent vortex tracking in incompressible flowfields," *Experiments in Fluids*, vol. 62, no. 8, pp. 1–11, 2021.

[8] A. Zemliak, "A modified genetic algorithm for system optimization," *COMPEL - The international journal for computation and mathematics in electrical and electronic engineering*, vol. 41, no. 1, pp. 499–516, 2022.

[9] F. Hajati, A. Rezaee, and S. Gheisari, "Genetic algorithms for scheduling examinations," *Advanced Information Networking and Applications*, vol. 227, pp. 524–532, 2021.

[10] S. Kolditz, T. Seitz, J. Nyhuis, M. Raatz, P. Nyhuis, and A. Raatz, "Adaptive aerodynamic part feeding enabled by genetic algorithm," *Production Engineering*, vol. 16, no. 1, pp. 1–8, 2022.

[11] S. Tavakkoli-Moghaddam, R. Sazvar, Z. Heydari, and J. Heydari, "A heuristic-based simulated annealing algorithm for the scheduling of relief teams in natural disasters," *Soft Computing*, vol. 26, no. 4, pp. 1825–1843, 2022.

[12] V. F. Yu, H. Jodiawan, P. Lin, T.-W. Huang, S.-W. Lin, and Yu-T. Huang, "A simulated annealing algorithm for the vehicle routing problem with parcel lockers," *IEEE Access*, vol. 10, pp. 20764–20782, 2022.

[13] Y. Zhang, X. Han, Y. Dong, J. Xie, G. Xie, and X. Xu, "A novel state transition simulated annealing algorithm for the multiple traveling salesmen problem," *The Journal of Supercomputing*, vol. 77, no. 10, pp. 1–26, 2021.

[14] H. Yu and J. Wang, "Ant Colony Algorithm in Tourism Route Planning," *2021 International Conference on Applications and Techniques in Cyber Intelligence*, vol. 81, pp. 218–222, 2021.

[15] F. Wu, "Contactless distribution path optimization based on improved ant colony algorithm," *Mathematical Problems in Engineering*, vol. 2021, no. 1, pp. 1–11, 2021.

[16] C. Gavidia-Calderon and I. Beltrán Castañon, "Isula: A java framework for ant colony algorithms," *SoftwareX*, vol. 11, Article ID 100400, 2020.

[17] M. D'Urso, G. Giardini, and C. Giardini, "Micro-EDM optimization through particle swarm algorithm and artificial neural network," *Precision Engineering*, vol. 73, pp. 63–70, 2022.

[18] M. Zhang, "Prediction of rockburst hazard based on particle swarm algorithm and neural network," *Neural Computing and Applications*, vol. 34, no. 4, pp. 2649–2659, 2022.

[19] S. Nezamivand Chegini, P. Ahmadi, B. Amirmostofian, B. Ahmad, and I. Amirmostofian, "Intelligent bearing fault diagnosis using swarm decomposition method and new hybrid particle swarm optimization algorithm," *Soft Computing*, vol. 26, no. 3, pp. 1475–1497, 2022.

[20] S. S. Vinod Chandra and H. S Anand, "Nature inspired meta heuristic algorithms for optimization problems," *Computing*, vol. 104, no. 2, pp. 251–269, 2022.

[21] T. Feng, H. Yang, C. Wang, Y. Dong, J. Xia, and M. Xia, "Multivessel computation offloading in maritime mobile edge computing network," *IEEE Internet of Things Journal*, vol. 6, no. 3, pp. 4063–4073, 2019.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 1007538, 10 pages
https://doi.org/10.1155/2022/1007538

Research Article

An Improved BP Neural Network Algorithm for the Evaluation System of Innovation and Entrepreneurship Education in Colleges and Universities

Xuying Sun and Yu Zhang

Office of Academic Affairs, Cangzhou Normal University, Cangzhou 061000, Hebei, China

Correspondence should be addressed to Xuying Sun; sunxuying@caztc.edu.cn

Received 5 May 2022; Revised 30 May 2022; Accepted 16 June 2022; Published 30 June 2022

Academic Editor: Wen Zhou

The ability of college students has important index to evaluate the training quality of universities. Domestic scholars begin to cultivate spirit and ability of students. With the rapid development of tourism industry and the continuous emergence of "tourism +" new business forms, there is an urgent demand for professionals with outstanding innovation and entrepreneurship ability. China's education field urgently needs a system that can scientifically evaluate the teaching quality. The purpose of this topic is to enrich the theoretical methods of universities. Taking S University as the research sample, the relevant evaluation index system is set up, and, on this basis, the evaluation model of network is established, providing relevant basis for evaluation and cultivation of universities. According to certain evaluation indicators, this paper constructs the main framework of teaching quality evaluation in colleges and universities. 7 representative universities in China are randomly selected, 6 of which are samples and 1 university is the research target, MATLAB is used to calculate the scores of each index, the current situation of quality in a university is analyzed, and corresponding improvements opinion is proposed. Based on the analysis of the current education in a university, it is found that, in the current education, innovation and entrepreneurship knowledge and professional knowledge are taken into account, and the academic achievements are remarkable, forming a preliminary education system, but it is also found that there are some problems of low educational practicality, and corresponding suggestions for this problem are put forward. If the evaluation system is put into practical application, it will improve the education level of cultivating innovative entrepreneurial talents in tourism major in universities.

1. Introduction

College students' education is the need to realize the value of life. College students should not only have theoretical knowledge but also have talents in entrepreneurship. It is helpful to help college students master entrepreneurial methods and develop the psychology and will to overcome difficulties and take risks.

Innovation and entrepreneurship in universities industries provide a huge entrepreneurial space for students. Universities can effectively support the development of entrepreneurial economy [1]. But, at present, entrepreneurship development at home and abroad has not been able to meet its expectations. Not only is the entrepreneurship rate in the tourism industry not good, but also the development of education in the tourism management major of universities is not conducive to entrepreneurship and tourism development. This requires colleges and universities to reform the major of tourism management, pay more attention to the education of cultivating students' entrepreneurial awareness, and teach students entrepreneurial skills and knowledge related to tourism. Improve the innovation and entrepreneurship ability of students majoring in tourism management, stimulate their willingness to start their own businesses after graduation, and encourage them to build a platform for their own businesses. By improving the quality of education in universities, it can reduce the employment pressure of college students and expand the development space of college students and tourism industry [2].

The talents are increasing day by day, which is also the urgent need of China's economic development. A scientific and systematic evaluation method for tourism education has not yet been formed. In order to solve this problem, this study starts from the nature of education, analyzes the impact of indicators, and adopts BP neural network calculation method to try to establish a perfect evaluation system of education for tourism majors in universities [3].

2. State of the Art

American Professor Tismon is known as a leader in education. His research fields cover innovative curriculum development, venture capital, venture financing, entrepreneurial management, and other aspects, and he takes Parkson Business School as the promotion place. The results have obvious characteristics: it is forward-looking in the period of the transition between traditional industry and new industry. The systematic arrangement of the curriculum system, entrepreneurs, business plans and resource supply, venture financing and development speed reasonable arrangement, the entrepreneurial ability of students; Use case method to thinking enthusiasm to solve the problems; Provide students with entrepreneurial practice opportunities [4].

During the 90s, UNESCO held many meetings to discuss higher education in the world and how to deal with a development in the 21st century's needs, and it was made clear that the concept of "degree is not equal to work" and emphasized that graduates should no longer be purely job seekers and become job creators, and it was put forward that "entrepreneurship" as content of the university graduates should be given. It is suggested that students' entrepreneurial skills are as important as initiative creativity [5].

After the 1990s, the perspective of entrepreneurship education in the United States and Canada has changed from the improvement of individual ability to the emphasis on team, company, and industry, taking entrepreneurship as a management style. Its role is no longer to establish new enterprises, but large-scale enterprises also need this quality. To cultivate students' "attitude, knowledge and skills necessary for self-employment" are clearly stated in the National Education Policy published by India [6].

In this study, the retrieval function of CNKI was used to select "journal" as literature source, set "innovation and entrepreneurship" and "education" as key words, and select only "core journal" and "CSSCI" as literature source, and 200 relevant literature works were retrieved. With "innovation and entrepreneurship" and "education" as keywords and "master and doctor" as literature sources, 13 related articles were retrieved. This can be illustrated in Figure 1 [7].

From the research level, the education of vocational college students and undergraduates is the main research object of scholars. Scholars mainly focus on exploring training mode and constructing system; for example, Giancristofaro et al. established the undergraduate education model by using the model of project exploration. Giancristofaro et al. proposed and constructed an education system of "one core, three platforms, and nine modules" [8].

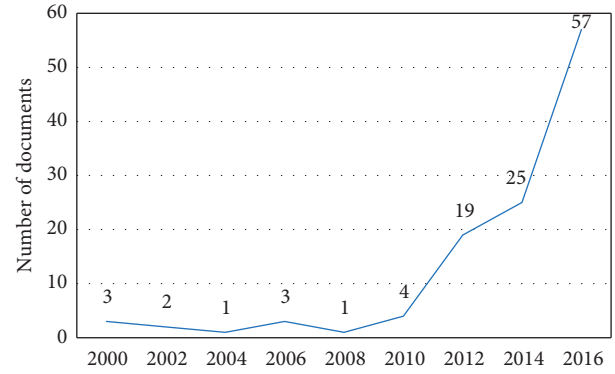


Figure 1: Distribution of relevant literature.

The evaluation of the study of curriculum system is very limited. Samuel et al. proposed the "four-in-one" evaluation system of education, which is the theoretical guidance. The education model of "mentor + project + team" was proposed by Samuel et al. and its effect remains to be discussed [9].

The current development status of education in China reflects that although it started late, it has not hindered the rapid education in China. In the process of research, exploration fields have been expanded and exploration levels deepened. In general, the research in China still needs to be further integrated and be systematic, and the research in this field needs to be constantly the actual situation in China.

ptIn Warner et al.'s work, innovation education refers to the positive influence of genetic and environmental, using leading role of education; they exert the students' cognition and practice of the subjective initiative and pay attention to student's main body to create consciousness, as well as the cultivation of innovation spirit and innovation ability, and form the innovation personality to adapt to the education of students' individual development [10]. Geisner et al. believe that the emergence of innovative education is an education concept with the rise of knowledge economy, which is based on creation and aims to cultivate innovative spirit in students' consciousness, ability, and personality [11]. Bejerholm et al. believe that innovative education is an education concept that emerges knowledge economy. It is an education model to shape innovative consciousness and innovative ability through the means of modern university [12]. Dillahunt-Aspillaga et al. from Zhenjiang Institute of Education and Science understood entrepreneurship education from its functional perspective and believed that it could transform the new labor force form from single to composite and from operation to intelligence, which was an important measure for the new generation of students to meet future challenges and adapt to market demand [13]. Zivin et al. believe that the cultivation of innovative talents should first start the training objectives, so that the attention to education can be reflected, and ensure that the personal and social value of education can be brought into full play [14]. Wu et al. focused on the main line and how to cultivate and who to cultivate and opened up a maker education and teaching mode of "integration of doing, learning, and teaching"

[15]. Based on "Internet +" and secondary vocational students' policies, this paper puts forward a set of targeted talent training strategies.

3. Methodology

3.1. Introduction to Innovation Education and Entrepreneurship Education. Both the educator and the educated need to have basic innovation spirit, innovation ability, and innovation personality. Through the exploration of traditional education and the construction of applicable theories and models, education should aim to tap people's creative potential, carry forward people's subject spirit, and promote the harmonious development of personality. Innovative education that appears with the rise of knowledge economy is based on creation and aims to cultivate innovative spirit in students' consciousness, ability, and personality [16]. Innovative education is a kind of educational idea that comes into being with information age and knowledge economy. It is a kind of educational mode that realizes the shaping of students' innovative spirit, through the means of modern university. Opposite to traditional acceptance education, it insists on "creation orientation" and focuses on cultivating students' ability of secondary discovery and practice. It is a unified form of idea and practice, which is the core of modern education as well as the reflection and sublimation of traditional educational idea model. At the same time, one of the educational activities is education, which is educational practice innovation ability [17].

Entrepreneurship education refers to starting a career and corresponding educational activities, emphasizing teaching reform, and cultivating innovative ability and entrepreneurial consciousness which aims at comprehensive qualities such as spirit and knowledge. Entrepreneurship education can promote the development of students' career ambition, enterprising spirit, pioneering spirit, innovative spirit, and so on [18]. It is a new educational concept and mode compared with employment education, which focuses on cultivating students' entrepreneurship and ability. To put it simply, it is to let students have all kinds of qualities and abilities needed in the process of entrepreneurship. In a broad sense, the purpose of entrepreneurship education is to stimulate students' entrepreneurial consciousness. The biggest goal is to shape potential successful entrepreneurs. In a narrow sense, it is entrepreneurship training behavior to cultivate the knowledge, quality, and skills needed for the purpose of independent entrepreneurship [19]. It is to cultivate people with entrepreneurial qualities. In the narrow sense, it is behavior to transform students from job seekers to entrepreneurs and provide students with comprehensive abilities needed in the process of transformation. In the broad sense, it is to improve the overall quality required by students in the process of entrepreneurship through relevant curriculum system. To become a pioneering person with innovative spirit, entrepreneurial consciousness, risk-taking spirit, stable mentality, and correct decision making; entrepreneurship education in the narrow sense is a kind of vocational education, and the purpose is to establish enterprises. To sum up, more attention is paid to the process of education. Entrepreneurship education in a narrow sense is a kind of vocational education, whose purpose is to let learners successfully establish enterprises [20].

3.2. Introduction to Artificial Neural Network. ANN is a model system composed of a large number of processing units (neurons). This system has strong independent and nonlinear, nonlocal characteristics. It tries to design a new machine with the information processing ability of the human brain by simulating the processing and memory of information by the neural network of the brain.

Artificial neural network takes neuron as the basic processing unit. It is a nonlinear device, and its structure is shown in Figure 2.

In the figure, the input signal is, $x_i w_{ij} \theta_j$. Is the external input signal as the set S, and is. The transformation of the jth neuron can be described as follows:

$$y_j = f\left(\sum w_{ij} x_i - \theta_j + s_j\right). \tag{1}$$

The running process of the network is calculated as follows:

$$net_{ij}^{(1)} = \sum_{n_{t-1}}^{n_{t-1}} W_{ij}^{(1)} g O_{ip}^{(l-1)}, \tag{2}$$

$$O_{jp}^{(1)} = f^{(1)}\left(net_{jp}^{(1)}\right). \tag{3}$$

The error energy function of BP network is

$$E_p = \sum_{i=1}^{n} \phi\left(e_{i,p}\right) = \frac{1}{2} \sum_{i=1}^{n} \left(y_{i,p} - \widehat{y}_{i,p}\right)^2. \tag{4}$$

The data is normalized so that it is between 0 and 1 and the expected output value is determined.

$$\widehat{y}_j = f\left[\sum_{i=1}^{n} w_{ij} x_i - \theta_j\right], \tag{5}$$

$$\widehat{z}_k = f\left[\sum_{i=1}^{n} w_{ik} y_j - \theta_k\right], \tag{6}$$

and the adjustment consensus is as follows:

$$W_{jk+1} = W_{jk} + \eta \delta_k V_j, \tag{7}$$

$$W_{ij+1} = w_{ij} + \eta \delta_j X_i. \tag{8}$$

We have that

$$\delta_k = \left(Z_k - \widehat{Z}_k\right) \widehat{Z}_k \left(1 - \widehat{Z}_k\right), \tag{9}$$

$$\delta_j = y_j \left(1 - y_j\right) \cdot \sum_{k=0}^{L-1} \delta_k \cdot W_{jk}. \tag{10}$$

The learning and training of BP network is a process of error back-propagation and correction. The total error E is calculated. If, the learning stops; otherwise, go to equation (3) recalculation. $E \le \varepsilon$ In practical network design, it will be

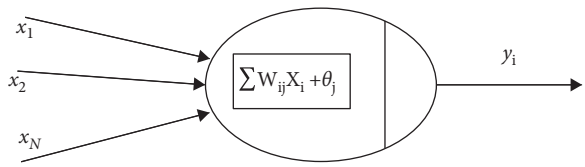


Figure 2: General description of a neuron.

slow, but if it is too large, the network will wobble. $\eta\eta$ a momentum ($0 << 1$) can be added into equation (4), i.e $\alpha\alpha$

$$w_{jk+1} = w_{jk} + \eta\delta_k y_j + \alpha \cdot \Delta W_{jk}, \tag{11}$$

$$W_{ij+1} = W_{ij} + \eta\delta_j y_i + \alpha \cdot \Delta W_{ij}. \tag{12}$$

The BP algorithm process is an iterative algorithm process; each round will adjust w again, so the iteration goes on until the error meets the requirements.

It is a kind of multilayer feedforward type network, which has very strong capability in nonlinear mapping. In this model, each layer is with adjacent neurons, and the neurons are at each layer. These neurons are shown in Figure 3.

In essence, the standard network learning algorithm takes the sum of squares of network errors as the objective function, and the gradient method uses the objective function to realize the minimum algorithm. The most basic principle is to propagate through the network, adjust the minimum error, calculate the learning process, and transmit the error back (as shown in Figure 3).

The research framework of this article is shown in Figure 4.

4. Result Analysis and Discussion

4.1. Construction of Evaluation Index System of Education. Referring to the teaching work evaluation index system of ordinary universities, the general content of the open questionnaire is extracted, and the result indexes are selected to reflect the scientific, comprehensive, accurate, and operational principles of this research. Then, 5 education evaluation experts and school supervision experts are interviewed. After listening to their preliminary opinions on the tourism specialty in universities, their opinions are adopted, and a quality evaluation system for education of tourism specialty in universities is preliminarily formulated. Different subsystems should be set up for teaching quality evaluation of tourism education in universities as shown in Figure 5.

This study conducted a survey: Open questionnaires were issued, indicators were initially screened, and questionnaires were generated under the guidance of experts. Rigorous statistical methods were used to analyze questionnaire of tourism major in S University. In the next step, 100 copies of the questionnaire were randomly distributed in the university town where S University is located, and 96 copies were effectively recovered with rate of 96%. The valid questionnaire data were input into SPSS to analyze them.

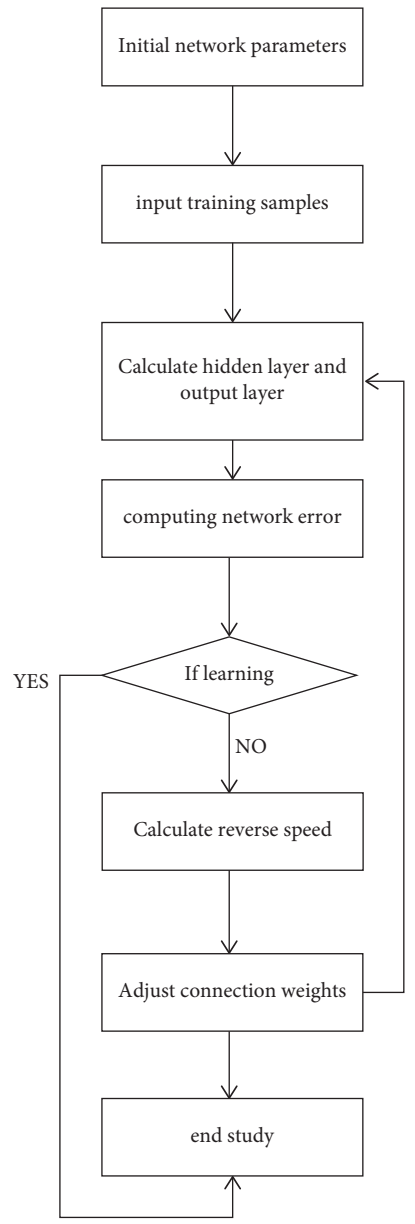


Figure 3: Neural network learning flow chart.

4.1.1. Reliability Analysis. From Table 1, according to the reliability analysis, Cronbach's alpha coefficient value can be calculated from some tables to be higher than 0.8, indicating that the developed questionnaire's reliability index is ideal, all indicators are consistent, and the questionnaire is reliable.

4.1.2. Validity Analysis. Generally speaking, the value of sampling adequacy can reflect the adequacy of the questionnaire sample. Bartlett and KMD of this survey are shown in table 2. Therefore, KMD coefficient value of the questionnaire is 0.915 and the probability is $0.00 < 0.01$, indicating that the questionnaire variables have many factors in Table 2.

The characteristics of education in tourism majors of different levels are comprehensively analyzed by following

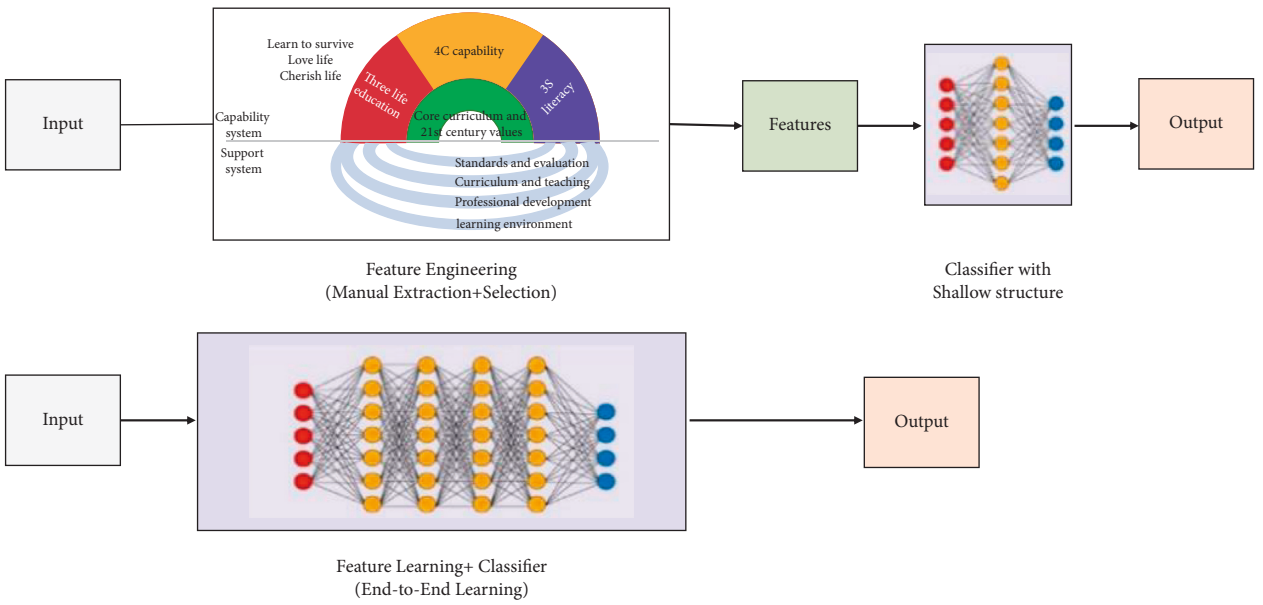


Figure 4: Entrepreneurship system evaluation and research framework.

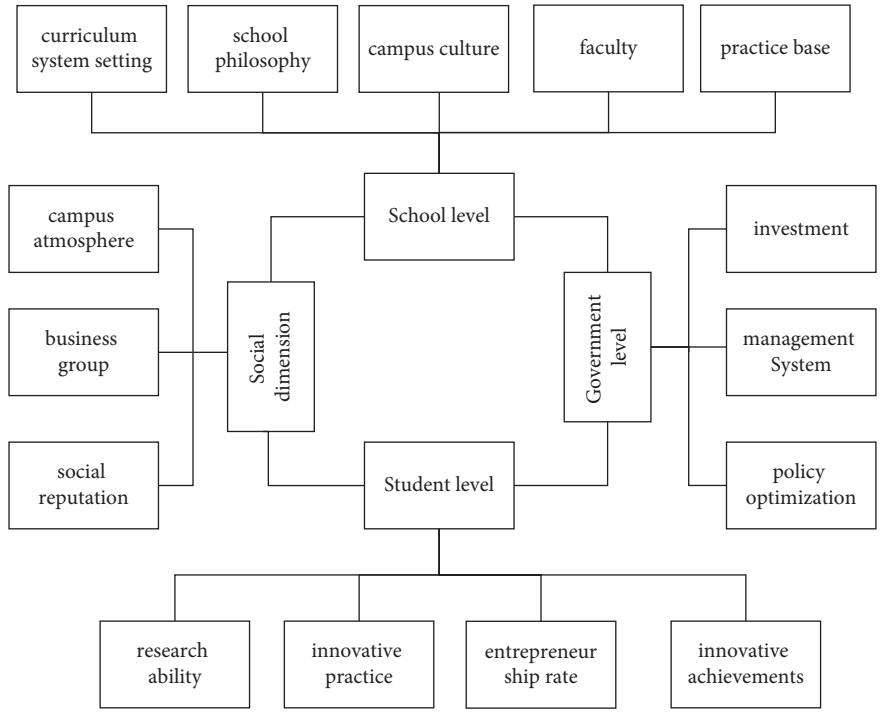


Figure 5: Dimensions of teaching quality evaluation of tourism education in universities.

Table 1: Reliability analysis table.

Cronbach's alpha	Cronbach's alpha based on standardized items	No. of items
0.873	0.863	25

the principles of strategic goal-oriented, comprehensive and complete, objective and scientific, dynamic and flexible, and systematic and operational principles. According to the students' personality, their own characteristics, and other factors, the index design and evaluation method are determined. The method is shown in Table 3.

Table 2: Validity analysis.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.915
Bartlett's test of sphericity	Bartlett's test of sphericity	11015.038
	D*f*	378
	Sig	0.000

Table 3: Teaching quality evaluation system of university tourism education.

Evaluation system	First level index	Secondary index	Three-level index
Evaluation index system of tourism education	University link	Soft environment	Entrepreneurial community *X*1
			The degree of implementation of national policy *X*2
			Number of entrepreneurship competitions held *X*3
			Number of school-enterprise cooperations *X*4
			Number of school-enterprise cooperation projects *X*5
			Number of innovative and entrepreneurial institutions *X*6
			Percentage of students starting a business after participating in entrepreneurship education courses *X*7
		Hardware support	Student coverage of entrepreneurship funds *X*8
			The service rate of infrastructure such as entrepreneurship park to students is *X*9
			Number of students received by entrepreneurship practice base *X*10
	Teaching link	Curriculum design. Teaching method	The conversion rate of innovation achievements *X*11
			Ratio of practical courses to theoretical courses *X*12
			Participation rate of practical courses *X*13
			Core curriculum ratio *X*14
			Entrepreneurs *X*15
			Degree of penetration of business management in the curriculum *X*16
			Cross-disciplinary curriculum opening rate *X*17

4.2. Construction of BP Neural Network in the Quality Evaluation Model of Education. There are 45 evaluation indicators about the quality of tourism education in S University, so the number of nodes of input layer is 45.

Hidden Layer Node. The constructed BP is the basis of hidden layer nodes. The time difference between input and output layers will have a certain impact, and the characteristics of sample data will also have a certain impact on the absolute fault tolerance and generalization of the optimal network (which will improve the test accuracy). The following formula is generally used to determine its impact:

$$q = \sqrt{n + m} + a. \tag{13}$$

Output Layer Node. The result of evaluation is the nodes. In this case, the number of nodes is 1, which is the comprehensive score value of tourism major in S University.

It is relatively hidden neurons, and there is no relevant theoretical basis at present as shown in Table 4.

Neural network is adapted to new data, the number of hidden layer nodes is reduced, and the training speed is improved. Therefore, on the premise of meeting the learning accuracy, the "trial-and-error method" is adopted: if there are too many training times within the specified training times or convergence conditions are not met, the training should be stopped. According to the evaluation system mentioned above, the number of hidden layers is determined to be 8 as shown in Table 5.

Therefore, the selection can only be based on past experience, and the learning rate in this model is between 0.005 and 0.9. Finally, according to the learning results, the learning rate is determined to be 0.04.

Based on the intelligence of each system, the output is the tourism business innovation teaching quality evaluation result, divided into outstanding, good, medium, pass, and fail. Therefore, this is a three-layer BP layer. However, there is only one output node in the output layer. The value range is {0, 1}.

4.3. Application of BP Neural Network in Quality Evaluation of Education. The neural network toolbox (NNT) of Matlab 7.0 software is used for modeling in this paper. MatrixLaboratory, short for MATLAB, is a set of scientific and engineering computing software based on matrix calculation developed by MathWorks in the 1980s. It has numerical calculation, visualization, and programming functions. In addition, it can also draw a variety of toolboxes to solve special scientific and engineering calculation problems. The calculation function is strong and the programming efficiency is high. MATLAB can be used with neural network toolbox for neural network system to provide analysis and design functions, can be directly called functions, images, and simulation tools and simplify the weight training process, and is excellent software for neural network training.

Table 4: Evaluation and grading standards.

Comprehensive evaluation	85–100	75–85	65–75	55–65	Less than 55
Grade	Superior	Good	Middle	Qualified	Unqualified

Table 5: Convergence comparison.

Hidden layer element	3	4	5	6	7	8
Number of training times	31	10	15	6	10	5
Error	9.73051	4.00131	3.98314	2.35444	7.31142	2.0122

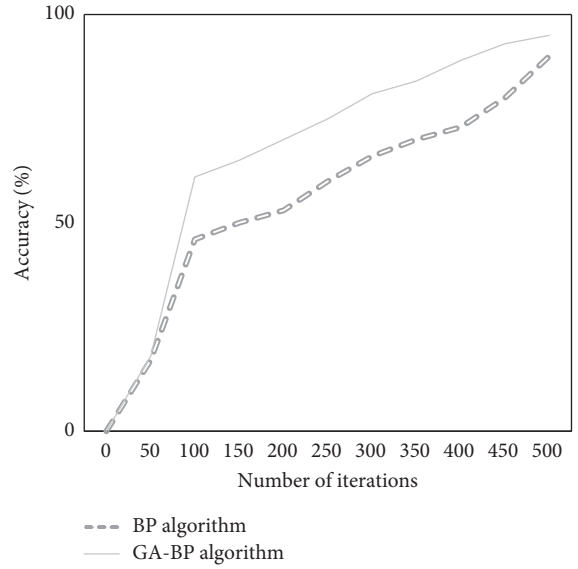


Figure 6: Changes in accuracy of the algorithm under different iterations.

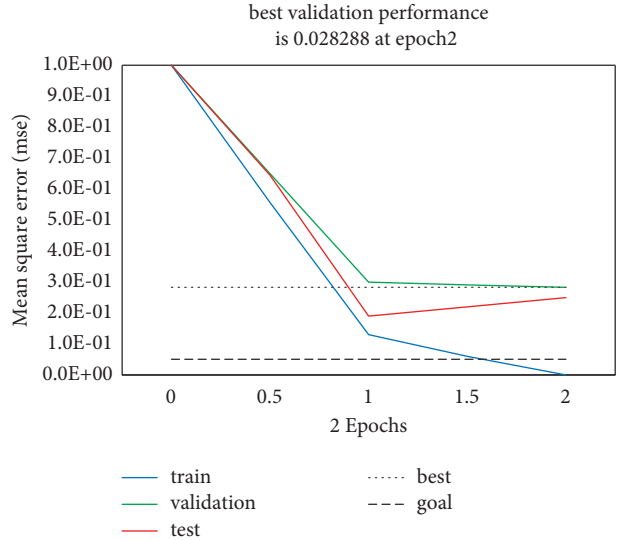


Figure 7: Neural network training.

Table 6: Error detection table.

Test the sample	$C5$	$C6$	$C7$
Expected output	0.68	0.75	0.72
Network output	0.6801	0.7123	0.7221
Error value	0.0001	0.0377	0.0021

Table 7: Output results of each indicator.

Indicators	Results	Indicators	Results	Indicators	Results	Indicators	Results	Indicators	Results
$X1$	0.8	$X11$	0.72	$X21$	0.40	$X31$	0.20	$X41$	0.65
$X2$	0.61	$X12$	0.49	$X22$	0.60	$X32$	0.42	$X42$	0.87
$X3$	0.71	$X13$	0.96	$X23$	0.72	$X33$	0.91	$X43$	0.92
$X4$	0.84	$X14$	0.51	$X24$	0.81	$X34$	0.87	$X44$	0.67
$X5$	0.96	$X15$	0.81	$X25$	0.45	$X35$	0.62	$X45$	0.97
$X6$	0.81	$X16$	0.67	$X26$	0.62	$X36$	0.90		

According to the above business travel innovation education teaching system, through data processing, a neural network model is established for the evaluation index of the scale.

According to the requirements of the standardization of the index system, the collected sample data are standardized, and the scoring data [0, 100] is converted into data between [0, 1], which is convenient for neural network operation. The neural network toolbox in MATLAB takes three steps to calculate:

(1) Initialization: set weights and initial values through init function, using init () command format, and Net is the return function, representing the initialized neural network. The ini () function represents weights and thresholds according to its arguments, net.intfcn and net.initparam. For BP networks, the value of net.intfcn is initwb as shown in Figure 6.

(2) Network training: since the function training is realized, the network is trained as shown in Figure 7.

(3) Network simulation: the function Sim is implemented according to the trained network for the book data simulation training.

The tested data is input into the trained BP model to obtain it with the expected value. The error table is obtained as shown in Table 6.

The university data collected from performance of education was evaluated by using the BP trained and improved above, and the output value of the comprehensive network was 0.7261. This proves that education in universities is at a medium level as shown in Table 7.

5. Conclusion

5.1. Result Analysis. The evaluation model of education based on BP is established and optimized to evaluate tourism specialty in S University.

Based on the survey results, status analysis, and quality model evaluation results, this study found the following achievements and deficiencies in the evaluation of education and teaching quality of tourism major in S University.

5.1.1. Both Innovation and Entrepreneurship Knowledge and Professional Knowledge. By analyzing the evaluation results of indicators $X4 = 0.84$, $X5 = 0.96$, $X14 = 0.96$, $X34 = 0.92$, and $X36 = 0.90$, it can be seen that teachers in S University have paid attention to encouraging students to start businesses in the field of tourism while teaching the courses of tourism specialty, and students have gradually begun to master relevant knowledge and use other disciplines and the Internet research new tourism professional business model. Besides teaching professional theoretical knowledge, it also pays attention to practical teaching. Combining with the characteristics of tourism specialty, it makes continuous improvement from the aspects of discipline design, internship, and after-school experiments. Through continuous efforts, the number of students attending special courses on innovation and entrepreneurship is increasing and they are satisfied with the teaching effect, which provides corresponding guarantee for the continued promotion of education. The school-enterprise cooperation has gradually increased and deepened.

5.1.2. Outstanding Academic Achievements. According to the evaluation indicators $X24 = 0.81$, $X33 = 0.91$, $X37 = 0.91$, and $X38 = 0.92$, it can be seen that S University has made great progress in academic research on tourism education, and its research results are gradually increasing journals and remarkable achievements in social practice. The proportion of academic competitions in related fields is increasing, and the social influence is increasing. By implementing the corresponding reward mechanism for award-winning teachers and students, we encourage more academic input into the research of relevant fields.

5.1.3. A Preliminary System of Extracurricular Activities. According to the evaluation indicators $X1 = 0.80$, $X3 = 0.71$, and $X15 = 0.81$, S University can regularly invite successful entrepreneurs and managers in related professional fields to participate in lectures, forums, training, and other activities related to innovation and entrepreneurship held by the university, which expands students' horizons and provides a primary channel for students to acquire knowledge in

related fields. Since the "entrepreneurial design competition" held by S University in 2004, the university has regularly provided corresponding information supply and teacher guidance for the competition and set up rich bonuses to encourage students to participate in it. On the other hand, the number of participants in this entrepreneurship competition has increased year by year. Through the simulated entrepreneurship course, students have realized the process of transforming knowledge into practical results and deepened their understanding of entrepreneurship.

5.1.4. Lack of Experience in Innovation and Entrepreneurship Teachers. The innovation and entrepreneurship teachers of S University are in the middle of the school. As teachers, they either have theoretical knowledge and lack management experience or lack teaching experience, so they cannot truly establish students' entrepreneurial awareness in the teaching process. Although S University has established a corresponding entrepreneurship guidance center and an entrepreneurship research center, the teachers in this position are temporarily held by relevant teachers or leaders of institutions. Teachers who impart relevant entrepreneurship knowledge generally have other teaching and scientific research tasks, which cannot guarantee it. The quality of education classrooms and scientific research results are under the condition that meets the requirements of reality.

5.2. Improvement Opinions on Education

5.2.1. Establish an Excellent Team of Tourism Innovation and Entrepreneurship Teachers. We need to establish an excellent team of teachers. Strong guidance ability is required. We need to be familiar with China's relevant policies, master the process of it, understand the risks of it, and even have certain experience in it, so as to guide and help students.

5.2.2. Create a Good Education Environment. Practice has proved that many students major in education environment during their school education. For example, some universities use various practical teaching conditions to establish corresponding travel agency college business departments to improve students' ability by operating practical projects. For another example, actively participating in and holding various innovation and entrepreneurship competitions at all levels is also a good way. "Shandong Huang Yanpei occupation education innovation and entrepreneurship competition."

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

This work was supported by the Office of Academic Affairs, Cangzhou Normal University.

References

[1] O. G. Avakian, Q. Li, and M. P. Peter, "What predicts the use of interaction-oriented pedagogies the role of self-efficacy, motivation, and employment stability," *Computers & Education*, vol. 184, no. 1, pp. 11-12, 2022.

[2] M. Casciato, "Post-heart transplant employment: rates, predictors, and interventions," *The Journal of Heart and Lung Transplantation*, vol. 41, no. 4S, pp. S198–S199, 2022.

[3] M. Joanne, "Juggling employment and studies: nursing students' perceptions of the influence of paid employment on their success," *Nurse Education Today*, vol. 92, p. 104429, 2020 (prepublish).

[4] M. Sidebotham, C. Walters, K. Baird, and J. Gamble, "Simulated employment interviews: a collaborative approach to gaining understanding of the graduate midwife employment process," *Women and Birth*, vol. 33, no. 5, pp. 455–463, 2020.

[5] M. Wise, C. Ossenberg, and A. Henderson, "The contribution of paid employment for students during their pre-registration nursing studies: an integrative review," *Nurse Education Today*, vol. 111, p. 105296, 2022.

[6] A. Whitworth, "The economic case for well-considered investment in health-related employment support: costs and savings of alternative modified Individual and Placement Support (IPS) models," *Disability and Health Journal*, vol. 11, no. 4, pp. 568–575, 2018.

[7] E. Bates James, A. Parekh, and R. Goodman Chelain, "The geography of employment outcomes for radiation oncology graduates in 2019," *International Journal of Radiation Oncology, Biology, Physics*, vol. 109, no. 4, pp. 1119–1123, 2020.

[8] R. A. Giancristofaro, S. Bonnini, and L. Salmaso, "Employment status and education/employment relationship of PhD graduates from the University of Ferrara," *Journal of Applied Statistics*, vol. 36, no. 12, pp. 1329–1344, 2019.

[9] M. Samuel, F. Adaba, A. Askari et al., "Home parenteral nutrition and employment in patients with intestinal failure: factors associated with return to employment," *Clinical Nutrition*, vol. 38, no. 3, pp. 1211–1214, 2019.

[10] A. Warner, J. Barrow, A. Williams, A. Davis, H. Hurst, and K. Riddle, "The relationship among BSN students' employment, educational, and health-related characteristics and semester grades: a multi-site study," *Journal of Professional Nursing*, vol. 36, no. 5, pp. 308–316, 2020, (prepublish).

[11] I. M. Geisner, J. Koopmann, P. Bamberger et al., "When the party continues: impulsivity and the effect of employment on young adults' post-college alcohol use," *Addictive Behaviors*, vol. 77, pp. 114–120, 2018.

[12] U. Bejerholm, M. E. Larsson, and S. Johanson, "Supported employment adapted for people with affective disorders-A randomized controlled trial," *Journal of Affective Disorders*, vol. 207, pp. 212–220, 2017.

[13] C. Dillahunt-Aspillaga, M. J. Pugh, B. A. Cotner et al., "Employment stability in veterans and service members with traumatic brain injury: a veterans administration traumatic brain injury model systems study," *Archives of Physical Medicine and Rehabilitation*, vol. 99, no. 2, pp. S23–S32, 2018.

[14] K. Zivin, M. Yosef, D. S. Levine et al., "Employment status, employment functioning, and barriers to employment among

VA primary care patients," *Journal of Affective Disorders*, vol. 193, pp. 194–202, 2016.

[15] H. Wu, S.-B. Tsai, and S. Gengxin, "An empirical study on the employment monitoring and early warning mechanism of medical graduates in universities with big data and complex computing system," *Discrete Dynamics in Nature and Society*, vol. 2021, pp. 1–10, 2021.

[16] Y. Wang and N. Xin, "Subjective employment obstacle of college students and its predictor model based on deep learning," *Wireless Communications and Mobile Computing*, vol. 2022, pp. 1–9, 2022.

[17] P. Cheng and N. Xin, "Employment data screening and destination prediction of college students based on deep learning," *Wireless Communications and Mobile Computing*, vol. 2022, no. 1506, pp. 1–10, 2022.

[18] H. Z. Farimah, K. Sayin Firat, and N. Elena, "Does an alignment of employment policies and individual preferences affect intention to stay in the profession?" *Evidence from Canadian MidwivesHealth policy*, vol. 125, no. 4, pp. 450–458, 2021.

[19] B. Alcott, "Should degrowth embrace the job guarantee?" *Journal of Cleaner Production*, vol. 38, pp. 56–60, 2013.

[20] K. Hardcastle, M. A. Bellis, K. Ford, K. Hughes, J. Garner, and G. Ramos Rodriguez, "Measuring the relationships between adverse childhood experiences and educational and employment success in England and Wales: findings from a retrospective study," *Public Health*, vol. 165, pp. 106–116, 2018.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 5426510, 9 pages
https://doi.org/10.1155/2022/5426510

Research Article

An Intelligent Recognition of English Translation Based on Improved GLR Algorithm

Jie Su[1] **and Zhan Du**[2]

[1]*Department of Humanities and Social Sciences, Shijiazhuang Institute of Railway Technology, Shijiazhuang, China*
[2]*Shijiazhuang Institute of Railway Technology, Shijiazhuang, China*

Correspondence should be addressed to Zhan Du; duzhan7810@163.com

Received 12 April 2022; Revised 19 May 2022; Accepted 10 June 2022; Published 29 June 2022

Academic Editor: Wen Zhou

English is a global language. In the process of China's internationalization, overcoming the difficulty of understanding English is the only way to achieve cultural exchanges, economic exchanges, and even scientific and technological exchanges. Especially in the context of globalization, translation between languages has become the focus of transnational communication. However, there are still problems such as low accuracy and singularity in current machine translation. Aiming at the above problems, based on the improved GLR algorithm (IGLR), this paper proposes a recognition method to solve the English translation problem. First, a corpus is built, and the number of label words reaches tens of thousands. In this way, the automatic search function of the phrase is realized. In addition, create an intelligent method for translation; and plan the intelligent recognition model with data collection, processing, and output; extract characteristic parameters to realize intelligent translation. Conduct an experimental analysis on the designed English translation method and record the experimental data. Through the experiment, it can be seen that the designed translation method can achieve accurate translation results and meet the actual needs.

1. Introduction

English is an international language. Although higher education has been there for many years, there is still a large gap in high English proficiency. In view of the real needs of our country, proficiency in English is particularly important. In order to improve the level of speaking English in daily communication, learning the pronunciation and the accuracy of speech should be further strengthened [1]. With the improvement of China's international status and the acceleration of the internationalization process, the status of Chinese has become increasingly important [2]. Effectively solving the "English-Chinese translation" problem and developing English-Chinese machine translation technology have a great social and economic value.

Machine translation is the use of computers to achieve automatic translation, or an attempt to fully automate or partially automate the translation process from one human language to another human language. Its core is the translation process automation [3]. The object of machine translation research is the natural language used for human communication, usually in the form of text. The tool used in machine translation is the computer, and its processing is automated. To realize the translation of natural language, machine translation must involve the processing technology of natural language. Since English-Chinese translation spans different language families and belongs to different cultural backgrounds, in the process of automatic translation, there are major technical problems such as difficulty in understanding English semantics, poor translation sorting technology, inability to reflect differences in language habits, and face more serious technical bottlenecks [4]. Traditional translation algorithms generally use rule-based methods, feature extraction, the Markov model, and so on and use cosine similarity to measure the semantic similarity of translation. In practical use, there are often some problems, such as inaccurate translation of ambiguity of English and Chinese structures, inaccurate translation of long sentences, and so on.

We propose an improved GLR algorithm (IGLR) for intelligent recognition of English translation using the maximum generalized likelihood algorithm. The paper has 5 sections. In Section 1, we introduce the research background. Section 2 studies the main methods and effects of current machine translation and proposes the research methods of this paper. Section 3 mainly introduces the memory of the generalized maximum likelihood algorithm and proposes an improved GLR algorithm. Section 4 mainly uses the designed GLR algorithm to verify the effect of machine translation. Section 5 mainly summarizes the work of the full text and proposes an imagination for the next step.

The innovation of this paper lies in the adoption of an improved GLR algorithm for English translation. On the one hand, the research presented in this paper has theoretical significance for algorithm optimization research; on the other hand, it can also provide reference for real machine optimization and has practical significance.

2. State of the Art

Machine translation technology is one of the application scenarios developed with artificial intelligence and has huge market demand in practice [5]. It is necessary to classify and organize vocabulary to improve translation quality and meet user needs [6]. Reasonable use of professional vocabulary can greatly improve the accuracy of translation [7].

The University of Southern California, Stanford University, IBM Corporation, AT&T Corporation in the United States, as well as universities in the United Kingdom, France, Germany, Canada, Japan, and other countries and research institutions have made outstanding contributions in the field of machine translation research [8]. A typical machine translation system is the translation system SYSTRAN, which has provided commercial services since 1970. It adopts the direct translation method and has multiple language-to-language translation versions [9]. SYSTRAN is a commercial machine translation system developed by Toma after improving the machine translation system of Georgetown University. The European Community has introduced the SYSTRAN system since 1976. The English-French translation system METEO of the TAUM research group of the University of Montreal in Canada adopts a conversion-based method, the European Community's multilingual system Eurotra, the French-Russian-French system GETA of the University of Grenoble in France, and the Saar University in Germany. The German-Russian-English-French multilingual system SUSY, the German-English system METAL of the University of Texas in the United States, and the Japanese-English system ATLAS-I of Fujitsu Corporation of Japan are all machine translation systems based on conversion [10]. The Russian-French system CETA of the University of Grenoble in France and the German-English system METAL of the University of Texas in the United States are based on the intermediate language translation method, the English-French machine translation system of IBM Corporation is based on the statistical machine translation method, and the English-Japanese experimental system of Kyoto University in Japan is based on an example. A useful attempt has been made in the method. The PANGLOSS system jointly implemented by New Mexico State University, the University of Southern California, and Carnegie Mellon University is a multi-engine Spanish-English machine translation system based on vocabulary conversion [11]. In recent years, some American research institutions such as Carnegie Mellon University have reached a high level of research on Chinese-English and English-Chinese machine translation.

Huang analyzed that the machine translation conforms to the nature. The construction of an English-Chinese phrase corpus for text translation. Emphasize the importance of the corpus and explain the PTA model [10]. Due to the disadvantages of low translation accuracy, a HowNet-based lexical semantic similarity and logarithmic linear model is designed, and the corresponding bilingual corpus is stored, which provides structured processing of language dependencies and ensures that Chinese [11]. For the correspondence between English and Chinese, calculating the input of HowNet operation requires semantic similarity, which further improves the accuracy of translation. The translation results obtained by this method have high accuracy [12]. After summarizing the above literature, it is found that the recognition of phrases is an important part of recognition [13]. The intelligent recognition of phrases satisfies the selection of samples [14]. It can be found from the literature that one of the difficult problems is structural ambiguity at present. A key technical method to solve this problem is speech recognition algorithm. This paper studies it and proposes an identification method as shown in Figure 1 below. Based on the improved generalized maximum likelihood ratio method, this paper proposes a new type of machine translation algorithm, which is used to construct about 740,000 English-Chinese labels. For vocabulary, phrase search and phrase corpus, phrases can be constructed through the central point of the phrase structure and the part of speech recognition results can be obtained. According to the linear list function of grammatical analysis, the structural ambiguity of English and Chinese part of speech recognition results can be corrected, and finally the recognition content can be obtained.

3. Methodology

3.1. GLR Algorithm. The GLR is an extensive analysis algorithm that uses techniques such as analysis chart structures and shared compression forests to achieve faster speeds. Conflict phenomenon analysis in the analysis table is commonly used in machine translation principles. The GLR has three parts: the analysis state table, the grammar rules, and the list of graph structures [15]. This algorithm is a suitable choice because intelligent recognition of English translations must be fast, efficient, and accurate. The flow chart of GLR analysis is shown in Figure 2.

The basic idea of the algorithm is as follows.

Given context-free grammar, parsing table, string to be parsed, initialized graph stack = {}, and shared forest = {};

Main control program: for $i = 0$ to n, execute the word analysis program PW(i), return to the shared forest, and

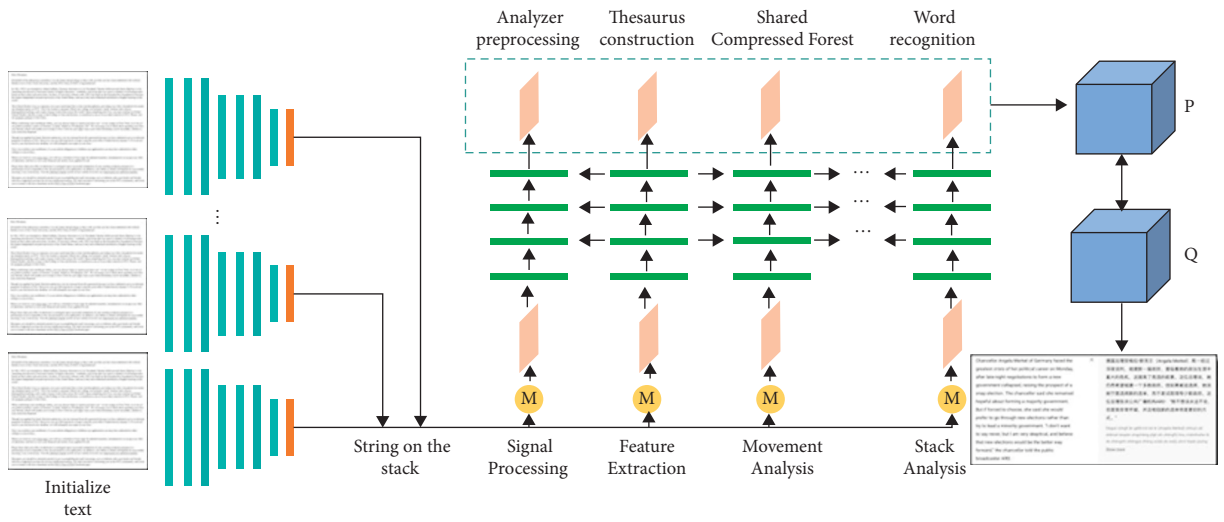


Figure 1: Intelligent recognition method of English translation based on improved GLR algorithm.

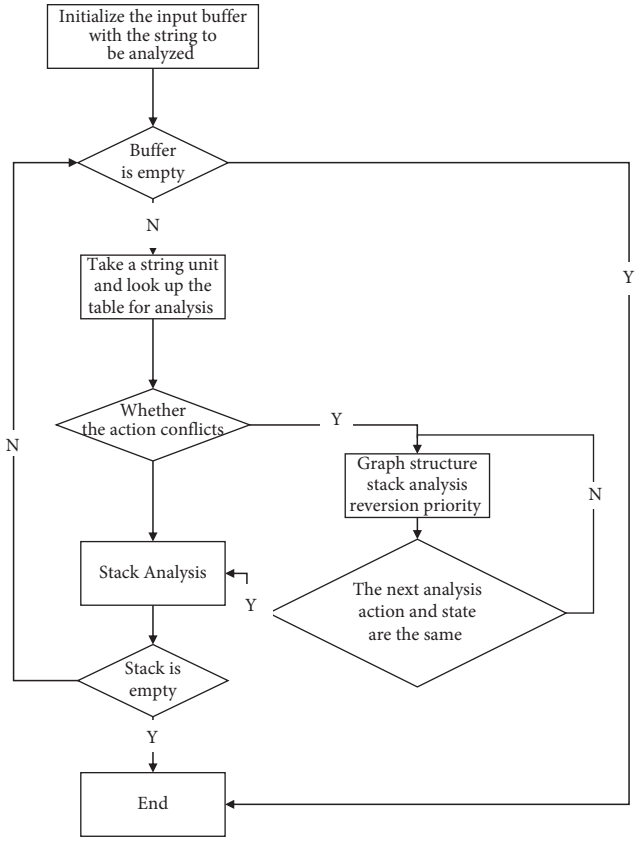


Figure 2: Analysis flow chart of GLR algorithm.

then store all the tops of the graph stack into A according to the FIFO.

(1) Take a state from A and set it as K

(2) Check the grid action with K as the row and W as the column in the analysis table, and set it as X

(a) If $x =$ "move in." If other tops of the graph stack have been pushed into the top of the secondary stack, merge the same parts in the graph stack; otherwise, at the current top of the graph stack at K, push W and push j at the same time to construct a shared forest.

(b) If $x =$ "reduction": if the left part of the h-th production is y and the length of the right part is m, remove $2m$ elements from the top of the graph stack, then push y into the top of the graph stack, and put In the transition table, take the top of the graph stack as the row, and the state in the grid with y as the column is pushed into the stack and put into the set A to construct a shared forest; return 1.

(c) If $x =$ "success", return to the shared forest.

(d) If $x =$ "error", return the error message and return.

(e) If $x =$ "move into j/reduce h. . ." conflict, then the graph stack branches at the top of the stack, and moves in and reduces according to 2.a and 2.b in turn.

(f) If $x =$ "reduction h specification l. . ." conflict, then the top branch of the graph stack, and the reduction is performed according to 2.b in turn.

(3) Check and repeat the above steps until A is empty

Designing an efficient GLR English translation intelligent recognition algorithm must have three analysis techniques: analyzer preprocessing, shared compression forest, and graph structure stack.

3.2. Analyzer Preprocessing. The preprocessing stage of the algorithm-based intelligent recognition of English translation mainly includes English word segmentation, part of speech tagging, and the establishment of analysis transfer table.

The construction of the English rule base has two meanings. The rule-based syntactic analyzer needs a large number of English grammar rules [16]. The quality of the

rule base construction directly affects the accuracy of the syntactic analyzer and provides a foundation for the subsequent construction of the probability rule base [16]. The purpose of constructing the English rule base is to provide support for the construction of the English tree base and to provide great help for the subsequent research on semantic analysis and dependency analysis. The English rule base is constructed from two aspects: first, the English rule base is constructed manually. It is constructed by English language experts. The disadvantage of such a constructed rule base is that it has limitations [17]. Second, the rules are extracted and constructed by manual division and annotation processing [18]. This paper adopts the method of constructing the rule base of multilingual information technology and constructs the English rule base through manual division, annotation processing, bracket matching algorithm, etc. Figure 3 shows the method flow of rule extraction, which is mainly carried out from two aspects: conscious manual tagging of the source corpus, grasping is tagging the word segmentation and part of speech of the source corpus, extracting the main structure, using parenthesis matching detection, and finally realizing the automatic extraction of rules; another method is to realize the automatic extraction of rules with the help of the part of speech automatic tagging system.

3.3. Shared Compression Forest. The shared compressed forest consists of a set of edges that hold all phrases obtained through bracket matching [19], where each edge contains the following information:

(1) Component marking: used to mark phrase edges and word edges.

(2) Component boundaries: to identify the starting and ending positions of words or phrases in a sentence.

(3) Syntactic tag: to store the syntactic tag information of the matched phrase.

(4) Compressed child node table: to save all the ambiguous structure combination information of this phrase component. Each structure combination is an edge number path composed of edge numbers of all sub-components to save space consumption.

(5) Best path mark: to save the pointer information of the best structure combination path obtained by disambiguation. Among them, 3, 4, and 5 only make sense for the phrase edge.

With a compressed shared forest structure, it has the following benefits:

(1) Through the compression of node information, a lot of storage space is saved, and the retrieval speed of phrase components is improved.

(2) Since all the structural ambiguities encountered in the analysis process are stored in the compression node, statistical disambiguation and pruning can be easily performed, so as to select an optimal analysis result.

Local ambiguity means that while parsing a sentence, the grammatical symbol M of a non-terminal node is formed by reduction, and the states of multiple paths appearing on the left and right sides of M in the parsing stack are the same, so we use local compression technology to merge, In this way, analyzing a sentence becomes the analysis of a path [20].

Figure 4 shows the processing flow of shared compression, from which you can see that there are equal nodes on the left and right sides of node A, so the two paths in the above figure can be merged into the structure shown in the following Figure 5. From Figure 4, we can find that if the local ambiguity is not handled during syntactic analysis, it will affect the time and space complexity. After merging the paths, the two original paths become one, which greatly saves the time complexity.

3.4. Graph Structure Stack. One of the core technologies used by the algorithm-based parser is the graph structure stack, which is a directed acyclic graph that includes two types of nodes: one is a part of speech node and the other is a state node, which is equivalent to the state in the DFA. Given a rule T and an input string a, the state of the DFA is constructed by these rules. This state node is a mutually disjoint set, and its number is $a + 1$. In the graph structure stack, the state node constructs one state at a time. The first state node is initialized as a 0 state node. When performing analysis, all "reduce" actions are performed in the current state, and the "closer" operation will create the next state node [21].

We start to create a node in the stack column as 0, which is represented as V_0 state. Begin to analyze and read the next character as a, and the table lookup action is "$S_{1.}$" According to the graph structure stack construction idea, we create the next state node marked as V_1, the state in the stack is 1, and so on. The construction process of the graph structure stack can be understood from the following illustration.

The above three diagrams describe several instances that are often encountered in the graph structure stack. The state node is represented by a circle, the state is represented in the circle, the symbol node is represented by a square, and the symbol is represented in a square graph. When the syntactic analyzer does not encounter a conflict, its processing is shown in Figure 5; that is, the linear relationship continues to analyze. When it encounters a conflict, the graph structure stack is split into several stacks for analysis, and each path executes actions as shown in Figure 5 above. Until they meet the action state of the same node, they will be merged into a stack to continue the analysis as shown in Figure 5 above.

3.5. Creating a Phrase Corpus. The role played by the corpus used in the intelligent translation model is crucial. The main functions of the corpus are to store data, mark short words, standardize phrase functions, and improve automatic phrase recognition algorithms, so that the timeliness and accuracy of translation are more accurate [22]. The information flow of the corpus can be seen in Figure 6. It mainly includes three aspects: the content of corpus marking, the way of marking, and the way of corpus application.

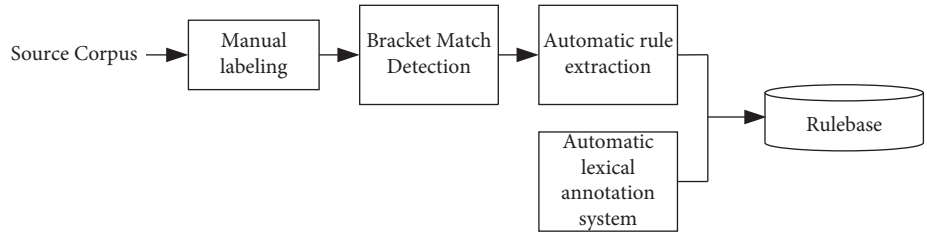


Figure 3: Rule extraction flowchart.

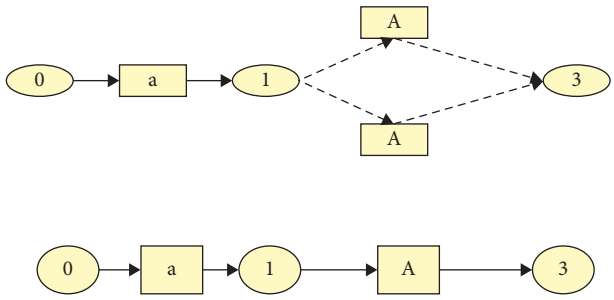


Figure 4: Local ambiguity.

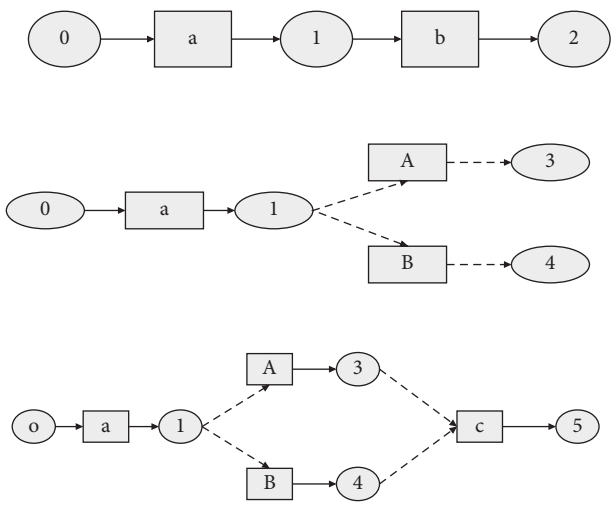


Figure 5: The construction process of the graph structure stack.

There are more than 700,000 words, which meets the actual needs. Figure 6 shows the structural composition of the corpus. The construction of the corpus is highly targeted.

3.6. Phrase Corpus. An important part of English phrase translation is the recognition of speech. How to optimize the recognition algorithm to improve the problem is very important. The segmentation processing is implemented to determine the translation sentence and word part of speech. Finally, the syntax is used to analyze the dependencies of the phrases, and the creation of the sentence syntax tree is realized [23]. Using quaternary cluster calculation to improve the phrase context likelihood of the GLR algorithm [24]:

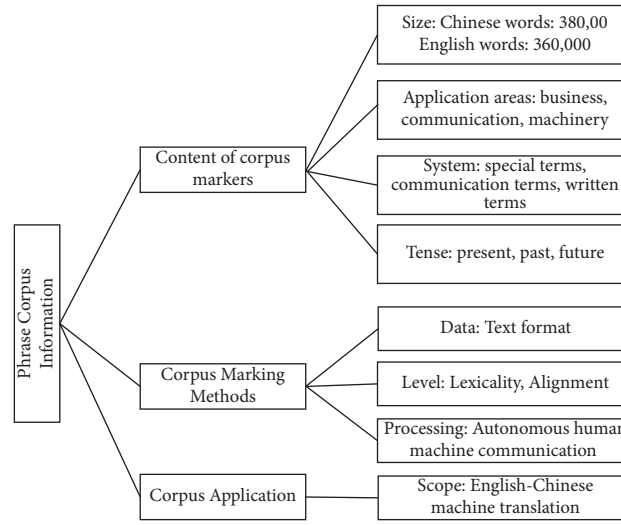


Figure 6: Phrase corpus information flow.

$$G_E = (V_N, V_r, S, \alpha). \tag{1}$$

In the formula, S is start cluster, V_N is the cycle symbol cluster, V_T is termination symbol cluster, and α is the phrase action cluster. If P represents any action in α and exists in V_N, it can be derived by derivation as follows:

$$P \longrightarrow \{\theta, c, x, \delta\}. \tag{2}$$

In the formula, θ, c, x, and δ represent the symbol on the right side of the action, the constraint value, the symbol of the center point, and the marking method, respectively.

The quaternion cluster algorithm can solve the problems of premature convergence, limited search space, and low accuracy. Therefore, this paper adopts this algorithm to improve the GLR algorithm.

4. Result Analysis and Discussion

A proper evaluation is necessary to demonstrate the performance of the IGLR method. The experimental evaluation team consists of professional translators, three engines, and professional raters. The part of speech analysis algorithms of the three engines are the statistical algorithm, dynamic memory algorithm, GLR algorithm, and enhancement algorithm. An improved GLR algorithm is implemented.

4.1. English Signal Processing. While finishing the model building work, it is necessary to process the collected speech signals, so as to obtain more accurate signals through processing and reduce interference items, thus helping the next step of translation. Figure 7 shows the processing of English signals. After the speech input, we first extract the features of the speech, then import the extracted features into the model database, match the pattern with the corpus in the model database, and finally output the recognition results.

The voice signal emphasis processing can be done by digital filter and perfect the accent detection system. The emphasis signal $y(n)$ can be seen as follows:

$$y(n) = T[x(n)] = ax(n) + b. \tag{3}$$

In this formula, $x(n)$ presents the voice input signal. The second step is to process the voice signal, and the field interference method is to implement frame-by-frame processing. In order to make the recognition step by step but repeatedly higher, we use formula (4) to divide into the t frames:

$$Z(n) = \frac{1}{t} y(n). \tag{4}$$

After the frame-by-frame operation is implemented, the speech signal is divided into small windows one by one and can be expressed as follows:

$$W(n) = \omega(n) \times z(n). \tag{5}$$

The double-threshold comparison method is used to monitor the end of the processed speech signal and the starting point and end point are obtained from the test, so as to process and store the data.

4.2. Extract Feature Parameters. First, we processed the data, then the parameter features are searched, and the subsequent calculation is finally performed. Figure 8 shows the algorithm structure used for feature extraction.

To get a continuous map, the signal spectrum is calculated by the discrete sampling value. Fast Fourier Transform FFT is obtained and a speech signal is improved to obtain the following formula:

$$X(K) = \sum_{n=0}^{N-1} x[n] e^{-j(2\pi/N)nk}, \quad k = 0, 1, 2, \ldots, N. \tag{6}$$

In the formula, $x[n]$ is the discrete sequence and $X[K]$ is the k-point reset sequence. Using FFT convert a discrete speech sequence to a Mel frequency scale as follows:

$$\mathrm{Mel}(f) = 2579 \lg\left(1 + \frac{f}{700}\right), \tag{7}$$

where $\mathrm{Mel}(f)$ is the Mel frequency and f is the actual frequency. The discrete cosine transform DTC is carried out on the filter output, and the feature parameter extraction result P of the speech signal $w(n)$ is obtained. The calculation formula is

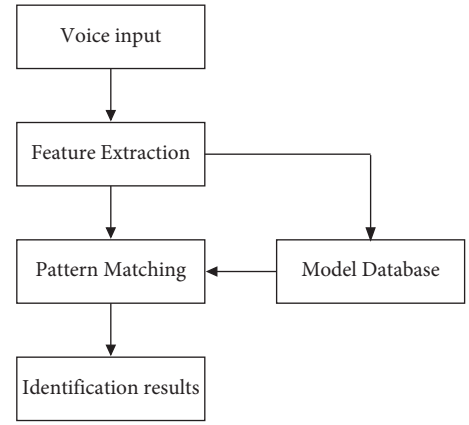


Figure 7: Processing of English signal.

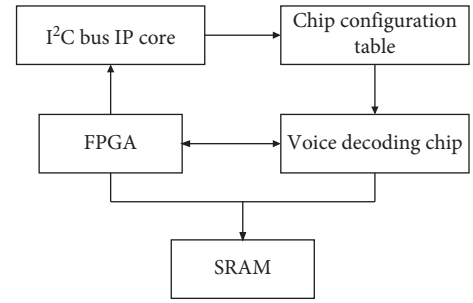


Figure 8: Structure of extracting feature parameters.

$$P = \overline{Z}_{n=1}^{N} F(l) w(n) \cos(\pi n(M + 0.5)). \tag{8}$$

Once a spectrogram has been generated for a portion of the speech signal, it must be emphasized and framed. Each short-range analysis window can obtain spectral information through fast Fourier transform, and then slope filtering is used to obtain a two-dimensional MFCC map. Using the above methods, features such as rhythm, speech rate, intonation, and intonation can be extracted.

4.3. Experimental Results and Analysis. To fully verify the validity of the intelligent recognition model for translation, the model is tested for English translation proofreading through experiments, and the data in the experiment process are recorded to analyze the system performance. In the experiment, there are 400 character proofreading vocabulary, 500 short text proofreading number, and 25 kB/s word recognition speed. By comparing the accuracy of results after proofreading and before proofreading, it can reflect the accuracy of English translation objectively and comprehensively by using comprehensive materials and diverse vocabulary. Table 1 shows the accuracy of translation before and after proofreading.

Table 1 shows the highest accuracy of the results before proofreading is 75.1%. After using the intelligent recognition module in the text, the accuracy is as high as 99.1% validity of the model. Experimental results are given in Figure 9.

Table 1: English translation accuracy before and after proofreading.

Experimental number	Translation accuracy	
	Before proofreading (%)	After proofreading (%)
1	58.2	99.1
2	72.4	98.6
3	67.5	98.4
4	72.1	99.1
5	75.1	98.5
Precision means value	69.06	98.74

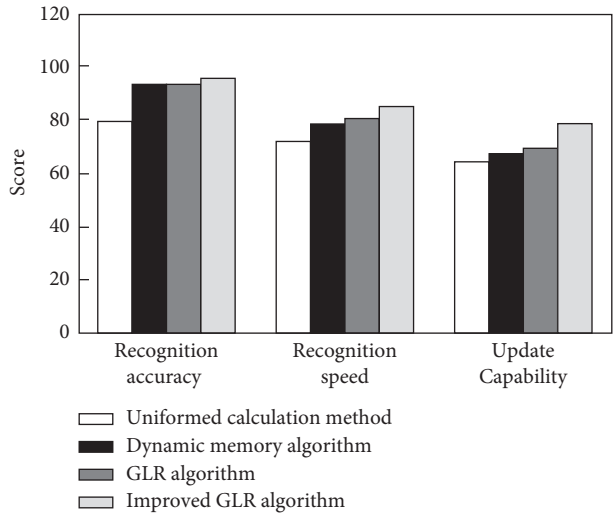


Figure 9: Evaluation results of translation algorithms.

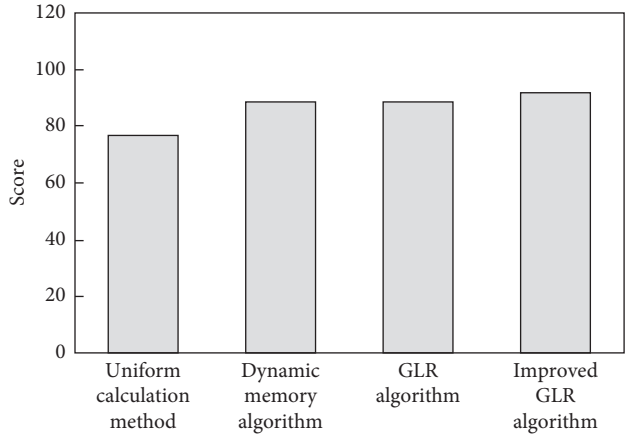


Figure 10: Comparison of comprehensive test scores.

From the figure, whether it is in accuracy, speed, or update ability, the translation effect of IGLR is the best among similar class.

Comprehensive evaluation results is shown in Figure 10, the highest score of IGLR algorithm is 92.3 points, and the lowest score based on the statistical is 76.8 points. In the final test results, there is little difference between the dynamic memory algorithm and the optimized GLR algorithm. The main gap is centered on the score for update ability.

The comparison experiment in this paper also adopts the experiment of actual translation cases, and selects the sentence "Xi'an Price Bureau limits the price of beef noodles" for translation, and finally obtains the machine translation. The experimental comparison results of human translation are shown in Table 2.

From Table 2, only the IGLR algorithm is the closest to the human. With the two algorithms of statistics and dynamic memory, the IGLR translation algorithm designed

Table 2: Comparison of translation example results.

Translation method	Translation content
Statistical methods	Xi'an explained beef noodles reduce: only because of the excessive price.
Dynamic memory algorithm	Xi'an explained beef noodles reduce: only because of the excessive price increase.
GLR algorithm	Xi'an price bureau explained that beef noodles reduce: only because of the excessive price rises.
Improved GLR algorithm	Xi'an price bureau gives the explanations of beef noodles reduce: only because of the excessive price rises.
Human translation	Xi'an price bureau gives the explanations of price control beef noodles: it is only because the rises have been too large.

has been more accurate. The translation is more accurate, and the accuracy can be more than 95%, reaching the level of human translation. The improved GLR algorithm has faster recognition, higher accuracy, and strong updating ability, so it has strong applicability and application performance in English translation.

5. Conclusion

To reduce the difficulty of structural ambiguity in translation and overcoming the disadvantage overlap in the traditional GLR algorithm, we propose an improved GLR algorithm for translation. The IGLR algorithm uses the phrase center point and corrects the structural ambiguity between English-Chinese in recognition. In this paper, various English essays and practical translation cases are used to conduct experiments on machine translation algorithms. The translation method of the IGLR algorithm is simple and fast to calculate, has lower difficulty, and has higher practicability.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work was supported by the Shijiazhuang Institute of Railway Technology.

References

[1] P. Aman, *Musical serendipity: designing for contextual music recommendation and discovery*, Doctoral Thesis, Aalto University, Espoo, Finland, 2018.

[2] G. S. Berns, C. M. Capra, S. Moore, and C. Noussair, "Neural mechanisms of the influence of popularity on adolescent ratings of music," *Neuro Image*, vol. 49, no. 3, pp. 2687–2696, 2018.

[3] Ö. Bakay, B. Avar, and O. T. Yildiz, "A tree-based approach for English-to-Turkish translation," *Turkish Journal of Electrical Engineering and Computer Sciences*, vol. 27, no. 1, pp. 437–452, 2019.

[4] S. Bi, "Intelligent system for English translation using automated knowledge base," *Journal of Intelligent and Fuzzy Systems*, vol. 39, no. 5, pp. 1–10, 2020.

[5] Y. Chen, "Business English translation model based on BP neural network optimized by genetic algorithm," *Computational Intelligence and Neuroscience*, vol. 2021, Article ID 2837584, 10 pages, 2021.

[6] W. U. Cong, "Research on Teaching Platform of Business English Literature Translation Based on Logistic Model," *Automation & Instrumentation*, 2019.

[7] J. Cui, "Tourism English translation system based on fuzzy clustering algorithm," in *Proceedings of the CONF-CDS 2021: The 2nd International Conference on Computing and Data Science*, Stanford, CA, USA, January 2021.

[8] E. Guo, "Application research of artificial intelligence English audio translation system based on fuzzy algorithm," *Journal of Intelligent and Fuzzy Systems*, vol. 1, pp. 1–10, 2021.

[9] J. K. Joseph, W. Chathurika, A. Nugaliyadde, and Y. Mallawarachchi, "Evolutionary Algorithm for Sinhala to English Translation," in *Proceedings of the 2019 National Information Technology Conference (NITC)*, Colombo, Sri Lanka, October 2019.

[10] D. Huang, "Design of Translation Accuracy Correction Algorithm for English Translation Software," *Modern Electronics Technique*, 2018.

[11] X. Lin, J. Liu, J. Zhang, and S.-J. Lim, "A novel beam search to improve neural machine translation for English-Chinese," *Computers, materials and continuum (English)*, vol. 10, p. 18, 2020.

[12] J. Mohammed Muthana, A. Mohammed Emad, and M. S. Jarjees, "Recognition of multifont English electronic prescribing based on convolution neural network algorithm," *Bio-Algorithms and Med-Systems*, vol. 16, no. 3, 2020.

[13] A. T. Nguyen, P. C. Rigby, T. Nguyen, D. Palani, M. Karanfil, and T. N. Nguyen, "Statistical translation of English texts to API code templates," in *Proceedings of the 2018 IEEE International Conference on Software Maintenance and Evolution (ICSME)*, Madrid, Spain, September 2018.

[14] Y. U. Qian and K. M. University, "Design of interactive English-Chinese translation system based on feature extraction algorithm," *Modern Electronics Technique*, 2018.

[15] W. Qu, "Algorithm design of translation accuracy correction for English translation softwares," *Journal of Physics: Conference Series*, vol. 1852, no. 4, p. 6, Article ID 42087, 2021.

[16] E. Scott, A. Johnstone, and R. Economopoulos, "BRNGLR: a cubic Tomita-style GLR parsing algorithm," *Acta Informatica*, vol. 44, no. 6, pp. 427–461, 2007.

[17] X. Wang, "Translation correction of English phrases based on optimized GLR algorithm," *Journal of Intelligent Systems*, vol. 30, no. 1, pp. 868–880, 2021.

[18] X. Wang, "Image recognition of English vocabulary translation based on FPGA high-performance algorithm," *Microprocessors and Microsystems*, vol. 80, Article ID 103542, 2021.

[19] L. Wu, "Research on English-Chinese translation of long and difficult sentences by generalized logistic regression parsing algorithm based on neural network," in *Proceedings of the 2020 Conference on Education, Language and Inter-cultural Communication (ELIC 2020)*, Zhengzhou, China, September 2020.

[20] Y. Wu and Y. Qin, "Machine translation of English speech: comparison of multiple algorithms," *Journal of Intelligent Systems*, vol. 31, no. 1, pp. 159–167, 2022.

[21] Y. U. Xiawei and J. Yuan, "Research on Chinese and English automatic translation combined authorship corpus," *Technology Intelligence Engineering*, vol. 4, 2018.

[22] Y. Xin, "Design and Application of English Chinese Translation System Based on Feature Extraction Algorithm," *Cyber Security Intelligence and Analytics*, Springer, Berlin, Germany, 2021.

[23] Y. Xiong, "The model building of hierarchical English machine translation depending on the intelligent fuzzy decision tree algorithm," in *Proceedings of the 2018 11th International Conference on Intelligent Computation Technology and Automation (ICICTA)*, Changsha, China, September 2018.

[24] Z. Yuan, C. Jin, and Z. Chen, "Research on language analysis of English translation system based on fuzzy algorithm," *Journal of Intelligent and Fuzzy Systems*, vol. 40, no. 3, pp. 1–9, 2020.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 6369692, 12 pages
https://doi.org/10.1155/2022/6369692

Research Article

A Particle Swarm Algorithm-Guided Psychological Stress Analysis to ECG Signal Collecting

Yang Li[1,2] **and Lihua Peng**[3]

[1]*College of Psychology, Beijing Normal University, Beijing 100091, China*
[2]*Centre for Mental Health Education, China People's Police University, Langfang 065000, China*
[3]*Periodical Department, Langfang Normal University, Langfang 065000, China*

Correspondence should be addressed to Yang Li; 202132061004@mail.bnu.edu.cn

Received 26 April 2022; Revised 1 June 2022; Accepted 15 June 2022; Published 28 June 2022

Academic Editor: Wen Zhou

In recent years, effective recognition and accurate assessment of psychological stress have been the focus of research. Because of the objectivity and authenticity of physiological signals, psychological stress recognition from physiological signals has become an important research content in the field of psychological stress recognition. As an important physiological signal, electrocardiogram has been proved to contain reliable physiological response to psychological stress. This paper designs a psychological stress analysis algorithm based on particle swarm optimization (PSO). The wavelet transform algorithm was used to filter and detect the ECG signal. RR interval was calculated from the detected *R* wave to obtain the ECG signal. An improved particle swarm optimization (PSO) algorithm was proposed, which introduced a particle swarm optimization model with contraction factor to eliminate the speed limit and realize the detection of psychological stress. Experimental results show that the recognition rate of the improved particle swarm optimization algorithm is significantly higher than that of the traditional method, which shows the effectiveness of the algorithm. On the one hand, the research of this paper has optimized the algorithm, which has theoretical significance; on the other hand, it can provide reference for the real psychological stress test, which has practical significance.

1. Introduction

With the increasingly close integration of the Internet and people's production and life, people's demand for virtual scenes is increasing, and chronic psychological stress poses a threat to the human health [1]. Because the external factors we accept are too complex, the degree of psychological pressure will be different for each person. When we are working or studying, a certain degree of psychological pressure can improve the efficiency of our work and study, but if the psychological pressure is too high and if it is too large or for too long, then this stress state will affect the health of the human body and lead to some kind of psychological or physiological disease. Modern medicine has proved that psychological stress can weaken the body's immune system, leading to external factors causing diseases in the body [2]. When people are under pressure, they will have a series of physical and mental reactions. If the pressure exceeds the range that people can bear, it will break the physiological balance of the human body and cause the nervous system of the human body to be in a disordered state, showing a series of symptoms, such as: insomnia, depression, endocrine disorders, cardiovascular disease [3]. Establishing an effective psychological stress assessment system can help identify the psychological stress states and then implement appropriate interventions. There are many ways to assess psychological stress. Currently, a questionnaire method is commonly used to assess psychological stress, but the assessment of this method is only a general assessment and the results of the assessment are not accurate enough. Nowadays, with the widespread popularity of a series of wearable devices such as smart watches and smart bracelets, it is more convenient to use physiological parameters to identify psychological pressure in daily life, and

it is helpful to reasonably adjust people's psychological pressure, which can make people's life easier. The quality, work efficiency, and learning efficiency are improved, and at the same time, it can effectively mediate people's mood, and avoid various diseases caused by psychological pressure.

Due to the objectivity and authenticity of physiological signals, psychological stress recognition from physiological signals has become an important research content in the field of psychological stress recognition and in physiological signal psychological stress identification research, mainly through the analysis of the collected psychological stress physiological signals, extracting the characteristics that can represent specific psychological stress, and establishing a psychological stress identification model for psychological stress identification. As an important physiological signal, ECG signal has been proved to contain reliable physiological response to psychological stress. At the same time, ECG signal is an important research object in medicine, and its signal processing technology has been relatively mature.

Based on this background, this paper proposes a psychological stress analysis algorithm under the particle swarm algorithm based on ECG signal acquisition. The wavelet transform algorithm is used to realize the filtering and detection of ECG signals, so as to calculate the RR interval through the detected R wave. In order to obtain the ECG signal and extract the ECG characteristic parameters that can characterize the degree of stress, an improved particle swarm optimization algorithm is proposed. The full text is divided into 5 chapters. Chapter 1 introduces the research background, research necessity, and chapter arrangement of the thesis; Chapter 2 mainly introduces some main research work on psychological stress detection at present, and introduces the research methods of this paper; Chapter 3 mainly introduces the collection and identification of ECG signals, and uses particle swarm algorithm to detect psychological stress; Chapter 4 mainly uses the designed detection algorithm to evaluate human psychological stress and examine the effect of evaluation. Chapter 5 mainly summarizes the work of the full text and proposes an imagination for the next step.

The purpose of this paper is to use the improved particle swarm optimization algorithm to detect psychological stress. On the one hand, the research of this paper has optimized the algorithm, which has theoretical significance; on the other hand, it can provide reference for the real psychological stress test, which has practical significance.

2. State of the Art

The increasing pressure of human life has gradually attracted people's attention to the research on the identification algorithm of psychological stress. Since the beginning of the 21st century, the use of physiological parameters to identify psychological stress has become the focus of domestic and foreign researchers. At present, there are many methods and means for the identification and assessment of psychological stress at home and abroad.

Professors Healey and Picard from MIT effectively assessed the driver's psychological state by collecting the driver's ECG signal, EMG psychological stress signal and breathing signal, mainly recording the psychological stress of drivers driving on a fixed road in downtown Boston and physiological signals, and proved the feasibility of using physiological signals to identify stress [4]. Setz et al. identified the characteristics of galvanic skin response through psychological stress LDA and SVM algorithms, and the recognition rate of LDA algorithm reached more than 80%. Students at the University of Augsburg use games to induce the psychological pressure of the human body. At the same time, the collected EMG signals and breathing signals under two different states of low pressure and high pressure are the research objects, and finally judged by LDA and Fisher. According to the analysis results, the average recognition rate of psychological stress is over 85% [5]. Minh et al. of Cameron University established a psychological stress model with support vector machine as a classifier, and proved through experiments that the support vector machine algorithm model is stable in identifying stress and has a higher recognition rate [6]. Javier Hemandez et al. first collected the physiological signals of call center employees, and collected two kinds of physiological signals, stressful and non-stressed, and then corrected the loss function of the support vector machine to identify the difference between stress and non-stress. Finally, different people are trained and tested by this method to obtain higher classification accuracy [7]. Hoover et al. used computer game characters to induce the psychological stress of the testers, collected the psychological stress under two different states of low work stress and high work stress, and then detected the human heart rate variability signal by using the sub-Gaussian fitting. Compared with the method of psychological stress and analysis, the experimental results show that the sub-Gaussian fitting method has higher recognition accuracy than the classical cumulative sum method [8]. Subahni AR employs a racing game to induce stress, collects ECG signals from six subjects, and extracts features of HRV in the time and frequency domains for analysis. It has been verified that HRV can predict psychological stress by detecting changes in the autonomic nervous system [9]. Singh et al. quantitatively analyzed the stress of the human body in the state of fatigue, proposed a method for inducing stress based on neural network, and performed statistical and time-frequency domain analysis on it, taking the characteristics of galvanic skin response as the research object. Finally, the psychological stress is identified through the recurrent neural network, and the average identification rate is 89.2% [10]. Mohammadi et al. used discrete wavelet transform to decompose the ECG signal into different frequency bands, and then extracted the corresponding features for classification using KNN and SVM classifiers, achieving an accuracy of 86.75%.

Professor Hu Bin of Lanzhou University used EEG signals to identify human stress, and chose K-nearest neighbor classifier as the classification algorithm in the system, and developed an online stress monitoring system based on EEG signals [11]. Yuan Tian developed a CNN model to detect the psychological pressure of college students, and the model detection accuracy reached 98% [12].

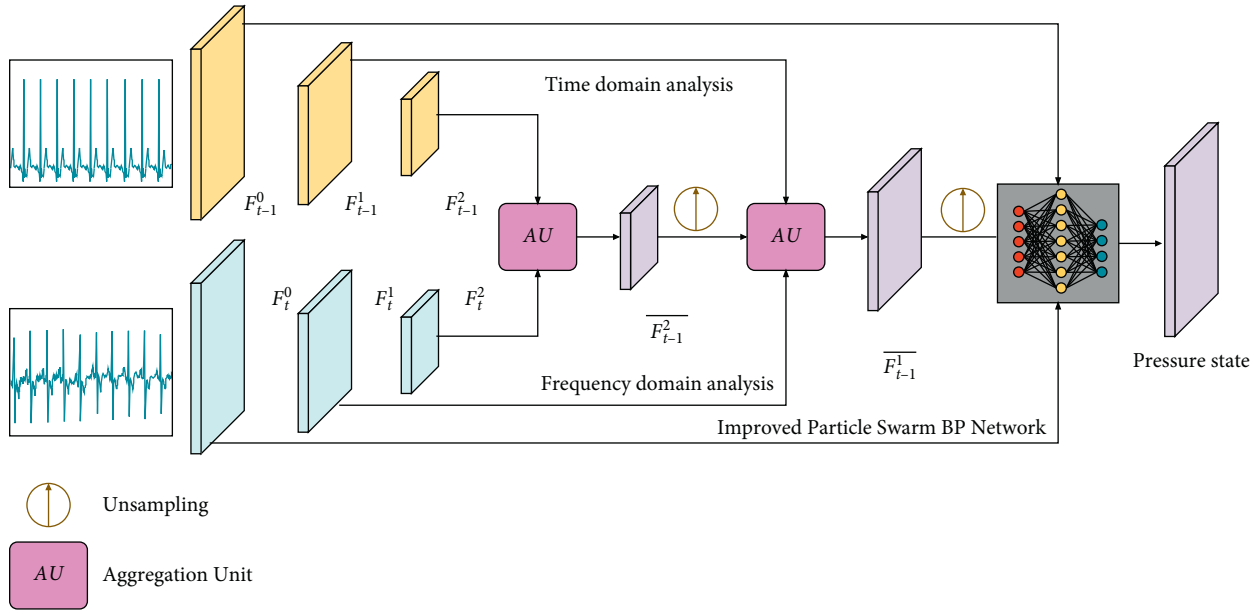


Figure 1: Psychological stress detection method under the particle swarm algorithm based on ECG signal acquisition.

Zhao Wen from Lanzhou University studied the psychological stress of specific groups of EEG signals, taking the mothers of seven mentally retarded children and the mothers of four normal children of the same age as the research objects, and using their EEG data as the data source [13]. Among them, the EEG data of mothers of mentally handicapped children was taken as stress data, and the EEG data of mothers of normal children was taken as stress-free data. First, the linear and nonlinear features extracted from EEG signals were compared, and then, combined with the evaluation scale PSQI and LZC complexity, alpha relative power and other features, finally, the psychological stress state was more effectively evaluated [14]. Professor Li Ting from Yanshan University led her team to first collect 36 sets of ECG signals, 18 sets of surface EMG signals, and 18 sets of finger pulse wave signals from nine test subjects, and used these signals as the raw data for identifying psychological stress. Then, the DS evidence theory and the SVM algorithm are combined to build a stress recognition model, and finally, the recognition of psychological stress is realized, which proves the validity of the model in evaluating the psychological stress state [15]. Professor Li Ting led her team to improve and study the algorithm for identifying individual differences in psychological stress, using EMG signal as the sample parameter for the study, and proposed an improved support vector machine (SVM) for psychological stress identification algorithm. In order to reduce the training error, the loss function of the support vector machine is improved by the method of clustering the samples, and the clustered information is assigned to the loss function to realize the recognition of psychological stress. It is shown that the algorithm can effectively resolve the individual differences in assessing the psychological stress [16].

To sum up, it can be seen from the domestic and foreign research results that it is feasible to extract HRV features to identify psychological stress. At present, most studies at home and abroad identify psychological stress through a variety of physiological signals, which can be applied in practice to a certain extent, but the accuracy still needs to be further improved, and there are relatively few studies on stress model construction based on HRV. This paper proposes a psychological stress detection method based on PARTICLE swarm optimization (PSO) for ECG signal acquisition, and its basic framework is shown in Figure 1. ECG signal is filtered by wavelet transform. At the same time, the algorithm was used to detect the filtered ECG signal, locate the *R* wave, calculate the RR interval, and get the HRV signal. Then, the improved particle swarm optimization algorithm is used to identify psychological pressure, which can make up for the shortcomings of previous literature research.

3. Methodology

3.1. ECG Signal. The internal cardiac structure of the human body includes four chambers: the left atrium, the right atrium, the left ventricle, and the right ventricle, and the power source is the heart. The heart is dominated by cardiomyocytes. Cardiomyocytes include special cardiomyocytes and ordinary cardiomyocytes. The function of special cardiomyocytes can produce excitatory effects. The composition of ordinary cardiomyocytes is the ventricular wall and the atrial wall. Its function is that it can act on the contraction of the cardiac chambers. If a person is subjected to some external stimuli, the human body will produce a state of psychological tension or nerve excitation, and at this time, it will be transmitted to the cardiomyocytes through the nerves, and the cardiomyocytes will dominate the heart, so that the diastolic and systolic functions of the heart will be accelerated., the heartbeat speed will be accelerated, therefore, it can be seen that psychological stress is closely related to ECG signal, and shows the regularity and stability of ECG signal waveform [17]. The waveform of the ECG signal is

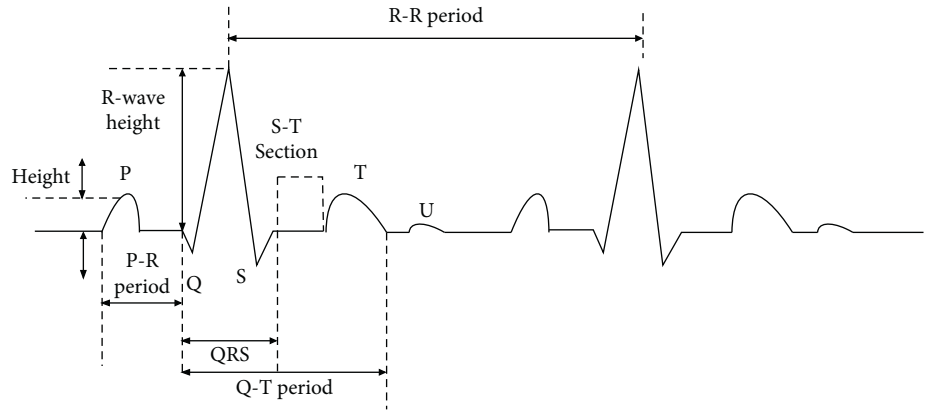


Figure 2: Typical ECG waveform.

mainly composed of five waveforms: Q, R, S, P, and T, and its characteristic intervals are: RR interval, PR interphase, QRS segment, ST segment, and QT interval. In the ECG waveform, if the lead mode is different, the ECG waveform will also be different, and the most obvious feature is the QRS complex. Therefore, doctors usually diagnose the patient's condition by the morphological characteristics of the ECG signal. A typical ECG waveform is shown in Figure 2.

P wave: under normal circumstances, caused by the right atrium and left atrium continuously, also known as myocardial depolarization wave. The highest amplitude of P wave generally does not exceed 0.25 mV, and the duration generally does not exceed 0.12s.

QRS complex: represents the excitation state of the left and right ventricles. The QRS complex is the most characteristic because the ventricular muscle is more developed than the atrial muscle, and its duration represents the time required for the ventricular muscle activation process. Under normal conditions, it does not exceed 0.1S, and the R wave amplitude ranges from 0.5 to 2 mV.

T wave: the potential change generated when the ventricular muscle is activated and recovered is the T wave, and its amplitude range is 0.1–0.5 mV, and its amplitude should be 1/10 lower than that of the *R* wave.

RR interval: refers to the time between the *R* waves of two QRS complexes. A cardiac cycle in the ECG is usually represented by the RR interval, and the time of the RR interval can also be used to calculate the size of the heart rate.

PR interval: refers to the part from the beginning of the P wave to the beginning of the QRS complex. The meaning of this part is the time between atrial depolarization and ventricular depolarization. The time range is 0.12–0.20s.

ST segment: refers to the part from the end of the QRS complex to the beginning of the T wave. The meaning of this part is the resting stage from ventricular depolarization to ventricular repolarization. It shows a smooth straight line on the waveform.

At present, the typical biomedical signal is the ECG signal, which is mainly analyzed from four aspects: the frequency spectrum of the signal, the amplitude of the signal, the impedance of the human body, and the noise of the ECG signal.

(1) The frequency range of ECG signal is 0.05–100 Hz, which is a low-frequency signal, and its spectral energy is mainly concentrated in 0.5–35 Hz.

(2) The amplitude of the signal is very weak, it is a weak signal, its amplitude range is between 0.01 and 5 mV, and the typical value is usually 2 mV.

(3) The ECG signal has high impedance. Since the human body is the source of the ECG signal, and the impedance of the human body is related to the wetness and cleanliness of the skin on the body surface, the impedance characteristics are relatively complex. The impedance value of the human body is generally in the range of several thousand ohms to tens of thousands between ohms.

(4) The interference noise is strong. The noise of the ECG signal mainly includes: power frequency interference, baseline drift, and EMG interference. Among them, the power frequency interference in my country is 50 Hz, and these interferences will affect the extracted HRV. It affects the recognition rate of psychological stress, so it is also very important to remove the interference noise in the ECG signal.

The human nervous system mainly includes the central nervous system (CNS) and the peripheral nervous system. The central nervous system not only affects most organs of the human body, but its physiological process also affects the psychological stress state of the human body. The CNS mainly regulates the psychological and physiological stimulation of the human body. When it receives some external stimulation, first, the hypothalamus is stimulated, and then the pituitary gland is stimulated. Then, the autonomic nervous system will perceive the stimulation, so that the body's limbs will be stimulated producing a corresponding reaction. The physical and psychological stress response model is shown in Figure 3.

When the human body is stimulated by the outside world, the body's receptors will perceive the stimulation, and then judge whether it feels pressure through the cerebral cortex. Response; if the cerebral cortex does not perceive pressure, then the human body will not have a stress

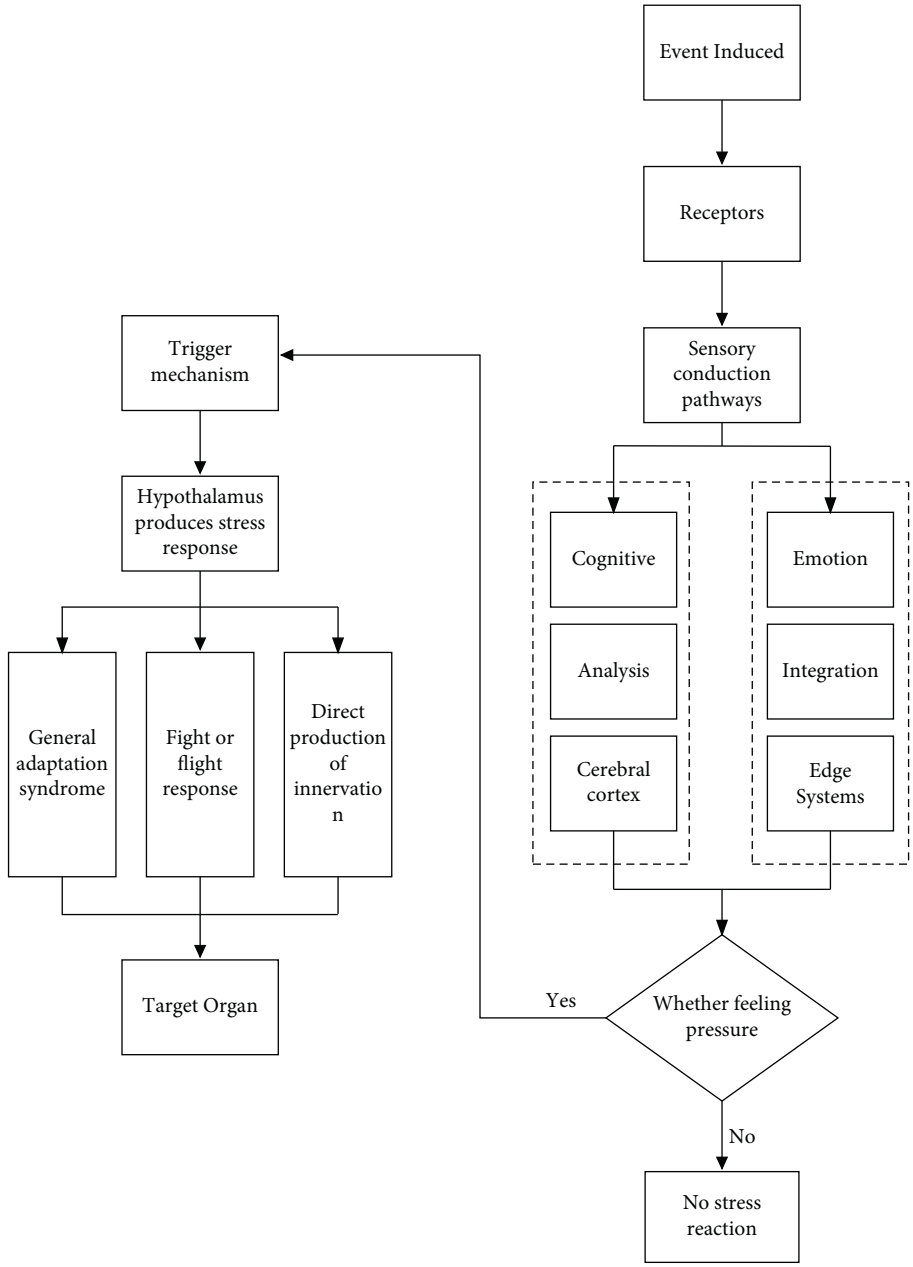


Figure 3: Model diagram of human psychological stress response.

response [18]. HRV can be used not only to measure the human heart activity, but also to detect autonomic nervous system activity, cardiovascular disease, etc. Therefore, by measuring HRV, the stability and activity of the autonomic nervous system can be assessed, as well as the psychological stress state of the human body.

3.2. ECG Signal Feature Extraction. The ECG signal is a biological signal. According to the response characteristics of ECG signal, the RR interval of ECG signal is generally calculated after *R* wave is detected and HRV is obtained. The HRV is analyzed and characteristic parameters are extracted. The characteristic parameters were extracted by linear analysis (time domain analysis and frequency domain analysis) and nonlinear analysis.

3.2.1. Time-Domain Analysis. The time domain features of HRV are extracted according to statistical methods. The formula for calculating the mean value of the RR interval is

$$\overline{RR} = \sum_{i=1}^{N} \frac{RR_i}{N(1)}, \tag{1}$$

where N represents the number of RR intervals, and RRi is the ith RR interval. SDNN represents the overall standard deviation, which acts on the autonomic nervous system of

the human body and is used to reflect the psychological stress of the human body. The calculation formula is

$$SDNN = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(RR_i - \overline{RR}\right)^2}. \quad (2)$$

RMSSD represents the root mean square difference of the RR intervals, is related to the vagus nerve, and measures the magnitude of the heart rate to reflect stressful states. The calculation formula is

$$RMSSD = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(RR_{i+1} - \overline{RR_i}\right)^2}. \quad (3)$$

SDSD represents the standard deviation of all adjacent RR interval differences, calculated as:

$$SDSD = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(\Delta RR_i - \Delta\overline{RR}\right)^2}. \quad (4)$$

Among them, ΔRRi represents the difference between adjacent RR intervals; ΔRR is the average value of the difference between N consecutive two RR intervals.

3.2.2. Frequency-Domain Analysis. Since the autoregressive (AR) model can not only overcome the shortcomings of nonparametric estimation but also can well reflect the smooth spectral curve of the peaks. Therefore, the frequency domain analysis adopts the AR model analysis method. The model can be expressed as

$$x(n) = -\sum_{k=1}^{p} a_k x(n-k) + u(n). \quad (5)$$

Through the z-transformation, the transfer function of the system can be obtained as.

$$H(z) = \frac{1}{A(z)} = \frac{1}{1 + \sum_{k=1}^{p} a_k z^{-k}}. \quad (6)$$

The power spectrum of the output sequence is

$$P(\omega) = \sigma^2\left|H\left(e^{jw}\right)\right|^2 = \frac{\sigma_w^2}{\left|1 + \sum_{k-1}^{p} a_k e^{-jkw}\right|^2}. \quad (7)$$

3.2.3. Nonlinear Analysis. According to the nonlinear analysis methods for HRV researched in most literature, it can be seen that there are few studies on human psychological stress recognition, and basically use nonlinear analysis methods to study pathology. Nonlinear feature extraction of HRV is done using Poincare scatterplot method to identify stress states. Using the scatterplot method analysis, two main parameters, SD1 and SD2, can be obtained, where SD1 reflects changes in HRV medium and very low-frequency components, which are related to sympathetic nerve changes; SD2 is a rapid change in HRV, which is related to vagal nerve activity.

$$SD_1 = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\frac{\left(RR_i - RR_{i+1}\right)^2}{2}}. \quad (8)$$

$$SD_2 = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\frac{\left(RR_i - RR_{i+1} - 2\overline{RR}\right)^2}{2}}. \quad (9)$$

3.3. Particle Swarm Optimization

3.3.1. Elementary Particle Swarm Optimization. Particle swarm optimization (PSO) is a behavioral research method which evolved from bird foraging behavior and is mainly used to solve optimization problems. Its basic principle is that in each problem to be optimized, one of its solutions is a particle in the search space, and each particle corresponds to a fitness value. The fitness function model is an optimization function model. In addition, the speed at which a particle searches can determine its direction and distance. When the direction and distance are determined, the direction and distance of the particle can be searched continuously until the optimal value is found [19]. It is found that particle swarm optimization algorithm can deal with some problems that traditional methods cannot deal with. Examples include nondifferentiable node transfer functions or no gradient information. The basic algorithm flow is shown in Figure 4:

Assuming that the number of input features is D, and there are m individuals in the population, the velocity of the ith particle is V, and the position is expressed as Xi. At this point, the position value of the particle is a solution to the problem we need to solve. At the same time, first, the fitness function model is established, then, the fitness value is calculated, and finally, an optimal solution is obtained by comparing the fitness value of each particle. Among them, we call the best position experienced by the current ith particle as Pbest, and by comparing all particles, the best position Gbest of the entire population is obtained. When the optimal solution of Pbest and Gbest is found, the next generation of particles is obtained by calculating the following two formulas, and the calculation is repeated repeatedly until an optimal solution is obtained.

$$\begin{aligned} V_i^{n+1} &= V_i^n + C_1\mathrm{rand}_1(\,)\left(Pb\mathrm{set}_i - X_i^n\right) \\ &\quad + C_2\mathrm{rand}_2(\,)\left(Gb\mathrm{set}_i - X_i^n\right). \end{aligned} \quad (10)$$

$$X_i^{n+1} = X_i^n + V_i^n, \quad (11)$$

where: c_1 and c_2 are learning factors; $\mathrm{rand}_1(\,)$ and $\mathrm{rand}_2(\,)$ are random vectors between 0 and 1; V is the velocity of the ith particle to the nth particle; X is the ith particle The position of the particle to the nth particle.

3.3.2. Improved Particle Swarm Algorithm. In order to avoid the elementary particle swarm optimization algorithm easy

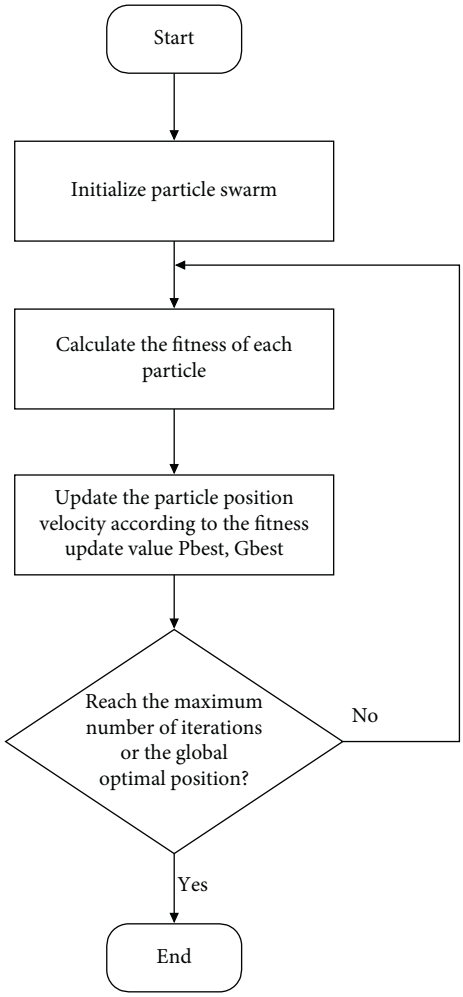


Figure 4: Algorithm flow of basic particle swarm.

to fall into local optimal, there will be premature convergence in the optimization process, resulting in a large error. Therefore, the fundamental particle swarm optimization algorithm will be improved. Among them, the empirical information contained in the remaining particles and the empirical information algorithm. C1 of the particles themselves are represented by learning factors C1 and C2 in the particle swarm optimization and C2 are particle trajectories that show mutual information in the particle swarm and the exchange. Therefore, once the value of learning factor C1 is set at a higher level, the particles will remain in a limited range and continue searching will be more difficult converging to a local minimum. To solve this problem, a particle swarm optimization model with shrinkage factor is introduced. Under the action of contraction factor, not only the velocity boundary limit will disappear, but also appropriate parameters can be selected to ensure the bounded convergence of PSO. Therefore, in order to improve the accuracy of analysis, this paper adopts the improved particle swarm optimization algorithm for analysis. The velocity formula and contraction coefficient formula are as follows:

$$V_i^{n+1} = \varphi\left[V_i^n + C_1 \mathrm{rand}_1(\,)\left(Pb\mathrm{set}_i - X_i^n\right) + C_2 \mathrm{rand}_2(\,)\left(Gb\mathrm{set}_i - X_i^n\right)\right]. \tag{12}$$

$$\varphi = \frac{2}{\left|2 - C - \sqrt{C^2 - 4C}\right|}, C = C_1 + C_2 > 4. \tag{13}$$

4. Result Analysis And Discussion

4.1. Stress-Induced Experimental Protocol Design. According to the ECG acquisition circuit and the designed program, the original ECG signal is obtained. On this basis, the HRV signal is calculated. Then, in order to carry out the follow-up research on psychological stress recognition algorithm, an effective psychological stress induction scheme must be designed. Firstly, stress-induced ECG signals were collected by stress induction experiment, and then the characteristic parameters of HRV signals were extracted. Finally, the characteristic parameters are used to study the mental stress recognition algorithm.

In the process of stress induction, one is to collect the psychological stress signals generated in our actual life or work. Another approach is to use experimental materials and equipment to induce pressure and then collect a signal. The former is closer to reality and more effective in analyzing psychological stress. At present, there are many researchers in the world to collect pressure signals in actual work and life, but this method requires greater labor intensity, material and financial resources, and requires experimental equipment [20]. In contrast, the latter is more convenient and uses laboratory equipment and materials to achieve psychological stress induction, which not only has reliable data, but also has less interference in the collection process, providing help for the identification and research of psychological stress [21]. In order to make the data collected more effective and reliable, the selection of stress induction program is also more important.

In this design, emergency induction is accomplished by mental arithmetic task. Mental arithmetic tasks were used as a laboratory method to induce stress in subjects. The mental arithmetic task significantly increased the subjects' cortisol production (effectively triggering stress). In order to evaluate the high pressure and low pressure states more effectively, in the emergency induction experiment, the calm state of the subjects was regarded as the low state, and the part of the mental arithmetic task was regarded as the high state. The specific implementation process is shown in Figure 5.

First, let the tester be in a calm state for 120s, and then start to induce stress by using a mental arithmetic task. The task is to allow the tester to correctly mentally calculate the subtraction of twenty-four-digit problems randomly appearing on the computer within 10s, and repeat the mental arithmetic 10 times. Finally, after the mental arithmetic task is completed, the tester rests and returns to a calm state. The experimental scheme of mental arithmetic task is shown in Table 1.

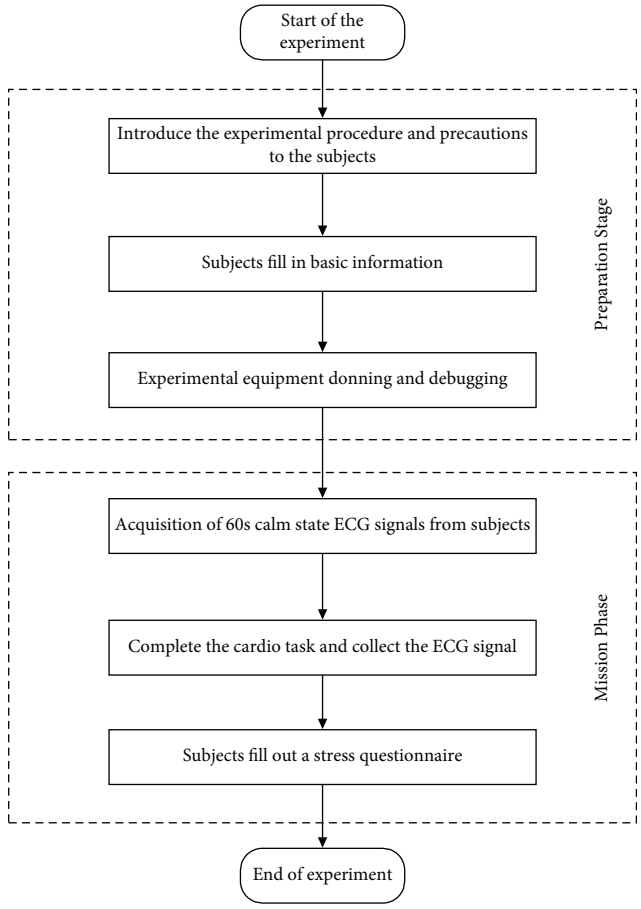


Figure 5: Stress-induced experimental procedure.

Table 1: Experimental scheme of mental arithmetic task.

Experimental content	Time/s	Pressure state
Rest	120	Low pressure
Subtract random twenty-four digits	10	High pressure
Rest	120	Low pressure

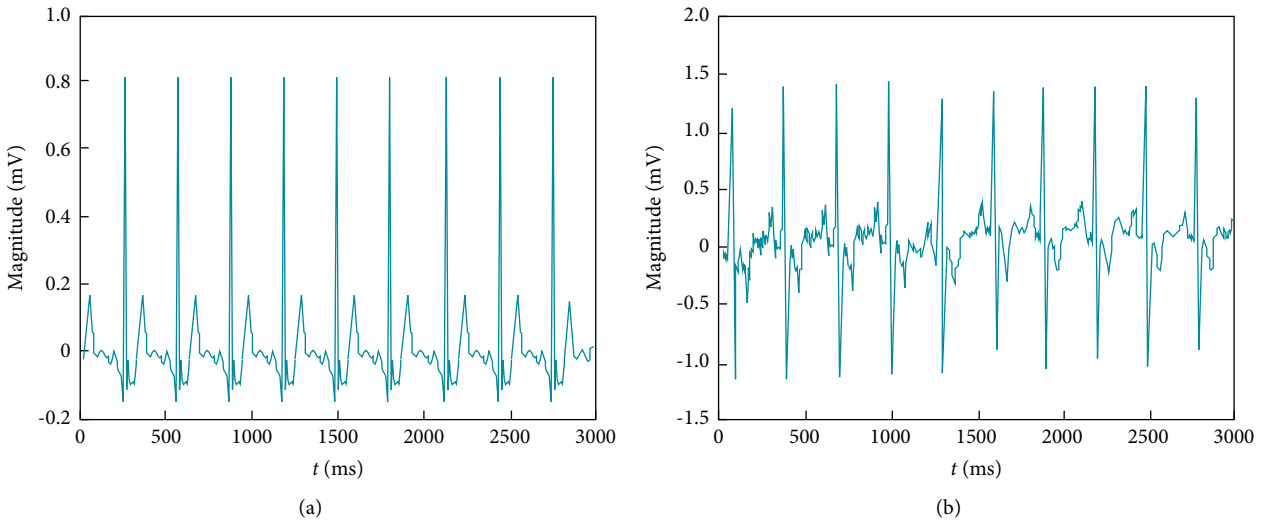
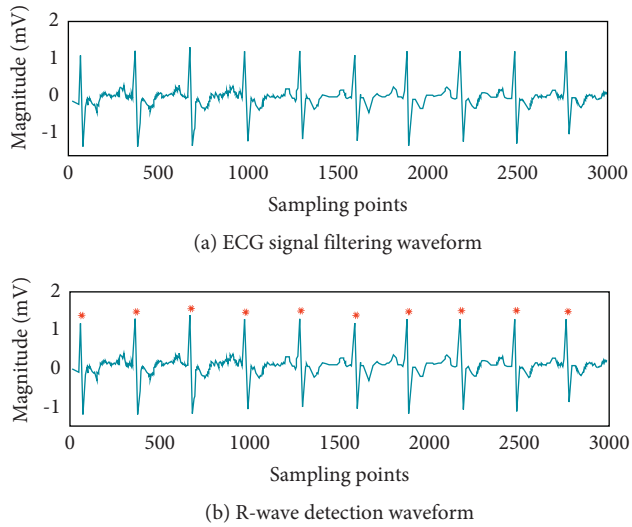


Figure 6: Low-voltage state and high-voltage state ECG signal waveform. (a) Low pressure. (b) High pressure.

In order to ensure the objectivity and scientific nature of the experiment, the subjects of this experiment were undergraduate and graduate students (19–26 years old), who did not have any mental or physical diseases and had clear cognitive ability and mental arithmetic ability. ECG signals of 30 graduate and undergraduate students were collected, a total of 200 groups of ECG data were collected, and unstable signals were removed. A total of 150 groups of effective data were collected, including 80 groups of high pressure data and 70 groups of low pressure data. 3 000 sample points during the calm phase were used as low pressure and 3 000 sample points during pressure induction were used as high pressure data. The waveforms of ECG signals under low pressure and high pressure are shown below.

From Figure 6 that the collected ECG signals in low-voltage and high-voltage states contain interference, namely, power frequency interference, baseline drift, and EMG interference. In order to more clearly compare the RR intervals under the two stress states from the waveform diagram, ECG signal processing will be performed, the RR interval will be calculated from the processed waveform diagram, the HRV signal will be obtained, and the stress-related signals will be extracted from the HRV characteristics. Therefore, the collected pressure-containing ECG signal is filtered through wavelet transform. Select the Symlets wavelet to decompose the ECG signal with 8 layers of wavelet, and use the Wden function and the Zeros function for filtering. The electrical signal is decomposed, and the number of decomposed layers is 4 layers. The waveforms of the filtered signal and the R-wave detection signal are shown in Figure 7.



(a) ECG signal filtering waveform

(b) R-wave detection waveform

Figure 7: Waveforms of filtered signal and R-wave detection signal. (a) ECG signal filtering waveform. (b) R-wave detection waveform.

4.2. ECG Signal Feature Extraction and Analysis. According to the feature extraction method in Section 3, the obtained ECG signal is feature extracted, and some stress-related feature data extracted by time domain, frequency domain, and nonlinear analysis methods are shown in Table 2.

Table 2: Characteristic data under different pressure states.

Parameter	Low pressure	High pressure
RR_{mean}	0.8713	0.7394
HR_{mean}	68.8644	81.1435
RMSSD	28.60	35.12
PNN_{50}	0.1711	0.2648
RR_{std}	0.1437	0.1639
HR_{std}	5.1	5.5
SDNN	48.8	50.1
SDSD	17.5	20.1
VLF	0.0761	0.0810
HF	0.8124	0.9201
LF	1.5899	1.0480
LF/HF	1.1321	1.0346
SD_1	45.66	48.1
SD_2	52.89	55.42

Since the extracted HRV features are related to the autonomic nerve activity of the human body and reflect the degree of psychological stress, the significance of the stress-related feature parameters is calculated and compared and analyzed. After analysis, it is found that among the extracted features, SDNN and HF show the most obvious difference under different pressure levels. The variation trend of SDNN and HF with pressure is shown in Figure 8.

Studies have shown that SDNN, PNN50, and NN50 are related to sympathetic nerve tone, and HF is related to cardiac vagal nerve activity [22]. Therefore, the comparison of features extracted from HRV can reflect the influence of human body on autonomic nervous activity under stress. SDNN and HF feature parameters appear obviously with the increase of the stress level. The significant changes showed that the activity of the heart's sympathetic and vagus nerves also changed significantly. It can be seen that when pressure increases, the function of the sympathetic nerve is inhibited, and the function of the vagus nerve is reversed. Therefore, the eigenvalue can effectively detect the pressure, and can be better used in the pressure recognition algorithm. This is because the optimized algorithm is more sensitive to the change of parameters and can reflect the change of nerves.

4.3. Analysis of Psychological Stress Recognition Results. In the simulation experiment, 120 samples were selected as the training set and 30 samples as the test set, that is, the training set and test set are about 4 : 1. Low pressure sample category label set to 1, high pressure sample category label set to 2. According to the above, BP neural network and PSO-BP neural network algorithm can make more accurate analysis according to the characteristics of ECG signal. Therefore, this paper selects these two algorithms for comparison. In the simulation experiment, the BP neural network algorithm and the improved PSO-BP neural network algorithm achieve the accuracy of psychological stress recognition, as shown in the Figure 9.

From Figure 9, the accuracy of the improved PSO-BP neural network test set is 93.33%, and the accuracy of the BP neural network test set is 86.67%, and the accuracy of the BP

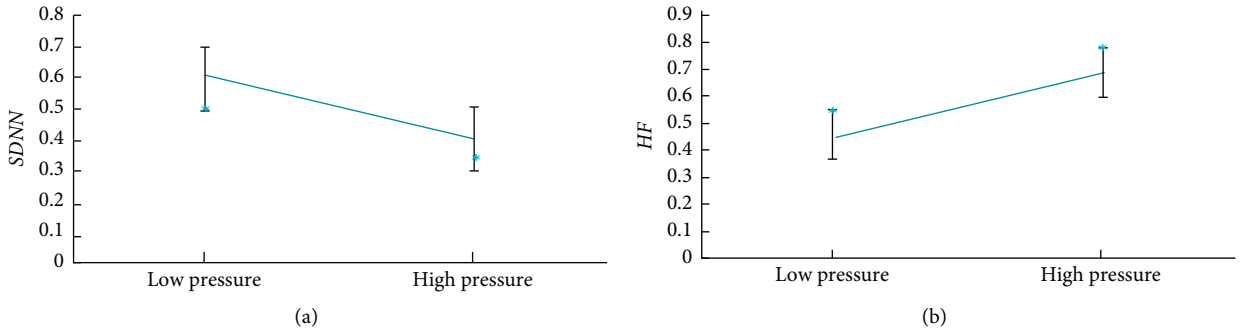


Figure 8: Variation trend of SDNN and HF with pressure. (a) SDNN. (b) HF.

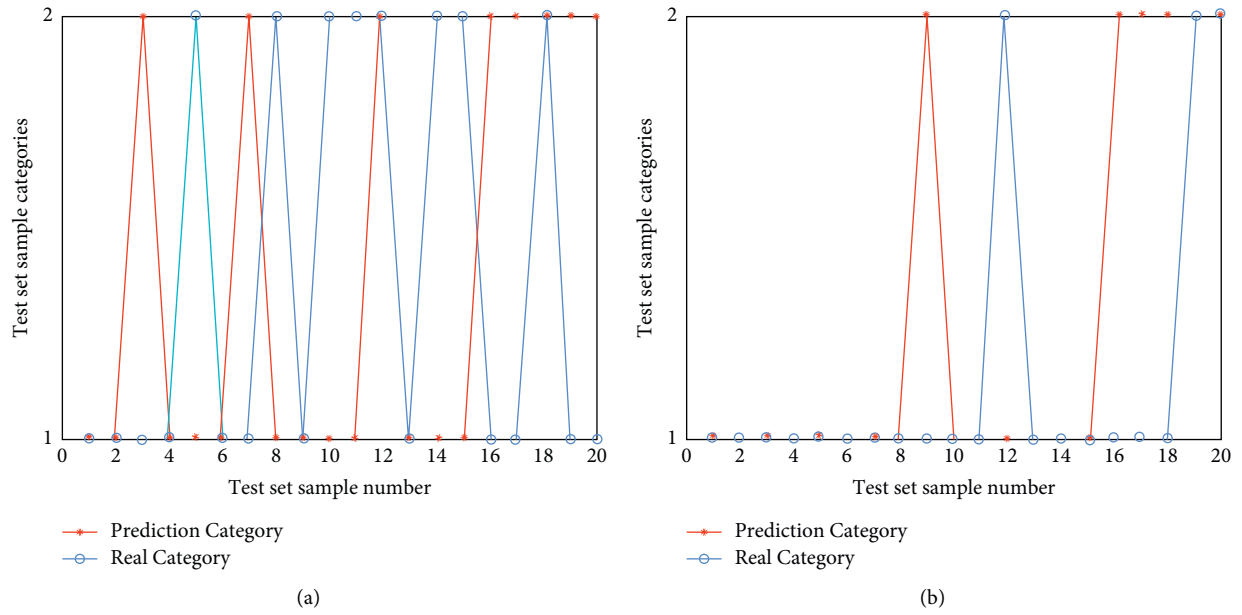


Figure 9: BP neural network and improved PSO-BP neural network test set accuracy. (a) BP neural network. (b) Improved PSO-BP neural network.

network model optimized by the improved PSO model is increased by 6.66%.

Figure 10 shows the average recognition rate of psychological stress by the BP neural network tested 20 times and the improved PSO-BP neural network. The recognition rate of HRV sample signals by the optimized neural network is relatively high and stable, and the recognition rate of psychological stress by the improved particle swarm optimization BP neural network (PSO-BP) algorithm is over 90%. As can be seen from the figure, the average recognition rate of BP neural network to psychological stress is 90.17%; the average recognition rate of improved PSO-BP neural network to stress is 94.83%; the average recognition rate of improved PSO-BP neural network is improved up 4.66%. The experimental results show that the improved PSO-BP algorithm can effectively improve the recognition rate of psychological stress, and the recognition rate is 94.83%, and the recognition rate of BP neural network is increased by 4.66% on average. The algorithm can effectively identify the psychological stress state, and provide a means for the intervention of psychological stress state and mental health.

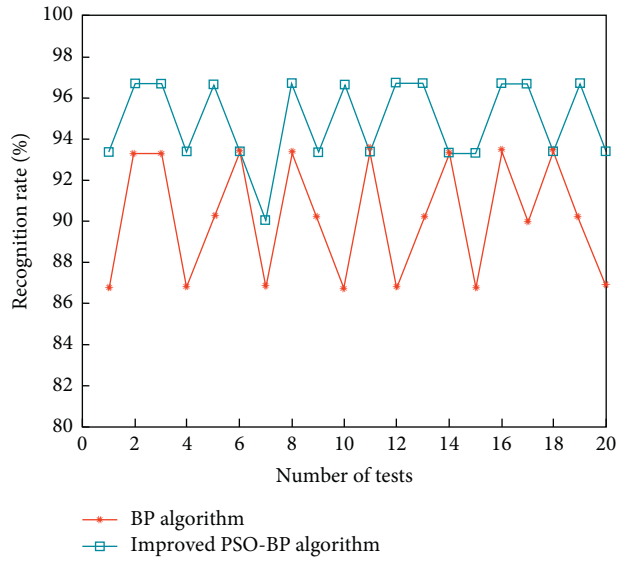


Figure 10: Comparison of the recognition rates of the two algorithms.

5. Conclusion

At present, the assessment of psychological stress is mainly carried out in two ways: questionnaires and physiological parameters. The method of questionnaire survey must allow the testers to actively cooperate and have subjective awareness, and the statistical data is often not reliable; and it is more accurate to evaluate psychological stress through the physiological parameter HRV. This method uses the human body's stress response to evaluate stress. When the human body is stimulated, the physiological balance of the body will be broken, and the physiological parameters of the human body will change at this time. The method is intelligent, accurate, and reliable. In order to improve the recognition rate of psychological stress, an improved stress recognition algorithm based on particle swarm optimization BP neural network is proposed in this paper. On the basis of the basic particle swarm (PSO) model, the algorithm introduces a shrinkage factor. Under the action of the shrinkage factor, the boundary limit of the velocity disappears. Appropriate parameters are selected to ensure the bounded and convergent characteristics of the PSO algorithm. There is optimization of BP Neural Networks. Use mental arithmetic tasks to induce stress, collect ECG signals under high and low pressure states, extract the characteristic values of heart rate variability related to psychological stress, and compare and analyze the characteristic data; establish a classification model of psychological stress degree, through the improved PSO model optimizes BP neural network to identify psychological stress. The results show that compared with the BP neural network, the improved particle swarm optimization BP neural network algorithm has fast convergence speed, small error, and high recognition rate. The recognition rate of this algorithm for psychological stress can reach 94.83%, and the recognition effect is better than the unoptimized BP neural network algorithm.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

This work was supported by the Key Special Topics at the University Level: Research and application demonstration on Key Technologies of police psychological quality VR training and protection system.

References

[1] V. Aguilera, M. R. Schaefer, K. Parris, A. Long, B. Triplett, and S. Phipps, "Psychosocial outcomes of parents in pediatric haploidentical transplant: parental hematopoietic cell donation as a double-edged sword," *Bone Marrow Transplantation*, vol. 57, no. 3, pp. 377–383, 2022.

[2] J. Bali, A. Nandi, P. S. Hiremath, and P. G. Patil, "Detection of sleep apnea in ecg signal using pan- tompkins algorithm and ann classifiers," *Compusoft*, vol. 7, no. 11, pp. 2852–2861, 2018.

[3] N. Betancourt, M. Flores-Calero, and C. Almeida, T. Guarda, F. Portela, and M. F. Santos, An Algorithm for Automatic QRS Delineation Based on ECG-Gradient Signal," in *Advanced Research in Technologies, Information, Innovation and Sustainability. ARTIIS 2021. Communications in Computer and Information Science*vol. 1485, Cham, Springer, 2021.

[4] C. Bock, T. Zimmermann, and K. G. Kahl, "The impact of post-traumatic stress on the mental state of university hospital physicians – a cross sectional study," *BMC Psychiatry*, vol. 22, no. 1, 2022.

[5] L. A. Ferguson and S. L. Leal, "Interactions of Emotion and Memory in the Aging Brain: Neural and Psychological Correlates," *Current Behavioral Neuroscience Reports*, vol. 9, pp. 47–57, 2022.

[6] A. Galli, G. Frigo, D. Chindamo, A. Depari, M. Gadola, and G. Giorgi, "Denoising ECG signal by CSTFM algorithm: monitoring during motorbike and car races," *IEEE Transactions on Instrumentation and Measurement*, vol. 68, no. 7, pp. 2433–2441, 2019.

[7] S. T. Hsieh and C. L. Lin, "Detection and parameter estimation of R peaks in ECG signal using optimization algorithm," in *Proceedings of the 2018 Sixth International Symposium on Computing and Networking Workshops (CANDARW)*, November 2018.

[8] C. A. Jenkins, K. N. Thompson, C. L. Nicholas, J. A. Hartmann, and A. M. Chanen, "Potential mechanisms underlying sleep disturbance in young people with borderline personality disorder features: an exploratory study," *Borderline Personality Disorder and Emotion Dysregulation*, vol. 9, no. 1, 2022.

[9] R. Jothiramalingam, J. Anitha, and D. J. Hemanth, "Diagnosis of coronary artery occlusion by fitting polynomial curve with the ECG signal based on optimization techniques," *Network Modeling Analysis in Health Informatics and Bioinformatics*, vol. 11, no. 1, 2022.

[10] W. S. Lee, Y. T. Chen, and T. H. Wu, "Optimization for ice-storage air-conditioning system using particle swarm algorithm," *Applied Energy*, vol. 86, no. 9, pp. 1589–1595, 2019.

[11] W. Li, B. Li, H. Meng et al., "The QRS complex detection of ECG signal based on IPCMM algorithm," in *Proceedings of the 2020 39th Chinese Control Conference (CCC)*, July 2020.

[12] X. Yuan, "Construction of moral education evaluation model based on quality cultivation of college students," *Scientific Programming*, vol. 2022, no. 1, Article ID 5641782, 2022.

[13] Z. Li, "Analysis of psychological health status of college students under examination stress based 上on EEG neuroscience," *Educational Sciences: Theory and Practice*, vol. 18, no. 5, 2018.

[14] M. Guanglong, X. Wang, and J. Yu, "ECG Signal Classification Algorithm Based on Fusion Features," *Journal of Physics: Conference Series*, vol. 1207, Article ID 012003, 2019.

[15] C. Schlee, C. Uecker, N. Bauer, A. K. Koch, and J. Langhorst, "Multimodal stress reduction and lifestyle modification program for patients with ulcerative colitis: a qualitative study," *BMC Complementary Medicine and Therapies*, vol. 22, no. 1, 2022.

[16] J. F. Schutte, J. A. Reinbolt, B. J. Fregly, R. T. Haftka, and A. D. George, "Parallel global optimization with the particle swarm algorithm," *International Journal for Numerical Methods in Engineering*, vol. 61, no. 13, pp. 2296–2315, 2018.

[17] M. Sevil, M. Rashid, M. R. Askari, S. Samadi, I. Hajizadeh, and A. Cinar, "Psychological stress detection using photoplethysmograph," in *Proceedings of the 2019 IEEE EMBS International Conference on Biomedical & Health Informatics (BHI)*, IEEE, Chicago, IL, USA, May 2019.

[18] M. U. Shaikh, W. A. W. Adnan, and S. A. Ahmad, "Secured electrocardiograph (ECG) signal using partially homomorphic encryption technique–RSA algorithm," *Pertanika Journal of Science and Technology*, vol. 28, pp. 231–242, 2020.

[19] Q. Shen, W.-M. Shi, X.-P. Yang, and B. X. Ye, "Particle swarm algorithm trained neural network for QSAR studies of inhibitors of platelet-derived growth factor receptor phosphorylation," *European Journal of Pharmaceutical Sciences*, vol. 28, no. 5, pp. 369–376, 2006.

[20] R. Zhou, C. Wang, P. Zhang et al., "ECG-based biometric under different psychological stress states," *Computer Methods and Programs in Biomedicine*, vol. 202, Article ID 106005, 2021.

[21] M. Srinivasulu, "Multi-lead ECG signal analysis using RBFNN-MSO algorithm," *International Journal of Speech Technology*, vol. 24, pp. 341–350, 2021.

[22] R. Vinoth, R. Sasireka, and R. V. Baskar, "Ecg signal using dct-algorithm and optimized rbfnn classifier," *International Journal of Emerging Technologies and Innovative Research*, vol. 6, no. 5, pp. 127–134, 2019.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 8194442, 10 pages
https://doi.org/10.1155/2022/8194442

Research Article

Application of Internet of Things Real-Time Monitoring Technology in Community Security Prevention and Control

Beibei Wang and Fei Yan

Railway Police College, Zhengzhou 450000, China

Correspondence should be addressed to Beibei Wang; wangbeibei@rpc.edu.cn

Received 12 April 2022; Accepted 26 May 2022; Published 24 June 2022

Academic Editor: Wen Zhou

In order to improve the real-time prevention and control effect of community security, this paper uses environmental monitoring as the background to design a ZigBee-based wireless sensor network scheme. The ZigBee nodes in the system are set as FFD nodes and have the ability of coordinator and the nodes are not connected with other networks, and a network is formed through a multinode system. Moreover, the proposed cluster routing protocol firstly determines the orientation of the cluster and determines the cluster head in the cluster according to the orientation information of the cluster so that the clusters in the network can be evenly distributed. In addition, the system in this paper is mainly monitored through the Internet of Things and data processing through big data. Therefore, this paper mainly analyzes the data mining, data transmission, and monitoring effect of the system, combined with the simulation software. Finally, through experiments, this paper verifies that the Internet of Things real-time monitoring technology proposed in this paper has a good application effect in community security prevention and control.

1. Introduction

Nowadays, informatization has become an important feature of modern society, and as the first resource, information resources have their core competitive advantages. Information management has penetrated into all fields of social development and directly affects all aspects of economic, cultural, and social development. Moreover, the popularization and application of informatization has its increasingly prominent significance and role. The informationization of the public security system is a powerful driving force for the development and progress of public security work and team building, an inevitable requirement for improving the level of public security work, and the only way for public security organs to reform police affairs [1]. Facing the new era, new situation, and new challenges, the information construction of the public security system also has higher requirements. The national public security system has carried out informatization construction led by the establishment of a "big intelligence" system. With regard to the reform of the police operation mechanism, local public security organs have shown a trend of catching up with each other and have promoted the construction of "information policing," and changing the traditional mode of public security combat effectiveness generation to relying on science and technology, especially high-tech technology with information technology as the core. By integrating police resources, reforming police processes, and innovating police models, we can reduce police costs, maximize police efficiency, improve the technical content and efficiency of public security work, improve the combat effectiveness of public security forces, maintain social stability, combat crime, and protect people's lives and property [2]. The role of modern information technology in public security administration, public security prevention and control, investigation and solving, law enforcement supervision, and team management is becoming increasingly important and prominent. As an important institution to ensure public safety, public security organs undertake the important task of defending the people. As part of the tasks of public security organs,

social security management plays a fundamental and important role. At present, the overall situation of social security is good, showing a stable and harmonious basic situation, but we should also clearly realize that there are still many problems in social security management, prevention and control, and many challenges are faced [3].

The Internet of Things is mainly composed of the following technologies. The first is radio frequency identification technology. Radio frequency identification (RFID) technology is a noncontact two-way communication using radio frequency signals and their spatial coupling and transmission characteristics to realize automatic identification of stationary or moving objects and an identification technology for data exchange [4]. A typical radio frequency identification system is composed of readers, electronic tags, and information processing systems. Its role is to identify objects and obtain information. The second is the wireless sensor network. Wireless sensor network is a technology that can detect changes in the surrounding environment. It is combined with related technologies to automatically sense, collect, and process various changes of data of the sensed object in its coverage area so that remote observers can use these data to judge the object's operating status or environmental changes, and further take corresponding actions, or automatically adjust by system settings, and so on [5]. The third is embedded technology. Embedded technology is a technology that combines hardware and software to form an embedded system. In the use of Internet of Things technology, all objects must have the ability to receive, transmit, and process information, so the development of embedded technology is very important. The fourth is nano- and micro-electromechanical systems. In order for all objects to have networking and data processing capabilities, the miniaturization and precision requirements of computing chips are getting higher and higher. Nanotechnology is used to make machine components more miniaturized, or to create new structures and materials to cope with various harsh environments. The development of micro-electromechanical technology achieves the accuracy of a series of processing that receives natural sound, light, temperature, and other signals and converts them into digital signals and then transmits them to the controller to respond to a series of processes [6]. The fifth is distributed information management technology. In an environment where things are connected, each sensor node is a data source and processing point and has operations, such as database access, identification, processing, communication, and response. Therefore, it is necessary to use distributed information management technology to manipulate these nodes. In this environment, distributed database systems are often used to manage these data nodes and connect them together in the network [7].

The core role of the Internet of Things is to obtain intelligence information. Obtaining intelligence information can be divided into three stages, namely, before the event, during the event, and after the event [8]. The Internet of Things system is an information system established on the basis of the existing security system, social security video system, intelligent transportation system, GPS, and other systems. Through this system, information before the occurrence of public security incidents can be effectively collected so that public security organs and other departments can quickly and effectively make response plans to avoid public security incidents. After a public security incident occurs, the public security organs can use the Internet of Things to timely and accurately determine the time, location, and surrounding environment of the public security incident, such as the temperature, humidity, and light of the incident, to facilitate the handling of public security incidents [9]. After quelling the public security incident, the public security organs further strengthened the monitoring of the area through the Internet of Things to prevent similar public security incidents from recurring. At the same time, the public security organs timely sent the handling results and precautions of the public security incident to the residents in the area through the Internet of Things. It is convenient for residents to understand the situation and strengthen the awareness of public security prevention. As a high technology, the Internet of Things has an immeasurable impact on social security [10]. For example, using the Internet of Things technology, public security organs and guardians can easily grasp the whereabouts of children and the elderly, which can reduce cases of women and children being trafficked, and the disappearance of the elderly; the public security organs can effectively monitor the society through the Internet of Things. It can enable public security organs and national security agencies to obtain more comprehensive and valuable intelligence information and provide a basis for public security agencies and national security agencies to make timely and accurate decisions [11]; apply the Internet of Things technology to deal with mass incidents. Therefore, we can grasp the nature, cause, time, and development status of mass incidents in time and provide us with a lot of valuable information to effectively deal with mass incidents; use the Internet of Things technology to prevent and control some key personnel, such as "Falungong" Members; persons released after serving their sentence, and so on, can detect the signs of the incident in time and take precautions against it [12].

At present, although the public security organs have extensively carried out informatization and technological work and have a large number of public security police information resources, the existing various information systems are still at the application stage of business inquiry and file management and most public security information systems. It is to solve the problems of "being" and "nothing" and is a basic data information system that serves the overall situation. Although there have been revolutionary changes to the traditional manual, manual, and paperwork modes, public security information resources have not been used more rationally, unable to create a higher social value. At the same time, all aspects of public security work are multifaceted. For the grassroots public security teams that are fighting at the forefront of social and community public security prevention and control work, what is needed is more practical, more targeted, and more creative in the actual work, a more effective public security application system. The main motives for the occurrence of illegal and

criminal acts that affect public security are financial and anger and social "special groups," including key populations, key public security personnel, and social workers, are committed to illegal and criminal behaviors in the community and undermine public security in the community.

This article combines big data technology and Internet of Things technology to conduct community security prevention and control research, builds a corresponding intelligent system, and conducts experimental verification on the community security system to provide a reference for subsequent community security prevention and control.

2. The Structure of the Internet of Things System

2.1. System Software Design. The system takes environmental monitoring as the background and designs a wireless sensor network solution based on ZigBee. Figure 1 shows the effect diagram of this scheme. Within the coverage of the coordinator of the wireless sensor network, several terminal nodes and routing nodes are arranged to implement wireless communication and network management between nodes.

ZigBee is an emerging wireless transmission technology based on the IE802.15.4 standard. It has the characteristics of self-organization, low cost, low power consumption, low complexity, and low transmission rate, and it works in an unlicensed frequency band, which is easy to use and has the advantages of ultra low cost. The system uses the ZigBee protocol stack to develop a set of wireless sensor networks according to the actual monitoring requirements in the laboratory. The nodes in the network are transmitted through the ZigBee protocol between nodes and between the nodes and the coordinator.

The environmental monitoring subsystem mainly includes servers, coordinators, routing nodes, terminal nodes, and various sensor devices. The main role of the coordinator in the network is to manage the network, gather data, provide the interface to connect to the computer, and realize the establishment of the sensor network data and data transmission channel. Multiple collection nodes realize the collection of data (temperature, smoke, harmful gas, etc.) in the laboratory under the control of the coordinator and transmit the collected various data directly to the coordinator or through the router to the coordinator to coordinate. The device communicates with the server through the serial port to transfer the collected data (temperature, smoke, harmful gas, etc.).

2.1.1. Coordinator. The coordinator is a communication bridge between the control center and the terminal node. It receives and processes the instructions sent by the control center, and the coordinator communicates with the control center through the serial port. It also needs to receive various data information collected by terminal nodes and routing nodes with the ZigBee wireless communication protocol and send it to the control center. Its flowchart is shown in Figure 2.

The ZigBee node in the system must be an FFD node and have the capability of a coordinator, and the node must not be connected to other networks. At this time, this node can

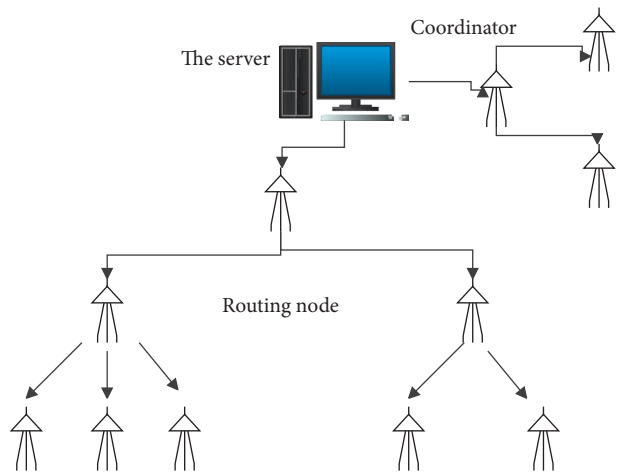


Figure 1: System network structure.

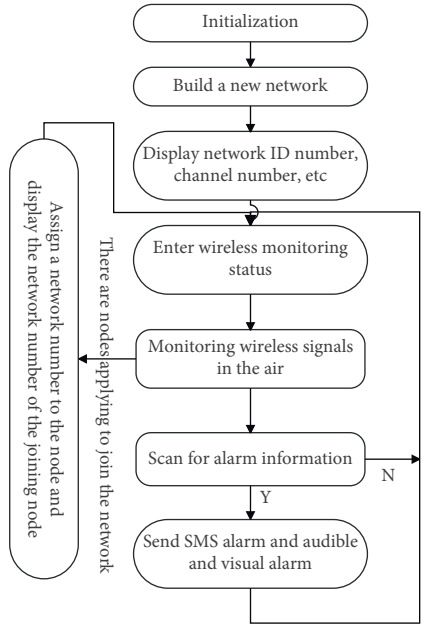


Figure 2: Coordinator flowchart.

build a network. Since a ZigBee wireless sensor network has one and only one coordinator, when a node is already connected to other networks, it can only be a child node of this network. In the network coordination, it first initializes the microcontroller CC2530, then initializes the protocol stack, and turns on the interrupt.

In addition, the coordinator also needs to have the function of building a network. The flowchart of its self-organizing network is shown in Figure 3.

In the ad hoc network process, it first determines whether the node is an FFD node to determine the network coordinator and then performs channel scanning. After finding a suitable channel, the coordinator will select a network identifier PANID, and this network D must be unique in the channel. At this point, the initialization of the network is completed, and the next step is to wait for other nodes to join.

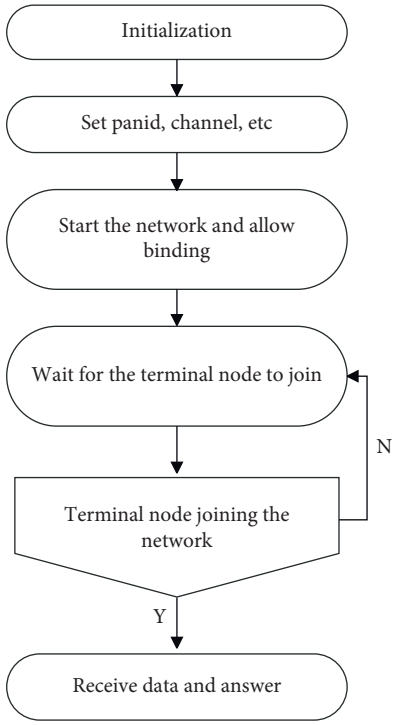


Figure 3: Flowchart of ad hoc network.

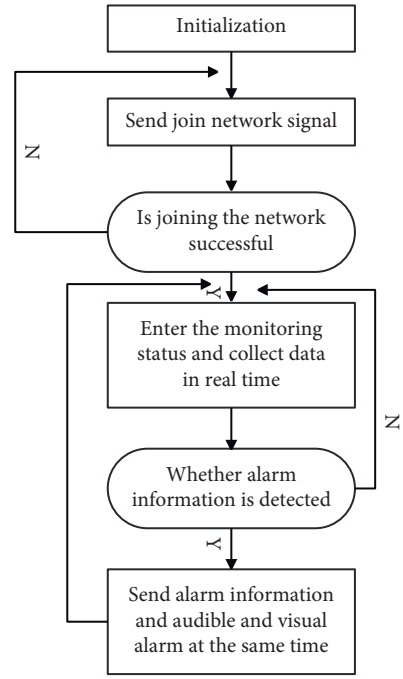


Figure 4: Terminal node flowchart.

2.1.2. Terminal Node. The information of each terminal node of this system is different. After the sensor detects the data, the collected data will be transmitted to the terminal node. In order to realize the data transmission in the system, it is necessary to establish a network connection. The terminal node needs to send a request to establish a network connection to the coordinator, and the coordinator will determine whether to allow the node to join the network according to the specific situation and then make a corresponding response to the request and send it to the node. After the node joins the network, it will establish a connection with the coordinator and then transmit data. The specific steps are to first find the network coordinator and send an association request command, then wait for the coordinator to process, and send a data transmission command to transmit data after the connection is established. The flowchart is shown in Figure 4.

As the terminal of the wireless sensor network, it first scans and finds the coordinator or front-end routing node in the network. If the beacon is not detected during the scanning period, the node will scan again until the network coordinator or front-end routing node is found. Then, the node sends an association request command to it, and the node also sends a data request command, waiting for the front-end routing node or network coordinator to process it. If it agrees to the node's joining request, it will assign a short address of 16 bits to the node. At this time, the node will send the collected data to the coordinator.

2.1.3. Routing Node. As the relay node in the WSN monitoring system, the routing node is suitable for large area and long distance. In a wireless sensor network, because the range of nodes is too wide, the network coordinator may be too far away from the terminal node to establish a connection and cannot communicate. At this time, the routing node can be used as a transit war to connect the coordinator and the terminal node in communication. Therefore, the system can expand the coverage of the wireless sensor network by increasing the number of routing nodes.

When setting up the routing node, the program first initializes the CC253O and protocol stack. After initialization, the system sends a signal to join the network, and the front-end routing node or network coordinator will respond to the node accordingly and will assign itself a network address when agreeing to join the network request. After the routing node joins the network, it starts to act as a transit station and has the function of forwarding data. The program flowchart is shown in Figure 5.

2.2. Design and Implementation of System Routing Algorithm. Some environmental monitoring locations in the system may not be able to provide a stable power supply. At the same time, in order to reduce the trouble caused by wiring, the nodes will work under battery power. In order to realize that the node can work uninterrupted for a long time, it is necessary to reduce the energy consumption of the sensor node. The most widely used clustering algorithm in WSN is the low-power adaptive LEACH routing algorithm, and other clustering algorithms also use this as a benchmark.

Before describing the algorithm, first make some assumptions about the wireless sensor network and sensor nodes, as follows:

(1) The wireless sensor network is a static network, and all nodes in the system are static and will not move after finishing the deployment

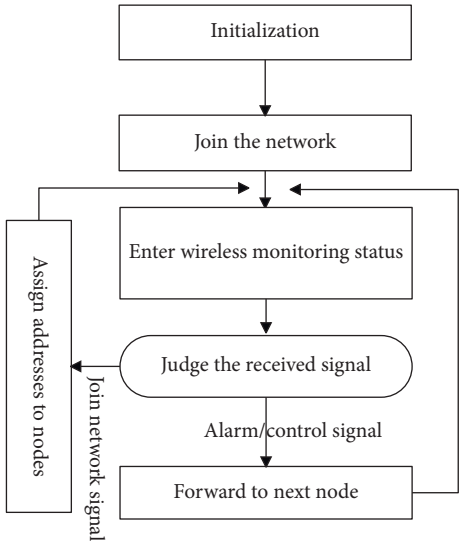


Figure 5: Routing node flowchart.

(2) The sensors are randomly and evenly distributed in the monitoring area

(3) The sensing nodes are isomorphic, and all sensor nodes in the network have the same initialization energy

(4) In order to know its location information, the sensing node in the system can rely on GPS, positioning algorithm, and other methods to obtain specific coordinates

(5) The coverage area of each node is the same

(6) The wireless channel is symmetrical

After determining the cluster head, the traditional clustering protocol randomly classifies the sensor nodes in the network, which leads to uneven network distribution and excessive energy consumption. Based on the above assumptions, the cluster routing protocol proposed in this paper first determines the location of the cluster and then establishes and determines the cluster head in the cluster according to the location information of the cluster so that the clusters in the network can be evenly distributed.

In practice, in the monitoring area A, in order to enable the network to achieve seamless coverage η, the number K of the first family to be selected can be determined as follows:

$$K = \left\lceil \frac{\ln(1-\eta)}{\ln\left(1 - 3\sqrt{3}/2M^2\right)} \right\rceil. \tag{1}$$

Here, r is the node transmission radius.

In the network, the number of effective nodes in the cluster will gradually decrease as the energy of the nodes is exhausted. The relationship between the new seamless network coverage $\eta_{\max}$ and the number of effective nodes S is as follows [13]:

$$\eta_{\max} = \left(\frac{S}{N}\right)\eta. \tag{2}$$

In this paper, the formation of clusters in wireless sensor networks is realized by fuzzy C-means clustering (FCM) algorithm. After the cluster is established, the system determines the cluster heads and candidate cluster heads in the cluster. When the energy of all cluster heads in a certain cluster decreases to the threshold, the system starts the next round of clustering. Its algorithm flowchart is shown in Figure 6.

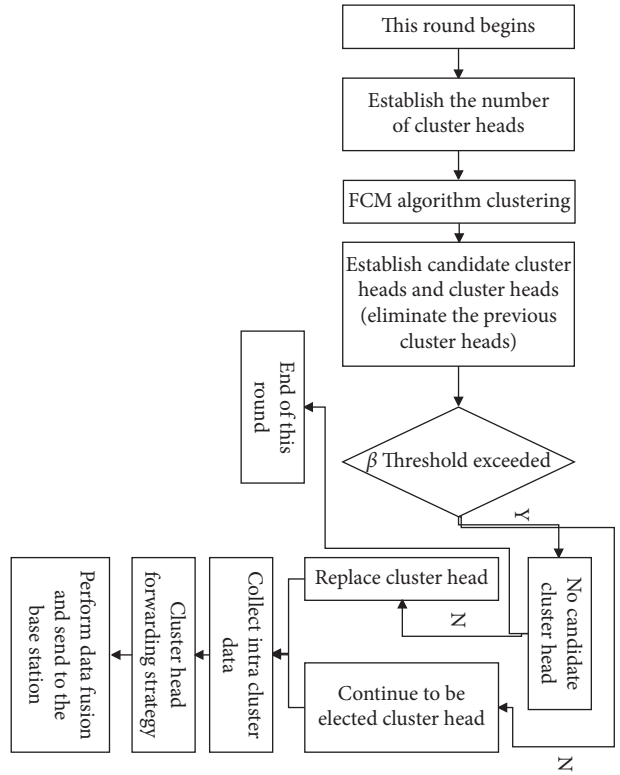


Figure 6: Algorithm flowchart.

N sensor nodes in the wireless sensor network have their corresponding coordinates, and the data convergence point composes the coordinates of the N sensor nodes into a set $X\{X_j, j = 1, 2, \ldots, N\}$. The N sensor nodes in the set are used as the N samples in the set. We set the center of each cluster to $V_i\{i = 1, 2, \ldots, N\}$, and $U(i, j)$ is the membership function of the jth node to the ith cluster [14].

Fuzzy C-means clustering algorithm (FCM) is a fuzzy objective function method. The objective function $J(U, V)$ is defined as [15]

$$J(U,V) = \sum_{i=1}^{c}\sum_{k=1}^{n} (u_{ik})^m (d_{ik})^2. \tag{3}$$

Here, a is the membership matrix and satisfies the following formula:

$$\sum_{i=1}^{c} \mu_{ik} = 1, \left(1 \le k \le n, 0 \le \mu_{ik} \le 1\right). \tag{4}$$

Here, the optimal range of m is [1.5, 2.5], and d is the distance from the kth sample to the ith category, which is defined as

$$d_{ik}^2 = \left\| x_k - v_t \right\|^2. \tag{5}$$

Therefore, we can adopt a new objective function to make the necessary conditions for formula (3) to reach the minimum value:

$$J(U, c_1, \ldots, c_2, \lambda_1, \ldots, \lambda_n) = \sum_{i=1}^{c}\sum_{j}^{n} u_{ij}^{m} d_{ij}^{2} + \sum_{j=1}^{n} \lambda_j \left(\sum_{i=1}^{c} u_{ij} - 1 \right). \tag{6}$$

Here, $\lambda_j (j = 1, \ldots, n)$ is the Lagrangian multiplier of n constraints of formula (3). The derivation of all the input parameters of the above formula is performed, and the necessary conditions for formula (3) to be minimized are as follows [16]:

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u_{ij}^{m}}, \tag{7}$$

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(d_{ij}/d_{kj} \right)^{2/(m-1)}}. \tag{8}$$

After obtaining the cluster by the FCM algorithm, the cluster head needs to be determined. The node closest to the center is the cluster center point. In order to select the preselected cluster head of the ethnic group, the system first calculates the Euclidean distance between the center point of the cluster and all nodes in the cluster and then selects the shortest Euclidean distance as the preselected cluster head. After that, the system manages all preselected cluster heads in the form of a queue, taking the head node in the queue as the head of the cluster, and the cluster head is responsible for collecting and fusing data collected by all nodes in the cluster.

In the cluster, the cluster mainly processes a large amount of data, and each processing of data consumes a large amount of energy. In order to prevent the cluster head's energy consumption from causing node failure due to excessive energy consumption, we set a threshold β. When the cluster head energy decreases to β, the cluster head will notify the next node in the queue to become a new cluster head, and this cluster head will become a normal node. The threshold β is set according to the energy of the node. At the beginning, the values of β and E_r are equal, and the value of β decreases after each clustering [17].

$$\beta = \begin{cases} Er, start, \\ Er/3, \mathrm{Re} > 0.01, \\ 0.Er < 0.01. \end{cases} \tag{9}$$

When the energy of all candidate cluster heads in the queue is less than threshold β or the energy consumption is complete, the network convergence point will recluster the remaining nodes (excluding dead nodes and missing candidate nodes) so that the redivided clusters can obtain the original difference and can also avoid the difference between the previous candidate cluster head and the current candidate cluster head.

After the clustering is completed, the data transmission in the network adopts the principle of cluster head forwarding. The cluster head far away from the base station will select the nearest cluster head for data transmission instead of directly communicating with the base station. Each cluster head performs corresponding processing and fusion of the data transmitted from other cluster heads and then forwards it to the next cluster head node, all the way to the convergence point where the data is transmitted. By adopting the principle of cluster head forwarding, the data transmission distance of nodes is shortened, and the energy consumption of cluster head nodes is greatly reduced. In the strategy proposed in this paper, there are multiple candidate cluster head nodes in each cluster group, and they can be elected cluster heads in turn. This not only ensures the stability of the cluster, but also maintains stability for a long time after the data transmission route is established for the first time.

3. Community Public Security Prevention and Control System Based on Big Data and Internet of Things

After the system is powered on, the system first initializes and checks whether the system is powered on for the first time. If it is powered on for the first time, the system calls the system default parameters and records related information. After the address is set, the program enters the loop state, asking whether it needs to read card processing or other corresponding processing. If it encounters a situation that needs to be dealt with, the system will automatically deal with the corresponding subroutine. If there is no need to deal with the situation, the system will go to sleep. In the dormant state, if there is information to be processed, the system will be awakened quickly in a short period of time. The main program flowchart is shown in Figure 7.

When the main program detects the card reader identification bit, the system executes the card reader processing subroutine. First, the system scans the card to read the information in the card, and the data read by the reader is finally transmitted to the computer. The main program in the computer judges the received data and judges whether it is valid data. If it is valid data, the program automatically reads the card number stored in the buffer and determines whether the card is a valid card. Then, it queries the current card status and the information in the card according to the card number, compares and authenticates with various information tables stored in the database, and then uses the comparison information to execute the command to open the door or refuse to open the door. The flowchart is shown in Figure 8.

In the access control system, the system judges the information in the ID card sent by the access controller. When it is judged that the card holder's card information is true and has authority, the computer control management center will send related control commands to the access controller. The access controller drives the access control module to send a high level to the relay to turn on the device, and the electronic door lock will automatically open at the same time. When the cardholder is judged by the system as an

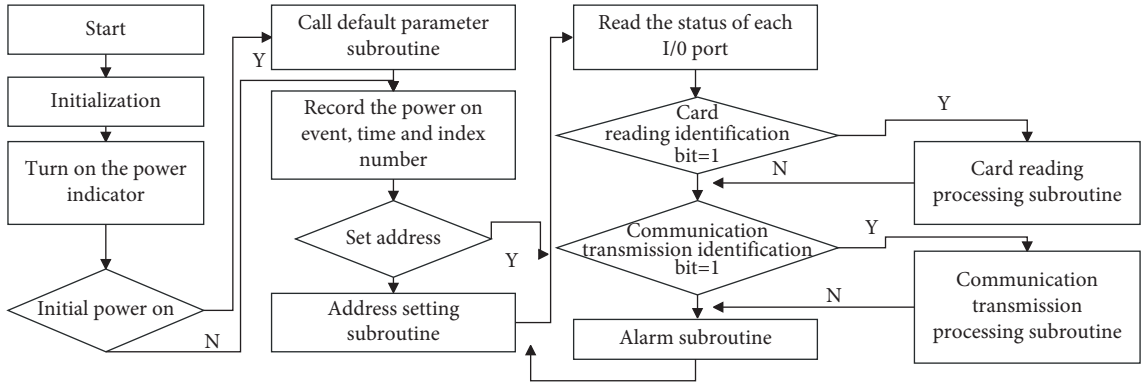


Figure 7: Flowchart of the main program.

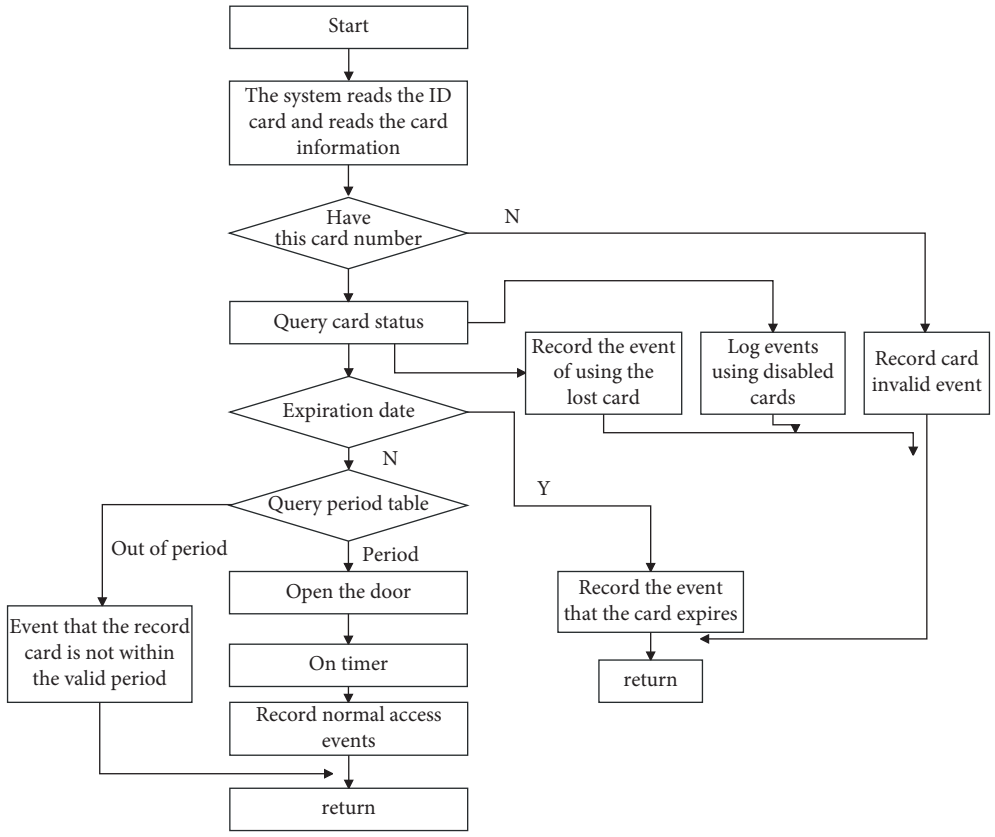


Figure 8: Flowchart of the card reading program.

illegal person or does not have this authority, the system sends an alarm command to the access controller and controls the alarm module to turn on the alarm and at the same time records the alarm information. The workflow is shown in Figure 9.

The security system mainly consists of perimeter infrared anti-overstepping monitoring at all levels of nodes in the ZigBee wireless network, residential window sill monitoring, intelligent antitheft doors and windows, and community monitoring platforms. This solution has the functions of automatically sensing threats and active warnings, and it cooperates with the community's video surveillance system and uses the rapid response of the owners, community properties, and the police to reduce accident losses. As shown in Figure 10, this security system uses multiple security lines of defense. The system builds a multilayer protection system around the entire community, building, and family to truly realize all-weather intelligent security.

Based on the advantages of ZigBee technology in wireless sensor networks, in this solution, the coordinator is the gateway node of the entire ZigBee network and is the core device of the entire system. The coordinator unites various routing nodes and terminal sensor nodes to form a mesh network. The coordinator is responsible for the establishment of the entire network, address binding, sensor data collection, and data transmission to the host computer

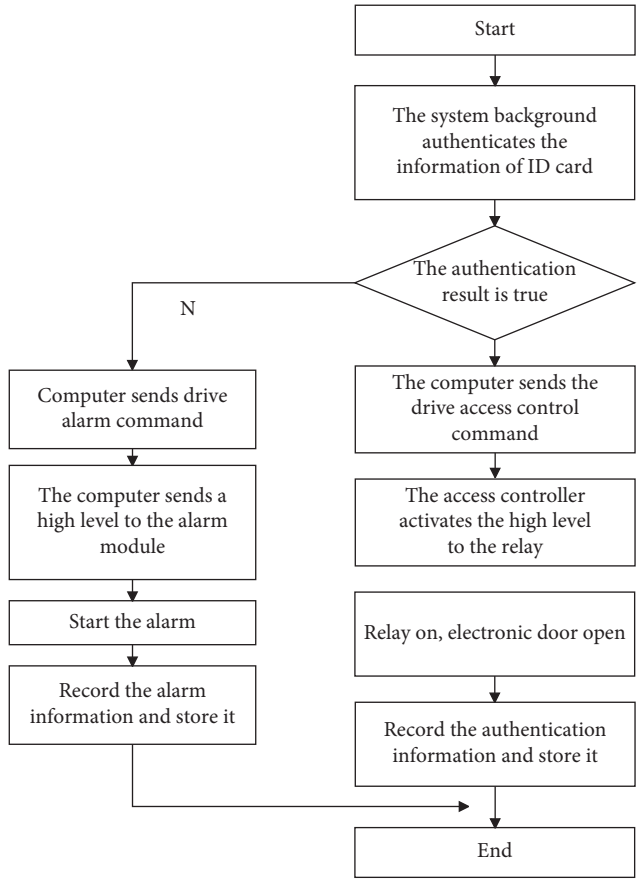


Figure 9: Workflow of electric lock and alarm.

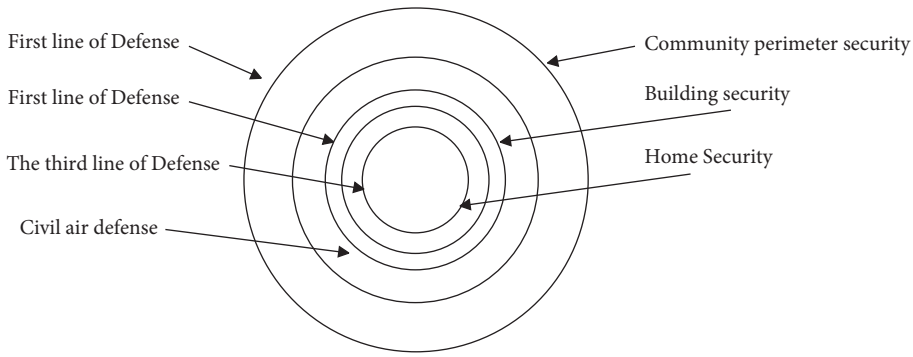


Figure 10: The security line of the community security system.

through the serial port. In the end, the data is provided to the community monitoring center for observation, and the system promptly starts video surveillance, calls for civil air defense, and other related processing. The overall layout of the security system is shown in Figure 11.

After constructing the above system, the performance of the system is verified. The system in this paper is mainly monitored through the Internet of Things and data processing through big data. Therefore, this paper mainly combines simulation software to analyze the data mining, data transmission, and monitoring effects of the system, and the results are shown in Table 1 and Figure 12.

From the above research, we can see that the community security prevention and control system based on big data Internet of Things technology constructed in this paper has good practical effects and has a certain effect on the security management and stability maintenance of modern communities.

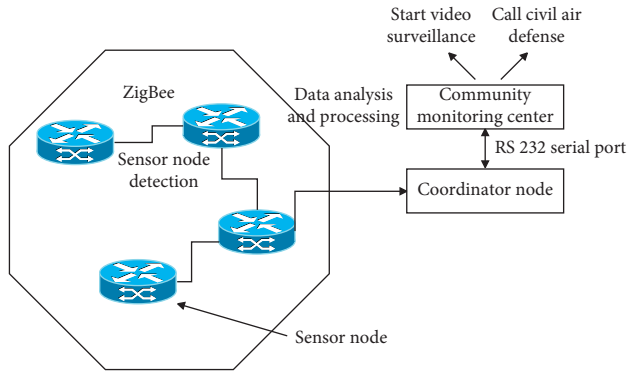


Figure 11: The overall layout of the security system.

Table 1: Performance test of community security prevention and control system based on big data and Internet of Things.

Number	Data mining	Data processing	Monitoring effect
1	90.59	95.65	93.35
2	91.47	97.45	88.45
3	93.14	93.08	86.14
4	93.57	94.53	86.12
5	95.07	94.31	94.56
6	95.62	93.28	94.73
7	91.52	97.41	92.27
8	94.96	96.69	85.13
9	95.01	95.82	90.87
10	93.74	98.28	94.51
11	94.98	92.90	92.08
12	93.43	94.07	93.02
13	90.82	95.37	91.61
14	94.14	96.72	89.90
15	93.07	94.03	85.76
16	90.34	90.25	90.49
17	91.01	92.91	92.78
18	91.36	94.72	89.28
19	91.45	97.84	90.24
20	94.85	93.28	85.32
21	90.49	95.08	89.02
22	93.21	97.57	87.83
23	91.24	94.04	87.75
24	95.74	95.16	88.66
25	94.40	98.44	94.48
26	94.26	93.23	90.83
27	90.46	94.41	96.39
28	92.27	93.25	94.99
29	95.60	91.93	91.66
30	93.19	94.99	95.97

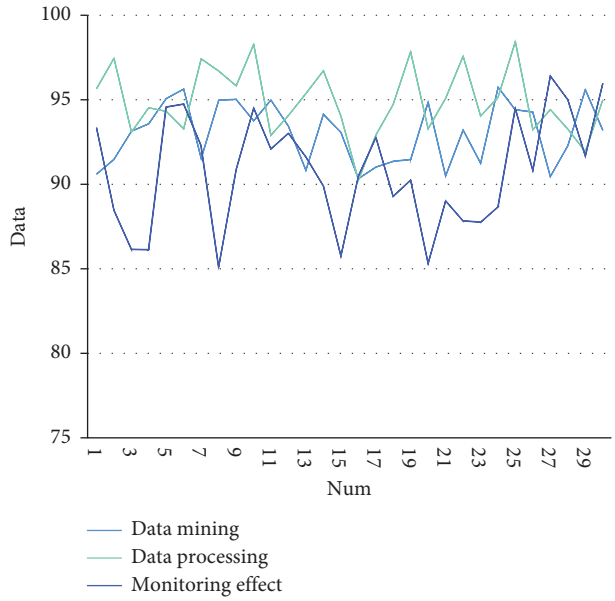


Figure 12: Statistical diagram of experimental statistical results.

4. Conclusion

This article builds and implements a community public security information analysis system to maximize data collection and dynamic control of the crowd. Moreover, this paper uses information elements, such as economic income, activity trajectory, and peer information to classify the personnel who meet specific conditions, dynamic management, high-risk early warning, and group judgment. In addition, this paper guides the police force to be targeted, intervene in advance, and act proactively, which is of substantial significance for reversing the situation where the police force passively follows the case. This article combines the Internet of Things technology and big data technology to construct a community security prevention and control system, monitors through the Internet of Things, and conducts data processing through big data. The security system mainly consists of perimeter infrared anti-overstepping monitoring at all levels of nodes in the ZigBee wireless network, residential window sill monitoring, intelligent antitheft doors and windows, and community monitoring platforms. After constructing the system, this paper designs experiments to verify the performance of the system. From the experimental analysis, we can see that the community security prevention and control system based on big data and Internet of Things technology constructed in this paper has good practical effects.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

Acknowledgments

This study was sponsored by Railway Police College, China.

References

[1] J. H. Abawajy and M. M. Hassan, "Federated internet of things and cloud computing pervasive patient health monitoring system," *IEEE Communications Magazine*, vol. 55, no. 1, pp. 48–53, 2017.

[2] D. He, R. Ye, S. Chan, M. Guizani, and Y. Xu, "Privacy in the internet of things for smart healthcare," *IEEE Communications Magazine*, vol. 56, no. 4, pp. 38–44, 2018.

[3] P. P. Ray, "Internet of things for smart agriculture: technologies, practices and future direction," *Journal of Ambient Intelligence and Smart Environments*, vol. 9, no. 4, pp. 395–420, 2017.

[4] Y. A. Qadri, A. Nauman, Y. B. Zikria, A. V. Vasilakos, and S. W. Kim, "The future of healthcare internet of things: a survey of emerging technologies," *IEEE Communications Surveys & Tutorials*, vol. 22, no. 2, pp. 1121–1167, 2020.

[5] B. H. Dobkin, "A rehabilitation-internet-of-things in the home to augment motor skills and exercise training," *Neurorehabilitation and Neural Repair*, vol. 31, no. 3, pp. 217–227, 2017.

[6] J. Yao and N. Ansari, "Caching in energy harvesting aided internet of things: a game-theoretic approach," *IEEE Internet of Things Journal*, vol. 6, no. 2, pp. 3194–3201, 2019.

[7] J. E. Siegel, S. Kumar, and S. E. Sarma, "The future internet of things: secure, efficient, and model-based," *IEEE Internet of Things Journal*, vol. 5, no. 4, pp. 2386–2398, 2018.

[8] M. A. Abd-Elmagid, N. Pappas, and H. S. Dhillon, "On the role of age of information in the internet of things," *IEEE Communications Magazine*, vol. 57, no. 12, pp. 72–77, 2019.

[9] A. Sheth, U. Jaimini, and H. Y. Yip, "How will the internet of things enable augmented personalized health?[J]," *IEEE Intelligent Systems*, vol. 33, no. 1, pp. 89–97, 2018.

[10] G. J. Joyia, R. M. Liaqat, A. Farooq, and S. Rehman, "Internet of Medical Things (IOMT): applications, benefits and future challenges in healthcare domain[J]," *Journal on Communications*, vol. 12, no. 4, pp. 240–247, 2017.

[11] N. Kshetri, "The evolution of the internet of things industry and market in China: an interplay of institutions, demands and supply," *Telecommunications Policy*, vol. 41, no. 1, pp. 49–67, 2017.

[12] S. Siboni, V. Sachidananda, Y. Meidan et al., "Security testbed for internet-of-things devices," *IEEE Transactions on Reliability*, vol. 68, no. 1, pp. 23–44, 2019.

[13] Y. Yang, M. Zhong, H. Yao, F. Yu, X. Fu, and O. Postolache, "Internet of things for smart ports: technologies and challenges," *IEEE Instrumentation and Measurement Magazine*, vol. 21, no. 1, pp. 34–43, 2018.

[14] Z. Li, Y. Liu, A. Liu, S. Wang, and H. Liu, "Minimizing convergecast time and energy consumption in green internet of things," *IEEE Transactions on Emerging Topics in Computing*, vol. 8, no. 3, pp. 797–813, 2020.

[15] P. P. Ray, "A survey on Internet of Things architectures," *Journal of King Saud University-Computer and Information Sciences*, vol. 30, no. 3, pp. 291–319, 2018.

[16] M. Mayer and A. J. Baeumner, "A megatrend challenging analytical chemistry: biosensor and chemosensor concepts ready for the internet of things," *Chemical Reviews*, vol. 119, no. 13, pp. 7996–8027, 2019.

[17] M. Saez, F. P. Maturana, K. Barton, and D. M. Tilbury, "Real-time manufacturing machine and system performance monitoring using internet of things," *IEEE Transactions on Automation Science and Engineering*, vol. 15, no. 4, pp. 1735–1748, 2018.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 4112575, 11 pages
https://doi.org/10.1155/2022/4112575

Research Article

Improved Music Recommendation Algorithm for Deep Neural Network Based on Attention Mechanism

Xin He

School of Fusion Media, Xinyang Agriculture and Forestry University, Henan, Xinyang 464000, China

Correspondence should be addressed to Xin He; 2008310030@xyafu.edu.cn

Received 11 April 2022; Accepted 23 May 2022; Published 24 June 2022

Academic Editor: Wen Zhou

With the increasingly close combination of the Internet and people's production and life, the total amount of global data and information also grows increasingly. In order to save users the time to find their favorite music among many music types, the music recommendation service arises at the historic moment and is widely concerned by scholars. Traditional music recommendation system based on the collaborative filtering algorithm has low recommendation accuracy, poor real-time performance, sparsity, system cold start, and so on. Moreover, the traditional music recommendation algorithm only simply uses user behavior characteristics and does not make good use of user history for listening to audio characteristics. In view of the above question, this section based on the attention mechanism of the deep neural network music recommendation algorithm, through the use of improved MFCC audio data preprocessing, the extracted audio combined with the user's own portrait features, through the AIN RNN network recommended list, by learning user history listening to songs, improves the model-recommended accuracy.

1. Introduction

With the increasingly close combination of the Internet and people's production and life, the total amount of global data and information has also grown increasingly. With the continuous development of digital multimedia technology, the music library has become more and more large, and the music resources are becoming more and more rich. In order to save users the time to find their favorite music in many music, music recommendation services emerge at the historic moment and are widely concerned by scholars. Music, as a kind of multimedia information, not only its own data volume is increasing but also the user demand is increasing, which puts forward higher requirements for the research of the music recommendation algorithm. In the music market, with the continuous development and application of digital multimedia technology, more and more music industries have turned to online music services. People can use Spotify, NetEase cloud music, Shrimp music, and other platforms. It is convenient to obtain music resources through online audition, online download, and other ways [1]. However, as the music library becomes larger and larger and the music resources increase, it takes a lot of time and energy for users to find their favorite music. In the past, people could only search for music through the keywords such as music name, singer, and classification, and the search results not only take into account the differences of users but also would lead to the long tail phenomenon of music. The emergence and application of the music recommendation system can effectively solve this problem. The recommendation system can predict the users' behavior preferences according to the user behavior information and music data characteristics and actively push the music to the users that meets their tastes [2]. Of course, the growing amount of music data and user demand put forward higher requirements for the research of music recommendation algorithm. On the one hand, traditional recommendation methods such as cold start in collaborative filtering need to be solved, and the original recommendation algorithm needs to be upgraded. On the other hand, with the development of machine learning and deep learning, the continuous emergence of new computing technology helps to fully tap users' potential preferences and improve the performance of the recommendation system.

Based on this background, this paper based on the deep neural network, from the analysis of users, music characteristics, introduce attention mechanism, puts forward a personalized music recommendation algorithm. It not only can bring great convenience to music users but also each music software provider want to achieve goals, so it has important research significance and broad application prospects. The text is divided into 5 chapters. Chapter 1 introduces the research background and research necessity and the main methods and effects of the music recommendation at present; Chapter 3 models the music recommendation algorithm based on deep neural network and introduces the attention mechanism to realize the accurate recommendation of the algorithm. Chapter 4 mainly uses the designed recommendation algorithm to recommend music and evaluates the recommendation effect. Chapter 5 mainly summarizes the work of the full text and puts forward the imagination of the next work.

The long tail theory was put forward by Chris Anderson of the United States. He concluded that the new business model brought by the Internet is the long tail market. According to the August 2 theory, only 20% of products can become popular products, have good marketing, and be known by others. As the Internet brings the characteristics of product diversification, the remaining 80% of products can also be known through the Internet platform. Although they are niche products, the Internet provides a publicity channel for them to have direct contact with the public, so as to increase the market of niche products. A little makes a lot. On the whole, niche products sometimes generate more overall profits than popular products.

2. State of the Art

However, in the era of big data, the recommendation methods for massive music data are facing new challenges and opportunities. On the one hand, the processing of massive data becomes complicated and needs personalized user needs. The original recommendation algorithm needs to be upgraded accordingly; on the other hand, the problems existing in the original recommendation algorithm also need to be solved, such as the cold start problem of collaborative filtering recommendation.

The NetEase cloud divides music recommendation into three parts: private FM, daily song recommendation, and recommended song list. Private FM has low accuracy and high diversity. Diversity and high energy bring freshness to users. If you find a song you have never heard but especially like, it will bring a sense of surprise and mobilize users' positive emotions.

Due to low accuracy, it is likely that the new song will not be liked by users, so set the "delete" and "next" buttons on the playback interface of private FM to facilitate users to switch songs. Daily song recommendation has high accuracy and low diversity. The high accuracy makes the 20 songs recommended every day better meet users' tastes, but there is the problem of simplification of music types. Therefore, playlists are set to provide users with the right to browse and operate and make up for the disappointment of users caused by simplification of tracks. In the accuracy and diversity of the recommended song list, the recommended song list is different from the other two personalized recommendation functions. The threshold of its accuracy and diversity is not only determined by the algorithm but also determined by its functional form. Firstly, the object-oriented function is divided into two categories: one is the user and the other is the UGC song list. The system labels the song list and the user, respectively, to improve the accuracy. Because the UGC song list is created by many users, the UGC song list has diversity. The combination of the two ensures the coexistence of accuracy and diversity.

With the powerful filtering and push function of the recommendation system, we can well solve the problem of poor search engine effect when users cannot clearly describe the needs. The recommendation system not only provides convenience to consumers but also has an impact on the decision of businesses. By analyzing user data, merchants provide services that are more in line with user preferences. At present, the recommendation system has been widely used in the products of the Internet giants, including music push, information retrieval, social networks, location services, and news push [3]. Personalized music recommendation is a very special field in the recommendation system. Burke proposed in ACM RecSys that there are many kinds of music. The cost of listening to a song is very low. A song only lasts for a few minutes, and the music is mostly used as background music, so users do not need to pay full attention to the music. Compared with books and movies, music has a high reuse rate, and many users will share their own music. To sum up, the music field is very suitable for using a personalized recommendation system for recommendation. In recent years, making music recommendations according to user preferences has become an integral part of online digital music services. For example, the foreign Tidal Review, Apple Music, Pandora, etc. [4], Domestic Douban FM, Kugou Music, Xiami Music, and others integrated into their own recommendation algorithms, greatly improve the engagement of users to the product, expand the product's voice in this field, and help users save a lot of time finding music. Spotify has added a music discovery feature that provides better recommendations, playlists, and music discovery. Like the more foreign well-known music websites, such as Last. The FM recommends the songs of common interest with the higher similarity between the users, which is judged by the user's listening list and collection list [5]. Pandora uses the basic characteristics of music, such as using labels and singers, to calculate the similarity between songs. Baccigalupo Claudio and Plaza Enric believe that the recommended results should be broader, so the more highly recommended songs are integrated into playlists to recommend to users, making users more satisfied with the recommended results [6].

A convolution matrix factorization model proposed by Guan et al. and Van et al. analyzed the hidden features of music and audio signals to solve the cold start problem of the system and achieved good results [6]. Jearanaitanakij has achieved good results by learning from user history preferences to build models for recommendations. However, because the model iterates the parameters in deep network

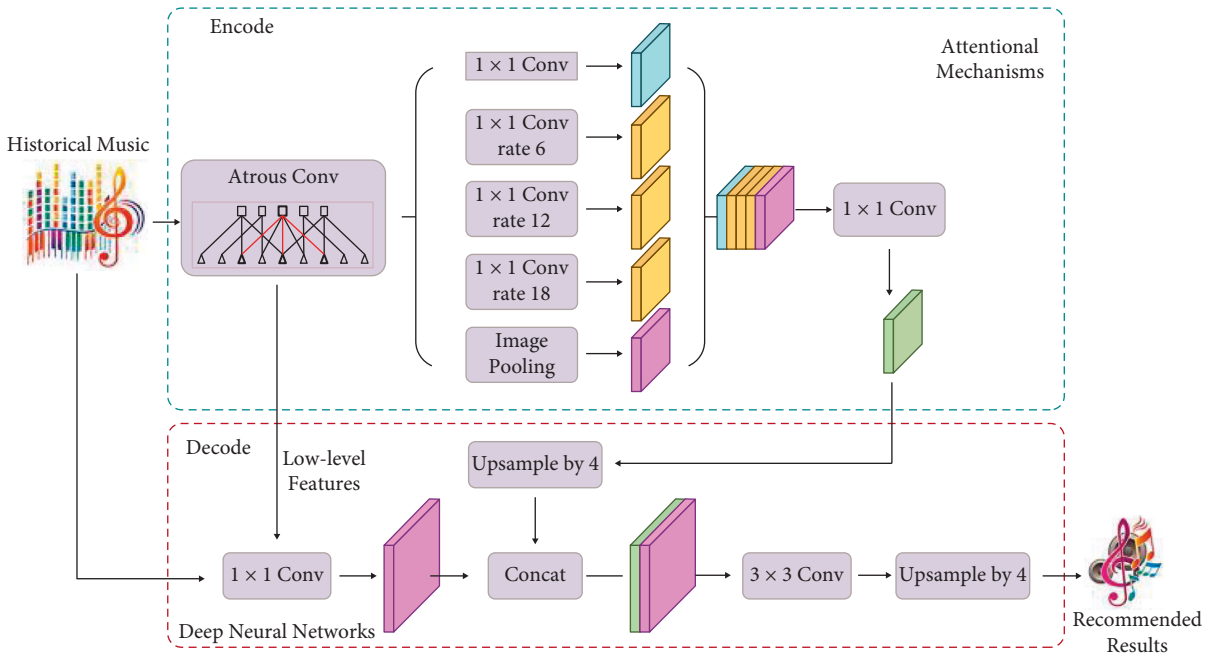


Figure 1: An improved framework of deep neural network music recommendation algorithm based on the attention mechanism.

training, the problem of parameter gradient disappearing or explosion occurs [7]. Jia extracted and segmented the long text features according to the language order, and the results obtained from the LSTM recommendation model were 4.1% higher than the RNN model [8]. Kowald et al. use the trust relationship in social networks to propose a method to determine the user influence degree and use the obtained influence degree to define a new collaborative filtering similarity index, giving greater weight to the users with greater influence [9]. Magron and Fevotte proposed a fusion model based on deep learning and collaborative filtering, using improved automatic encoder and convolutional neural network mining to climb the hidden features of music, combining deep learning model and collaborative filtering model, considering the music characteristics and user preferences, supervising the collaborative filtering process, and solving the scoring problem in the sparse matrix of prediction accuracy which is not high [10]. Zhou and Zhou proposed a simple effective convolutional neural network (MCRN) to learn the audio content features of music, specifically converting audio into a "spectrum map" through the Fourier transform. MCRN can effectively extract music content features from the spectrum and experimentally demonstrate that MCRN outperforms other models in music classification and recommendation accuracy [11]. Zhao et al. use matrix decomposition technology to obtain long-term features of users and songs, then natural language processing technology to obtain musical context features, and finally use long and short memory network model to train the real dataset, which gives good experimental features [12].

From the analysis of a large number of research literature and results, we can see that, due to the various features of audio signals and the long time scale, how to reasonably allocate computing power to the important characteristics of model learning users is also a problem to be solved. In recent years, the attention mechanism has given a solution to the above problems. The attention machine mechanism has evolved from human vision, and it was born to solve the high complexity and long time of the neural network. Niyazov and Mikhailova integrated attention mechanism on the basis of deep network DNN, and experiments showed that it has a certain effect on improving the accuracy of recommendation [13]. Scholar Zhang uses CNN networks based on attention mechanism to predict the next step of user behavior. Zhang et al. proposed a low accuracy and long music classification model by adding the attention mechanism to improve the accuracy of classification and proved that this model greatly improves the accuracy of classification [14]. But as of June 2020, there are very few studies on music recommendation areas introducing attention mechanisms. Aiming at the low accuracy of independent recurrent neural network mentioned above and inspired by the application of attention model, this paper proposes a music recommendation system based on attention mechanism, as shown in Figure 1. By integrating the attention mechanism, more attention can be paid to the audio characteristics that affect users' personal preferences, so as to better learn from users' music preferences and improve the accuracy of recommendation.

Move on to the next type of music recommendation—special topics. PGC can be understood as a special project done by professional editors to edit some relevant songs together for "packaging" recommendation. With the advent of the era of Web 2.0, this production right has been delegated to ordinary users. Users can make any theme according to their own interest and music calendar, that is, the so-called UGC, user-generated content (strictly speaking, the selected collection made by users is not comparable to the theme made by PGC in terms of layout beauty and flexibility,

but it is not the core value of this kind of products). Not only the production right but also the popular recommended position has gradually been transferred from PGC to high-quality UGC. Now, this mode of using high-quality UGC as PGC is very mainstream, and so is Internet music services. Typical domestic cases that encourage UGC to do music topics include the selected collection of https://xiami.com and the song list of NetEase cloud music. It is worth mentioning that some of the music services still dominated by PGC in China have made good achievements, such as the arrest of more than ten years of operation, and still adhere to high-quality independent music recommendation.

From PGC to UGC, music recommendation sources have been greatly enriched, and under the effective design mechanism, the quality of the displayed music content has only increased. However, this process only enriches the content source and still does not change the mechanism of music recommendation. The way for users to obtain information is still to search or browse popular content (similar to song list). Next, let us take a look at the most mainstream music recommendation mechanism.

By the way, if you think about it carefully, are the essence of the several types of music product forms we have mentioned, from the original album, to the list, to the special topic, and the radio station to be mentioned later, all of which are song lists! The core difference between different types of song lists is only the correlation of songs for different reasons. A concept album may consist of ten songs around a story, a theme may consist of several representative works of a singer, and so on. At present, the most thorough implementation of the concept of song list in domestic music products is NetEase cloud music. By using it, you can concretely understand the view that "everything is song list" I put forward here.

3. Methodology

3.1. Music Recommendation Algorithm Based on the Neural Network. Conventional machine learning techniques are limited in processing natural data in their original form. Model building for machine learning systems or pattern recognition has long been very difficult and takes considerable time and effort to complete. Because the feature extractor needs the assistance of professional knowledge to effectively analyze the original data (such as pixels and audio signals of the image and appropriate feature representation) for the classification subsystem to classify and predict the input original data [13]. Deep learning is one of the most popular research fields today, and its proposal brings new opportunities for machine learning. Unlike other machine learning, deep learning methods have multiple learning methods, which are divided into multiple representation levels, and each learning method can be composed of simple but nonlinear modules, each converting the previous level into a higher abstract level representation. With sufficient combinatorial transformations, the learning system can learn very complex functions, just like simulating the perceptual process of human brain neural networks on external stimuli [15].

In order to understand the importance of attention mechanism, we must consider that neural network is actually a function approximator. Its ability to approximate different types of functions depends on its architecture. The typical implementation form of neural network is chain operation composed of matrix multiplication and nonlinearity on elements, in which the input elements or eigenvectors will only interact with each other through addition.

For the classification task, higher-level representations amplify aspects of distinguishing important features and suppress unrelated changes. For example, the first layer of deep learning learns only partial features, regardless of location; the second layer begins to learn the correlation between local features, and the third layer begins to combine partial features according to the correlation to obtain partial features on a larger scale. Therefore, deep learning has better adaptability than other machine learning. More importantly, these feature extraction models are not manually designed, but are adjusted by neural networks through continuous learning, which are effective for different data sources. In terms of application, deep learning has made great progress in intelligent recognition in the field of speech and image and achieved good results, which has greatly promoted the development of artificial intelligence and the leap of human intelligence interaction technology. Deep learning is unique in that it allows it to be composed of multiple processing layers, each of which can be both a traditional neural network layer or processing algorithms in other fields, so that the computational model can not only extend but also learn the representation of data with multilevel abstraction [16].

As shown in Figure 2, the recommendation system based on deep learning mainly includes three layers. The input layer data can be explicit or implicit feedback data, such as the user's score, browsing or clicking behavior data, or the user's portrait and item content data, such as the user's preference, age, image, and audio content, and the data can also be user- generated auxiliary data such as comments. The model layer can use other deep learning models such as deep belief networks, convolutional neural networks, recurrent neural networks, and autoencoders [17]. The role of the output layer is to generate a recommendation list of items for users by using Softmax classification function, similarity calculation, combined with the hidden representations of users and items learned by the model [18]. In addition to the research content to be covered, deep learning can be integrated into any traditional recommendation system. In content-based recommendation systems, collaborative filtering and hybrid recommendation systems can also be applied to recommendation systems based on social networks and situational awareness.

Suppose the number of input layer nodes is N, the number of hidden layers is M, the output layer nodes are L, and the order input vector is x, $x = x_1, x_2, \ldots, x_N$. The output vectors are y, $y = y_1, y_2, \ldots, y_L$. The neural network is calculated in the following form:

$$\begin{aligned} h_i &= \omega_{ji} \cdot x_j + b_i, \\ o_j &= f_i(\beta_i \cdot h_i), \\ y_l &= v_{ik} \cdot o_i, \end{aligned} \tag{1}$$

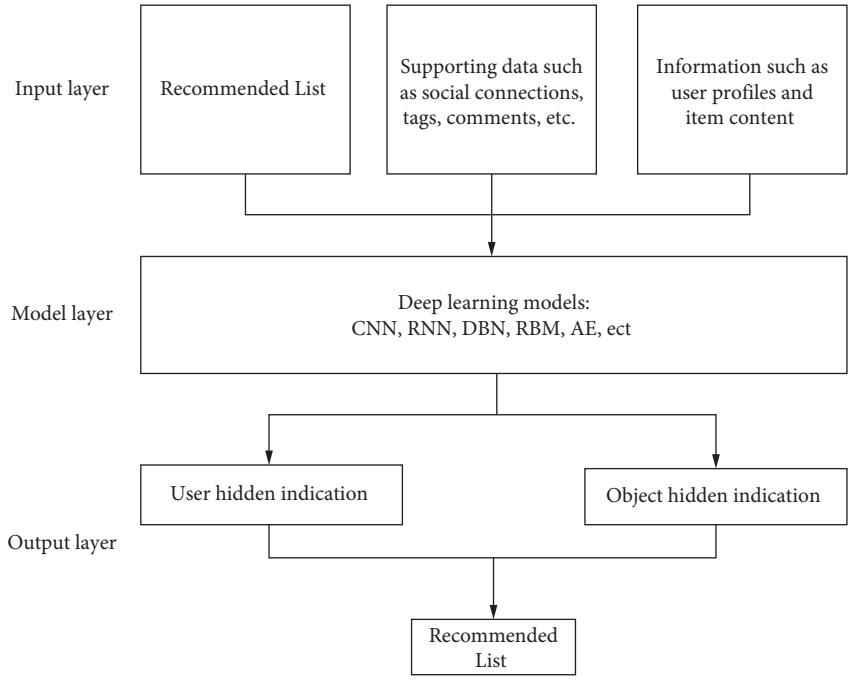


Figure 2: A recommended system framework based on deep learning.

where $\omega_{ji}(j = 1, 2, \ldots, N, i = 1, 2, \ldots, M)$ represents the weights from the input layer to the hidden layer and b_i represents the bias of the ith neural node. f_i represents the activation function of the first neural node. f_i represents the coefficients of the activation function, and this parameter is introduced to regulate the activation ability of neurons in the hidden layer. v_{ik} represents the weights from the hidden layer to the output layer, o_i and b_i are two intermediate quantities, h_i is the output value of the input layer to the hidden layer input signal after calculation, and o_i is the output value of the neural node after the activation function activation. The sum of error (SSE) is defined as

$$\mathrm{SSE} = \sum_{i=1}^{k} \left(y - y'\right)^2. \tag{2}$$

There are three commonly used activation functions. Choosing different activation functions will affect the training and prediction of CNN network models. Compared with sigmoid and tanh, ReLU is more widely used in deep learning, which can not only converge quickly and improve the training efficiency but also effectively alleviate the problem of gradient disappearance. For the above reasons, this paper finally chose the modified linear unit ReLU as the activation function of the training model of the deep neural network.

$$\begin{aligned} \mathrm{sigmoid}(x) &= \frac{1}{1 + e^{-x}}, \\ \tanh(x) &= \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}, \\ \mathrm{ReLU}(x) &= \max(0, x). \end{aligned} \tag{3}$$

3.2. Attention Mechanism of Neural Networks. Note that the mechanism calculates a mask for multiplying features. This seemingly innocuous expansion will have a significant impact: suddenly, there is a lot more function space that can be approximated by neural networks, making new use cases possible. Why is that? Although I have no evidence, the intuitive idea is that there is a theory that neural network is a general function approximator, which can approximate any function and achieve any accuracy. The only limitation is the limited number of hidden elements. In any practical setup, this is not the case. We are limited by the number of hidden units that can be used. Consider the following case: we want to approximate the product of neural network inputs. Feedforward neural network can only simulate multiplication by using (many) addition (and nonlinearity), so it needs a lot of neural network foundation. If we introduce multiplicative interaction, it will become simple and compact.

The birth of attention mechanism is to solve the problems of excessive neural network complexity and long time. It is derived from the mechanism of human visual attention. Human vision first browses the global image information, from which the areas need to focus on attention, and second, pay attention to this area, so as to obtain the detailed information of this area, while reducing the reading of useless information and reducing the waste of resources [19]. The core goal of the attention mechanism is to select information that is more critical to the current task objectives from large amounts of information, so as to improve accuracy and remove information redundancy to reduce algorithmic complexity [20].

Figure 3 shows the weights of the Attention mechanism. Understand each element in Source as a set of key value pairs of key and Value. Given a data in the target, by calculating the correlation or similarity of each data with each key, it

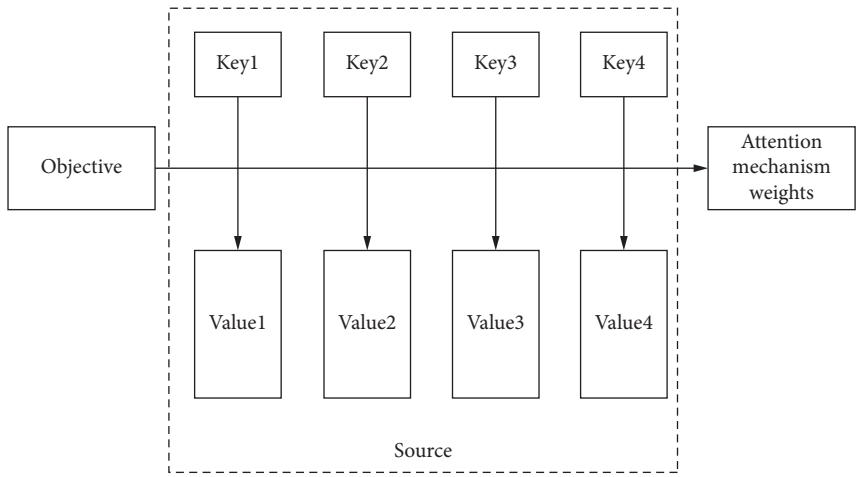


Figure 3: Attention mechanism.

obtains the weight coefficient of each key and then weighted sums the Value and finally obtains the weight value of the attention mechanism. The weight represents the importance of the information; the larger the weight, the more the focus on its corresponding Value value, and the Value is its corresponding information. So, essentially, the Attention mechanism is a weighted sum of the Value values of the elements in the Source, while the target and Key are used to calculate the weight coefficient of the corresponding Value. That is, its essential idea can be rewritten into the following formula:

$$\text{Attention}(\text{Target}, \text{Source}) = \sum_{i=1}^{L_x} \text{Similarity}(\text{Target}, \text{Key}) * \text{Value}_i, \tag{4}$$

where L_x represents the length of the source. Since the music recommendation system needs to analyze the audio that users listen to historical music and the music audio has many features and long timing, using the attention mechanism to weigh the audio can reduce the complexity of the algorithm and improve the accuracy of the algorithm.

3.3. Improved Music Recommendation Algorithm for the Deep Neural Network Based on Attention Mechanism. Three-dimensional user portraits can bring subversive traditional big data aided decision-making solutions to traditional retail chains or enterprises, rather than making decisions and judgments through various qualitative analysis results by upstream and downstream service providers at all levels. In fact, it is also an impact and break on the value chain of the existing retail chain industry.

Personalized music recommendation algorithm learns users' preferences through users' behavior data and finally predicts users' favorite songs and pushes them to the system users. This purpose can be abstracted as a dichotomous mathematical problem [21]. A hybrid recommendation algorithm based on attention mechanism and independent recurrent neural network by RNN (AINRNN) is improved based on the deep learning neural network.

In the algorithm data preprocessing stage, the training set is divided into two parts: user history listening to audio and user portrait. User history listening audio is provided by the user listening to music. The user portrait is composed of three parts: user age, user listening to song language, and song type [22]. The framework diagram of this algorithm is shown in Figure 1. During the feature extraction phase, first, the user history listening audio is extracted through the improved MFCC (Mel Frequency Cepstral Coefficient), HFC (high frequency content), HPCP (harmonic pitch class profiles), and other audio feature extraction algorithms. At the same time, the user portrait data is feature extracted, subsequently combining the audio extraction features with the user features and training through the AINRNN network. Finally, the recommendation list is obtained through the first layer (softmax). This is the framework of this paper based on an improved personalized hybrid recommendation model of AINRNN. The attention mechanism used represents the number of users listening to songs as the user's preference of song characteristics, so that the model can better learn the personalized weight of users' music preferences.

The user history listening records and user portrait in the training set are taken as input to the model, and the output recommendation list is the favorite song set of the model. AINRNN recommendation algorithm builds a deep INDRNN network by stacking the basic neural structure of INDRNN layer by layer, while introducing attention mechanism and changing the network input processing mode of residual connection to full connection mode, giving a hybrid recommendation algorithm based on attention mechanism and improved RNN. With the help of the ReLU unsaturated activation function, over a time step, the model gradient can be consistently mapping, while being directly propagated to other layers. The structure diagram and flow charts of the algorithm model are shown in Figures 4 and 5.

Figure 5 shows a flowchart of the hybrid recommendation algorithm based on attention mechanism and improved AINRNN. It is divided into data preprocessing and prediction stages. In the data preprocessing stage, the data is extracted from the input list in order, the data is extracted into music audio data and user portrait, the user history

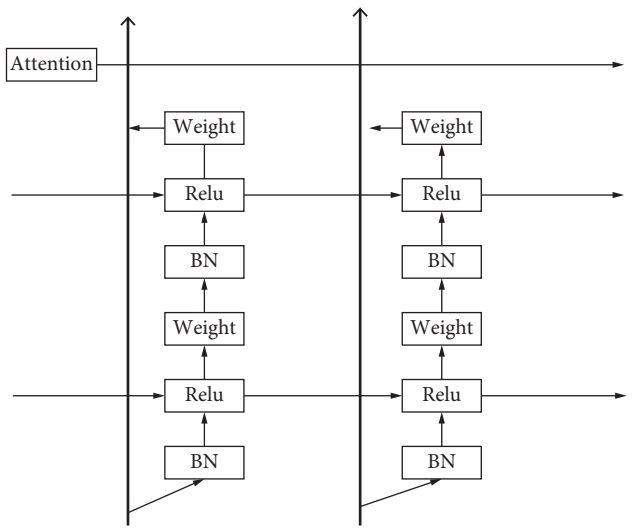


Figure 4: Model structure diagram of the AINRNN recommended algorithm.

music audio features are extracted by scattering transformation, and the extracted audio features are taken as input to the above algorithm. In the prediction stage, the above extracted features are used through the attention mechanism and the improved AINRNN hybrid recommendation algorithm, and finally, the list is generated and the data is recorded, while judging whether the input list is completely traversed. If so, display the results to the user from high to low; otherwise, process the next data and repeat the above steps until completion.

4. Result Analysis and Discussion

4.1. Experimental Dataset and Preprocessing. In the field of deep learning vision, relevant enterprises and organizations at home and abroad have opened many excellent benchmark datasets such as MNIST, COCO, CIFAR, and Open Image. Image Net, for different application scenarios, is commonly used for researchers. These publicly available datasets play a crucial role in promoting research and development in related fields. However, unlike the large number of publicly available images or texts, the field of music information retrieval or recommendation has been lacking in large, mature, complete, and easy-to-use benchmark datasets. This has to some extent limited the research and application of models such as deep neural networks that usually require large amounts of data training in this field. Some publicly available music data sets are listed in Table 1.

From the above table, it can be seen that audio files may be subject to strict copyright control by record companies, and only some small data sets will distribute audio files. For large data sets, such as audio sets and acoustic Brainz, audio files are not directly provided, and important information such as user records is not included. Only audio features are included, or audio download links are provided. In all of the above datasets, only the MSD dataset contains both the audio and the required user record information. The music dataset used by the algorithm is Million Song Datasets or

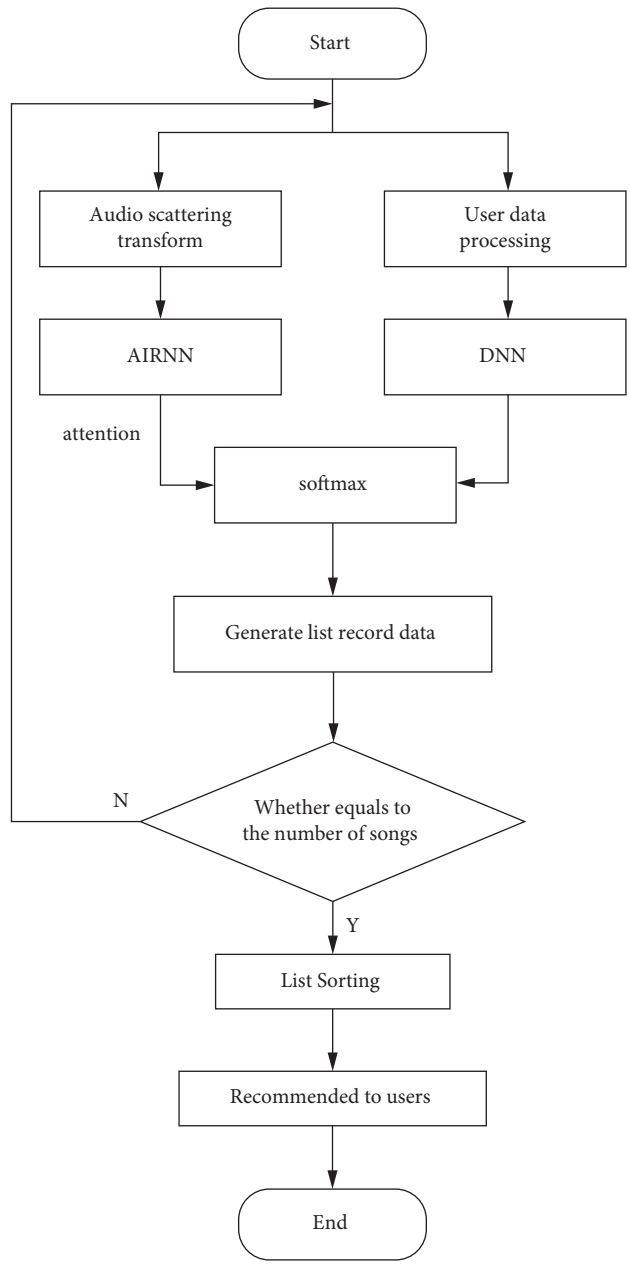


Figure 5: Flow chart of the AINRNN algorithm.

Table 1: Currently commonly used publicly available music data sets.

Data set	Sample number	Audio frequency	User records
Ballroom	698	Have	Not have
GTZAN	1000	Have	Not have
ISMIR 2004	1458	Have	Not have
MagnaTagAtune	25863	Have	Not have
MSD	1000000	Interlinkage	Have
Audioset	2084320	Interlinkage	Not have
AcousticBrainz	252473	Not have	Not have

MSD, the million music dataset. MSD is the first public dataset in the field of music recommendation. It is a resource integration platform, which brings together multiple authoritative and well-known music community data,

containing information on 1 million songs. The simulation comparison test mainly uses the audio feature set in the core data set of MSD and the data provided by its subset Taste Profile.

Since MSD has information about 1 million songs and a total of 283 GB, not screening will seriously slow down the training speed of the model. First, to ensure that the model calculation was valid, users with less than 100 historical listening tracks were removed, with 359,687 songs and 82,310 users remaining. Then, using the mainstream ten-fold cross-validation method, the filtered user data was evenly divided into 10 copies, one as the test set, and the rest as the training set. During the model training process, the overfitting parameter was set to 0.5, and the learning rate was set to 0.0005. When the convergence range of the simulation accuracy curve is stable, we will stop training and save the model.

4.2. Feature Extraction of the Fused Residual Network and Identification Algorithm of MRF Grayscale Information. We use the designed algorithm to analyze the recommended results of music and test the effect of the algorithm. Due to the diversified evaluation indexes of the recommendation algorithm, the user satisfaction, accuracy, and normalized loss cumulative gain indexes are selected for simulation verification. The accuracy is defined as shown in the following equation. Taking the first k of the recommended list calculated by the model, we can intuitively judge the prediction results.

$$\text{accuracy} = \frac{\sum_k (L(k) \cap T(k))}{\sum_k T(k)}. \tag{5}$$

NDCG represents the ranking position score situation of the high correlation degree of model output and input and is an important indicator to evaluate and measure the performance of music recommendation algorithm. The NDCG definition is as follows:

$$\text{NDCG} = \frac{\sum_{i=1}^{p} \left(\text{rel}_i / \log_2 (i+1)\right)}{\sum_{i=1}^{|\text{rel}|} \left(2^{\text{rel}_i - 1} / \log_2 (i+1)\right)}. \tag{6}$$

Here, rel_i represents the benefit of the i'th result in the recommendation list, and |rel| represents the results ranked in the optimal way.

User satisfaction index can make users intuitive to evaluate the performance of the recommendation algorithm. This simulation uses a questionnaire survey to obtain user satisfaction. There are 10 grades on the questionnaire, and 10 is the highest score. To evaluate the importance of the index by using the subjective empowerment method Liszt scale, the score was used as the basis for the weight calculation, while the mean score was used as the original relative influence coefficient. Thirty volunteers were investigated to experience three different music recommendation algorithms based on LSTM, INDRNN, and AINRNN. The anonymous scores of volunteers were investigated by a questionnaire. The weighted sum was used as the satisfaction score. The overall satisfaction score of the algorithm was the average value of the satisfaction score of volunteers.

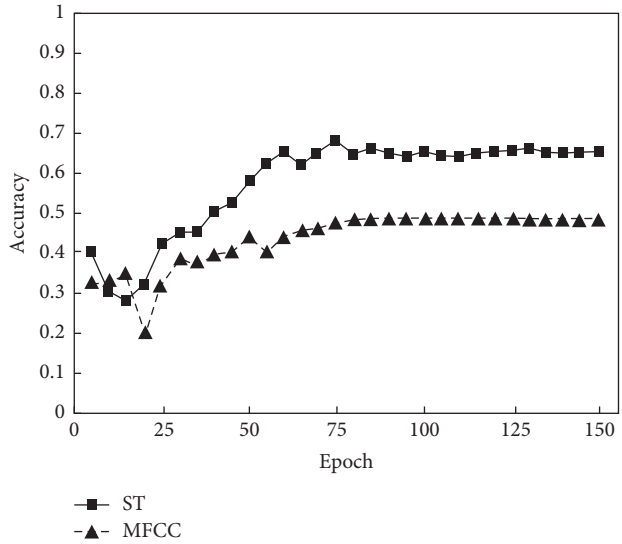


Figure 6: Effect of ST and MFCC preprocessing methods on algorithm accuracy.

Figure 6 shows the influence of MFCC and ST on multiple algorithms for two different preprocessing methods of audio, and the model is trained with a 5-layer AINRNN network. The results show that when the accuracy stabilizes, i.e., the training reaches 75 epochs, the ST of the simulation group is 19.7% higher than the MFCC accuracy of the simulation group. This also verifies the conclusion that the algorithm gives in the data preprocessing stage and that the scattering transformation can compensate MFCC for losing audio features over 25 ms during feature extraction. At the same time, it also intuitively proves that the audio features of more than 25 ms are potentially related to whether the user likes the song, and the longer the features, the better the prediction effect.

Figure 7 compares the accuracy of the AINRNN algorithm with the accurate INDRNN network algorithm and the classical LSTM network algorithm. As can be seen from Figure 7, the accuracy of the LSTM algorithm is always far from the other two algorithms, with AIN RNN with an accuracy of 67.8% and IND RNN with an accuracy of 61.8%.

Although, AINRNN and IND RNN in the figure above, the NDCG index of AINRNN is 7.3% higher than INDRNN in Figure 8. It shows that AINRNN can learn the potential relationship between audio sequences well and solve the problem of RNN and LSTM gradient explosion to some extent, thus confirming that AINRNN algorithm has a good performance on music recommendation. As k is worth increasing, the accuracy trend of the three algorithms gradually changes from rising to decreasing and finally approaches zero. As can be seen from Figure 7, for the inflection point of this function at k values of 8–10, it is appropriate to set the recommendation list to 10 heads. Compared with the current popular music portals such as QQ and NetEase cloud, the mainstream online music recommends 15 songs every day. Excluding a small number of recommended songs is not determined by the recommendation algorithm, but by the

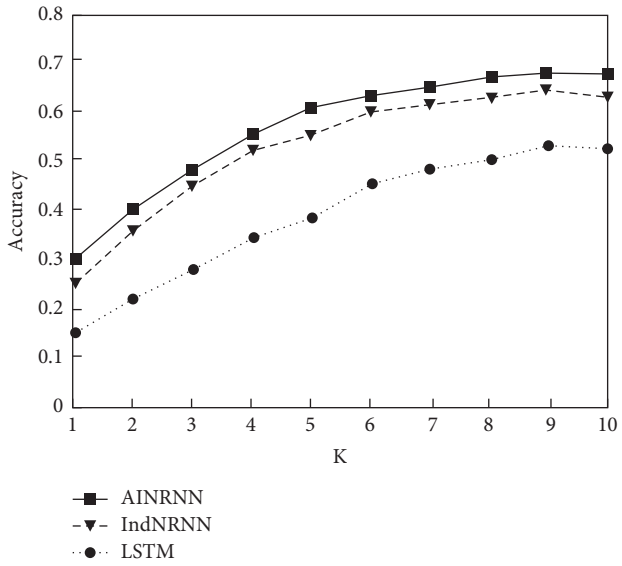


Figure 7: Precision of the three algorithms.

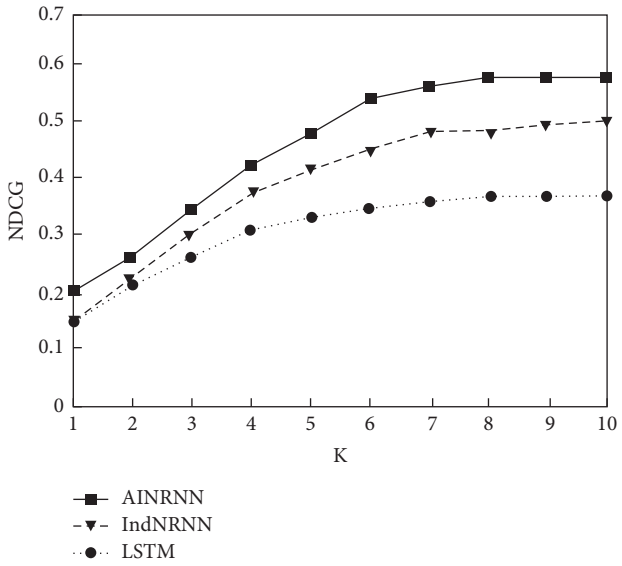


Figure 8: The effect of k values on NDCG indicators.

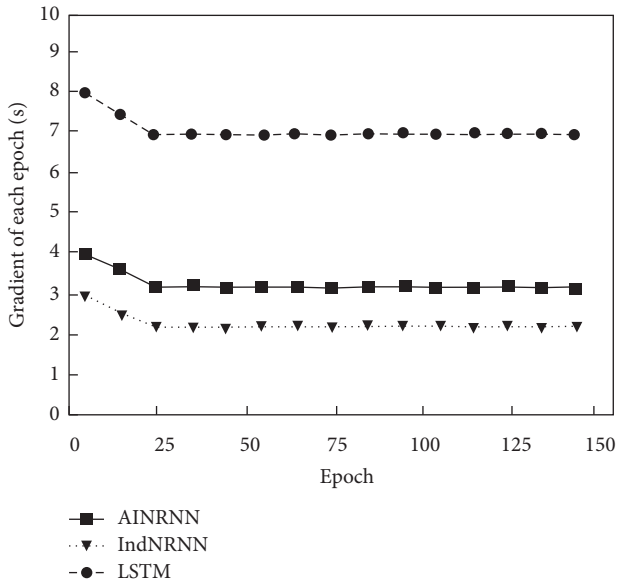


Figure 9: Training time of the three algorithms.

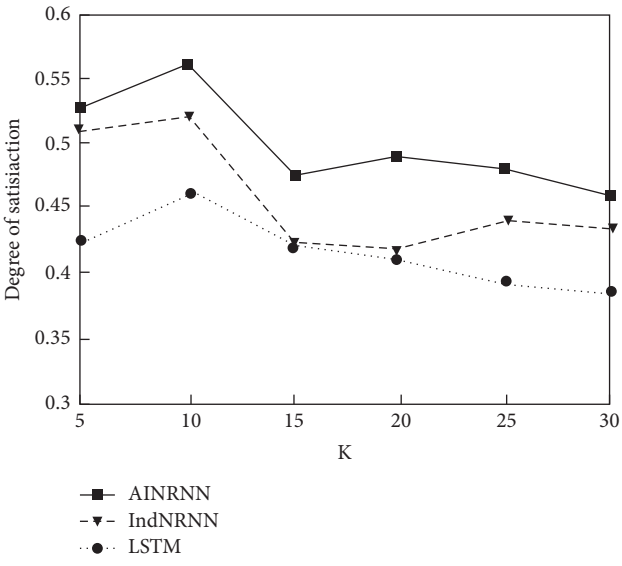


Figure 10: User satisfaction.

business promotion model. The number of remaining music recommendations is similar to the simulation results in this section.

Figure 9 represents the training time of the different algorithms in the music recommendation systems. It can be seen that the classical LSTM algorithm not only has a long training time but also has the worst effect. The training time is the shortest, the AIND RNN state algorithm increased by 1.1 s compared with IND RNN, but combined with Figures 8 and 9, AINRNN NDCG index is 58.1%, 7.8% percentage points higher than IND RNN, and the accuracy index is also 6% higher. According to the model of mainstream commercial music business, it is mainly divided into offline calculation and online recommendation, with the frequency of once a day. It is acceptable to sacrifice a small amount of computing time to improve the accuracy of the algorithm and NDCG index.

Figure 10 shows that the user satisfaction based on the hybrid recommendation algorithm of attention mechanism and improved RNN is also the highest. It can be shown that the above improved algorithm can be better applied in the field of music recommendation.

5. Conclusion

The recommendation algorithm resets the user's recent behavior right high, so the system is easy to recommend a large number of similar types of songs, reducing the user's aesthetic fatigue and excitement. It is suggested to add the analysis of users' use scenes into the algorithm and limit the

number and location of songs of the same type. For long tail unpopular songs, due to the relatively small amount of data, we should pay more attention to effect feedback. Deeply mine data and enrich recommendation elements, such as recommending music, albums, and singers that affect a user's favorite singer according to his/her creation/growth background. With the increasingly close combination of the Internet and people's production and life, the total amount of global data and information has also grown increasingly. In order to save users the time to find their favorite music in many music, the music recommendation service arises at the historic moment and is widely concerned by scholars. Traditional music recommendation system based on the collaborative filtering algorithm has low recommendation accuracy, poor real-time performance, sparsity, system cold start, and so on. This paper focuses on solving the problem of low accuracy of the recommendation system and considering the cold start problem of the system. To solve the problem of low accuracy of music recommendation algorithm, a hybrid recommendation algorithm based on attention mechanism and improved AINRNN is proposed and is implemented by a neural network composed of independent recurrent neural network model and attention mechanism. The scattering transformation can be used to extract the characteristics of the long-time signal, to data preprocess the historical audio heard by the user and to extract the effective features. Then, the model is trained through the independent recurrent neural network with mixed attention mechanism. The attention mechanism can solve the problem of long and difficult deep learning training time, and finally, the recommendation list is obtained through the softmax layer. The results show that the algorithm proposed in this paper can solve the problem of music recommendation well and improve the highest accuracy of the independent recurrent neural algorithm by 8.5% and 20.9% compared with the classic LSTM (long and short-term memory network) music recommendation algorithm. Therefore, the hybrid algorithm can indeed better improve the recommendation accuracy, and we hope to conduct more indepth experiments in future research.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This study was supported by the Role of Creative Dissemination of Red Music Culture of Dabie Mountains in the Construction of Modern National Identity in the New Era; Phase Achievements of Henan Soft Science Research Project (project no. 202400410223); the Role of Creative Inheritance of Red Opera Culture in the Construction of National Identity in the New Era; Henan Education Department Humanities and Social Sciences Research General Project Stage Achievement (project no. 2020-ZZJH); and Study of Xinyang's Red Music Culture from the Perspective of History; Xinyang Soft Science Research Phase (project no. 20200052).

References

[1] A. Baijal, V. Agarwal, and D. Hyun, "Analyzing images for music recommendation," in *Proceedings of the 2021 IEEE International Conference on Consumer Electronics (ICCE)*, IEEE, Las Vegas, NV, USA, January 2021.

[2] P. Åman, *Musical serendipity : designing for contextual music recommendation and discovery*, Aalto University, Espoo, 2018.

[3] G. S. Berns, C. M. Capra, S. Moore, and C. Noussair, "Neural mechanisms of the influence of popularity on adolescent ratings of music," *NeuroImage*, vol. 49, no. 3, pp. 2687–2696, 2018.

[4] Y. Deldjoo, M. Schedl, and P. Knees, "Content-driven music recommendation: evolution, state of the art, and challenges," 2021, https://arxiv.org/abs/2107.11803.

[5] M. S. Fathollahi and F. Razzazi, "Music similarity measurement and recommendation system using convolutional neural networks," *International Journal of Multimedia Information Retrieval*, vol. 5, pp. 1–11, 2021.

[6] F. Guan, C. Yu, and S. Yang, "A gan model with self-attention mechanism to generate multi-instruments symbolic music," in *Proceedings of the 2019 International Joint Conference on Neural Networks (IJCNN)*, Budapest, Hungary, July 2019.

[7] K. Jearanaitanakij, T. Boonloy, A. Thongpuek, R. Chawuthai, and B. Pasaya, "Music recommendation by using favorite level," in *Proceedings of the The TNI Academic Conference 2017*, Bangkok, Thailand, May 2017.

[8] Y. Yiyi, L. Jia, and L. Depeng, "Effect of perceived in-depth differences on employees' voice behavior: the mechanism of perceived emergent states," vol. 39, pp. 97–112, 2017.

[9] D. Kowald, M. Schedl, and E. Lex, "The unfairness of popularity bias in music recommendation: a reproducibility study," in *Proceedings of the Advances in Information Retrieval, 42nd European Conference on IR Research, ECIR 2020*, Lisbon, Portugal, April 2020.

[10] P. Magron and C. Fevotte, "Leveraging the structure of musical preference in content-aware music recommendation," in *Proceedings of the ICASSP 2021 - 2021 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Toronto, ON, Canada, June 2021.

[11] Q. H. Nguyen, T. Do, T. B. Chu et al., "Music genre classification using residual attention network," in *Proceedings of the 2019 International Conference on System Science and Engineering (ICSSE)*, Dong Hoi, Vietnam, July 2019.

[12] H. F. Zhou and L. Y. Zhou, "Music session recommendation algorithm with Word2Vec," *Communications Technology*, 2019.

[13] A. Niyazov, E. Mikhailova, and O. Egorova, "Content-based music recommendation system," in *Proceedings of the 2021 29th Conference of Open Innovations Association (FRUCT)*, Tampere, Finland, May 2021.

[14] H. Zhang, K. Zhang, and N. Bryan-Kinns, "Exploiting the emotional preference of music for music recommendation in daily activities," in *Proceedings of the 2020 13th International Symposium on Computational Intelligence and Design (ISCID)*, Hangzhou, China, December 2020.

[15] M. Schedl, "Investigating country-specific music preferences and music recommendation algorithms with the LFM-1b

dataset," *International Journal of Multimedia Information Retrieval*, vol. 6, no. 1, pp. 71–84, 2017.

[16] C.-D. Wang, W.-D. XI, L. Huang, Y.-Y. Zheng, Z.-Y. Hu, and J.-H. Lai, "A BP neural network based recommender framework with attention mechanism," *IEEE Transactions on Knowledge and Data Engineering*, vol. 34, no. 99, p. 1, 2020.

[17] S. Liu, X. Tu, X. A. Cheng, and L. Renfa, "Deep neural networks with attention mechanism for monocular depth estimation on embedded devices," *Future Generation Computer Systems*, vol. 131, 2022.

[18] W. Jiao, H. Wang, and G. Zhong, *MusicCNNs: a new benchmark on content-based music recommendation*, Springer, Cham, 2018.

[19] T. Yoshida and T. Hayashi, "OtoPittan: a music recommendation system for making impressive videos," in *Proceedings of the IEEE International Symposium on Multimedia*, San Jose, CA, USA, December 2016.

[20] M. Schedl and C. Bauer, "Online music listening culture of kids and adolescents: listening analysis and music recommendation tailored to the young," in *Proceedings of the 11th ACM Conference on Recommender Systems (RecSys 2017): International Workshop on Children and Recommender Systems (KidRec 2017)*, Como, Italy, August 2017.

[21] Y. Tao, Y. Zhang, and K. Bian, "Attentive context-aware music recommendation," in *Proceedings of the 2019 IEEE Fourth International Conference on Data Science in Cyberspace (DSC)*, Hangzhou, China, June 2019.

[22] L. Zhu, Y. Chen, and W. Jiang, "A hybrid approach for music recommendation," in *Proceedings of the 2009 International Conference on Computational Intelligence and Natural Computing*, June 2009.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 3851103, 8 pages
https://doi.org/10.1155/2022/3851103

Research Article

Interior Design Effectiveness Modelling for Public Buildings with BIM-Based Technology

Zhu Zhu

College of Humanities and Arts, Chongqing University of Science and Technology, Chongqing 401331, China

Correspondence should be addressed to Zhu Zhu; 2003043@cqust.edu.cn

Received 1 May 2022; Revised 31 May 2022; Accepted 8 June 2022; Published 23 June 2022

Academic Editor: Wen Zhou

In recent years, with the continuous development of urbanisation, the proportion of interior design in public buildings has been increasing year by year. At the same time, there is a tendency in many places for the interior spaces of public buildings to be upscale and retro. This indicates that people are paying more and more attention to the spiritual aspect of their lives, in addition to the materialistic pursuit of enjoyment. The current phenomenon of overdecoration in society can lead to excessive luxury and wastefulness. In these wasteful interiors, the beauty of the building itself is lost. In addition, this type of interior design is not only expensive but also poses certain safety risks to some extent. In the modern society, public buildings are essential places for public activities. To be specific, they are closely linked to public services and social management attributes. As a result, public buildings usually play a decisive role in facilitating communication and cooperation between various persons. Thus, the construction requirements of public buildings are currently increasing and the structural shapes of buildings are becoming more complex. In addition, the level of technology and the use of public buildings are becoming increasingly demanding. As a result, it is quite important to examine how modern and emerging technologies can be applied to public building design in order to improve its effectiveness. At the same time, with the continuous and rapid development of China's economy and the promotion of the concept of environmental protection, the greening of public buildings has become an object of concern and research. There are many different types of existing public buildings in China, and in the design process, the energy consumption of the building throughout its life cycle and its impact on the surrounding environment are not fully considered, resulting in problems such as high energy consumption and poor indoor comfort in the actual use of the building. However, the demolition and reconstruction of buildings can lead to waste of resources and environmental pollution. Therefore, it is feasible and necessary to study the application of green building technologies in the design of public buildings. This study models the effectiveness of public building interior design based on BIM technology from the perspective of integrated design as well as parametric design. This model enables the interior design of public buildings to become energy efficient, emission reducing, and environmentally sustainable. After all, the integration of architecture and interior design can reduce unnecessary decorative waste. In addition, this model can also respond to the government's efforts to develop an ecological civilisation, creating a new way of living that is resource efficient.

1. Introduction

The construction industry is one of the pillars of China's national economy and also one of the oldest industries in the country. The construction decoration industry is an old but new industry belonging to the construction industry, including public building decoration and residential decoration [1]. With the advancement of urbanisation, the building decoration industry has been developing at a rapid pace. As a result, the interior decoration of buildings becomes a system project that can offer a number of decorative materials and products [2]. At the same time, they can be customised and produced according to the needs and environmental requirements of the user in order to create a perfect artistic space [3]. It is a cross-regional, cross-sectoral, multi-product, high-technology emerging industry. Interior decoration provides people with a spatial environment that is easy to use, comfortable and safe, and has perfect artistry [4]. To be specific, it can greatly improve people's various needs and enhance their quality of life, thus satisfying their material

and spiritual needs. It is more artistic and environmental than traditional architecture and is characterised by its applicability, comfort, artistry, diversity, variability, and renewability [5]. There are many different types of public buildings; however, office buildings are one of the most numerous types of public buildings in cities. Large and important office buildings are essential symbols of the city and have a significant impact on the urban form [6]. With the rapid development of the tertiary sector and the knowledge economy, more than 50% of the workforce in developed Western countries is already employed in various forms of office buildings [7]. The quantity and quality of office buildings have become a crucial measure of the social, political, economic, technological, and cultural development of a city or region, as well as the degree of urbanisation.

In recent years, as the pace of urban planning and construction has accelerated, the layout, design, and decoration of public buildings have also faced higher requirements [8]. The image and tone of public buildings must be in harmony with the overall outline of the city and the natural environment. At present, the consumption of interior decoration in public buildings in China accounts for a large proportion and is on the rise, and the cost of interior decoration in public buildings is enormous [9]. For instance, Figure 1 shows that the interiors of some public buildings are becoming very wasteful. Also, the construction waste during the design phase becomes a severe issue [10]. Another major problem facing architectural decoration is the loss of the timelessness of the artistic value of architecture as a result of the boom in popular culture. This has led to the disappearance of the truly valuable principles of the architectural system, with financial gain taking over as the only criterion for evaluation [11]. In today's human-centred world, the most essential issue in the design of architectural interiors is also safety, with problems arising from changes to the structure of houses during renovation or from the environmental quality of materials [12]. As the concept of low carbon and environmental protection continues to grow, the environmental and safety aspects of interior decoration are becoming increasingly essential. In recent years, as environmental degradation and resource scarcity continue to occur, all walks of life are focusing on the topic of low carbon [13, 14]. There is a growing awareness that sustainable development can only be achieved through low-carbon production and low-carbon lifestyles. Also, in recent years, the world has been focusing on green buildings, and the same is true for the interior design of our public buildings, which are so productive [15]. To be specific, it is important to look not only at the environmental aspects of decorative materials but also to fundamentally change people's attitudes. Only in this way, can we reduce the waste of social resources and thus achieve a healthy development of interior design.

After nearly 40 years of rapid development since reform and opening up, China's construction industry has achieved world-renowned results [16]. Both the total number of buildings and the construction techniques have developed significantly. Public buildings, in particular, have been increasing in recent years as important places of work and activity [17]. These public buildings provide a great deal of convenience for the production and living of urban dwellers, and they also contribute significantly to the country's social and economic development. However, behind the economic prosperity, there are many problems with public buildings, such as huge energy consumption [18] and poor functionality [19]. Specifically, although the total floor area of many large public buildings is less than 3% of that of civil buildings, the energy consumption of these buildings accounts for more than 20% of the total energy consumption of civil buildings [20]. The rapid development of China's construction industry has brought with it huge energy consumption, of which public buildings account for a large proportion (Table 1). Public buildings, because of their function and characteristics, have a relatively high energy consumption. On the other hand, the pursuit of more and more diversified building forms, the increasing demand for intelligent and functional buildings, and the increasing complexity of building construction techniques are becoming more and more important [21]. In this context, traditional architectural design concepts are becoming increasingly insignificant in the face of increasing building forms and construction requirements.

Despite the many challenges facing the development of public buildings, there are also many opportunities for the construction industry due to the development of new technologies and concepts. One great opportunity is the support being given to the development of green buildings in order to address the high energy consumption of the construction industry [22]. Green buildings emphasise the need to maximise environmental protection and reduce pollution throughout the life cycle of a building, thus providing a healthy, suitable, and efficient space for people to use. As can be seen from the construction requirements and its design philosophy, the green building design process requires an ever-increasing amount of building information to be processed [23]. Traditional design methods and processes are no longer sufficient to meet the needs of green buildings. However, the rapid development of information technology has met this demand for green building design [24]. In essence, green building is the implementation of a mindset of architectural design. This means that the current destructive way of life must be adapted to maintain a balance with the fragile living environment. On the other hand, architects must approach all design elements with a green mindset and be innovative in their approach to new technical measures to bring architectural work into greater harmony with the environment.

Information is now one of the three main elements of social development, along with matter and energy [25]. The model is a way of representing information to enable people to better understand, analyse, and transform things. The core concept of BIM technology is to integrate all kinds of information about a building into a model and to use the model to represent all kinds of information about the building [26]. BIM technology puts the information about the building and its components in a central database and digitises all the properties of the building and its components. This ensures that the building information is

Figure 1: Overdecorated public buildings.

Table 1: Energy consumption of various types of buildings.

	Coal for construction	Electricity for residential use	Electricity for public buildings	Electricity for private buildings
Energy consumption	25–30 kgce/(m^{2*}year)	15–25 kWh/(m^{2*}year)	150–2500 kWh/(m^{2*}year)	30–60 kWh/m^2/year

inherently uniform and computable and avoids the information silos caused by the current two-dimensional diagrams. In addition, BIM technology uses parametric modelling, which allows the building information contained in the BIM model to be coordinated and computable [27]. This building information will make it easier to analyse energy efficiency and the environment in the design process of green buildings.

BIM technology is based on computer technology and three-dimensional digital technology, through the organic integration of the advantages of modern computer technology tools and project engineering parameters. The process of establishing a BIM model is a process of editing and collating information about the overall design of the project [28]. The establishment of a 3D simulation model has a positive effect on the project from planning and design to the construction process and postconstruction operation and maintenance. To be specific, the model built using BIM technology can contain specific information about the project and its design parameters. A collaborative design platform for all parties involved in a construction project, therefore, allows BIM technology to be used throughout the life cycle of a project, from design to operation and management [29]. Designers can apply the BIM model to provide an intuitive and effective virtual reality experience for all parties involved in the project planning phase, thus enabling visualisation of the project design. In addition, the virtual reality capabilities of the model allow engineers to understand and grasp the parameters of the building system during the design and construction phase [30]. As a result, they are able to respond to possible situations in the most effective manner. In addition, once the project is completed and in use, the BIM model can be used to pinpoint the exact location of the incident and the surrounding environment. This will provide a more convenient service for project management and reduce the pressure on property management.

This study aims to provide a comprehensive understanding of the current interior design problems in public buildings and to raise awareness of the importance of interior design. In addition to this, this study investigates green building design methods by applying theories and methods related to BIM modelling, both in terms of the design process and parametric design. By breaking down the information barriers in architectural design, the BIM-based interior design effectiveness model for public buildings is constructed, thus providing a theoretical basis for the further development of information technology in construction projects. The design model is scientific, systematic, advanced, and operable and will play a role in expanding and improving the theory of public building design in China.

2. Interior Design for Public Buildings

In China, the architectural design market is growing at an average rate of around 15% per year. In such a large industry, energy consumption accounts for around 40% of total energy consumption. Since the 20th century, environmental degradation and resource scarcity have led to a focus on low-carbon issues in all sectors. There is a growing awareness that sustainable development can only be achieved through low-carbon production patterns and lifestyles. As a result, the design of public buildings must also consider the concept of green.

2.1. Analysis of Current State of Interior Design for Public Buildings. In the process of interior design and renovation of public buildings, interior safety problems are constantly arising due to the destruction of load-bearing structures by private demolition, as shown in Figure 2. For example, some buildings that could have withstood earthquakes of magnitude 5 or 6 have had their load-bearing structures destroyed by the renovation process, resulting in a significant reduction in seismic resistance. There have been many cases of people being injured by falling ceiling light fittings in luxurious decorations. The materials used in the decoration contain a large number of toxic substances, which can harm people and pollute the environment at the same time. In addition, many building materials are highly flammable and will burn quickly in the event of a fire, releasing high levels of toxic and harmful gases.

2.2. Cost Analysis of Interior Design for Public Buildings. If the interior design of a public building is not well thought out, then it can result in a significant waste of resources. On

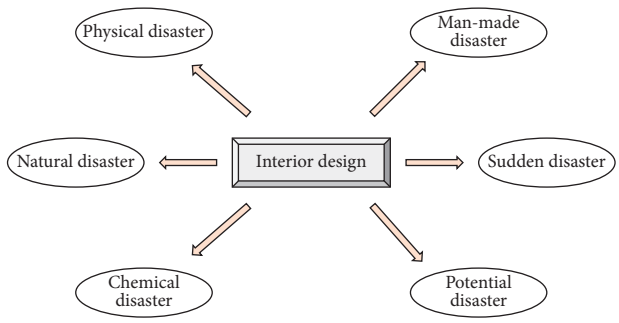


Figure 2: Indoor hazards in public buildings.

the one hand, when buildings are redecorated for various reasons, the reuse of original decorative materials becomes very low. On the other hand, the waste caused by poor design and low levels of construction can also be significant. In addition, even if reproducible resources can be used, they are consumed too quickly and can outstrip the rate of renewal.

The cost of interior decoration in public buildings is more than double the cost of the average civil construction, while the life cycle is only 3–5 years. As a result, there is a lot of unnecessary waste caused by repeated renovations. There are even many facilities that have been kept in good condition only to be removed and reinstalled because the style has become obsolete. This unnecessary waste is a burden on the country and the planet. The main components of the renovation process are the construction and material costs for civil alterations, plumbing, rewiring, and so on. Table 2 presents a cost analysis of the interior decoration of a public building.

3. BIM Technology

Collaborative working can provide a platform for building participants in the design process and support the implementation of an integrated design process. The analysis of public building standards shows that the design process requires extensive building performance analysis in order for buildings to meet green building standards. Parametric modelling is essential to such an iterative performance analysis process. Parametric modelling makes it easier and more accurate to enter building information, which used to take up most of the workload in the performance analysis process.

3.1. Difference between BIM Design and Traditional Design. In the traditional two-dimensional design process of construction projects, different design disciplines generally adopt the software tools corresponding to their own disciplines to complete the design content of their own disciplines. Each profession uses AutoCAD as a tool to draw 2D drawings of the design content of the profession, and finally, the design results of each profession are combined together in the form of 2D drawings to form the final design results of the project. There is no effective way to exchange information between the various disciplines during the design process. As a result, changes in design information between disciplines cannot be effectively negotiated with other disciplines, and the impact of changes in one discipline on other disciplines can be overlooked. In practice, the integrated design software alone is far from being able to meet the requirements of collaborative design for complete and timely information transfer and sharing.

Both BIM-based public building interior design and traditional 3D building design are capable of constructing 3D models of buildings, but there are still differences between the two (Table 3). The BIM model is a parametric information model, but the BIM model can be used to automatically count the materials used in the model with the support of the software and eventually produce a detailed list of materials used. In this way, the BIM model provides guidance on how to control the amount of materials used in the later stages of the construction process. In addition, the BIM model supports collision checking. Specifically, the BIM software allows for collision checking of the model to effectively reduce the impact of design errors on the construction process prior to delivery of the design results. As the BIM model is a parametric information model, there is a logical correspondence between the BIM model and the final 2D construction drawings. This means that when the information in the BIM model changes, the corresponding information in the construction drawings will also change.

BIM-based collaborative design has many advantages over traditional collaborative design methods. In the traditional design process, each design discipline works individually to produce its own drawings. As a result, if there is a conflict between the design elements, then each design discipline will propose changes to the conflicting issues through a coordination meeting. However, coordination through coordination meetings alone is not efficient and many conflicting issues require negotiation of multiple factors. During the design phase of a project, the overall design of the project is completed by the designer alone without the involvement of the builder and owner. This can lead to discrepancies between the design and the owner's or contractor's requirements, which increases the potential for design changes.

3.2. Design Staff Composition. In the traditional interior design process, the design is usually carried out separately in separate disciplines. For example, architects work alone on the conceptual aspects of the design and structural engineers on the structural design. This method of working often excludes most of the key designers from the decision-making process. The result is that the design is required to start again because it does not meet the standard requirements for the interior design of public buildings. This can have a serious impact on the efficiency and quality of the design of the building, as shown in Figure 3.

However, in the BIM-based interior design process for public buildings, each process involves the involvement of designers, engineers, and other professionals from the various trades involved. Therefore, with an effective communication mechanism, they can use their expertise to inform the decisions of the overall coordinator. The roles and importance of the design participants are constantly

Table 2: Cost analysis of the interior decoration of a public building.

Project name	Unit	Quantity of construction	Price (yuan)	Unit price (yuan)	Total price (yuan)
Stone floor	m^2	214.5	2839.25	139242.21	158293.29
Ceiling	m^2	3829.4	6759.24	245283.44	267289.35
Stone wall	m^2	89.2	1208.79	92873.07	104589.71
Decorative line	m	18273.9	18273.9	78928.19	99283.98

Table 3: Difference between traditional 3D model and BIM model.

	Traditional 3D model	BIM model
Function	Renderings and virtual reality	Renderings, virtual reality, analysis, and management
Parametric model	No	Yes
Coordination efficiency	Low	High

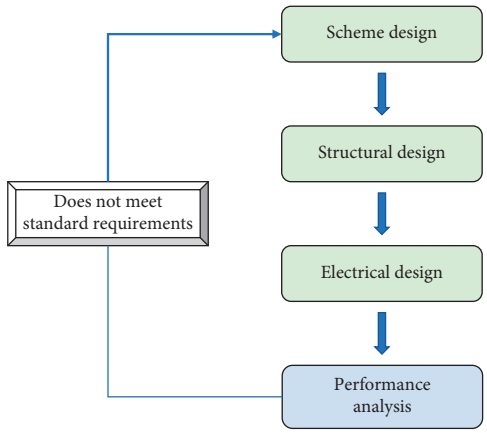


Figure 3: Process of traditional design approaches.

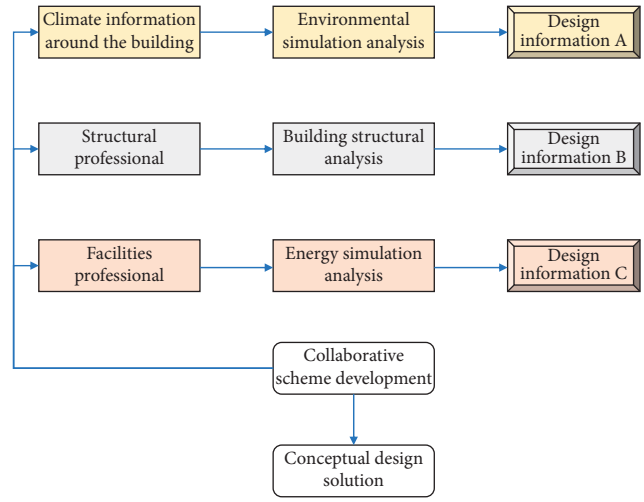


Figure 4: Involvement of key players in BIM-based interior design for public buildings.

being adjusted during the different design phases. To be specific, Figure 4 illustrates the involvement of the key players in the BIM-based interior design process for public buildings.

3.3. BIM Collaborative Design. BIM-based collaborative design requires the cooperation of designers from all disciplines. In order to achieve the ultimate goal of collaborative design, the design process of each profession should follow a certain workflow to ensure that the design tasks of each profession are carried out in an orderly manner. Figure 5 shows the general workflow of BIM collaborative design.

In order to achieve collaborative design between disciplines, a BIM design information exchange platform needs to be defined in the preparation phase of the project. At the same time, all disciplines need to share their design content on this platform. The software and hardware required for collaborative design are then determined and suitable 3D design software is selected for the construction of the BIM model. Each profession sets up its own project template under its own familiar software interface and completes the preparation of the project design. The core of collaborative design is the sharing of information between disciplines. Specifically, different disciplines can share their design information on a common professional design platform. This allows designers to access the latest model information on the shared platform at any time to meet different requirements in the design process.

Conceptual design works almost exclusively on the knowledge and experience of the architect in conventional design. If, after analysis, the construction objectives are not met, then the scheme needs to come back and be changed based on the feedback. After the scheme is finally formed, a lot of time is spent on design deepening, as shown in Figure 6. Nevertheless, in the BIM-based public building design, the parametric design of BIM technology allows the model solution formed after conceptual design to be automatically drawn in accordance with requirements and drafting standards. This approach saves the designer time in drawing production and allows the designer to spend more time and energy on the design of the scheme.

The traditional design approach to building models consists of a two-dimensional planar model made up of basic geometric elements. As a result, the model contains only flat information about the constituent elements. In contrast, the building information model constructed by BIM technology contains three-dimensional information parameters for all components. The BIM model, which consists of these basic components with three-dimensional properties, stores a

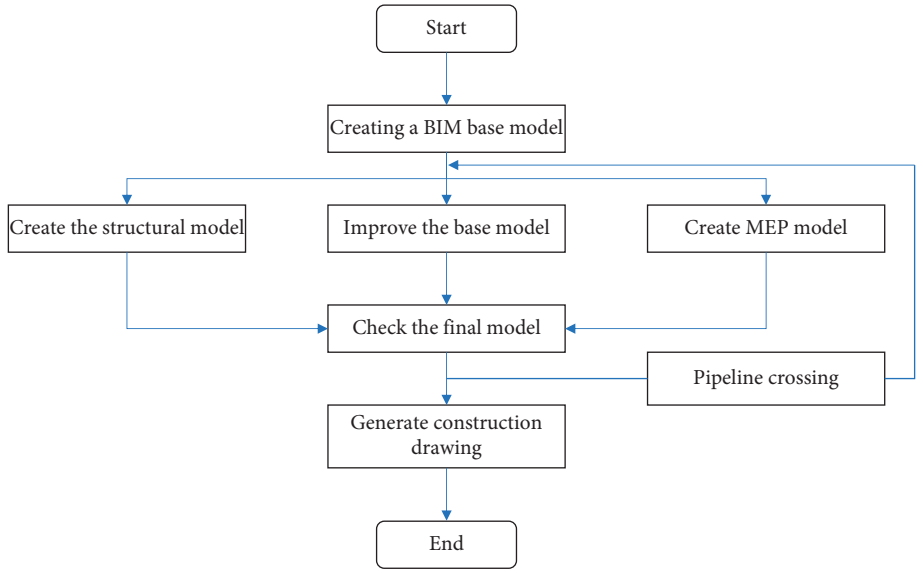


Figure 5: General workflow of BIM collaborative design.

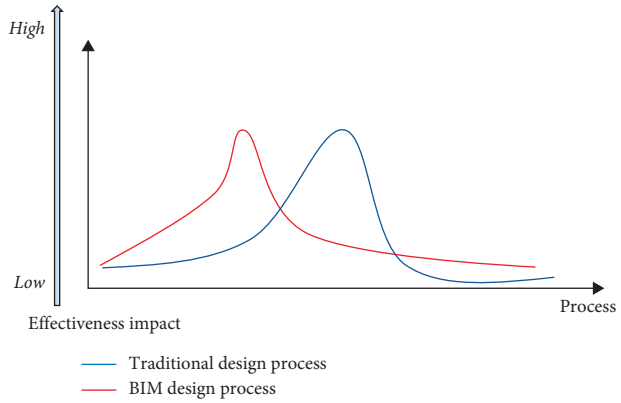


Figure 6: Relationship between effectiveness impact and the design process.

large amount of design information in the form of parameters in the large database of the model. This correlation of the modified information in the BIM model provides the basis for information sharing in collaborative design, avoiding the potential for missing information in traditional design methods and thus effectively improving the accuracy of information transfer.

4. Conclusion

The traditional process of interior design for public buildings has become difficult to adapt to the requirements of modern green building-related standards. It is therefore particularly important to consider how new techniques and theories can be used to improve the design of public buildings. This study focuses on this topic as follows:

First, this study analyses the necessity of applying BIM technology in the interior design of public buildings. The feasibility of applying BIM technology to the interior design of public buildings is investigated from a number of perspectives, including the characteristics of green buildings and the advantages of BIM technology. Second, this study investigates the application of BIM technology in green building evaluation and analyses the various forms of information transfer methods, including direct call and information extraction. In addition, this study proposes a BIM-based interior design effectiveness model for public buildings. The study also elaborates on the composition of the team, the construction of the technical platform, and the involvement of the designers in the different design phases.

However, given that BIM technology is still at an early stage of development, there are still many aspects that need further improvement. In this study, the following recommendations are conducted. Although 3D simulation software has advantages in the design process that 2D software does not have, it cannot fully meet the current requirements of designers for design work. In the subsequent software development and upgrading process, it is necessary to launch a version of the application that is more suitable for the current situation of domestic design, so as to provide good technical support for the popularisation of BIM technology. What is more, the relevant departments should revise the software-

related specifications as soon as possible and develop a unified standard suitable for China's national conditions, so as to establish a perfect industry system for the development of BIM in China.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work is supported by the College of Humanities and Arts, Chongqing University of Science and Technology.

References

[1] B. Cheng, C. Fan, H. Fu, J. Huang, H. Chen, and X. Luo, "Measuring and computing cognitive statuses of construction workers based on electroencephalogram: a critical review," *IEEE Transactions on Computational Social Systems*, vol. 9, pp. 1–16, 2022.

[2] P. Sun, N. Zhang, J. Zuo, R. Mao, X. Gao, and H. Duan, "Characterizing the generation and flows of building interior decoration and renovation waste: a case study in Shenzhen City," *Journal of Cleaner Production*, vol. 260, Article ID 121077, 2020.

[3] H. Chen, Y. Zhang, T. Zhong, Z. Wu, X. Zhan, and J. Ye, "Thermal insulation and hydrophobization of wood impregnated with silica aerogel powder," *Journal of Wood Science*, vol. 66, no. 1, p. 81, 2020.

[4] Z. Wu, H. Li, Y. Feng, X. Luo, and Q. Chen, "Developing a green building evaluation standard for interior decoration: a case study of China," *Building and Environment*, vol. 152, pp. 50–58, 2019.

[5] E. J. Sugeng, M. De Cock, P. E. Leonards, and M. Van de Bor, "Electronics, interior decoration and cleaning patterns affect flame retardant levels in the dust from Dutch residences," *Science of the Total Environment*, vol. 645, pp. 1144–1152, 2018.

[6] J. H. Choi and K. Lee, "Investigation of the feasibility of POE methodology for a modern commercial office building," *Building and Environment*, vol. 143, pp. 591–604, 2018.

[7] M. Najjar, K. Figueiredo, M. Palumbo, and A. Haddad, "Integration of BIM and LCA: evaluating the environmental impacts of building materials at an early stage of designing a typical office building," *Journal of Building Engineering*, vol. 14, pp. 115–126, 2017.

[8] B. Cheng, J. Huang, J. Li, S. Chen, and H. Chen, "Improving contractors' participation of resource utilization in construction and demolition waste through government incentives and punishments," *Environmental Management*, vol. 70, pp. 1–15, 2022.

[9] S. Dongmei, "Research and application of energy consumption benchmarking method for public buildings based on actual energy consumption," *Energy Procedia*, vol. 152, pp. 475–483, 2018.

[10] R. Yuan, F. Guo, Y. Qian et al., "A system dynamic model for simulating the potential of prefabrication on construction waste reduction," *Environmental Science and Pollution Research*, vol. 29, no. 9, Article ID 12589, 2022.

[11] B. Adembri, L. Cipriani, and G. Bertacchi, "Virtual anastylosis applied to the architectural decoration of mixtilinear buildings in Villa Adriana: the case study of the scattered friezes of the Teatro Marittimo," *Applied Geomatics*, vol. 10, no. 4, pp. 279–293, 2018.

[12] M. Gong, "Analysis of architectural decoration esthetics based on VR technology and machine vision," *Soft Computing*, vol. 25, no. 18, Article ID 12477, 2021.

[13] B. K. Sovacool and M. C. Brisbois, "Elite power in low-carbon transitions: a critical and interdisciplinary review," *Energy Research & Social Science*, vol. 57, Article ID 101242, 2019.

[14] K. Liu, M. Wang, J. Li et al., "Developing a Framework for Spatial Effects of Smart Cities Based on Spatial Econometrics," *Complexity*, vol. 2021, Article ID 9322112, 2021.

[15] M. Braulio-Gonzalo and M. D. Bovea, "Relationship between green public procurement criteria and sustainability assessment tools applied to office buildings," *Environmental Impact Assessment Review*, vol. 81, Article ID 106310, 2020.

[16] J. Hong, C. Z. Li, Q. Shen, F. Xue, B. Sun, and W. Zheng, "An Overview of the driving forces behind energy demand in China's construction industry: evidence from 1990 to 2012," *Renewable and Sustainable Energy Reviews*, vol. 73, pp. 85–94, 2017.

[17] M. Ma, L. Shen, H. Ren, W. Cai, and Z. Ma, "How to measure carbon emission reduction in China's public building sector: retrospective decomposition analysis based on STIRPAT model in 2000–2015," *Sustainability*, vol. 9, no. 10, Article ID 1744, 2017.

[18] A. Cibinskiene, D. Dumciuviene, and M. Andrijauskiene, "Energy consumption in public buildings: the determinants of occupants' behavior," *Energies*, vol. 13, no. 14, Article ID 3586, 2020.

[19] A. Ahmed, M. Mateo-Garcia, D. McGough, and M. Gaterell, "Methodology for evaluating innovative technologies for low-energy retrofitting of public buildings," *Energy Procedia*, vol. 112, pp. 166–175, 2017.

[20] X. Yang, S. Zhang, and W. Xu, "Impact of zero energy buildings on medium-to-long term building energy consumption in China," *Energy Policy*, vol. 129, pp. 574–586, 2019.

[21] D. W. Kim, Y. M. Kim, and S. E. Lee, "Development of an energy benchmarking database based on cost-effective energy performance indicators: case study on public buildings in South Korea," *Energy and Buildings*, vol. 191, pp. 104–116, 2019.

[22] L. Zhang, J. Wu, and H. Liu, "Turning green into gold: a review on the economics of green buildings," *Journal of Cleaner Production*, vol. 172, pp. 2234–2245, 2018.

[23] V. J. Gan, I. M. Lo, J. Ma, K. T. Tse, J. C. Cheng, and C. M. Chan, "Simulation optimisation towards energy efficient green buildings: current status and future trends," *Journal of Cleaner Production*, vol. 254, Article ID 120012, 2020.

[24] M. Gluszak, R. Gawlik, and M. Zieba, "Smart and green buildings features in the decision-making hierarchy of office space tenants: an analytic hierarchy process study," *Administrative Sciences*, vol. 9, no. 3, 52 pages, 2019.

[25] Y. Lu, Z. Wu, R. Chang, and Y. Li, "Building Information Modeling (BIM) for green buildings: a critical review and future directions," *Automation in Construction*, vol. 83, pp. 134–148, 2017.

[26] T. O. Olawumi, D. W. M. Chan, and J. K. W. Wong, "Evolution in the intellectual structure of BIM research: a bibliometric analysis," *Journal of Civil Engineering and Management*, vol. 23, no. 8, pp. 1060–1081, 2017.

[27] X. Yang, M. Koehl, and P. Grussenmeyer, "Parametric modelling of as-built beam framed structure in BIM environment," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. 42, pp. 651–657, 2017.

[28] A. Costin, A. Adibfar, H. Hu, and S. S. Chen, "Building Information Modeling (BIM) for transportation infrastructure–Literature review, applications, challenges, and recommendations," *Automation in Construction*, vol. 94, pp. 257–281, 2018.

[29] B. Cheng, K. Lu, J. Li, H. Chen, X. Luo, and M. Shafique, "Comprehensive assessment of embodied environmental impacts of buildings using normalized environmental impact factors," *Journal of Cleaner Production*, vol. 334, Article ID 130083, 2022.

[30] S. Tang, D. R. Shelden, C. M. Eastman, P. Pishdad-Bozorgi, and X. Gao, "A review of building information modeling (BIM) and the internet of things (IoT) devices integration: present status and future trends," *Automation in Construction*, vol. 101, pp. 127–139, 2019.

Hindawi
Mobile Information Systems
Volume 2023, Article ID 9795729, 1 page
https://doi.org/10.1155/2023/9795729

Retraction

Retracted: Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics

Mobile Information Systems

Received 8 August 2023; Accepted 8 August 2023; Published 9 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.

References

[1] J. Zhang and M. Zhao, "Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics," *Mobile Information Systems*, vol. 2022, Article ID 5610892, 7 pages, 2022.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 5610892, 7 pages
https://doi.org/10.1155/2022/5610892

Research Article

Effect of Running Pose Control Training on Ground Reaction Force, Lower Limb Kinetics

Jinjin Zhang and Manman Zhao

School of Physical Education, Xi'an Peihua University, Xi'an, Shaanxi 710125, China

Correspondence should be addressed to Jinjin Zhang; j12021303@st.sandau.edu.cn

Received 26 April 2022; Revised 26 May 2022; Accepted 7 June 2022; Published 23 June 2022

Academic Editor: Wen Zhou

As a new strength training method, running form control training has been widely used in foreign athletes' strength training and public rehabilitation. As a means of auxiliary strength training, running form strength has attracted wide attention in China. In order to keep up with the latest international strength training theory and technology, the reaction force of people's running style on the ground was compared with the kinematics and dynamics of lower limbs and studied deeply. The significantly reduced load rate in the absence of running posture transformation is speculated to increase to the adaptation strategy of social body after changing shoe conditions. After training, the load rate was deep than that of the control group, increasing that even though the load rate could be reduced by the training method adapted to the ground hardness, the training effect with a clear goal was more significant. Through the comparison of lower limb joint kinematics and training effect, some flexor strength training methods can be added, and the load intensity and quantity can be appropriately increased, so that the proportion of the strength level of the extensor muscle of the lower limb joint can be coordinated, so as to better improve the coordination force level.

1. Introduction

As the most popular and common way of exercise, running has attracted more and more people's attention. However, the impact load of 2 to 3 times body mass per touchdown during running is considered to be a major risk factor for overuse injury. Therefore, how to reduce the impact force and the impact damage caused by running has always been a hot issue in related fields. At present, the effect of sneakers to reduce the impact of running is not obvious. Figure 1 shows the anatomy of running form training. Running injury rates have not changed significantly in the last 50 years despite advances in sneaker cushioning technology. In life, if you observe carefully, you will find that there are many people who run on the sole of their feet, and the sound of landing is relatively loud. In fact, the actual movement is in running, with the empty foot landing to the middle foot first. This is an ankle and knee protection to prevent periostitis. Arm swing is to maintain the balance and cohesion of the body during running, so that the swing of the body is more and more in line with the competition of human energy. When you swing your arms, just remember not to expose your elbow before and your hand after, and swing naturally with your feet. The AI team used traditional appearance analysis knowledge to conduct preliminary research on human motion, and found, found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb muscle group. Therefore, researchers began to reexamine the issue in terms of lower limb posture control during running landing. Many factors can affect the occurrence of running injury, including internal factors such as human anatomy, injury history, biomechanics of lower limb movement, and neuromuscular control in movement and external factors such as training methods, running shoes, and running road surface. The running surface is considered to be one of the most important factors affecting running injuries. Regarding the effects of different soils on kinematics, dynamics, neuromuscular control, and low-speed sports injuries, it seems

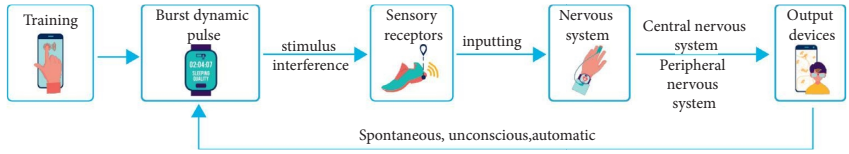


Figure 1: Analysis of the role of running form training. Exploring how to reduce the impact force during running and the resulting impact injury has always been a hot issue in related fields.

that when running at different speeds, the human body can adjust the kinematics through its own neuromuscular displacement function, accept mutations, and adjust the lower extremities to a similar degree impact. However, most studies on biomechanical changes of running on different road surfaces only focus on one aspect of kinematic dynamics and neuromuscular regulation. Further detailed 3D biomechanical data and specific neuromuscular regulatory mechanisms for such biomechanical adjustments are lacking.

2. Literature Review

Cveticanin said that the impact load of several times body mass per touchdown during running is considered a major risk factor for overuse injuries. Therefore, how to reduce the impact force and the impact damage caused by running has always been a hot issue in related fields [1]. Yu et al. put forward that, from an evolutionary point of view, many of the forms that modern humans possess (such as narrow pelvis and arches) evolved to adapt to bipedal running about 2 million years ago [2]. Kim and Duin put forward that the incidence of running injuries among runners is as high as 40% to 50% per year. Among running injuries, the knee joint is the most common site of injury, followed by ankle and foot. Repeated overloading may lead to acute injury (such as sprains, bone, and intra-knee disorders) or overwork injury such as stress fracture of the second metatarsal [3]. Millour et al. put forward that the kinematics research of different ground running mainly focuses on gait cycle, stride length, stride frequency, and hip, knee, and ankle joint angle characteristics [4]. Kang et al. held that, before the designed big data training, all subjects ran heel landing, and there was no significant difference in impact peak between different shoe conditions. However, wearing imitation bare foot shoes significantly increased the maximum load rate ($P < 0.05$) and decreased the time to reach the first and second peak values as well as the total touchdown time ($P < 0.05$) [5]. Cai et al. said that the effect of ground surface on running kinematic characteristics showed that the maximum flexion angle of knee joint remained unchanged under different hardness of ground. However, with the increase of the hardness of the ground, the hip joint flexion angle decreases, the maximum hip joint flexion angle decreases, and the peak value of hip joint closure angle increases [6]. Quak et al. said that wearing sneakers with strong cushioning function cannot effectively change the impact performance of the human body and the muscle activation degree of lower limb muscle groups when the human body actively lands [7]. Peracaula and Yu put forward that a large number of virtual machines must be properly placed on physical nodes and the constraints must be met. The static allocation methods include polling scheduling, minimum connection scheduling, first-adaptation, best-adaptation descending first-adaptation, descending optimal adaptive scheduling, destination address hash scheduling, and source address hash scheduling [8]. George and Mathew said that, from a very early time, the whole process of running landing force is the interaction and comprehensive effect of external forces such as ground reaction force and internal forces such as lower limb muscle force. Therefore, possible defects may exist in improving triceps muscle strength through training alone and hoping to adapt the Achilles tendon to the centrifugal load or radial load caused by running quickly and repeatedly [9]. Adarsh and Priya held that, when running on the hard low surface (such as sandy lawn), the hip and knee flexion angle and maximum flexion angle during the first touchdown stage and the middle support stage were greater than those on the hard surface (such as asphalt concrete). At the same time, running on a hard surface significantly reduced vertical acceleration compared to running on a hard surface, possibly reducing the risk of shin injury [10].

3. Research Method

3.1. Building a Human Model. A cautious attitude should be kept when using simulation method to get the impact force because the simulation method deduces the impact force through the method of building human body model and lacks the comparison with the actual situation. The data obtained in the laboratory can verify the accuracy of the input model data and the accuracy and validity of the model prediction results [11]. How similar the data obtained by simulation is to the actual data and to what extent it can represent the actual situation is a problem worth demonstrating. There are few researches on this aspect in China. In order to verify the accuracy and reliability of LifemMOD simulation method based on infrared light spot capture (motion) and 3D video shot by camera, the force curves obtained by simulation of vertical movement of steps at different heights are similar to those measured by force table [12]. Preliminary research found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb, and the human body is in constant energy consumption and is easy to show fatigue, then if you can use your will to straighten your back, so you want to improve the humpback condition which is actually very simple. The effective mass of the lower limbs can be reduced by adjusting the angle of inclination at which

the plantar makes contact with the ground (e.g., when the foreball touches the ground), thereby reducing the risk of impact injury. The study found a lower incidence of impact injuries when using the forepaw. In the follow-up study, barefoot or minimalist shoe training was used to achieve the forepaw touching the ground, so as to achieve the effect of reducing the risk of lower limb impact injury. It is worth thinking that bare foot is not the key to impact force, but the change of running posture brought by it is the main reason to affect impact force and lower limb biomechanics, which obviously needs to be established on the basis of long-term running posture change. For running on different surfaces, the variation of kinematic variables may not be significant due to the difference of individual running mechanisms, but there are observable changes [13]. Figure 2 shows the relationship between the force and the reaction force when running on the new rubber-modified asphalt surface and the moving surface of acrylic acid, and there is no significant difference in the kinematic variables on different surfaces, but there is an observable difference in the initial joint angle peak and angular velocity. The peak angle of ankle-knee joint increased when running on the new rubber-modified asphalt surface and acrylic surface, which was speculated to be related to the different mechanisms of individual runners' adaptation to different surfaces. In the future, further studies on large samples of different surfaces or stricter inclusion criteria for runners can be carried out to observe whether there are significant differences in kinematic variables of running on different surfaces. The LifeMOD interface software of Python language is used to convert Motion's 6 data and 2 kinematics data obtained from analysis and generate Slf files that LifeMOD can recognize. The height, weight, and other information of the subjects were input, and the 19-link human model was established through LifeMOD's own human morphology database. Figure 3 shows the posture adjustment after data is given. The collected kinematic data is given to the model, and then through posture adjustment and balance analysis, the floor pad model is established, and the contact between the human body model and the floor pad is established. The contact force between the human body model and the floor pad model, the force and moment of each link of the human body model, and the kinematic index of each link were simulated for 1s to obtain 1000 data, which was the same as the acquisition frequency of the force table [14]. Formula (1) of inertia for strength training is shown as follows:

$$j\theta + k\theta = T(t). \tag{1}$$

j is the rotational inertia matrix and T is the generalized torque vector.

All sports need the basic two but because of the different running posture, there is a need for basic strength for explosive training technical support [15]. And explosive force is the ability to generate maximum force in a short period of time, and formula (2) for force and speed is as follows:

$$p = F * V, \tag{2}$$

where F represents force and V represents speed.

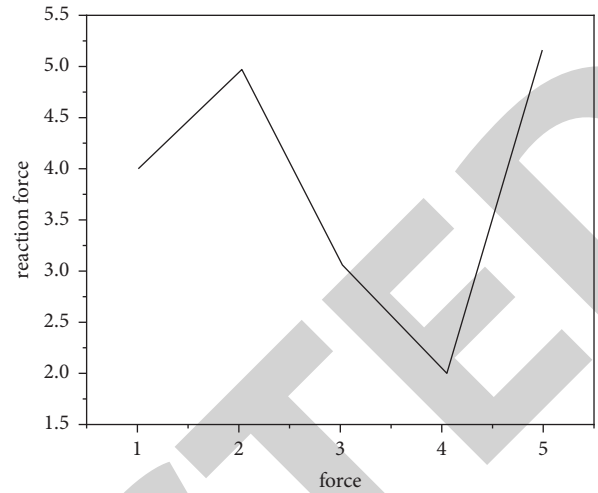


Figure 2: The relationship between action and reaction. Changes in kinematic variables may not be significant, but there are observable changes.

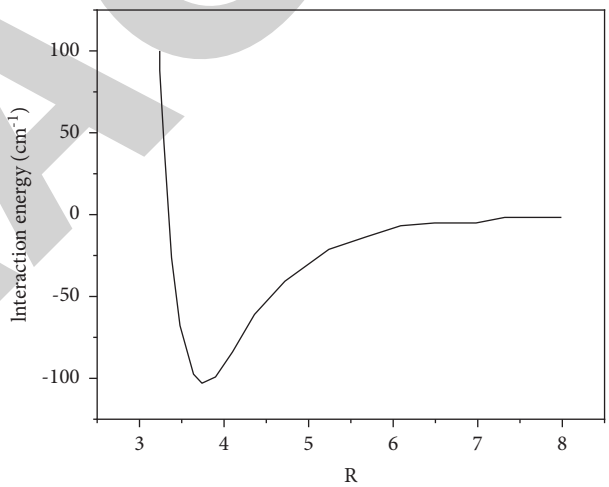


Figure 3: Pose adjustment after data is given. Through posture adjustment and balance analysis, establish a floor mat model.

In other words, explosive force is equal to big force plus fast speed. If it is inversely proportional, then the performance of explosive force cannot reach the optimal corresponding force formula (3) as

$$L = F^2 + N. \tag{3}$$

3.2. Alteration of the Original Running Pose. The subjects were asked to touch the ground with their forepaws while running at a moderate intensity optional speed while wearing minimalist shoes [16]. Subjects were informed of their approach to the ground by the acoustic feedback provided by wearing custom pressure insoles. The training was progressive three times a week for 12 weeks. The weekly running time was 5, 10, 15, 20, 25, 30, 35, 40, 42, 44, 46, and 48 min (in the last 4 weeks, in order to avoid exceeding the

subjects' original exercise, the increase was slowed down). The intervention only replaced part of the amount of training, leaving the participants' original total weekly running distance unchanged. All subjects need to record training logs, and they need to wear the issued minimalist shoes and pressure sensing insole every time they run. The experimenters check with the training logs through cloud data. Inclusion criteria were as follows: all as required. No more than 3 times of intermittent training are required, and all completed the last 3 weeks of training as required. Run with a steady head and shoulders. Look straight ahead, chin slightly in but not down. When running, the shoulders are relaxed and drooped first, then as far as possible up, stay for a while, restore the original position, and repeat. Hold the hands slightly, bend the arms to about 90 degrees, and swing back and forth naturally. Pay attention to keeping the elbows on the front arm and your hands on the back arm. During training, shoe conditions have an effect on biomechanics of running before and after training, but the effect is similar, mainly in the condition of imitation bare foot shoes, the foot contact angle decreased, and the joint and power increased [17]. Figure 4 is the characteristic diagram of reaction force. This suggests that running in a faux barefoot shoe produces more thrust and can improve performance. The study found that the increased cross-sectional area and stiffness of the Achilles tendon in forepaw runners increased the running economy and reduced the risk of injury during long distance running compared to heel runners. The study found that, after 12 weeks of training, heel runners were more likely to run on the forefoot and exhibit a similar kinematic pattern to barefoot running. The results of the study found that six weeks of form conversion training may change the movement pattern of habitual heel landing runners. But what kind of mechanical influence does this kind of running form transformation training have on the Achilles tendon? Figure 5 is shown below and the normal ground force is shown in formula (4):

$$F = F_{Ya} + F_{YY}. \tag{4}$$

The reaction force is the upward reaction from the ground to the lower limbs to propel the body forward and from the lower part of the body to the feet [18]. And the formula for the reaction is as follows:

$$F' = -F. \tag{5}$$

For example, when objects collide, their speed and force will change accordingly. The formula is as follows:

$$Ft = mv' - mv. \tag{6}$$

F is the force of the collision, t is the time of the collision, v is the initial velocity of the object being touched, v' is the velocity of the object being touched.

3.3. Adjust the Hardness of the Ground. The study found that all plantar variables and pressure areas were similar when running on asphalt and concrete surfaces. When running on natural grass, there is more contact time and surface area in the back and forefoot areas. Running on asphalt leads to greater load in the lateral area of the back foot. But when running on natural grass, the pressure peak was significantly lower than on other surfaces [19]. Therefore, if runners control the amount and intensity of exercise, compared to the hard ground, running on low-hardness surfaces (natural grass) may place a lighter load on the musculoskeletal system, possibly reducing the risk of injury. The surface hardness is shown in Figure 6. By analyzing the plantar pressure data of running on standard plastic track and indoor treadmill with buffering performance and without buffering performance, the results were found. In the process of landing, there was no significant difference in the

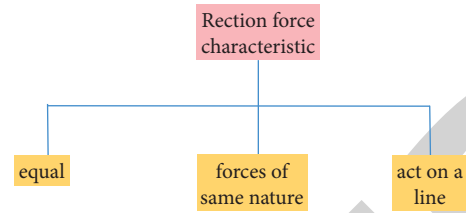


Figure 4: Reaction force characteristic. Decreased foot contact angle and increased stomping knuckle and power under simulated barefoot conditions.

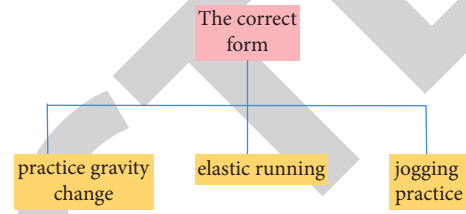


Figure 5: Correct running style training features. Heel runners are more likely to use the forefoot stance, while exhibiting a kinematic pattern similar to barefoot running.

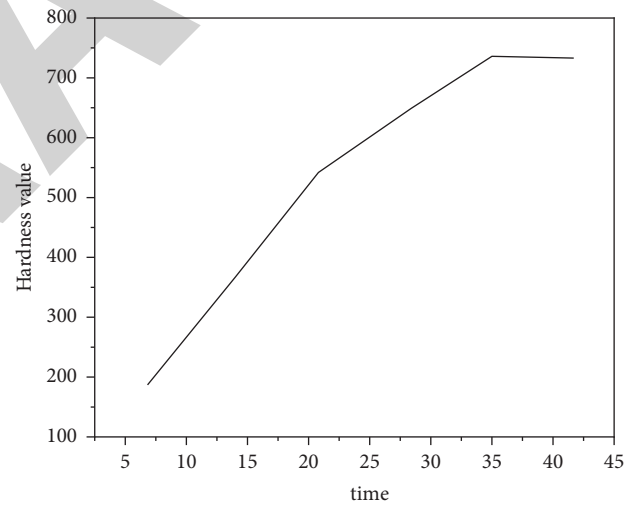


Figure 6: Surface hardness number. The musculoskeletal system may experience lighter loads when running on low-hardness surfaces.

distribution of the maximum plantar pressure peak (and occurrence time) on the three different running surfaces of the cement track without buffer (without buffer). When you are running, you can choose to use the thigh to drive the calf, and the knee joint must be towards the toe direction, lift to a reasonable height and then put down, and repeat. Preliminary research found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb. Compared with other surfaces, both grass and buffering treadmill (with buffering) reduced part of the peak pressure at touchdown, but there was no significant difference in the distribution of maximum pressure. At the same time, there was no significant difference in tibial acceleration on all surfaces. Firstly, through the comparative analysis of walking on the ground and on the treadmill, it is found that the dynamics parameters of the two conditions are basically similar, and the differences are also within the range of repeatability. Therefore, it is considered that the dynamics of walking on the treadmill and on the ground are very similar [20]. Then, by comparing the dynamic parameters of running on the treadmill and on the ground, it was found that the peak propulsive force on the treadmill and the ground reaction force inside the peak decreased significantly. The surfaces were further divided into concrete and grass and compared to running on a treadmill. It was found that running on a treadmill had less maximum plantar pressure than running on concrete or grass, mainly in the inner forefoot, big toe, and little toe areas. Compared with ground running, treadmill running increases the time the foot is in contact with the ground, alters the plantar pressure distribution, and reduces peak pressure, especially in the inner heel metatarsal and big toe areas. See Figure 7. As a result, there is a significant difference in plantar pressure between the treadmill and the ground, and the treadmill has a smaller pressure peak. Running on a treadmill can be used as an early training method to provide lower plantar load for people with lower limb injuries. The hardness of the ground can also be calculated by the Richter hardness:

$$HL = 1000 * \frac{VB}{VA}. \tag{7}$$

In addition, it can also be calculated by shore hardness:

$$HS = HRC + 15. \tag{8}$$

4. Result and Analysis

The impact development is thought to be the main cause of deep limb overuse injury. The effective mass can be reduced by adjusting the angle between the job and the project when the forepaw touches the ground, so as to avoid the high impact caused by the heel touching the ground [21]. In addition, load rate, which is a very sensitive indicator of impact force when running to the ground, decreased significantly after training in both groups in the study. It is

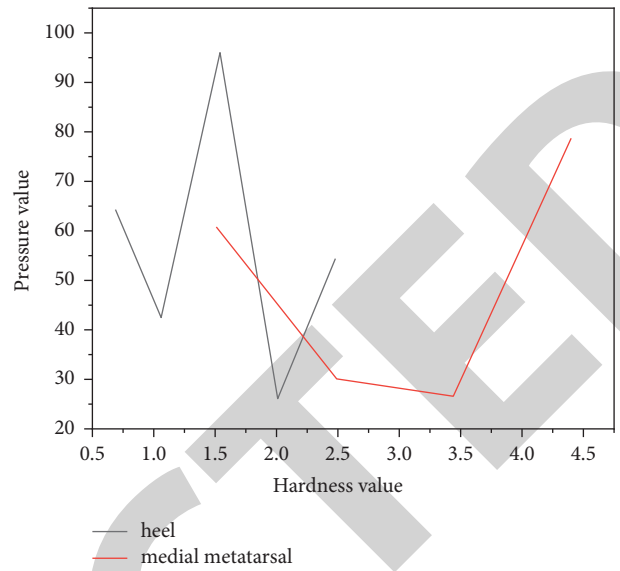


Figure 7: Ground hardness against the metatarsal pressure on the inside of the heel. Changing plantar pressure distribution while reducing peak pressure, especially in the heel, medial metatarsal, and big toe areas.

speculated that the reason is that the first peak impact force is avoided, and the load rate is reduced by the change of touchdown mode after the change of running form, which is the same as the results of other communication projects. Preliminary research found that wearing sneakers with strong cushioning function cannot effectively change the impact performance of human body when actively landing and muscle activation degree of lower limb. Running consistently will give you a strong heart and cardiovascular system. When the maximum oxygen uptake is increased, the amount of oxygen delivered to various organs of the body is greatly increased, and the work quality of each organ is naturally greatly improved. In addition, long-distance running will accelerate blood circulation, so that the coronary arteries have sufficient blood supply to the heart muscle, thereby preventing various heart diseases. Through the movement of the lower limbs, it promotes venous blood flow back to the heart and also prevents venous thrombosis. With a strong cardiovascular system, the blood quality of runners is better than that of ordinary people, and the body's adaptive changes to long-term long-distance running can improve metabolism and reduce blood lipid and cholesterol levels. However, the load rate of the control group was significantly reduced without running posture transformation, which was speculated to be related to the adaptation strategy of human body after changing shoe conditions. After training, the load rate was lower than that of the control group, indicating that even if the training method being adapted to shoe conditions can reduce the load rate, the training effect with a clear goal is more significant, suggesting that minimalist shoes can better reduce the load rate and avoid the peak impact force. From the perspective of neuromechanics, the human neuromuscular system can respond to changes in the external environment. Use signal

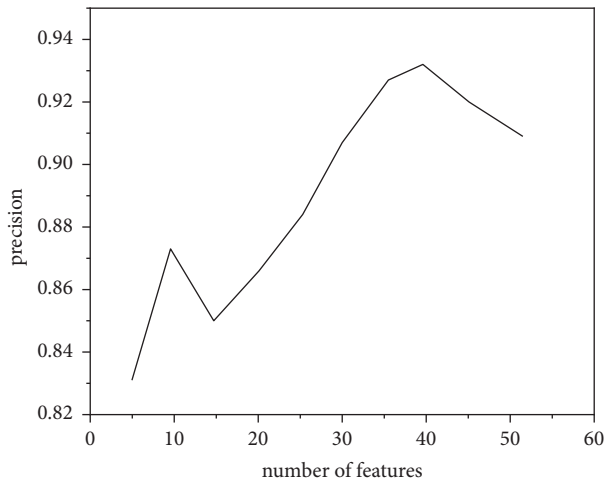


Figure 8: Changing the ground accuracy effects. Preactivation of the peripheral neuromuscular system to perform appropriate actions according to different environments.

feedback mechanism to balance the input and output signals to adapt to the changing external environment. See Figure 8. At the same time, the central nervous system of the human body will carry out feedforward adjustment to the changes in the external environment and preactivate the peripheral neuromuscular system to perform appropriate actions according to the different environment. On different surfaces, runners adjust their lower limb stiffness in time through neuromuscular control, which allows runners to maintain similar centroid motion (i.e., maintain the same ground contact time and stride frequency) while running, regardless of ground hardness. Shifting from hard to soft ground, lower leg stiffness increases by adjusting leg stiffness to match ground stiffness to maintain similar motion mechanics. At the same time, on different surfaces, the body quickly adjusts its leg position on the first step of the new surface to maintain the same center of gravity. The study on the changes of kinematics and mechanics of human lower limbs and the change rules of human neuromuscular control mechanism during running will help to explain why the mechanical changes of lower limbs occur during running.

5. Conclusion

In modern society, running, as the most popular and common way of mass fitness and competitive sports, has attracted more and more people's attention. However, the impact load of 2-3 times body weight per landing is considered to be the main risk factor for overuse injuries such as stress fracture/fracture, femoral joint pain syndrome, plantar fasciitis, and injuries. This study investigated the relationship between running posture, landing impact, and lower extremity biomechanics by comparing the changes of landing impact and the kinematics and dynamics of the lower extremity hip, knee, and ankle before and after 12-week running posture control training with forefoot touching the ground. Running form control training has a significant effect on the biomechanical properties of Achilles tendon, and the Achilles tendon strength is significantly higher during running after training, which enables the Achilles tendon to complete energy storage and release more effectively during running. The increased mechanical properties of Achilles tendons and the decreased RMS amplitude of EMG indicated that the muscle activation was lower but more efficient at the same running speed, suggesting that running form control training can positively improve the Achilles tendons' ability to withstand loads, thus preventing and reducing the risk of injury. Running is the best exercise anyone can do to raise cholesterol, reduce the risk of blood clots, and exercise the 50 percent of your lungs that often sit idle. Correct running form can also boost your immune system by boosting your lymphocytes. In addition, for runners who are accustomed to heel contact, it is recommended to adopt a gradual way of running form transformation training and try to coordinate with the strengthening exercise of lower limb muscle groups. A successful exercise intervention model was established by using the heel landing mode combined with the wearing of minimalist shoes, and the runners who originally landed on the heel were converted to the heel landing mode (conversion rate was 78%). Just as good running form is good for your body, so is good running form for your mind. By overcoming a series of obstacles while running, you learn focus and determination. After a long run or any other event that you almost gave up on, you will find that the mental and physical strength you develop while running gives you the same focus and determination you have in other areas. The specific performance is as follows. ① The impact peak can be more effectively avoided to reduce the maximum load rate, thus reducing the risk of running injuries caused by impact. ② The stiffness of lower limbs was significantly improved, suggesting that it was possible to improve running economy and corresponding energy utilization rate. ③ The stronger purpose makes the training effect (i.e., the efficiency of running form change) higher. After summarizing the causes of running injury, it was found that the main causes supported by epidemiology were weekly running miles, previous running injury history, faster running speed, and less running experience. The strongest factor affecting running injury was mileage per week, and the relationship between running surface and running injury was not mentioned. Research limitations of this paper are as follows. Due to the long training time and the difficulty of later training, the subjects lost more due to personal reasons, resulting in a small sample size. Although the training of subjects is monitored by cloud data, at the same time, the log records are used for investigation. However, each person's learning ability of actions will lead to different training effects. It is not possible to provide timely feedback through cloud monitoring. In addition, surface electromyography should be included in future research to analyze more deeply how the running posture of runners changes during training and under different shoe conditions.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 3534167, 8 pages
https://doi.org/10.1155/2022/3534167

Research Article

Interaction Design System for Artificial Intelligence User Interfaces Based on UML Extension Mechanisms

Yiyi Zhao

Department of Art and Design, Shijiazhuang University of Applied Technology, Shijiazhuang 050081, China

Correspondence should be addressed to Yiyi Zhao; 2013010678@sjzpt.edu.cn

Received 18 April 2022; Revised 6 May 2022; Accepted 27 May 2022; Published 16 June 2022

Academic Editor: Wen Zhou

With the rapid development of computer network technology in recent years, more and more demands have been placed on the functionality and attributes of the user interface. In the development of many computer projects, the variability and flexibility of user interface requirements have greatly increased the complexity of program development for researchers. In addition, the poor reusability of page access control writing has created a pressing need for a highly standardized and flexible way of developing software. Thus, the development and design of user interfaces for application software systems occupy an important position and have been a hot topic of research in the field of human-computer interaction. The traditional methods of describing user interaction, such as state transitions and data flow diagrams, are not based on global and intuitive concepts. Moreover, there is little support for the design of user interface interaction behavior, resulting in user interfaces being ignored at design time and left to implementers to grasp at coding time. It is therefore an issue that needs to be addressed in order to integrate traditional methods and intuitive descriptions from the user's perspective into a new interface development model and methodology. This research creates a user interface framework based on interaction behavior from the user's perspective. Furthermore, UML extension mechanisms are used to enable the user interface framework to better support UML-based modelling environments. In addition, the UML is structured and extended to include structural elements that support interface generation, and a structured use case model is proposed, which drives the analysis and design of the individual submodels. The extracted abstract interface elements and their mapping to concrete interface elements are documented in a way that explores the generation of different target languages under different platforms. This study incorporates user requirements and provides a scientific reference for the development and design of user interfaces.

1. Introduction

With the rapid development of computer technology and information technology in recent years, mankind has entered a new digital era of pay. Due to the booming development of the digital industry, computer technology has played an increasingly important role in social economy, politics, culture, and people's daily lives, gradually becoming an indispensable part of people's lives [1]. In the usage environment of digital products, the user interface, as the core of the product, plays an irreplaceable role in improving the attractiveness of the product, strengthening the brand image, and enhancing the user experience [2]. As a result, the development and design of user interfaces is attracting more and more attention from users and developers. Accordingly, the study of user interface design has become one of the most active research directions in the field of design and computing in recent years. The user interface is the core part of human-computer interaction and is a two-way channel for information exchange between the user and the computer hardware and software [3]. The understanding of the user interface has been changing for a long time along with the development of human-computer interaction systems. While computer technology has continued to evolve, human-computer interaction technology has also undergone significant changes [4]. In line with this trend, the user interface has undergone a dramatic transformation from a command language user interface to a virtual reality user interface. The current commercial success of speech recognition technology and computer handwriting recognition

technology has opened up a wide range of prospects for natural human-computer interaction [5]. At the same time, with the further development of computer technology and information technology [6], new interaction technologies and forms of user interfaces will continue to emerge, such as multitouch interfaces [7] and intelligent spatial interaction interfaces [8]. In a sense, the interface represents the entire software system for the user, and its development quality and efficiency have become an important factor in the quality of the entire software product. Furthermore, in order to provide effective support for user tasks, an increasing proportion of user interaction is taking place in application software systems. From the user's point of view, user interaction with the application software system is mainly reflected in the operation of the user interface controls.

For the user, in the process of analysis and design of the entire system software, the description and design of the user interface is the key to reflecting the user's thoughts, meeting the user's requirements, and understanding and using the system. Hence, the intuitiveness and readability of the user interface will have a direct impact on the user's understanding of the entire digital product [9]. It is important for developers to be able to guide developers easily, quickly, and effectively through the design of the user interface in response to complete user requirements, to shorten the software development cycle, and to ensure that it is usable and accurate. However, user requirements change all the time and it is difficult for designers or users to identify specific requirements. In addition, the traditional approaches to describing user interaction are to use state transitions [10] or data flow diagrams [11], for example, with the help of pseudo-code and natural language. It is difficult for designers and users to establish a global and intuitive concept through such descriptions, and there is little support for user interface interaction design, making it difficult to design user interfaces. The issue of how to integrate these traditional methods and intuitive descriptions from the user's point of view into a new interface development model and methodology is an issue to be addressed. Therefore, in order to support the design of the user interface and interaction behavior, it is necessary to describe not only the layout and style of the user interface but also the dynamic interaction behavior part of the user interface. Actually, this description can help to characterize the whole system and facilitates the maintenance of the model and its engineering implementation [12].

In recent years, the separation of user interface design and system function design has become a trend in software development, and the automatic generation of interface code based on interface description models has become the goal of developers. So far, various ideas have been proposed for the automatic generation of interfaces, including specification language-based user interface generation [13], data structure-based user interface generation [14], model-based user interface generation [15], and some approaches using machine learning [16]. Among them, model-based interface generation has received a lot of attention because it is easy to understand. With the gradual proliferation of interface development tools and their programming languages, the limitations of completing user interface development on a particular environmental platform are increasing. User interfaces may have services that provide similar or common essentials, yet there are certainly technical implementation differences due to the different platforms and development languages on which they are implemented, resulting in a waste of personnel. This has led designers to focus on conceptual models of user interaction interfaces. The significance of a conceptual model is that the user interface can be described in detail at a higher and more abstract level, enabling rapid development and exploitation of the user interface for different programming languages and in the context of the used system [17]. The development of a model-based interface system is a process of creating and redefining the user interface model. The primary feature of this model is the depth of the semantic hierarchy, which eliminates the need for early interface detailing, and its reusable approach to interface development facilitates the maintenance of the system at a later stage [18]. The main advantage of using models to support the development of user interfaces is that they can be built using different levels of abstraction, thus supporting the systematic design and implementation [19]. Also, they can provide infrastructure models that support the automatic generation of user interfaces [20]. Moreover, the model-based interface generation can increase the level of abstraction of the interface description, so that the interface is designed in a loosely coupled form independent of the design, development, and runtime platform. However, the current model-based approach to user interface development cannot be widely applied due to the lack of effective reusability mechanisms. Therefore, in order to facilitate the reusability of user interfaces, developers have introduced the concept of models into user interfaces as a way to speed up the process and efficiency of user interface development. Interface design patterns have become a new research hotspot in the design field, focusing on the creation of reusable standard solutions to help developers solve common problems.

The Unified Modelling Language (UML) is the industry standard for object-oriented software design. In many successful projects, UML has played a significant role in software design. However, UML cannot support the design of graphical user interfaces to a great extent, especially in the modelling process where it is difficult to describe them directly and accurately [21]. In the majority of interface designs, UML also neglects the more important design description of interaction behavior [22]. Therefore, it is necessary to extend UML in order to better support user interface and interaction design. As the user interface is the most changeable part of a software system, more and more software systems require not only the ability to quickly develop a quality user interface but also new requirements for the extensibility of the user interface, i.e., the implementation of end-user modifiability of the user interface. End-user modifiability allows developers and end-users to extend the user interface at little cost even after the software system has been released [23]. Traditional development approaches applying RAD tools often solidify the user interface code in the application and require the software system to be redistributed once the user interface has changed, which greatly limits the extensibility of the user

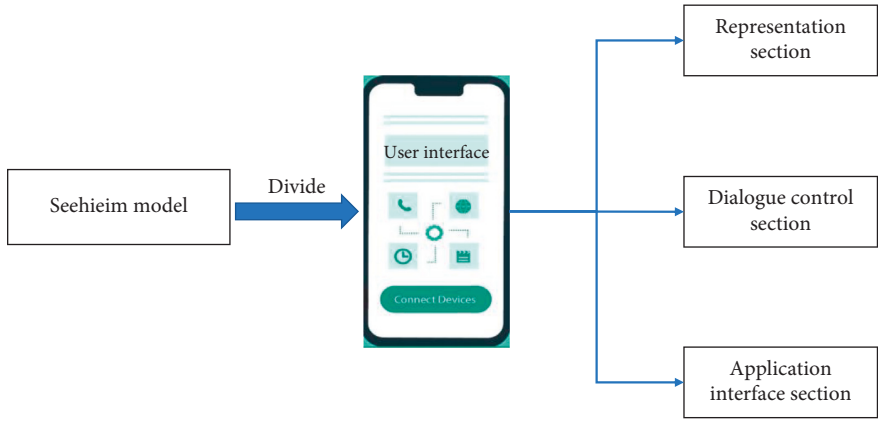


Figure 1: Three components of the Seeheim model.

interface [24]. The Extensible Markup Language (XML) provides a reference for the solution to this problem. Due to its advantages of extensibility, flexibility, and self-descriptiveness, XML has been widely used in many areas such as e-commerce [25], services [26], electronic health record system [27], and web development [28, 29]. As a result, XML has become the standard in the field of data exchange in the software industry.

To address the above issues, this paper focuses on the use of an extended model based on the user's point of view to describe the user interaction behavior in modelling applications. The design based on user interaction behavior attempts to highlight the characteristics of the user and the nature of the interaction task by analyzing and modelling the tasks of the application to meet the user interface usability requirements. Extending to application engineering, this approach will reduce the time and development costs of user interface design, thus reflecting a user-centered design philosophy.

2. Model-Based User Interface Development

The conceptual model of the user interface uses three basic models to support the automatic generation of the interface, namely, the application model, the dialogue model, and the representation model. Typical representatives of this class of models are Seeheim model, PAC model, and MVC model.

2.1. Seeheim Model. Seeheim model was the first proposed model of the user interface. As shown in Figure 1, this model divides the user interface into three components. The representation section deals with the external representation of the interface, and the rest of the interface cannot communicate directly with the outside. The dialogue control section specifies the structure of the dialogue between the user and the system. The application interface section establishes the communication links with the application semantics, describes the data structures accessible to the interface, and is responsible for calling these procedures. Logically, these three sections are independent of each other and communicate with each other by sending words.

Seeheim model is a language-based model. The three components correspond to the lexical, syntactic, and semantic levels. A distinctive feature of the model is the emphasis on the role of the control part of the dialogue. However, in a direct manipulation dialogue, the user interacts with the graphical representation of individual application semantic objects, rather than with the application as a whole. This means that the syntax associated with the individual objects should be contained within the individual graphical representations, rather than as a unified and separate part. In addition, semantic feedback is important to increase user involvement. Semantic feedback is sometimes required even for operations that are considered to be at the lexical level. For instance, dragging a graphical object is a lexical operation. However, user engagement is greatly increased if feedback is given on the potential semantic effect of the action. This requires the semantics to be more closely related to the representation part. Clearly, this model does not support the requirement for direct manipulation of syntax and semantics. Although it deals with the logic of conversational interaction in a linear way, it provides a theoretical basis for other models.

2.2. PAC Model. The PAC model divides the system into an abstraction layer, a control layer, and an expression layer from a system perspective (Figure 2). The abstraction layer is responsible for the interaction with the functional kernel. The control layer is responsible for receiving control from the outside and passing it on to the outside, where it interacts directly with the abstraction layer. The expression layer is responsible for direct interaction with the user, including input and output, and the expression layer can interact directly with the control layer. The expression layer of the PAC model communicates with the abstraction layer via the control layer.

2.3. MVC Model. Figure 3 shows the basic framework of the MVC model. Based on the MVC concept and the adaptability to C/S and B/S platforms, the structure of the user interface code consists of three layers: static presentation, logical support, and backend resources. The aim is to obtain a loose coupling between layers and a strong intralayer aggregation. The static presentation layer is the interface presentation layer and therefore the data input and output

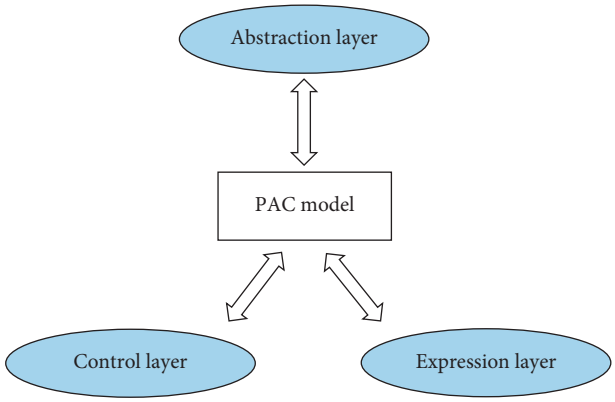


Figure 2: Layers of the PAC model.

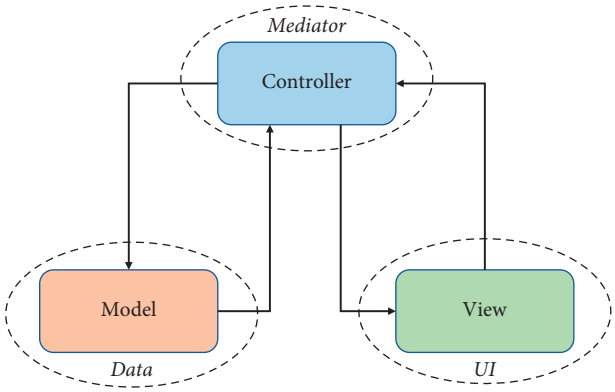


Figure 3: Framework of the MVC model.

layer, which consists of input and output controls and visible components. The code that performs local constraints and checks on inputs also belongs to this layer. The logical support layer is the service layer for external service calls, event response to the view layer, and view refresh processing. This layer is loosely related to the interface presentation layer and interface functionality. The backend resource layer is the provisioning layer for external data and component services. The different system and component services are the main components of this layer, most of which are existing code or prebuilt components provided by the system.

PAC and MVC models belong to the object-oriented multiagent model, whose distinguishing features are modularity, parallelism, and distributed processing, and have become the conceptual basis for interface control and implementation. However, the conceptual models are conceptually based and lack a design-oriented representation of the engineering implementation, and their application depends on the designer's awareness and application and cannot support full process development.

3. User Interface Model Based on Interaction Behavior

The ultimate goal of user interface design is to satisfy the needs of the user as much as possible, which are mainly achieved through the interaction behavior in the system. By describing the interaction between the user and the system, it is possible to effectively define the data and information that the system will operate on and the functional behavior that the system will provide to the public.

3.1. User Interface Requirement. User interface requirements are the initial definition of the characteristics or features of the overall system interface required by the user. Therefore, when analyzing user interface requirements, it is necessary to identify the origin and characteristics of the users of the whole system. At the same time, user interface requirements should be clearly articulated and carefully analyzed with regard to the user's specific tasks, so that the strategies and responses to these tasks can be aligned with the characteristics of the system's users. On the other hand, user interface styles are often varied and are closely related to the functionality of the system and the data that it needs to process. Hence, it is necessary to describe the tasks of the system users and the important information data that is relevant to the creation and completion of the functions in the system and the user interface.

In the initial stages of user interface development, it is difficult to obtain the exact and specific software requirements of the user. When the user is an enterprise, the acquisition of user requirements is usually not a problem that can be handled by a computer. When the user is a normal user, the designer must design a convenient and intelligent interaction tool to capture and analyze the specific needs of the user. In addition to this, the interaction tool can automatically analyze and standardize the various types of user requirements and understand what the user really means in terms of requirements. In addition, user requirements are becoming increasingly complex and the attempt to understand them all at once is clearly no longer sufficient to meet the systematic requirements of developing software. Therefore, at the beginning of the requirements analysis, the user interface requirements need to be described in detail until the bulk generation of the entire system interface has become an urgent issue to be addressed throughout the software design and implementation process.

3.2. Framework for User Interface Implementation. The user interface model based on interaction behavior should have the following characteristics: Firstly, the user interface should support user needs and interaction behavior as a whole. The user requirements of a software system are mainly reflected in the set of actions that users perform on the application system interface. User interaction is mainly reflected in the user's manipulation of the various controls in the interface. This user interface model adds a complementary point to existing approaches to interface design and builds on this to propose user-centered features. Specifically, it is a design process to parse user requirements and provide feasible solutions. Secondly, this user interface model should satisfy a description of user requirements at an abstraction level. To be specific, user requirements need to be abstracted after they have been captured and described as a specific

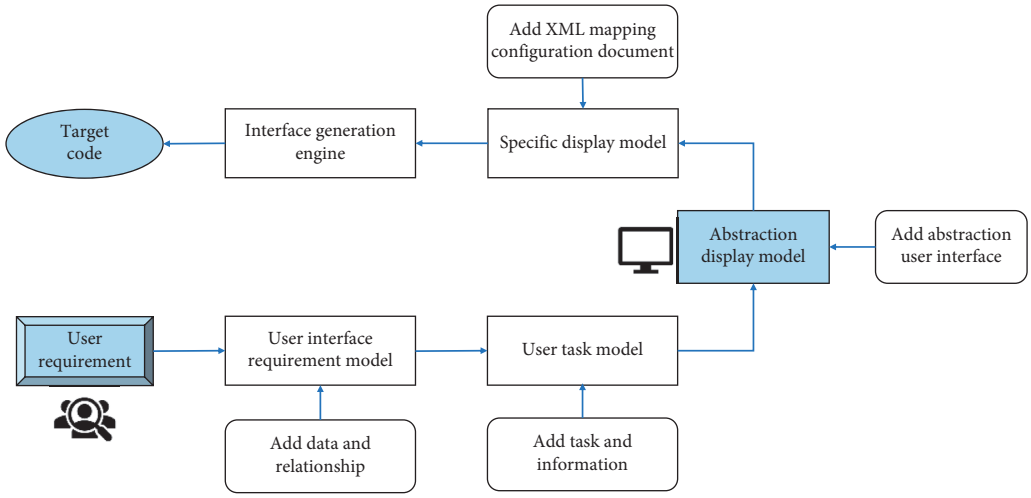


Figure 4: Framework of the user interface model based on interaction behavior.

abstract task in order to build the user interface requirements model.

Based on these two characteristics, a framework for generating user interface models based on interaction behavior can be developed, as shown in Figure 4. The input model of the framework must follow the definition and structure of the structured use case model or be able to be transformed into an instance conforming to the structured use case model by means of a designed parser. The transformation of the platform-related models is then achieved by following the relevant rules.

Furthermore, based on the description of the interface requirements in XML, the interface template information is queried using query techniques in markup languages. The interface template information previously obtained during the development of the system can then be stored in the format of an XML document to create a general repository of interface template information. The interface template information can be queried in terms of document name, description of the interface information, etc. The query can then be added to the current project design and implementation with simple modifications and extensions, which can greatly improve the efficiency of development. The reuse relationship is shown in Figure 5.

3.3. Principle of User Interface Generation. The overall structure of the user interface generation is shown in Figure 6, which technically combines semantic technology with automatic interface generation technology and further refinement of its ideas.

The detailed steps of user interface generation are shown as follows (Figure 7):

(1) Generate the interface description file based on some of the requirements for the interface provided by the user

(2) Initialize the interface data based on the data information from the front page and assign initial values to each corresponding component

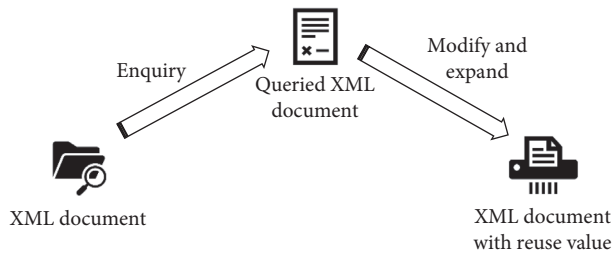


Figure 5: Diagram of reuse relationship.

(3) Initialize the interface generation engine

(4) Read and parse the interface description file using the interface generation engine to obtain the corresponding property information

(5) Based on the interface description information, the interface component elements are constructed using the interface automation engine and manipulated for layout and interface display

3.4. Structured Use Case Model Design. Use case descriptions are abstract and unstructured, while user interface elements are concrete and structured. In order to transform the abstract use case model into a user interface, this study adds some structural elements to the abstract unstructured traditional use case design, defines them in a structured way, and builds a structured use case model to support the organization of the user interface and the acquisition of interface elements. In this way, the use case model has been largely enriched and made ready for conversion to a user interface.

The structured use case model consists of a basic event stream and one or more alternative event streams. The event stream includes multiple use case events and the relationships between them. Data and control constraints can be bound to the use case events. The data can be operation objects, input and output objects, and action calls for the use case event. If a use case event has multiple post conditions,

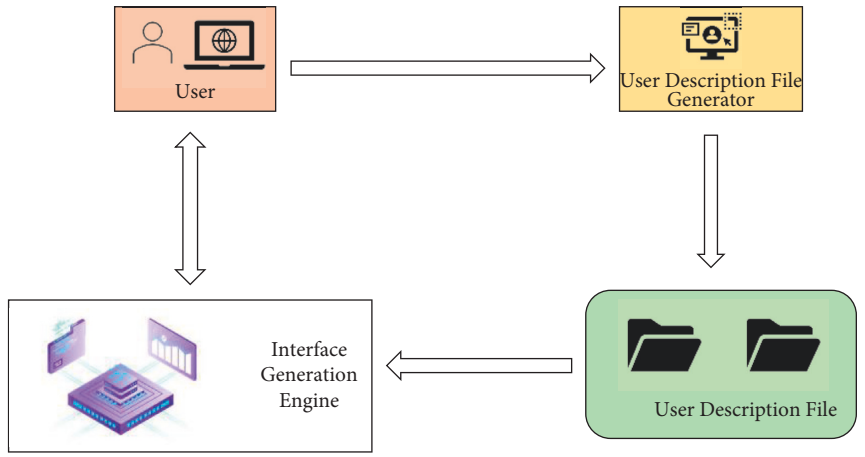


Figure 6: Structure of user interface generation.

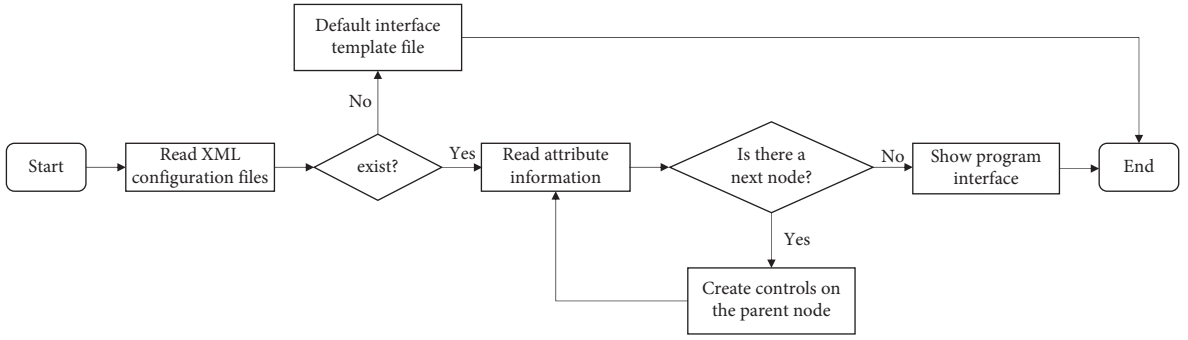


Figure 7: Principle of user interface generation.

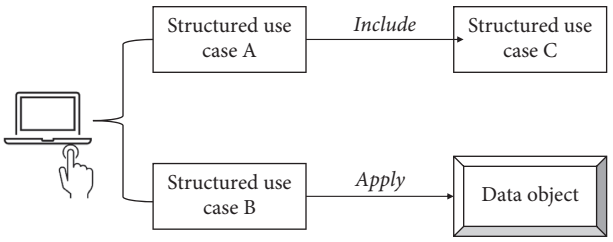


Figure 8: Structured use case diagram.

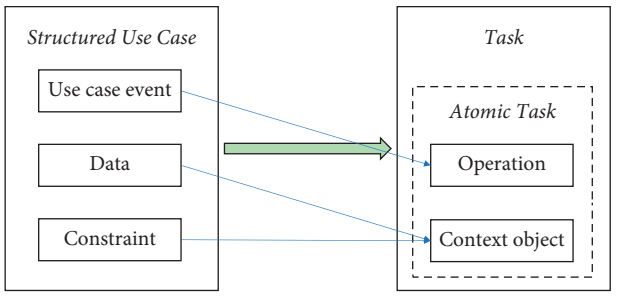


Figure 9: Mapping relationship between structured use case and tasks.

the jumping of the use case event is controlled by branching the conditions. When describing user interface requirements using a structured use case model, the tasks that may involve the user interface should be broken out and refined as much as possible. A use case can correspond to one or more views of the user interface. The view is an area of the user interface that performs a particular task. This research applies a structured use case diagram to describe the user requirements for the interface, as shown in Figure 8.

Use cases are designed for requirements analysis, and they do not provide information about the control flow associated with the task. Use cases can be considered as high-level tasks, which can then be analyzed for tasks to achieve the use case objectives. Based on the analysis of structured use cases and tasks, the mapping relationship between them is shown in Figure 9.

On the whole, the mapping transformation relationship mainly contains two aspects. On the one hand, XML documents contain different types of model information, such as presentation, interaction, and object, so it is important to clarify the mapping between various models. On the other hand is the the mapping relationship between the target language and the model constituent elements. The architecture model contains controls and the relationships between controls, their global variables, and shared functions. The object model contains classes, objects, views, and other elements and their generalization and association with each other. The interaction model reflects the interface objects and their static relationships and expresses the dynamic interaction between them, including the invocation of

program methods between objects, use cases, roles, and collections and the relationship with the interface navigation.

4. Conclusion

This paper analyses the relationship between user interaction behavior and user interface and focuses on how to use user interaction behavior as the basis for user interface modelling. Firstly, from the user's point of view, an interface generation framework based on user interaction behavior is proposed by extending and improving the concept of packages in the UML library. Next, by structuring and extending the traditional UML use cases, the structured use case model is proposed and used as the main thread through the analysis and design of each submodel to better realize the mapping transformation between the submodels. After that, structured use case diagrams are used to describe user requirements for the interface, the mapping of structured use cases to interaction behavior tasks is investigated, and activity diagrams are used to design the interaction tasks. A method for deriving a presentation model from the interaction behavior model design is then investigated to document the mapping of interface elements to specific elements.

However, there is still much room for further research and refinement of user interface generation models based on interaction behavior. In the future, contextual descriptions such as user preferences could be added and learning mechanisms could be introduced to enrich the user experience. In addition, the adaptability of the interface generation framework needs to be further demonstrated, as well as the implementation of a model processor for conversion to different platforms.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work was supported by the Shijiazhuang University of Applied Technology.

References

[1] B. Cheng, C. Fan, H. Fu, J. Huang, H. Chen, and X. Luo, "Measuring and computing cognitive statuses of construction workers based on electroencephalogram: a critical review," *IEEE Transactions on Computational Social Systems (SCI)*, Article ID 3158585, 2022.

[2] J. Ruiz, E. Serral, and M. Snoeck, "Unifying functional User Interface design principles," *International Journal of Human-Computer Interaction*, vol. 37, no. 1, pp. 47–67, 2021.

[3] A. A. Karpov and R. M. Yusupov, "Multimodal interfaces of human-computer interaction," *Herald of the Russian Academy of Sciences*, vol. 88, no. 1, pp. 67–74, 2018.

[4] A. Dix, "Human-computer interaction, foundations and new paradigms," *Journal of Visual Languages & Computing*, vol. 42, pp. 122–134, 2017.

[5] Z. Song, "English speech recognition based on deep learning with multiple features," *Computing*, vol. 102, no. 3, pp. 663–682, 2020.

[6] B. Cheng, K. Lu, J. Li, H. Chen, X. Luo, and M. Shafique, "Comprehensive assessment of embodied environmental impacts of buildings using normalized environmental impact factors," *Journal of Cleaner Production*, vol. 334, Article ID 130083, 2022.

[7] L. J. Schmitt and A. Weinberger, "Fourth graders' dyadic learning on multi-touch interfaces-versatile effects of verbalization prompts," *Educational Technology Research & Development*, vol. 67, no. 3, pp. 519–539, 2019.

[8] N. Streitz, D. Charitos, M. Kaptein, and M. Böhlen, "Grand challenges for ambient intelligence and implications for design contexts and smart societies," *Journal of Ambient Intelligence and Smart Environments*, vol. 11, no. 1, pp. 87–107, 2019.

[9] S. Zhou, H. Jeong, and P. A. Green, "How consistent are the best-known readability equations in estimating the readability of design standards?" *IEEE Transactions on Professional Communications*, vol. 60, no. 1, pp. 97–111, 2017.

[10] N. Hubballi and J. Santini, "Detecting TCP ACK storm attack: a state transition modelling approach," *IET Networks*, vol. 7, no. 6, pp. 429–434, 2018.

[11] O. V. Demyanova, A. Kireeva-Karimova, and L. M. Zabirova, "The process approach in a deyatelnyost of industrial company," *Journal of Engineering and Applied Sciences*, vol. 12, no. 19, pp. 4952–4957, 2017.

[12] B. Zhang, H. Yang, T. Warner et al., "A luminescent solar concentrator ray tracing simulator with a graphical user interface: features and applications," *Methods and Applications in Fluorescence*, vol. 8, no. 3, Article ID 037001, 2020.

[13] S. Maoz and J. O. Ringert, "Spectra: a specification language for reactive systems," *Software and Systems Modeling*, vol. 20, no. 5, pp. 1553–1586, 2021.

[14] W. Chen, F. Guo, D. Han et al., "Structure-based suggestive exploration: a new approach for effective exploration of large networks," *IEEE Transactions on Visualization and Computer Graphics*, vol. 25, no. 1, pp. 555–565, 2019.

[15] J. Hussain, A. Ul Hassan, H. S. Muhammad Bilal et al., "Model-based adaptive user interface based on context and user experience evaluation," *Journal on Multimodal User Interfaces*, vol. 12, no. 1, pp. 1–16, 2018.

[16] Y. Qian, S. Chen, J. Li et al., "A decision-making model using machine learning for improving dispatching efficiency in Chengdu Shuangliu airport," *Complexity*, vol. 2020, Article ID 6626937, 16 pages, 2020, https://doi.org/10.1155/2020/6626937.

[17] B. Biswas and P. C. Singh, "Restructuring of membrane water and phospholipids in direct interaction of neurotransmitters with model membranes associated with synaptic signaling: interface-selective vibrational sum frequency generation study," *Journal of Physical Chemistry Letters*, vol. 12, no. 11, pp. 2871–2879, 2021.

[18] A. M. Madni and M. Sievers, "Model-based systems engineering: m," *Systems Engineering*, vol. 21, no. 3, pp. 172–190, 2018.

[19] J. Ruiz, E. Serral, and M. Snoeck, "Evaluating user interface generation approaches: model-based versus model-driven development," *Software and Systems Modeling*, vol. 18, no. 4, pp. 2753–2776, 2019.

[20] N. Tsuruta, A. Khayyer, H. Gotoh, and K. Suzuki, "Development of Wavy Interface model for wave generation by the projection-based particle methods," *Coastal Engineering*, vol. 165, Article ID 103861, 2021.

[21] M. Thomas, I. Mihaela, R. M. Andrianjaka, D. W. Germain, and I. Sorin, "Metamodel based approach to generate user interface mockup from UML class diagram," *Procedia Computer Science*, vol. 184, pp. 779–784, 2021.

[22] S. Haga, W.-M. Ma, and W. Chao, "Structure-behavior coalescence method for formal specification of UML 2.0 sequence diagrams," *Journal of Computing Science and Engineering*, vol. 15, no. 4, pp. 148–159, 2021.

[23] M. Philip, "A quantitative approach to analyze modifiability in software architectural design of agile application systems," *Information Technology and Control*, vol. 49, no. 2, pp. 249–259, 2020.

[24] D. S. Purnia, "Implementasi metode RAD pada rancang aplikasi BAN-SOS ter distribusi berbasis mobile," *Indonesian Journal on Computer and Information Technology*, vol. 3, no. 1, 2018.

[25] Z. Brahmia, H. Hamrouni, and R. Bouaziz, "TempoX: a disciplined approach for data management in multi-temporal and multi-schema-version XML databases," *Journal of King Saud University - Computer and Information Sciences*, vol. 34, no. 1, pp. 1472–1488, 2022.

[26] A. M. Eassa, M. Elhoseny, H. M. El-Bakry, and A. S. Salama, "NoSQL injection attack detection in web applications using RESTful service," *Programming and Computer Software*, vol. 44, no. 6, pp. 435–444, 2018.

[27] K. Seol, Y.-G. Kim, E. Lee, Y.-D. Seo, and D.-K. Baik, "Privacy-preserving attribute-based access control model for XML-based electronic health record system," *IEEE Access*, vol. 6, pp. 9114–9128, 2018.

[28] S. Jan, A. Panichella, A. Arcuri, and L. Briand, "Search-based multi-vulnerability testing of XML injections in web applications," *Empirical Software Engineering*, vol. 24, no. 6, pp. 3696–3729, 2019.

[29] S. Aggarwal, "Modern web-development using reactjs," *International Journal of Recent Research Aspects*, vol. 5, no. 1, pp. 133–137, 2018.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 8341442, 9 pages
https://doi.org/10.1155/2022/8341442

Research Article

Improved Siamese Network-Based 3D Motion Tracking Algorithm for Athletes

Tao Lan

Hebei Sport University, Shijiazhuang 050041, China

Correspondence should be addressed to Tao Lan; lantao0575@hepec.edu.cn

Received 19 April 2022; Accepted 28 May 2022; Published 15 June 2022

Academic Editor: Wen Zhou

For the last few years, the application of Siamese network in athletes' three-dimensional motion tracking has greatly improved the efficiency of sports training. However, the accuracy of the Siamese network tracking algorithm is limited to a large extent. To solve the above problems, based on the channel attention mechanism, the key feature information perception module is innovatively proposed to promote the discriminant ability of the network model and make the network focus on the convolution feature changes of the target. On this basis, an online adaptive mask strategy is proposed, which adapts the subsequent frames according to the output state of the cross-correlation layer learned online to highlight the foreground object. Compared with other algorithms in annotated data set and MOT17 data set, this algorithm has more stable initial tracking performance, significantly improved accuracy compared with the benchmark, and high robustness tracking effect in complex scenes.

1. Introduction

Human motion recognition and motion evaluation is a research hotspot at present. Action recognition analyses and processes the input video or 3D action data to determine which category different actions belong to. Motion recognition technology has practical application value in various industries such as human-computer interaction scene [1], surveillance video [2], gesture recognition [3], rehabilitation training [4], robot [5], and behaviour understanding [6]. Action evaluation is to judge the completion quality of specific actions. It is generally used in sports, dance, Tai Chi [7], and other professional fields. It can assist referees and coaches in scoring and help people with movement analysis and training.

As early as the 1970s, Johansson et al's motion perception experiment of moving light spot confirmed that the three-dimensional human motion information can be analysed with the help of the two-dimensional model, which aroused many researchers' interest in human motion recognition. A large number of subsequent research work on motion recognition emerged and achieved remarkable results. On the other hand, the research on movement evaluation is still in its infancy. Although there are some successful cases, such as golf swing [8] and badminton swing [9], what can be handled is mainly single and highly repetitive movements. For more complex movements, such as competitive aerobics [10], dance, 24 style Tai Chi [11], and opera [12], etc., thins become completely different. For these complex actions, we should not only compare the "appearance similarity" but also make a breakthrough in the deeper "professional similarity."

After full and in-depth investigation, this paper discusses the differences and relations between action recognition and action evaluation and summarizes the technical framework of action recognition and action evaluation from the perspective of complete data processing flow as shown in Figure 1.

In order to improve the accuracy of Siamese network tracker [13], on the basis of maintaining real-time performance, this paper innovatively proposed a new key feature information perception module to improve the discriminant ability of the Siamese network model, which includes multiscale feature extraction and attention mechanism [14]. This paper is used to remove all connection layer AlexNet [15] as a network of feature extraction, presents a multiscale sampling method to extract the target under the multiscale feature information, and uses the attention mechanism as the key to

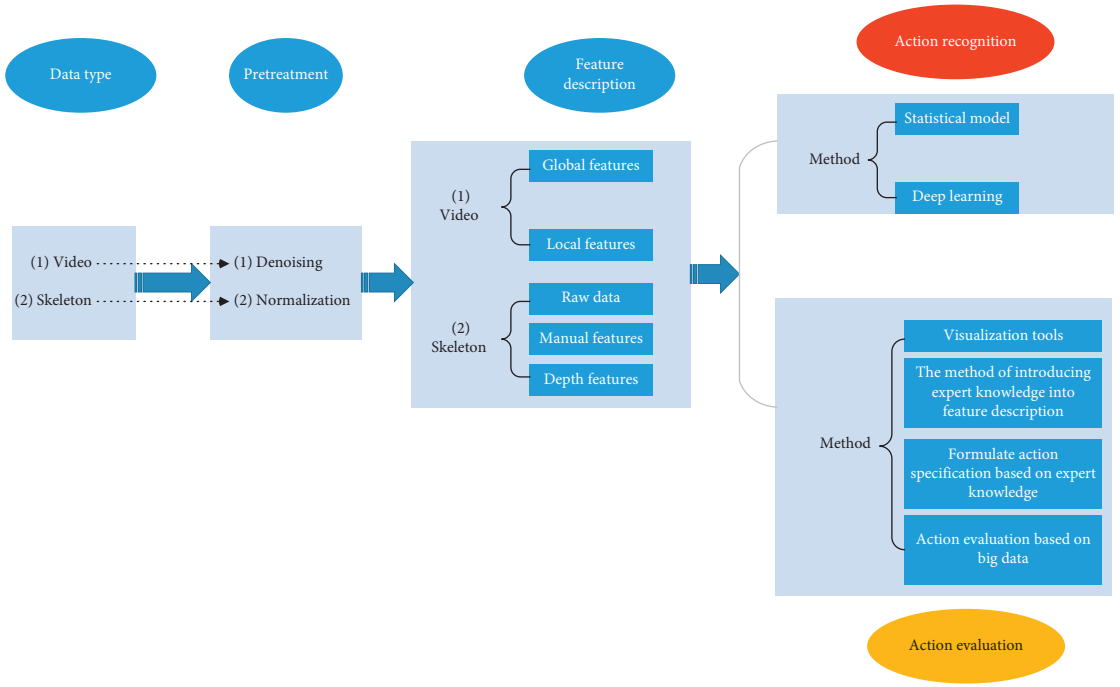


Figure 1: Technical framework of action recognition and action evaluation.

enhance the target information, to capture the most distinct abstract semantic features [16], and then the similarity discriminant features are captured; the experimental results show that the tracking accuracy is significantly improved. In addition, in order to enhance the ability of Siamese network tracker to deal with complex scenes, a low-time consumption online adaptive mask strategy is proposed. By learning the complexity of background noise in the search image through cross-correlation output, we can mask the search image adaptively according to the complex situation and suppress a lot of background noise interference [17]. The tracker can maintain robust robustly performance in complex scenes.

2. Methodology

2.1. Siamese Neural Network. Figure 2 shows the structure of Siamese neural network. It has two or more neural networks with the same substructure. Each sub network has the same structure and shares parameters and weights [18]. The idea of Siamese network is to let two inputs pass through two subnetworks, respectively, and then extract the characteristics to get the characteristic vectors of the two inputs. Then, by constructing distance measurement functions, such as cosine distance [19] and Euclidean distance [20], it can be used to calculate the matching degree of the two inputs. During training, learn a similarity matching function according to the results for subsequent matching.

Siamese neural network can be divided into the following two parts from the network structure.

2.1.1. Feature Extraction. The main part of the Siamese network is used to extract the characteristics of the two inputs, respectively, to obtain the feature information that

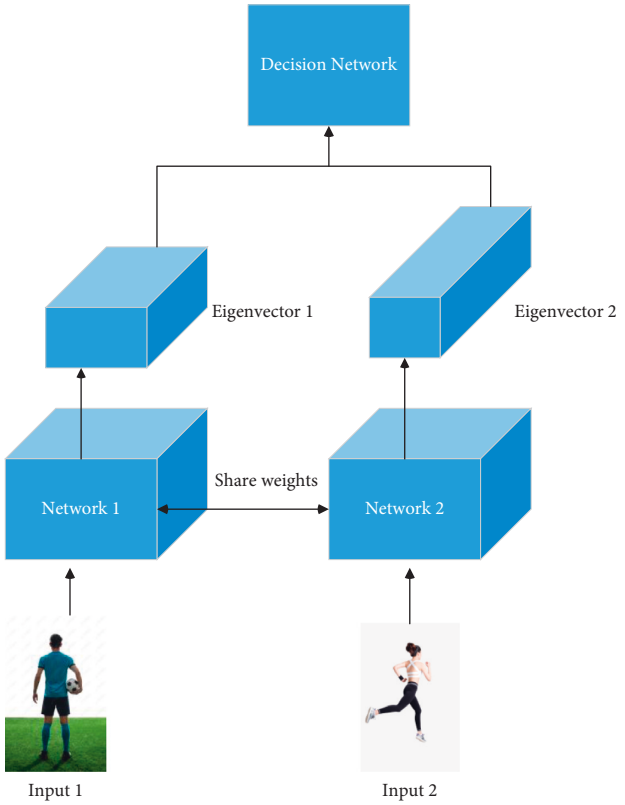


Figure 2: Typical Siamese network structure.

can effectively describe the input. It is usually realized by convolutional neural networks (CNNs) [21]. CNN usually includes convolution layer, pooling layer, full-connection layer, nonlinear activation function, and other parts, which can

extract the high-dimensional semantic information of the input image. Compared with hog feature, LBP feature, and CN colour feature, CNN feature has better robustness under the influence of complex background change and target appearance change.

2.1.2. Decision Network. After extracting the characteristics of the two inputs, it is necessary to determine their similarity according to the matching function. During training, the model parameters are continuously adjusted in combination with the network output and the real output to acquire a decision function with good performance. In different tasks, decision networks have different forms. Some are measured directly by loss function [22] and measurement function [23], and some continue to use neural networks [24] to verify the confidence of results, which improve decision reliability.

2.2. Target Tracking Algorithm for Siamese Network. In the target tracking algorithm of Siamese networks, the input is target image Z and candidate image X. through template feature and correlation matching, a correlation response graph based on candidate image x is obtained, and then the location of the tracking target is determined by the maximum response. The problem of target tracking is transformed into a problem of learning similarity function.

The similarity function of fully connected Siamese network is defined as follows:

$$f(k,i) = \varphi(k)^{*}\varphi(i) + h, \tag{1}$$

where φ is the CNN feature extraction function, $*$ represents the convolution operation, and the correlation between them can be calculated. H is the deviation value, and $f(k,i)$ represents the similarity score of k and i. The more similar the reference target k is to the candidate image i, the higher the return score of the function is, and vice versa. Several candidate images are selected through a certain strategy in the frame to be detected, and a fractional response can be obtained after calculating the similarity score, respectively. The position with the highest score in the response graph is the target position of the tracking object in the frame predicted by the algorithm.

In the tracking phase, in the current frame, a large search area i is obtained centred on the target centre detected in the previous frame, which can be obtained by padding the bounding box of the previous frame. Then, feature extraction function is used φ The features of the reference target i in the region and the first frame are extracted, respectively, such as $\varphi(k)$ and $\varphi(i)$; then these features are obtained by convolution operations $\varphi(k)$ and $\varphi(i)$. The similarity score vector $f(k,i)$ is used to obtain the similarity score map, in which the position with the largest score is the position corresponding to the target in the frame.

Taking the Siamese FC algorithm as an example, in model training and tracking, the network input is the real marker box of the first frame and the search area of the current frame, respectively. The two input images are 127×127 and 255×255, respectively, and the final network output fractional image size is 17×17. Each position in the score graph represents the confidence value of a candidate region as the target region. Later, using appropriate processing methods can get more accurate target centre position.

2.3. Key Feature Information Perception Module. The Siamese network tracker can be modelled by the following formula as follows:

$$R(i,k) = CORR(\varphi(i), \varphi(k)), \tag{2}$$

where i and k are the input template image and search image, respectively, φ is the feature extraction network, $CORR$ is the cross-correlation operation, R is the matrix response graph, and the target centre is located through the maximum value in R. In the formula, φ parameter is shared in template image and search image branch. Simply using AlexNet as the feature extraction network cannot fully tap the potential of the Siamese network structure, so this paper proposes a key feature information sensing module embedded in AlexNet. In order to prove the universality and effectiveness of the module, SiamFC-DW is also used as a benchmark for comparative experiments.

This paper chooses to embed this module after the third layer of AlexNet because the features extracted from the first three layers are relatively shallow image features, while the last two layers are more abstract semantic features. In this paper, the key of design feature information perception module is as shown in Figure 3. Firstly, feature information of different scales is obtained through the maximum pooling sampling layer in various scales and fused. It enables the receiving field of each pixel to have rich convolution characteristics, thus providing the tracker with more prior knowledge about the target position. This paper adopts the sampling pooling under nuclear size of 3×3 and 5×5. However, in the process of feature information fusion at different scales, a large amount of interference information is brought, resulting in unstable performance of the tracker. As shown in Table 1, on the basis of SiamFC, the multiscale feature extraction strategy was used to train the models for many times in the same way, and their performance was tested. The results showed that the performance fluctuation was large and the improvement was not obvious.

In order to obtain stable and more robust performance, the network should selectively enhance the key feature information of the target and suppress useless feature information, that is, only capture the most significant image attributes of the target. A simple and effective way is to assign different weights to different channels of convolution features, which can be expressed by the formula as follows:

$$\bar{P} = Ps = \sum_{z=1}^{C} p_z s_z, \tag{3}$$

where $P = [p_1, p_2, \ldots, p_c]$ said untreated convolution, C is the characteristics of the channel number, $\bar{P} = [\bar{p}_1, \bar{p}_2, \ldots, \bar{p}_C]$ said each channel gives different weights to produce new features, and $s = [s_1, s_2, \ldots, s_C]$ *a*s

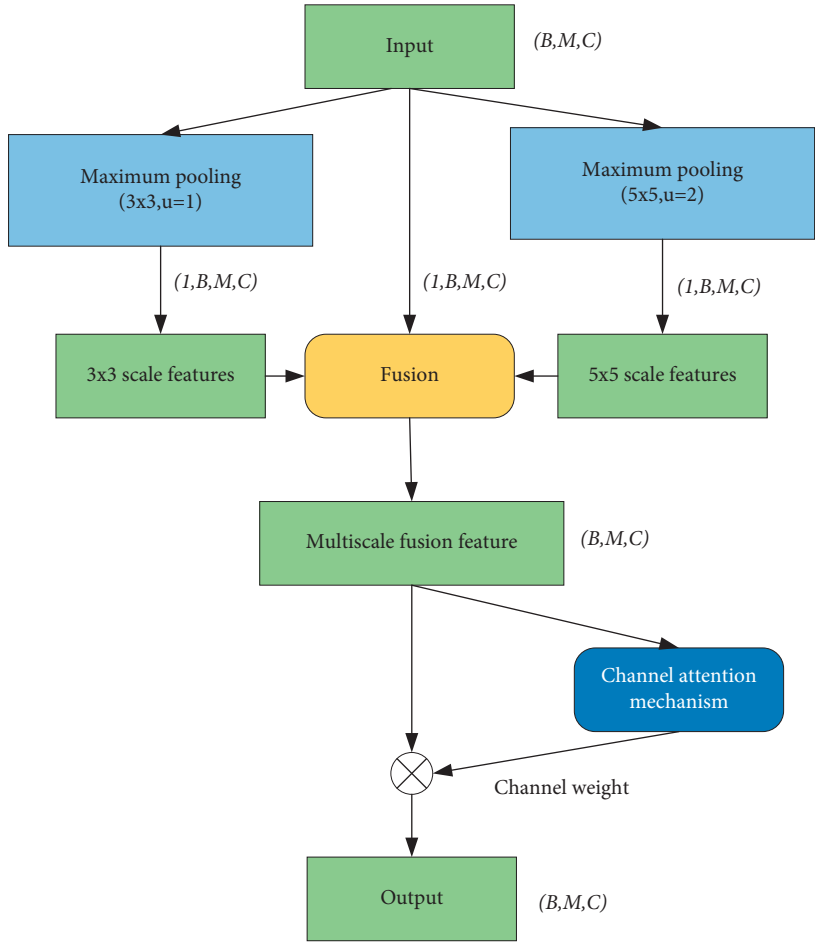


Figure 3: Key feature information perception module structure 1.

Table 1: AUC performance of the training model on OTB100.

SiamFC (%)	Model l (%)	Model 2 (%)	Model 3 (%)	Model 4 (%)	Model 5 (%)
58.3	58.6	60.8	60.2	57.5	60.4

weights. This paper adopts channel attention mechanism to generate channel information weight value s from the origin.

Figure 4 shows the channel attention module. By explicitly modelling the interdependence between channels, it adaptively recalibrates the characteristic response of channels and applies it to Figure 3, which only slightly increases the model complexity and computation burden but significantly improves the accuracy. The process for generating the weight s through the channel attention mechanism is split into "squeeze" and "incentive." Firstly, Adaptive avgpool is used to compress the global features into a channel descriptor. Formally, the spatial dimension of P, $B \times M \times C$, is compressed into a statistical vector $k \in \mathbb{R}^C$, and the k element of z is calculated by formula as follows:

$$k_z = F_{sv}(\mathbf{u}_z) = \frac{1}{B \times M} \sum_{x=1}^{B} \sum_{y=1}^{M} \mathbf{u}_z(x, y). \tag{4}$$

The rest of the scheduling operation follows the Squeeze operation. The scheduling aims to learn the nonlinear dependencies and non-murexes between the channels because you want to make sure that you allow the model to emphasize multiple channels and not just perform one-hot activation. Choose to use the activation function Sigmoid with the threshold mechanism. The procedure is illustrated by the following formula:

$$s = F_{ei}(k, M) = \sigma(a(k, M)) = \sigma\left(M_2 \delta\left(M_1 k\right)\right), \tag{5}$$

where δ represents the parameters of ReLU, M_1 and M_2, respectively, which enhance the generalization ability of attentional mechanism through continuous full-connection layer structure. σ represents Sigmoid function. Sigmoid function is often used as the activation function of neural network. It can map a real number to the interval of (0, 1) and can be used for binary classification. The effect is better when the feature difference is complex or the difference is not particularly large.

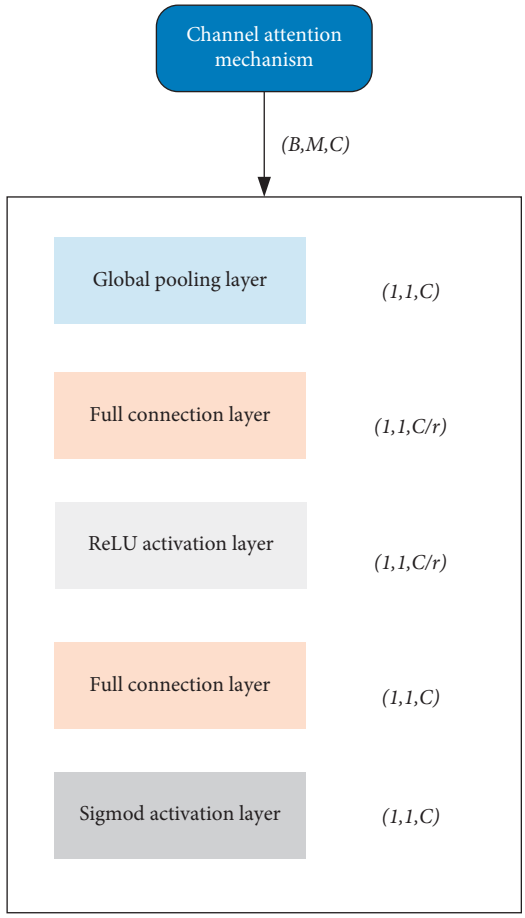


Figure 4: Channel attention module.

This paper also proposes another structure that can replace Figure 3, which is shown in Figure 5. Different from Figure 3, the features obtained by sampling under multiscale maximum pooling are not directly fused. Instead, the features of these different scales are input into channel attention for weight allocation, and finally the calibrated features are fused. This paper uses SiamFC and SiamFC-DW as reference algorithms to compare these two structures. The comparison results are shown in Table 2. SiamFC with structure 1 improved its accuracy by 6.6% compared with the benchmark, exceeding the maximum increase of 4.1% in Table 1, and its speed decreased by 16fps. With structure 2, the accuracy improved by 7.3%, and the speed drop increased to 30fps, but it was still well above the real-time requirements. SiamFC-DW improved by 2.7% and 3.5%, respectively, under two different structures, indicating that the key feature information sensing module proposed in the paper has enhanced on the basis of strong enough network discrimination ability.

In this paper, structure 1 of Figure 3 is embedded into SiamFC feature extraction network AlexNet. After end-to-end training, the model is applied to Bolt and Board, two video sequences of OTB100, and the feature information output from the cross-correlation layer learned by the model is visualized.

2.4. Online Adaptive Mask. After embedding key feature information sensing module in feature extraction network, the discriminant ability of the model has been improved qualitatively. However, the performance of the tracker is still not robust enough in complex scenes to resist the interference of some seriously similar objects. Therefore, this paper also proposes an online adaptive mask strategy to suppress the interference information and highlight the foreground object to deal with the complex scene. The strategy achieves adaptive effect through online learning of mask parameters. Compared with the traditional image mask, the adaptive mask in this paper can capture the dynamic information of the target in the video stream. However, the traditional method cannot adapt to the change of the target, and the suppression process will bring loss to the foreground information of the image.

The form of the online adaptive mask is as follows:

$$\left.\begin{aligned} f^*(i_n, j_n) &= f(i_n, j_n) \cdot A(i_n, j_n) \\ A(i_n, j_n) &= \frac{1}{\alpha\sqrt{2\pi}\,\sigma_{i_n}\sigma_{j_n}} exp - \left(\frac{i_n^2}{2\sigma_{i_n}^2} + \frac{j_n^2}{2\sigma_{j_n}^2}\right) \end{aligned}\right\}, \tag{6}$$

where f and f^* represent the search image before and after the mask, respectively, n represents the current frame sequence, i_n and j_n represent each pixel of the search image, A represents the Gaussian mask function, and the parameters σ_{i_n} and σ_{j_n} represent the horizontal mask degree and vertical mask degree of the search image. The following three steps can complete the detailed online adaptive mask.

Step 1. According to the aspect ratio of the target frame, the degree of mask σ_{i_1} in the horizontal axis and σ_{j_1} in the vertical axis of the search image in frame 1 can be determined by formula (7). The adaptive process first needs to know the confidence information of the historical frame, so the Gaussian mask function parameter of the previous x frame is the same as that of the first frame.

$$\left[\sigma_{i_1}, \sigma_{j_1}\right] = \begin{cases} [\beta, \beta(1-\theta)], \frac{b}{m} \geq nr, \\ [\beta(1-\theta), \beta], \frac{m}{b} \geq nr, \\ [\beta, \beta], \end{cases} \tag{7}$$

where nr and θ are set to 1.8 and 0.1, respectively, and β is the initial value of σ and is set to 95.

Step 2. The confidence factor adopted in this paper is the average peak correlation energy (APCE). The APCE is obtained from the response graph obtained by searching the image of the current frame and then compared with the average APCE of several historical frames. Thus, the magnitude of σ_{i_n} and σ_{j_n} can be determined by the APCE formula as follows:

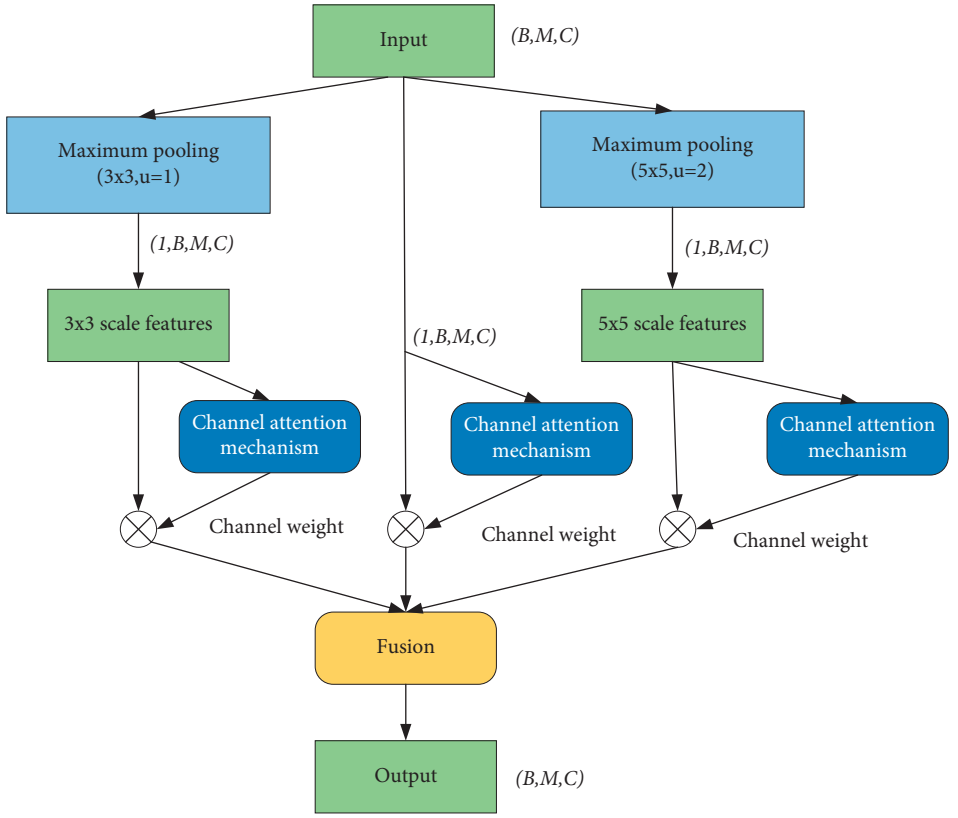


Figure 5: Key feature information perception module structure 2.

Table 2: Comparison algorithms of two different key information perception structures.

Algorithm	Parameter quantity (M)	Calculation amount (B)	Accuracy (%)	Fps
SiamFC	3.31	0.69741	58.3	132
SiamFC (Structure 1)	3.32	0.69747	64.9	116
SiamFC (Structure 2)	3.35	0.69758	65.6	102
SiamFC-DW	2.46	0.80826	62.1	156
SiamFC-DW (Structure 1)	2.48	0.80843	64.8	149
SiamFC-DW (Structure 2)	2.56	0.80874	65.6	138

$$\mathrm{APCE} = \frac{\left|r_{\max} - r_{\min}\right|^2}{\mathrm{mean}\left(\sum_{m,b}\left(r_{m,b} - r_{min}\right)^2\right)}, \tag{8}$$

where $r_{\max}$, $r_{\min}$, and $r_{m,b}$ represent the maximum value and minimum value of the response graph fraction obtained by cross-correlation between the search image features and the target template image features and each value of row W and column H, respectively.

Step 3. Finally, the values of σ_{i_n} and σ_{j_n} are adaptively updated according to formula (9) during the online tracking process of subsequent frames.

$$\sigma_{i_n} = \begin{cases} \sigma_{i_{n-1}}(1+\mu), & \varepsilon_{di\ v} \geq \tau_1, \\ \sigma_{i_{n-1}}(1-\mu), & \varepsilon_{di\ v} \leq \tau_2, \\ \sigma_{i_{n-1}}, & \text{others}, \end{cases} \tag{9}$$

where μ is the factor of change of mask degree, set as 0.2, and the thresholds τ_1 and τ_2 are set as 1.175 and 0.825, respectively. The above formula only gets σ_{i_n}, and the determination method of σ_{jn} is the same. $\varepsilon_{\mathrm{div}}$ represents the ratio of the current APCE to the average APCE of historical I frames, which can be calculated from formula (10), where x is set to 3.

$$\varepsilon_{\mathrm{div}} = \frac{\mathrm{APCE}_n}{\left(\sum_{z=n-x}^{n-1}\mathrm{APCE}_z\right)/x} = \frac{x \cdot \mathrm{APCE}_n}{\sum_{z=n-x}^{n-1}\mathrm{APCE}_z}. \tag{10}$$

3. Result Analysis and Discussion

In the Literature [25] paper, experimental results are based on the MOT16 data set and nonstandard detectors. In this paper, the detection branch results of Literature [26] are used as the input of Literature [25] tracking stage, and the appearance features extracted by Literature [26] are used as the input of Literature [25] appearance similarity

Table 3: Results of the proposed method.

Output	Index	
Human body bounding box detection	Accuracy	99.81%
	Recall rate	98.63%
	Mean IOU	76.35%
Head bounding regression box	Mean IOU	87.15%
Orientation prediction	$CS_{Loss} < 0.001$	72.23%
	$CS_{Loss} < 0.003$	91.21%
	$CS_{Loss} < 0.010$	99.67%

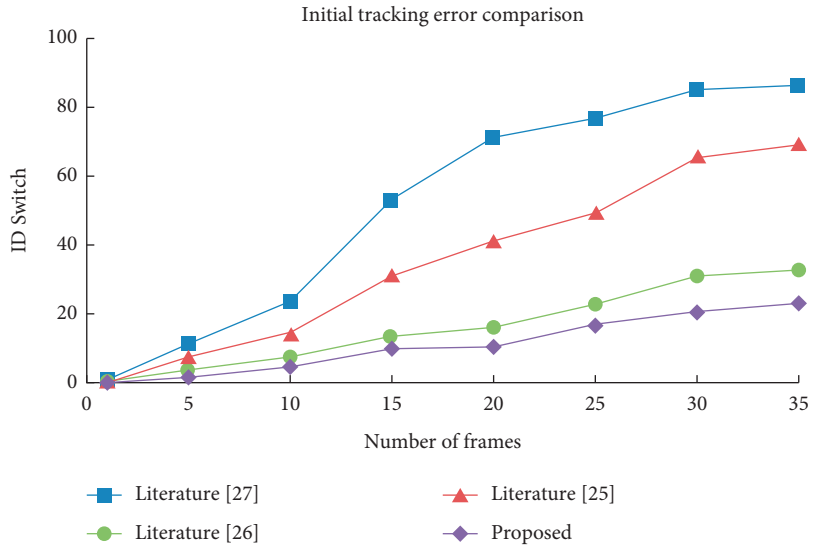


Figure 6: Initial tracking error of MOT17 data set.

calculation. Since MOT16 data set does not provide camera internal and external parameters, this paper carries out the comparison experiment of Literature [26] network on MOT17 data set and carries out the comparison experiment of overall tracking algorithm on annotation data set.

3.1. Data Correlation. MOT17 dataset is a public data set to evaluate the effectiveness of the multitarget pedestrian tracking algorithm and provides MOTA, MOTP, MT, and other evaluation indicators. The training of Literature [26] requires additional target orientation information and head bounding box, so this paper manually annotates the pedestrian orientation information and head bounding box based on MOT17 data set. Finally, this paper uses 4 training videos (3012 frames) and 3 test videos (2575 frames) in the data set and manually marks the orientation information and the human head bounding frame. The annotation data set is 3805 frames of pedestrian videos taken by ourselves. Like MOT17 data set, the information of pedestrian bounding frame, head bounding frame, and orientation are manually annotated, and the external and internal parameters of surveillance cameras are collected. In the training phase, the input data were randomly mirrored, and the padding processing in the lower right corner was used to ensure that the image length and width were equal. In this paper, the two branches of Literature [26] were trained in sections. Resnext-50 of the trunk network used the standard weights of ImageNet classification data set to train, cut the layers after Conv4, and then train the RPN and RCNN of the detection branch. After the training of the detection branch, the weight of the trunk network was fixed. The training is complete after network convergence. The Sigmoid activation function is used after Conv3 for the prediction branch and FC2&FC3 for the detection branch, and the ReLU activation function is used for the rest.

The branch *Loss* function uses Smooth_{L1} for detection, and the branch *Loss* function uses CS_{Loss} for prediction of mean cosine similarity errors toward O_u and label toward O_a. Adam is used for training optimizers of both branches. The configuration of the experimental platform is CPU i7 8700K, GPU Nvidia GTX1080Ti 11 GB, Ubuntu16.04, and Tensorflow 1.11.

3.2. The Results. The test results of the proposed method on annotated data sets are shown in Table 3. The network detection branch achieves the same excellent detection performance as Faster RCNN under the structure of multitask branch and feature sharing. The accuracy of orientation prediction was evaluated by three value domains. About 72.23% of the predicted orientations were almost identical with the original labelled orientations, 91.21% of the predicted orientations were highly consistent with the

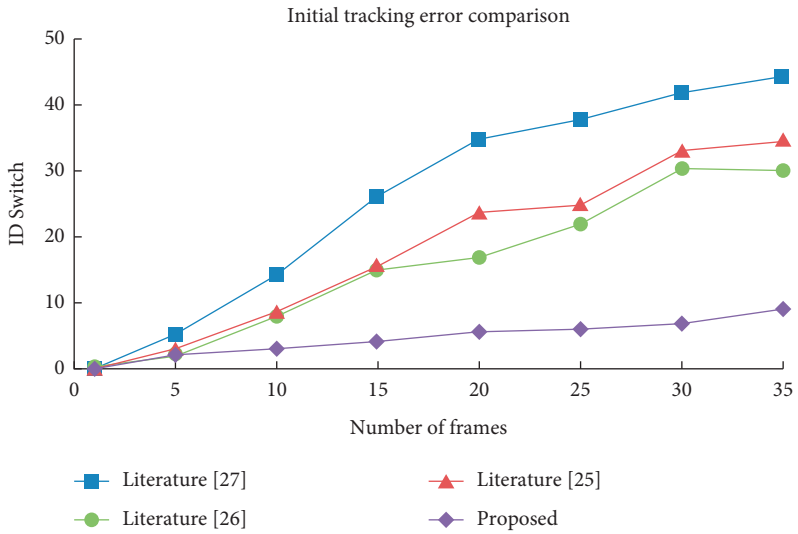


Figure 7: Initial tracking error of labelled data set.

Table 4: Multitarget tracking index result.

Algorithm	MOTA	MT (%)	ML (%)	ID switch (%)
Literature [27]	60.5	24.9	27.5	24.4
Literature [25]	63.3	38.5	22.3	13.8
Literature [26]	65.7	55.4	17.2	12.5
Proposed	71.3	54.2	5.4	8.6

original labelled orientations, and 99.67% of the predicted orientations were similar to the original labelled orientations.

In MOT17 data set, the Literature [26] and Literature [27] and Literature [25] algorithms are used to compare the tracking effect. Figure 6 shows the average accumulative number of ID Switch occurrences of the three algorithms with multiple frame inputs on MOT17 data set. It can be seen that the initial ID Switch error of the Literature [27] and Literature [25] algorithm increases rapidly and then tends to be stable. The initial tracking performance of this paper is obviously better than that of other algorithms.

This paper compress and tests the complete tracking algorithm on annotated data sets. Figure 7 is the result of the initial tracking error of the algorithm on the labelled data set. Different from Figure 6, the curve gap between Literature [26] and Literature [25] is small. After analysing the test data, it is found that compared with the labelled data set, MOT17 data set is more densely populated, which is prone to ID Switch error, while the labelled data are relatively sparse. This happens less frequently. Compared with Literature [26], the camera model projection proposed can effectively reduce ID Switch errors in another case. Table 4 shows the MOT evaluation indexes of each algorithm on the annotated data set. The algorithm proposed in this paper has higher MOTA and effectively reduces the occurrence of ID Switch.

4. Conclusion

This paper presents a three-dimensional motion tracking algorithm based on improved Siamese network. The tracking algorithm from two-dimensional plane is transferred to three-dimensional space, which reduces the occurrence of ID Switch and improves the initial stability of the tracking algorithm. In addition, a feature reuse network is proposed to reduce the calculation overhead of the algorithm.

To improve the accuracy of the Siamese network tracker, a general key information feature sensing module was proposed based on the channel attention mechanism to enhance useful information selectively. The module was embedded in the feature extraction network to effectively improve the network model's discrimination ability. In this paper, a low-time consumption online adaptive mask strategy is proposed to highlight the foreground target, suppress the interference of background information to a large extent, and further improve the tracking accuracy while taking into account the tracking speed.

The proposed algorithm in this paper on the data from the routine surveillance cameras made excellent tracking performance, but real fisheye camera in the scene is also more common. Fisheye camera is spherical imaging, a wide-angle, image distortion, and spherical imaging characteristics different from general type straight surveillance cameras; how compatible fisheye camera is the research focus of next step.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work was supported by the Hebei Sport University.

References

[1] W. Liang, "Scene art design based on human-computer interaction and multimedia information system: an interactive perspective," *Multimedia Tools and Applications*, vol. 78, no. 4, pp. 4767–4785, 2019.

[2] Z. Shao, L. Wang, Z. Wang, W. Du, and W. Wu, "Saliency-aware convolution neural network for ship detection in surveillance video," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 30, no. 3, pp. 781–794, 2019.

[3] G. Li, H. Tang, Y. Sun et al., "Hand gesture recognition based on convolution neural network," *Cluster Computing*, vol. 22, no. S2, pp. 2719–2729, 2019.

[4] D. Hansen, A. Abreu, P. Doherty, and H. Voller, "Dynamic strength training intensity in cardiovascular rehabilitation: is it time to reconsider clinical practice? A systematic review," *European journal of preventive cardiology*, vol. 26, no. 14, pp. 1483–1492, 2019.

[5] M. H. Huang and R. T. Rust, "Engaged to a robot? The role of AI in service," *Journal of Service Research*, vol. 24, no. 1, pp. 30–41, 2021.

[6] J. Hao, X. Li, X. Zeng, D. Li, J. Mao, and Z. Guo, "Deeply understanding the Zn anode behaviour and corresponding improvement strategies in different aqueous Zn-based batteries," *Energy & Environmental Science*, vol. 13, no. 11, pp. 3917–3949, 2020.

[7] Y. C. Hsu, M. H. Nguyen, L. R. Mo et al., "Combining hepatitis B core-related and surface antigens at end of nucleos(t)ide analogue treatment to predict off-therapy relapse risk," *Alimentary Pharmacology & Therapeutics*, vol. 49, no. 1, pp. 107–115, 2019.

[8] M. Kim and S. Park, "Golf swing segmentation from a single IMU using machine learning," *Sensors*, vol. 20, no. 16, p. 4466, 2020.

[9] C. L. Hung, M. H. Hung, C. Y. Chang, H. H. Wang, C. S. Ho, and K. C. Lin, "Influences of lateral jump smash actions in different situations on the lower extremity load of badminton players," *Journal of Sports Science and Medicine*, vol. 19, no. 2, pp. 264–270, 2020.

[10] L. Jia and L. Li, "Research on core strength training of aerobics based on artificial intelligence and sensor network," *EURASIP Journal on Wireless Communications and Networking*, vol. 2020, no. 1, 164 pages, 2020.

[11] L. Zou, P. D. Loprinzi, J. J. Yu et al., "Superior effects of modified chen-style Tai Chi versus 24-style Tai Chi on cognitive function, fitness, and balance performance in adults over 55," *Brain Sciences*, vol. 9, no. 5, 2019.

[12] G. Muscogiuri, L. Barrea, D. Laudisio et al., "The opera prevention project," *International Journal of Food Sciences & Nutrition*, vol. 72, no. 1, pp. 1–3, 2021.

[13] Y. Meng, Z. Deng, K. Zhao, Y. Xu, and H. Liu, "Hierarchical correlation siamese network for real-time object tracking," *Applied Intelligence*, vol. 51, no. 6, pp. 3202–3211, 2021.

[14] Z. Xiong, D. Wang, X. Liu et al., "Pushing the boundaries of molecular representation for drug discovery with the graph attention mechanism," *Journal of Medicinal Chemistry*, vol. 63, no. 16, pp. 8749–8760, 2019.

[15] H. Ismail Fawaz, B. Lucas, G. Forestier et al., "InceptionTime: finding AlexNet for time series classification," *Data Mining and Knowledge Discovery*, vol. 34, no. 6, pp. 1936–1962, 2020.

[16] Z. Chen, Y. Fu, Y. Zhang, Y. G. Jiang, X. Xue, and L. Sigal, "Multi-level semantic feature augmentation for one-shot learning," *IEEE Transactions on Image Processing*, vol. 28, no. 9, pp. 4594–4605, 2019.

[17] T. G. Harmon, C. Dromey, B. Nelson, and K. Chapman, "Effects of background noise on speech and language in young adults," *Journal of Speech, Language, and Hearing Research*, vol. 64, no. 4, pp. 1104–1116, 2021.

[18] Y. Yi, H. Wang, and Q. Li, "Affective video content analysis with adaptive fusion recurrent network," *IEEE Transactions on Multimedia*, vol. 22, no. 9, pp. 2454–2466, 2020.

[19] D. Liu, X. Chen, and D. Peng, "Some cosine similarity measures and distance measures between q-rung orthopair fuzzy sets," *International Journal of Intelligent Systems*, vol. 34, no. 7, pp. 1572–1587, 2019.

[20] O. E. R. Lehmann, M. D. Ezcurra, R. J. Butler, and G. T. Lloyd, "Biases with the Generalized Euclidean Distance measure in disparity analyses with high levels of missing data," *Palaeontology*, vol. 62, no. 5, pp. 837–849, 2019.

[21] P. G. Brodrick, A. B. Davies, and G. P. Asner, "Uncovering ecological patterns with convolutional neural networks," *Trends in Ecology & Evolution*, vol. 34, no. 8, pp. 734–745, 2019.

[22] D. Debortoli, J. Kim, J. Lindé, and R. Nunes, "Designing a simple loss function for central banks: does a dual mandate make sense?" *The Economic Journal*, vol. 129, no. 621, pp. 2010–2038, 2019.

[23] I. L. Abma, B. J. D. Butje, P. M. Ten Klooster, and J. V. D. W. Philip, "Measurement properties of the Dutch–Flemish patient-reported outcomes measurement information system (PROMIS) physical function item bank and instruments: a systematic review," *Health and Quality of Life Outcomes*, vol. 19, no. 1, pp. 1–22, 2021.

[24] M. Alber, S. Lapuschkin, P. Seegerer, M. Hagele, K. T. Schutt, and G. Montavon, "iNNvestigate neural networks!" *Journal of Machine Learning Research*, vol. 20, no. 93, pp. 1–8, 2019.

[25] D. Li, F. Porikli, G. Wen, and Y. Kuai, "When correlation filters meet siamese networks for real-time complementary tracking," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 30, no. 2, pp. 509–519, 2020.

[26] H. Li, K. Qiu, L. Chen, X. Mei, L. Hong, and C. Tao, "SCAttNet: semantic segmentation network with spatial and channel attention mechanism for high-resolution remote sensing images," *IEEE Geoscience and Remote Sensing Letters*, vol. 18, no. 5, pp. 905–909, 2021.

[27] Y. Kang, S. Huihui, and Z. Kaihua, "Real-time visual tracking based on dual attention siamese network," *Journal of Computer Applications*, vol. 39, no. 6, pp. 1652–1666, 2019.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 7249397, 10 pages
https://doi.org/10.1155/2022/7249397

Research Article

The Application of Semantic Analysis Technology in the Analysis of Chinese and Korean Literature Mutual Translation

Yueqi Zhao

Konkuk University, Seoul 05029, Republic of Korea

Correspondence should be addressed to Yueqi Zhao; zhaoyueqi@konkuk.ac.kr

Received 31 March 2022; Accepted 30 April 2022; Published 31 May 2022

Academic Editor: Wen Zhou

In order to improve the effect of the mutual translation of Chinese and Korean literature, this article combines the semantic analysis technology to analyze the mutual translation of Chinese and Korean literature. Moreover, this article explores the analysis of Chinese and Korean literature mutual translation through intelligent semantic analysis methods and analyzes the theoretical basis of densely connected networks based on the semantic analysis and verification methods of densely connected networks and multilayer attention. Finally, this article implements semantic matching verification through the densely connected BiLSTM structure and adds a multilayer attention mechanism to the network to better interact with sentences to obtain the semantic relationship of sentences. The simulation analysis shows that the Chinese and Korean literature mutual translation system based on semantic analysis proposed in this article has a good translation effect and can effectively promote Sino-Korean literature exchanges.

1. Introduction

Since the establishment of diplomatic relations between China and South Korea, the exchanges and cooperation between the two countries in the fields of politics, economy, trade, diplomacy, and culture have been deepened. Both China and South Korea are deeply influenced by Confucianism and share many similarities in cultural heritage, and there are many similar rules and techniques to follow in Chinese and South Korean translation practice.

Traditional translation studies focus on the comparison of words and sentences between the original text and the translated text and pay too much attention to the analysis of morphological and syntactical aspects, failing to deal with the translation and transformation of texts larger than sentences, that is textual translation problems. However, the establishment and development of text linguistics have had a huge impact on translation studies. Translation refers to the process of converting the meaning of the language and characters of one country into the language and characters of another country, so that readers can accurately understand the connotation of the original work. Translation pays attention to "faithfulness, eloquence, and elegance," among which, "faithfulness" is the most critical part of translation. Three principles should be followed when translating Chinese and Korean works. One must be faithful to the original text. Specifically, it is to accurately translate the things, phenomena, truths, and the author's thoughts and feelings described in the original work. Second, the language should be fluent and clear and avoid rigid translation; otherwise, it will cause confusion in the meaning of the translation, and it will not be smooth. The third is to keep the original style as much as possible. Therefore, in the process of translation, translators must consider many factors, not only to understand the literal meaning of words, but also to consider the cultural environment and situation in which the text information is located.

Before the introduction of Western stylistic theories into China, the Chinese people's understanding of "style" was relatively simple. Style mostly refers to "genres of essays" (quartiles: poetry, fiction, drama, and prose). At the same time, it also refers to a relatively stable and unique style of works of different systems and styles, which is a stipulation of the literary genre itself. After the mid-1980s, Western

stylistic theories were introduced to China, and foreign language scholars usually used stylistic, style, and register as synonymous concepts. The three meanings of "genre," "norms," and "style" contained in the Korean word style are concentrated on the word "style" in Chinese. In this way, the meaning of the word "wen style" in Chinese has expanded a lot. At present, in modern literary theory, style generally has three levels of meaning: one is the genre of the work; the other is the language form of the work; the third is the writer's style or genre characteristics.

In recent years, the term "stylistic" has become the same as critical concepts such as "structure" and "form" and has various meanings: sometimes it refers to genre, stylistic norms, and writing style. The literary style is a system with certain rules and flexibility established according to a certain collective aesthetic taste, and its generation and evolution are the aesthetic choices and social mentality that directly point to the times. From the surface, the style is the language order and style of the work; from a deep perspective, the style also carries the cultural spirit of the society and the personality connotation of the author and is connected with the social and cultural spirit. Generally speaking, stylistics is an extremely important dimension of translation studies, especially the growth of stylistics has promoted the development of literary translation studies based on stylistics. When discussing the relationship between literary stylistics and novel translation, it is regarded as complicated. But unfortunately, the real combination of stylistics and translation studies only gradually emerged in the early 1980s, and only in the field of comparative studies of Chinese and Korean languages, the relevant research results are still very rare.

This study analyzes the mutual translation of Chinese and Korean literature by combining semantic analysis technology, explores the analysis of Chinese and Korean literature mutual translation through intelligent semantic analysis methods, and improves the effect of Chinese and Korean literature mutual translation.

2. Related Work

The similarity calculation method based on character matching determines the degree of similarity of two texts from the similarity of factors such as part-of-speech and form of the surface of the table text [1]. Reference [2] uses the minimum edit distance to measure the degree of similarity of texts. Reference [3] uses the Jaccard distance to represent the number of occurrences of k words in a text and the proportion of the corresponding words in the text. The degree of similarity between texts, where k is the size of the n-gram (n-gram) window used. The method of text similarity calculation cannot achieve the degree of simple string matching. Due to the diverse and complex semantic representations of Chinese, the similarity calculation based on surface strings cannot solve practical problems. It is necessary to achieve text similarity based on the semantic level. Matching involves the mining of semantics and the problem of how to represent [4]. Existing algorithms are mainly considered from two directions of statistical methods and semantic rules. The text similarity algorithm is used for statistical natural language processing; this similarity algorithm completely relies on the corpus and calculates the similarity in the text according to the word frequency of the keyword in the text [5]. Statistics-based text similarity algorithms can be divided into three models according to the different forms of constructing vectors: vector space model, topic model, and neural network model. The vector space model (VSM) represents the text as an independent feature vector group $(p_1, p_2, ..., p_n)$ and assigns specific weights according to the importance of its impact on semantics in the text. And the weight vector group is combined into a text vector space as the corresponding coordinate value, and the text similarity is calculated by calculating the vector angle between the two vectors [6]. VSM requires a large-scale high-quality complete corpus, but it is impossible to cover all corpora in reality, so there will be a high-dimensional matrix sparse problem [7].

The topic model believes that each text has its own topic, the topic is the link between the core keywords and the text, and the topic can represent the underlying semantic information of the text, so the similarity of the two texts does not only depend on the word frequency on the surface text. Word form and other information, mining the hidden semantic association of the text is the key [8]. The proposed LSA (latent semantic analysis) model organizes and summarizes the words in a large-scale corpus, generates a matrix composed of terms and documents, and uses singular value decomposition to filter out useless singular values for text reduction. Noise can solve the high-dimensional sparse problem and then convert the vector distance into the low-dimensional space to represent the text similarity [9]. Another common topic model, LDA (latent Dirichlet distribution) model, mainly models discrete data topic information and can identify topic information in corpora and large-scale text sets. LDA calculates the topic probability distribution by mining the representative words of the text, and the text obtains the text similarity by calculating the corresponding topic probability distribution, which makes LDA only suitable for the text similarity calculation of long texts. The number of representative words is small, and LDA cannot achieve good expected results in topic mining of short texts [10]. Reference [11] uses the implicit Dirichlet distribution to establish the topic space of the text to enhance the vectorized representation of the text. The implicit Dirichlet distribution only models the topic of the document and retains the topic information of the text that can represent the semantics of the text. It has a good effect on processing large-scale document sets. With the development of deep learning methods and the substantial improvement in computer computing performance in recent years, neural network models have also received extensive attention in text similarity calculation. The text similarity algorithm based on language rules mainly uses the artificially constructed semantic knowledge base to calculate the text similarity. Different semantic knowledge bases can use different organizational forms of concepts as the feature items of words to perform similarity calculation. Various organizational forms include the hyponymous relationship between concepts, synonymous and antonymous

relationships, and each in the tree-like concept hierarchy. Elements (such as the path length between nodes, network density, the depth of a node in a tree graph, the amount of information a node contains, etc.) [12].

Unsupervised hashing algorithms learn hash functions from unlabeled data and aim to keep the learned hash codes as similar as possible to the original data [13]. Locality-sensitive hash (LSH) [14] maps the original data into a compact hash code by selecting a hash function that satisfies the location sensitivity, which greatly reduces the dimension of the data, and calculates the distance between the compact hash codes. To speed up the query, the sample is queried. The hash algorithm based on graph structure [15] learns a suitable hash code by discovering the inherent neighborhood structure. In order to speed up the calculation, an anchor graph is used to obtain an easy-to-handle low-rank adjacency matrix, and finally multiple Bit hash code. The iterative quantization algorithm (ITQ) [16] first extracts feature vectors from high-dimensional data and retains the feature vectors before eigenvalues, and then maps these dimensionality-reduced feature vectors to the vertices of the hypercube and minimizes the mapping error, by iterating the above operations to perform hash learning.

3. Semantic Analysis Technology Algorithm

In order to improve the accuracy of semantic matching, literature translation text data is formed according to literature translation, and the data are processed.

Literary translation terminology is a special language system. Before sorting out the data, it is necessary to analyze the characteristics of the literary translation in order to clarify the characteristics of the data, so as to make an accurate judgment on the processing method of the data. In the process of literary translation, both Chinese and Korean language needs to be implemented according to strict standards. Furthermore, both parties must ensure that the language is accurate and unambiguous and that synonyms cannot be used in place of standard vocabulary. According to literary translation standards, all key instructions need to be read back in the process of literary translation, and both incorrect and incomplete read back will have an impact on the translation results.

After converting the text data of literary content, it is necessary to organize and label the text data. According to the literary translation standard, the content of literary translation mainly includes three types of dialogues: command-recitation, command-response, and request-response. Errors in recitation-type dialogues can be classified into errors in rehearsal information and lack of recitation content, and errors in question-and-answer dialogues can be classified into irregular language and incomplete answers. Among them, missing recitation and incomplete answer belong to the problem of missing information, so they are uniformly marked as incomplete content. Finally, the literature translation data are divided into four parts, which are labeled as correct, wrong in recitation, irregular in terminology, and incomplete in content. The labeling specifications for each type of data are as follows [17]:

3.1. Correct. Data where the instruction is consistent with the response message and the wording conforms to the standard are marked as correct.

3.2. Recitation Error. The data that are inconsistent with the readback information is marked as readback error, such as the readback error of altitude, heading, call sign, and runway number.

3.3. Irregular Terminology. The use of irregular words results in ambiguous information, or the responses contain content irrelevant to the instruction, such data are marked as irregular words.

3.4. Incomplete Content. It refers to the incomplete response to the content required by the directive, and this type of data is marked as incomplete.

According to the labeling specification, double labeling method is used for data labeling. If the two labeling results are the same, it is regarded as valid, and the labeled data are stored in the database. If the two labeling results are different, it will be judged by professional air traffic controllers to determine the label type to ensure the accuracy of data labeling.

After the labeling is completed, each sample in the dataset consists of instruction sentences, recitation sentences, and labels. Labels are represented by numbers, and 0, 1, 2, and 3 indicate the meanings of labels are correct, wrong in recitation, incomplete in content, and irregular in terms, respectively.

Deep networks are an important analytical method in natural language processing. Moreover, deep networks have a better ability to capture semantic matching and mismatching relationships, but as the number of network layers increases, the problem of parameter excess and overfitting will also follow. Therefore, through the study of deep network, this chapter proposes to use multilayer densely connected network and multilayer attention to achieve semantic analysis of literary translation. As shown in Figure 1, the network consists of four parts. First, sentence vector representation is obtained from the input mapping layer. Then, the sequences are semantically extracted using a densely connected network, and an attention mechanism is added to the network to make the sentences interact. Finally, the obtained semantic vector is subjected to operations such as pooling, and a fully connected network is used to achieve semantic matching verification.

Introducing rich information during input can promote the subsequent semantic analysis, and use the combination of word vector and feature flag for sentence representation. Through the input layer, the vector representation $C = \{C_1, C_2, \ldots, C_m\}$ of the instruction sentence and the vector representation $P = \{P_1, P_2, \ldots, P_n\}$ of the reply sentence can be obtained. Among them, C_j represents the vector representation of the jth word in the instruction, P_j represents the vector representation of the jth word in the

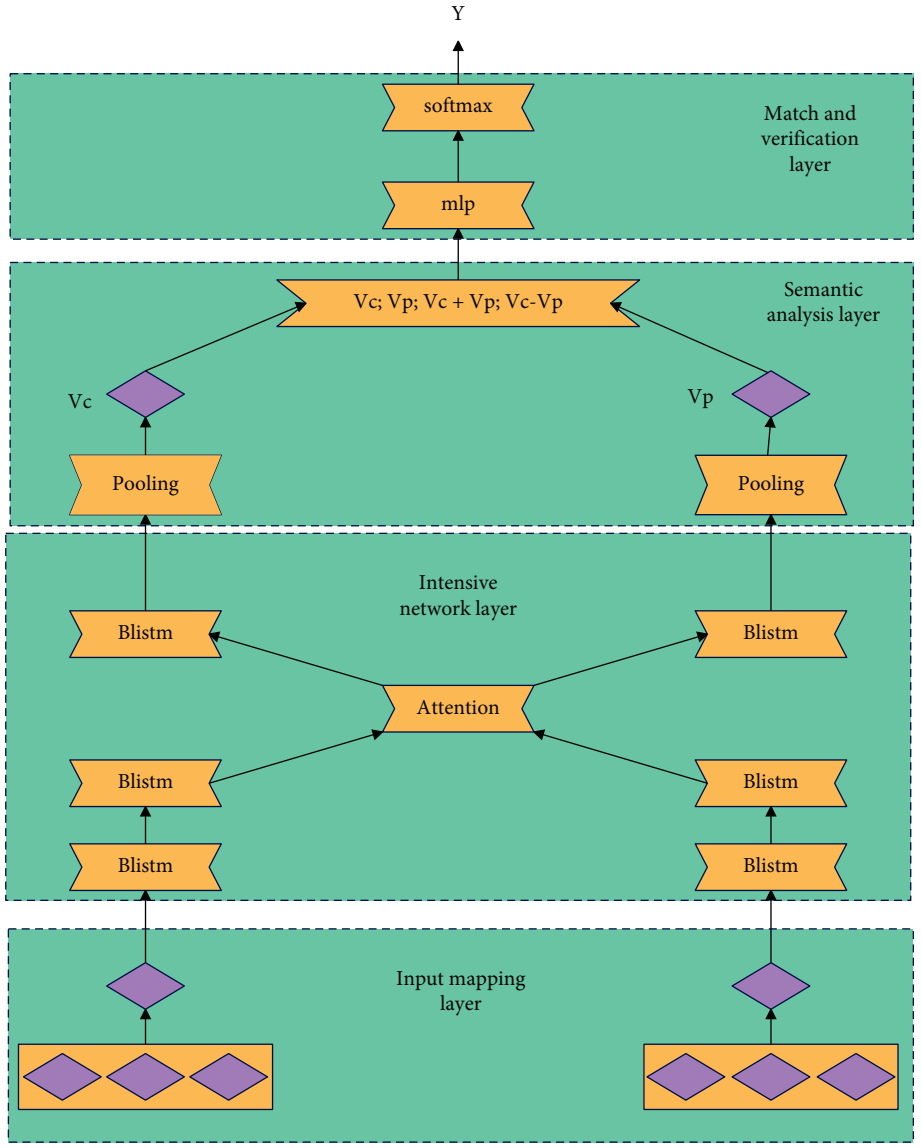


Figure 1: Semantic analysis model based on dense network and multilayer attention.

reply, and m and n represent the sentence lengths of the instruction and reply, respectively [18].

The stacking of the multilayer RNN network is to use the output sequence of the previous layer as the input of the next layer, which will cause the problem of gradient explosion and gradient disappearance, making the multilayer network difficult to train. However, the dense connection method can achieve better representation of semantic information through the reuse of features. Since BiLSTM is suitable for processing sequences, a multilayer BiLSTM structure is used in the dense network layer, and the sequence is semantically encoded by splicing. The network structure is shown in Figure 2.

Using a densely connected network not only hinders the transmission of information, but also retains the original information, so that the output value of the first layer can also be effectively transmitted to the last layer, avoiding problems such as gradient disappearance. The hidden states in the network are shown in formulas (1) and (2):

$$h_t^l = H\left(x_t^l, h_{t-1}^l\right), \tag{1}$$

$$x_t^l = \left[h_t^l, x_t^{l-1}\right], \tag{2}$$

where H is the BiLSTM structure and x_t^l represents the number of layers of the network. After the sequence obtained by the input layer is encoded by the dense network, the semantic vector $h_c = \left\{h_{C_1}, h_{C_2}, \ldots, h_{C_m}\right\}$ of the instruction and the semantic vector $h_P = \left\{h_{p_1}, h_{p_2}, \ldots, h_{p_n}\right\}$ of the reply can be obtained.

In order to obtain the semantic matching features of sentences, an attention mechanism is added to the model, and the calculation method of the attention mechanism is shown in formulas (3)–(5) [19]:

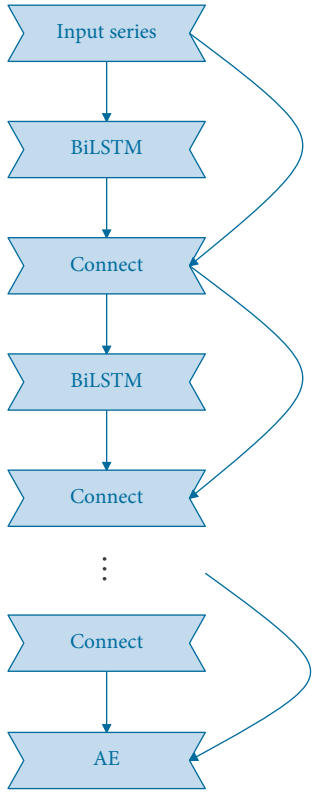


Figure 2: Structure diagram of densely connected network.

$$e_{ij} = F\left(h_{C_i^l}\right)^T F\left(h_{P_j^l}\right), \tag{3}$$

$$a_{ij} = \sum_{j=1}^{n} \frac{\exp\left(e_{ij}\right)}{\sum_{k=1}^{n}\left(e_{ik}\right)}, \tag{4}$$

$$a_{C_i} = \sum_{j=1}^{n} a_{ij} h_{P_j}, \tag{5}$$

where $F(\cdot)$ represents the feedforward neural network and e_{ij} represents the relative weight of each word in the matrix.

Two connection methods of attention mechanism are used. The first one is to connect the attention of a single layer, that is the sentence vector is extracted through the dense connection network to extract semantic features, and then the feature vector output by the dense connection network is used to calculate the attention weight. Finally, the calculated results are spliced with the output vector of the densely connected network.

The second approach is to incorporate multiple layers of attention in densely connected networks. The method is to splicing the attention weight with the output value of BiLSTM after the weight distribution of each word in the opposite sentence is obtained through the attention calculation. Moreover, it takes the semantic vector containing the matching relationship as the input of the next layer. After adding the attention mechanism, the state of the hidden layer of the densely connected network is shown in formulas (6) and (7) [20]:

$$h_t^l = H\left(x_t^l, h_{t-1}^l\right), \tag{6}$$

$$x_t^l = \left[h_t^{l-1}, a_t^{l-1}, x_t^{l-1}\right], \tag{7}$$

where H is the BiLSTM structure, l is the number of layers of the network, and x_t^l is the input of the first layer sequence at time t. At this time, the input of the lth layer sequence at time t is obtained by splicing three parts, and x_t^{l-1}, h_t^{l-1}, and, a_t^{l-1} represents the input, output, and attention weight of the previous layer at the same time.

Since the densely connected network will lead to the problem of excessive parameters as the network deepens, this will lead to excessive pressure on the final fully connected layer. Therefore, adding an auto-encoder at the end of the network to compress the dimension can help compress the huge vector representation obtained by the densely connected network, while maintaining the original information. The network structure after adding multilayer attention and dimensional compression layers is shown in Figure 3.

The semantic feature analysis layer is to process and analyze the output of the previous layer, extract semantic matching features, and obtain vectors for semantic matching verification. The method adopted by the model is to perform maximum pooling and average pooling operations on the semantic vectors obtained by the previous layer. Then, it uses an association strategy on the vectors obtained after pooling to ensure that the integrity of the feature information can be preserved while transforming the features. The structure of the semantic feature analysis layer is shown in Figure 4.

First, the semantic vectors h_c and h_i of instructions and responses are processed by means of average pooling and maximum pooling. The calculation methods are shown in formulas (8)–(13):

$$v_{\text{arg}}^C = \frac{1}{m}\sum_{i=1}^{m} h_{C,i}, \tag{8}$$

$$v_{\text{arg}}^C = \max_{i=1}^{m}\left(h_{C,i}\right), \tag{9}$$

$$V_C = \left[v_{\text{arg}}^C; v_{\max}^C\right], \tag{10}$$

$$v_{\text{arg}}^P = \frac{1}{n}\sum_{i=1}^{n} h_{P,j}, \tag{11}$$

$$v_{\max}^P = \max_{j=1}^{n}\left(h_{P,j}\right), \tag{12}$$

$$V_P = \left[v_{\text{arg}}^P; v_{\max}^P\right]. \tag{13}$$

The pooled semantic feature vector representations of commands and replies can be obtained as V_C and V_P, respectively. In order to ensure the integrity of feature information and transform features explicitly, an association strategy is used to represent feature semantics, that is the results of vector splicing, parametric addition, and parametric subtraction are spliced together. The calculation method is shown in the following formula:

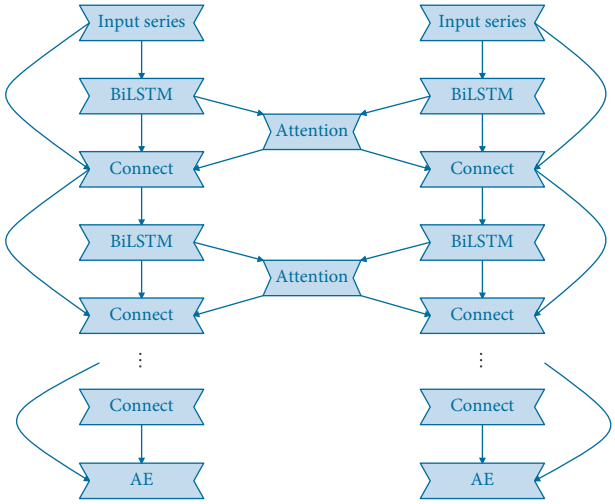


Figure 3: Densely connected network structure with multilayer attention added.

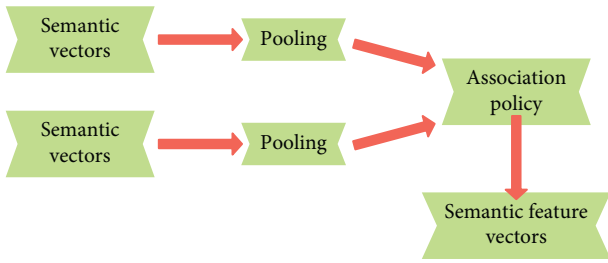


Figure 4: Semantic feature analysis layer structure.

$$v = \left[v_C; v_p; v_C + v_p; v_C - v_p\right]. \tag{14}$$

The task of the semantic matching verification layer is to make judgments on the semantic matching results of the instructions and responses. In the model, a two-layer fully connected neural network is used to complete the semantic matching verification work. The purpose is to input the matching vector v into the hidden layer to further mine the matching information between the instruction and the reply to obtain deep matching features. First, the semantic matching features are calculated through a two-layer fully connected network. The calculation method is shown in the following formula:

$$x = \left(x_1, x_2, x_3, x_4\right)^T = W_2 \cdot \sigma\left(W_1 \cdot v + b_1\right) + b_2, \tag{15}$$

where W_1 and W_2 represent the weight matrices of the hidden layer and the output layer in the fully connected neural network, respectively. b_1 and b_2 represent the bias of the hidden layer and output layer, respectively, and α represents the activation function, and the ReLU function is used here.

Then, the matching score is normalized by the softmax function to obtain a probability vector, which is the probability that the input sample identified by the model belongs to each data category. The calculation method is shown in the following formula:

$$p\left(y = N_i|x\right) = \frac{e^{x^T\theta_j}}{\sum_{m=1}^{M} e^{x^T\theta_m}}, \tag{16}$$

where $p(y = N_i|x)$ represents the probability that the sample to be discriminated belongs to the category N_i ($i = 1, 2, 3, 4$).

In the process of model training, each training instance is a sample, that is, a set of dialogues consisting of instructions and responses. The cross-entropy function is selected as the optimization target in the model training. Through the back-propagation and gradient descent algorithms, the parameters of the network are adjusted through multiple iterations, so that the value of the cross-entropy function is minimized. The cross-entropy function is shown in the following formula:

$$\text{loss} = -\sum_{n=1}^{N}\left[y^{(i)}\log\left(p^{(i)}\right) + \left(1 - y^{(i)}\right)\log\left(1 - p^{(i)}\right)\right], \tag{17}$$

where $y(i)$ represents the true label of the ith input sample and $p(i)$ represents the predicted label.

In the process of model training, the optimization algorithm used is Adam, because it has the advantages of high efficiency and simple parameter adjustment, and has great advantages compared with other types of random optimization algorithms. The Adam algorithm can adapt to unstable objective functions by calculating the first-order moment estimation and the second-order moment estimation of the gradient, and can design independent adaptive learning rates for different parameters. The Adam algorithm combines the advantages of the root mean square propagation algorithm and the adaptive gradient algorithm and can also solve the coefficient gradient and noise problems.

In order to evaluate the results of model classification, the test accuracy is uniformly used as the evaluation index. The calculation method is shown in the following formula:

$$ACC = \frac{N_{\text{correct}}}{N}, \tag{18}$$

where N represents the total number of samples in the test set, and N_{correct} represents the number of samples in the test sample whose semantic discrimination results are consistent with the true labels.

4. Analysis System of Mutual Translation of Chinese and Korean Literature Based on Semantic Analysis

According to the needs of the platform, this article designs a new technical architecture of the translation business management platform based on the SOA idea, as shown in Figure 5.

According to the needs of the platform, some functions are published as web services to facilitate the expansion and invocation of external systems. Some method functions are declared as web methods and packaged in specific class web services and published in the form of web services, as shown in Figure 6.

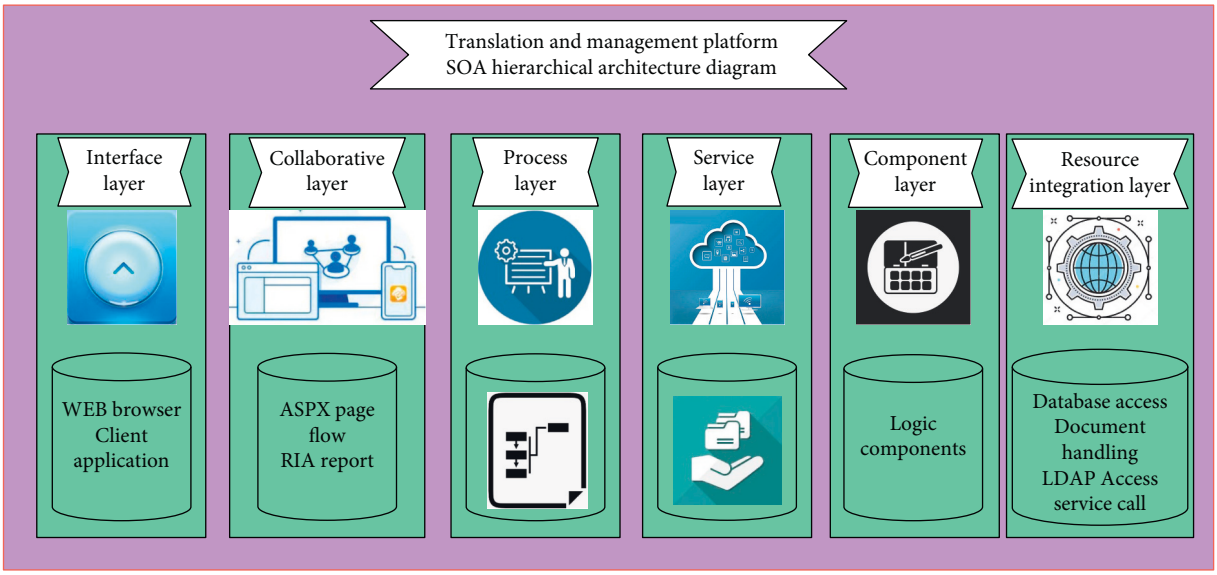


Figure 5: System technical architecture.

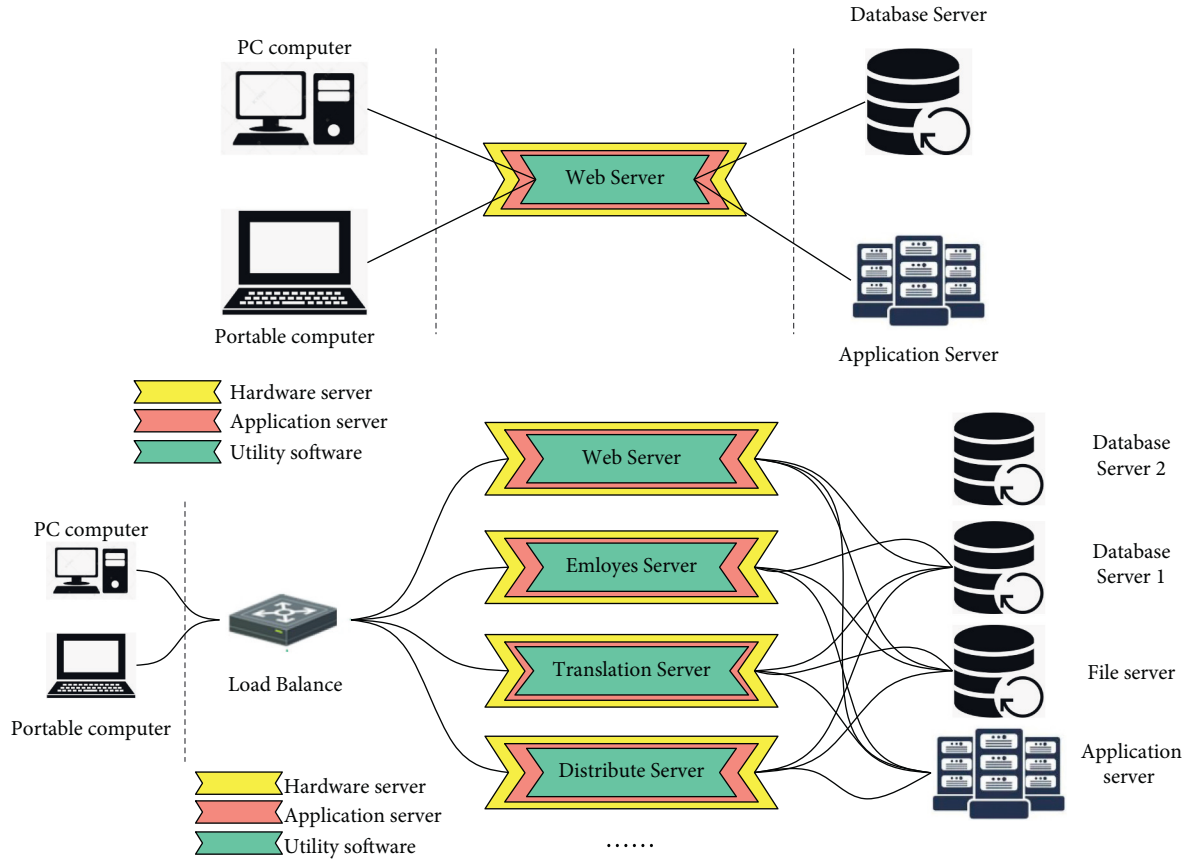


Figure 6: Webservice connection.

On the basis of constructing a balanced dataset, the method of ensemble learning is introduced. By comprehensively considering the classification results of multiple base classifiers, the classification accuracy of negative class samples is not reduced as much as possible while ensuring the classification accuracy of positive class samples. The term recognition model is shown in Figure 7.

The overall architecture design diagram is shown in Figure 8.

The first part: 1. Thesaurus loading: When starting the dictionary, the system will query whether the local thesaurus exists, and if the database is started for the first time, the thesaurus file will be loaded. 2. Enter the system interface: If it is not the first time to start and the database has loaded the

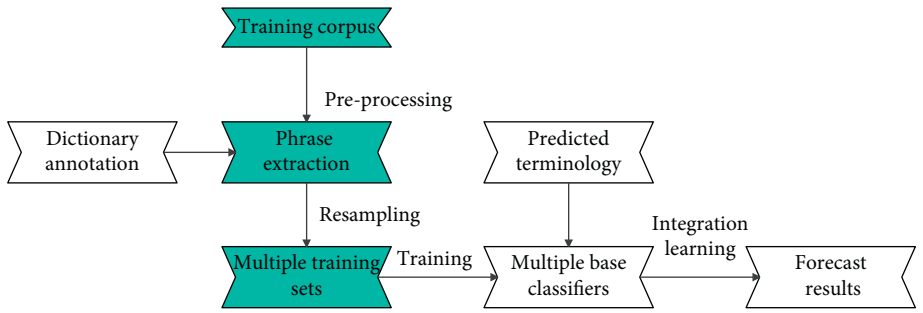


Figure 7: Term recognition model.

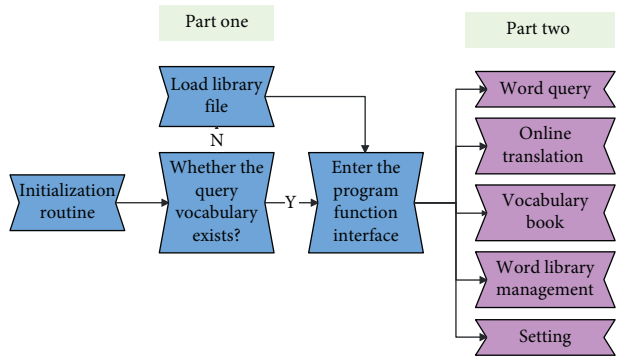


Figure 8: Overall design of the system.

Table 1: Evaluation of translation effect of Chinese-Korean literature mutual translation system based on semantic analysis.

Num	Intertranslation effect	Num	Intertranslation effect	Num	Intertranslation effect
1	85.53	25	78.30	49	78.06
2	85.12	26	86.69	50	82.60
3	81.04	27	79.31	51	86.08
4	84.33	28	86.84	52	81.69
5	88.58	29	83.02	53	86.59
6	79.36	30	84.72	54	87.60
7	87.32	31	83.87	55	78.94
8	82.44	32	85.20	56	78.19
9	81.98	33	78.94	57	86.88
10	80.83	34	85.74	58	84.38
11	84.35	35	81.76	59	88.40
12	84.88	36	80.31	60	83.96
13	82.04	37	78.80	61	88.71
14	83.68	38	82.22	62	84.81
15	81.27	39	81.27	63	84.71
16	79.77	40	79.82	64	88.61
17	81.86	41	80.34	65	83.91
18	86.44	42	79.31	66	80.14
19	87.51	43	78.23	67	85.69
20	81.17	44	85.64	68	88.69
21	84.21	45	78.69	69	87.07
22	80.02	46	85.08	70	82.25
23	82.94	47	83.20	71	78.10
24	78.67	48	83.00	72	84.64

thesaurus file, skip the thesaurus loading process and directly start the program interface. The second part: After entering the program function interface, the system is regarded to a major function of word query: The system local word query function is as follows: (1) Input words or phrases. (2) The word query system automatically searches and compares the input content with the local thesaurus and displays the relevant matching words in the drop-down list. (3) It displays the query result. After clicking the word to be translated in the drop-down list, the program enters the result display interface and displays the parts of speech and definition of the word stored locally.

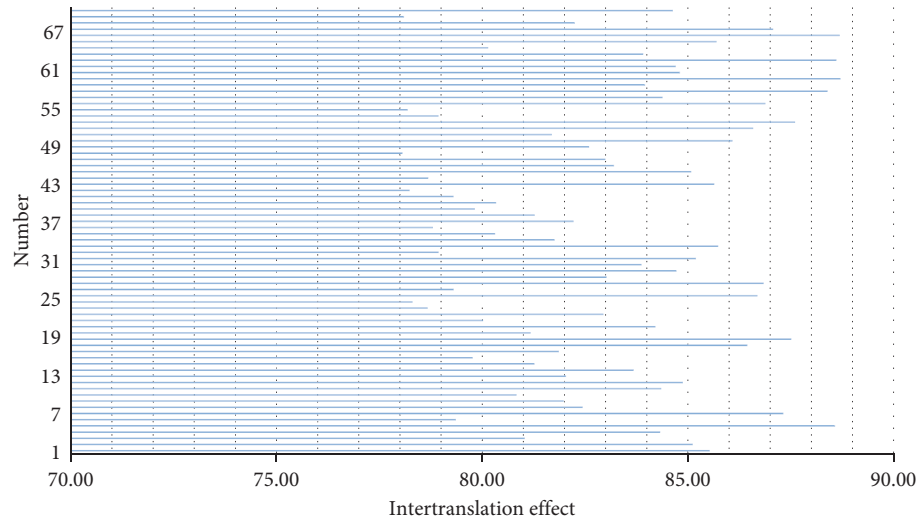


Figure 9: Statistical diagram of translation effect of Chinese-Korean literature mutual translation system based on semantic analysis.

The above constructs a Chinese-Korean literature translation system based on semantic analysis. Next, this study evaluates the effect of the system, analyzes the effect of mutual translation of Chinese and Korean literary works, simulates it through the MATLAB simulation platform, and obtains the results as shown in Table 1 and Figure 9.

From the above analysis, it can be seen that the Chinese-Korean literature mutual translation system based on semantic analysis proposed in this article has a good translation effect and can effectively promote Sino-Korean literature exchanges.

5. Conclusion

Contemporary linguistics and translation researchers have broken through the traditional translation research method of using words to analyze words and sentences to sentences, and then expand the translation unit to the discourse level. Translation research is no longer limited to the study of sentences in the original language and the target language, but expands the field of vision to the communicative function of the context and language. For example, discourse analysis treats text as a communicative activity rather than a set of stereotyped text structures, while pragmatics studies the use of language rather than language as an abstract system. It can be seen that the communication and context of language make discourse analysis and translation closely related. Knowledge and research on discourse analysis can not only help us understand the original text correctly, but also provide theoretical basis for choosing the appropriate translation. This study combines semantic analysis technology to analyze the mutual translation of Chinese and Korean literature and explores the analysis of Chinese and Korean literature mutual translation through intelligent semantic analysis methods. The simulation analysis results show that the Chinese-Korean literature mutual translation system based on semantic analysis proposed in this article has a good translation effect and can effectively promote Chinese-Korean literature exchanges.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This study was sponsored by Konkuk University.

References

[1] E. J. Tao, "A picture's worth: the future of copyright protection of user-generated images on social media," *Indiana Journal of Global Legal Studies*, vol. 24, no. 2, pp. 617–636, 2017.

[2] P. Devarapalli, "Machine learning to machine owning: redefining the copyright ownership from the perspective of Australian, US, UK and EU law," *European Intellectual Property Review*, vol. 40, no. 11, pp. 722–728, 2018.

[3] H. B. Essel, R. B. Lamptey, and K. O. Asiamah, "Awareness of law students of Kwame Nkrumah University of Science and Technology (KNUST) on copyright law: emphasis on photocopying and fair use," *All Nations University Journal of Applied Thought*, vol. 6, no. 2, pp. 71–87, 2019.

[4] B. Bodó, D. Gervais, and J. P. Quintais, "Blockchain and smart contracts: the missing link in copyright licensing?" *International Journal of Law and Info Technology*, vol. 26, no. 4, pp. 311–336, 2018.

[5] T. He, "The sentimental fools and the fictitious authors: rethinking the copyright issues of AI-generated contents in China," *Asia Pacific Law Review*, vol. 27, no. 2, pp. 218–238, 2019.

[6] C. S. Myers, "Plagiarism and copyright: best practices for classroom education," *College & Undergraduate Libraries*, vol. 25, no. 1, pp. 91–99, 2018.

[7] J. H. Rooksby and C. S. Hayter, "Copyrights in higher education: motivating a research agenda," *The Journal of Technology Transfer*, vol. 44, no. 1, pp. 250–263, 2019.

[8] N. H. Sharfina, H. Paserangi, F. P. Rasyid, and M. I. N. Fuady, "Copyright issues on the prank video on the Youtube," in *Proceedings of the International Conference on Environmental and Energy Policy (ICEEP 2021)*, pp. 90–97, October 2021.

[9] K. Nekit, H. Ulianova, and D. Kolodi, "Website as an object of legal protection by Ukrainian legislation," *Amazonia Investiga*, vol. 8, no. 21, pp. 222–230, 2019.

[10] V. Lunyachek and N. Ruban, "Managing intellectual property rights protection in the system of comprehensive secondary education," *Public Policy and Administration*, vol. 17, no. 1, pp. 114–125, 2018.

[11] S. Schroff, "An alternative universe? Authors as copyright owners- the case of the Japanese Manga Industry," *Creative Industries Journal*, vol. 12, no. 1, pp. 125–150, 2019.

[12] M. Finck and V. Moscon, "Copyright law on blockchains: between new forms of rights administration and digital rights management 2.0," *IIC - International Review of Intellectual Property and Competition Law*, vol. 50, no. 1, pp. 77–108, 2019.

[13] N. K. S. Dharmawan, "Protecting traditional Balinese weaving trough copyright law : is it appropriate?" *Diponegoro Law Review*, vol. 2, no. 1, pp. 57–84, 2017.

[14] J. P. McSherry, "The labor of literature: democracy and literary culture in modern Chile by jane D griffin," *Journal of Global South Studies*, vol. 35, no. 2, pp. 448–450, 2018.

[15] G. Carugno, "How to protect traditional folk music? Some reflections upon traditional knowledge and copyright law," *International Journal for the Semiotics of Law - Revue internationale de Sémiotique juridique*, vol. 31, no. 2, pp. 261–274, 2018.

[16] R. Matulionyte, "Empowering authors via fairer copyright contract law," *University of New South Wales Law Journal, The*, vol. 42, no. 2, pp. 681–718, 2019.

[17] E. Hudson, "The pastiche exception in copyright law: a case of mashed-up drafting?" *Intellectual Property Quarterly*, vol. 2017, no. 4, pp. 346–368, 2017.

[18] M. Sag, "The new legal landscape for text mining and machine learning," *Journal of the Copyright Society of the U.S.A*, vol. 66, no. 2, pp. 291–367, 2019.

[19] S. Geiregat, "Digital exhaustion of copyright after CJEU judgment in Ranks and Vasi¦evičs," *Computer Law & Security Report*, vol. 33, no. 4, pp. 521–540, 2017.

[20] W. Slauter, "Introduction: copying and copyright, publishing practice and the law," *Victorian Periodicals Review*, vol. 51, no. 4, pp. 583–596, 2018.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 3684422, 12 pages
https://doi.org/10.1155/2022/3684422

Research Article

Garden Landscape Design of Sponge City Residential Area Based on Digital Technology

YunJuan Sun[1] **and Fang Jiang**[2]

[1]*Fine Arts School, South-Central Minzu University, Wuhan 430074, China*
[2]*Hubei University of Education, Wuhan 430205, China*

Correspondence should be addressed to YunJuan Sun; 3091308@mail.scuec.edu.cn

Received 1 April 2022; Accepted 4 May 2022; Published 31 May 2022

Academic Editor: Wen Zhou

In order to improve the effect of garden landscape design in the residential area of sponge city, this paper combines digital technology to carry out the garden landscape design of the residential area of sponge city, and conducts the research on it through the intelligent system. Moreover, this paper studies the digital color processing algorithm and proposes a digital technology-based color processing algorithm for the garden landscape design of the residential area of the sponge city. In addition, this paper builds a garden landscape design system for sponge city residential areas on the basis of algorithms. Through the simulation test research, we can see that the garden landscape design of sponge city residential area based on the digital technology proposed in this paper can meet the needs of the sponge city garden landscape design.

1. Introduction

Sponge city is a new generation of urban stormwater management concept, which means that the city has good "elasticity" in adapting to environmental changes and responding to natural disasters caused by rainwater, and can also be called a "water elastic city." It is likened to a city like a sponge, which can absorb, store, infiltrate, and purify rainwater on the spot when there is rainfall, replenish groundwater, and regulate the water cycle. However, in the event of drought and water shortage, it has the conditions to release the stored water and make use of it. The international term is "Low-Impact Development Stormwater System Construction." Its essence is to change the rainwater through pipelines, pumping stations, and other gray facilities to quickly discharge the terminal concentrated mode to the slow discharge and slow-release source dispersion mode through rain gardens, green roofs, wetlands, and other green "sponges." The sponge city advocated is to organize and link the rivers, lakes, and groundwater systems in the city through ecological infrastructure and engineering technology to form a cooperating whole. These include a variety of green "sponges" such as rain gardens, green roofs, ecological wetlands, and forests.

The proposal of the sponge city theory marks a new understanding of the urban rainwater problem, and its adoption in official documents means that the ecological rainwater management ideas and technologies have moved from academia to the management level and have been effectively promoted in practice. The residential green space occupies an important position in the urban green space, and the green area is relatively large and the environmental benefits are good, which undoubtedly provides good conditions for the "sponge city" and urban ecological rainwater management and the construction of rainwater gardens.

In the continuous expansion of the city, high-rise residential buildings are rising everywhere, and the proportion of impermeable roads is increasing, resulting in rain disasters in low-lying areas every rainy day. The idea of a sponge city is to lay rainwater pipes in the traditional way while adopting development technology with less impact so that hydrology and ecology cannot be affected, and in the event of natural disasters, it has the "elasticity" similar to a sponge. In the construction of a sponge city, it needs to be

controlled at the source, in the middle and in the later stage with the help of less influential development technical solutions. Source control measures include green roofs, shallow ditch for vegetation, seepage wells, early rainwater abandonment, etc.; mid-term control measures include rainwater sedimentation ponds, permeable pavement, retention ponds, sunken green spaces, etc.; and late-stage control measures include yes, wet ponds, stabilization ponds, infiltration ponds, constructed wetlands, rain gardens, etc. The requirements of modern people for the living environment are not only limited to the grade and quality of the house, but the requirements for the living environment are getting higher and higher. Garden landscape is an important part of the urban living environment and plays an important role in improving the living environment and quality of life in residential areas. Therefore, the quality of residential landscape design also determines the spatial quality of the entire residential project to a large extent. Landscape plays a vital role in the success or failure of a project.

In this paper, digital technology is used to design the garden landscape of the residential area of the sponge city, and the research of the garden landscape design of the residential area of the sponge city is carried out through the intelligent system, so as to improve the effectiveness of the garden landscape design of the residential area of sponge city.

2. Related Work

Literature [1] studies the recycling of urban rainwater adopts the sunken optimization design method and transforms the urban green space square, which can not only prevent the long-term erosion of rainwater but also prevent part of the green space from subsidence, allowing rainwater to penetrate into the city. In the soil, the natural cycle is completed. Literature [2] carried out in-depth research on the reconstruction plan, the purpose of which is to effectively solve and utilize the natural precipitation problem based on the concept of ecological sponge city and the method of "ecological drainage + water drainage." Literature [3] conducted a detailed investigation and research on wetland parks, which effectively solved the problem of urban waterlogging. The foundation is the rainwater safety pattern. As a green sponge complex, the function of the wetland park is mainly to carry urban rainwater. The urban rainwater is collected into the wetlands, and the wetlands are used for digestion. The development model of "water-collecting urban areas-water-collecting wetlands" has been formed [4]. The multilevel sponge terrain is created at a low cost by the fill and dig technology, and the multilevel wetland system is constructed to form a more favorable topography for the system [5]. The construction of a multilevel and multifunctional wetland system can realize the functions of gathering, purifying, and replenishing groundwater. In addition to realizing ecological circulation, it can also play a role in soil and biological purification. The purified rainwater flows into low-lying areas to replenish groundwater resources [6].

Literature [7] introduces the concept and function of planting shallow grass trenches in detail and expounds on its design. Literature [8] explores the rainwater utilization landscape of different sites through the research on the rainwater block project and summarizes the landscape rainwater facilities such as road tooth expansion pool, rainwater lawn planting, rainwater garden planting belt, and grass planting ditch. Literature [9] explored different aspects of rainwater utilization and the concept of green streets and proposed different gardening elements to improve the rainwater treatment capacity. Literature [10] studies international stormwater management from the perspective of landscape optimization and proposes the selection and collocation method of plant species on-site under the premise of stormwater management. Literature [11] discusses rainwater management from the perspective of landscape ecology, proposes the concept of green rainwater facilities, and explains the security pattern of landscape ecology. Literature [12] studies the aesthetics and safety aspects of rainwater landscape construction and proposes optimization measures and optimization design procedures for flood management facilities.

Literature [13] conducted a comprehensive study on the natural hydrological conditions of the city and pointed out the related problems of the overall planning of the sponge city. Only with the help of physical or biological technology, the natural ecology can be fully utilized to build perfect urban drainage, leakage prevention, roads, green space, and other systems; reduce the urban land area as much as possible; and restore the ecological appearance of the city. Literature [14] deeply studied the urban low-impact development of rainwater systems and proposed that to build a sponge city, the impact on the water circulation system must be reduced, and the green space, squares, wetlands, etc., in the city must be fully utilized. Literature [15] deeply analyzed the problems faced by the construction of sponge cities, and put forward the following suggestions: first, we should take the government the leading role to establish a perfect water cycle treatment system; secondly, we should strengthen the management of the approval process, and at the same time attract capital from all aspects. attention, broaden the source of funds, then establish an incentive mechanism or business model to encourage and promote the construction of sponge cities, and finally call on the whole society to pay attention to and participate in urbanized water environment governance, which can attract international cooperation to improve governance and construction. le Polain de Waroux et al. [16] pointed out that only by breaking the limitations of traditional concepts and realizing innovation in urban construction can we build a new ecological civilization city, promote the development of sponge cities, use ecological land, and create an ecological water cycle system. Literature [17] believes that the management of rainwater resources is currently in a disordered state and has not been incorporated into the overall planning of urban water resources. Rainwater resources are not only underutilized but also have become an important factor in urban waterlogging. Rainwater should be considered in planning.

Literature [18] summarizes and classifies stormwater facilities in combination with the concept of low-impact development of sponge cities and evaluates the design effect of Shangyang Avenue through the construction of SWMM, thus confirming that the road of the concept of a sponge city is closer to the hydrological environment than before. Literature [19] takes landscape control of stormwater as a new perspective and summarizes the calculation methods and selection methods related to stormwater design under different stormwater control objectives. Literature [20] explores the design of rainwater gardens, which includes rainwater design. The types and functions of gardens, the design and calculation methods of rain gardens in different spatial states, and the selection of relevant green plant species. It also analyzes the influencing factors of the growth environment of green plants and explores the matching methods and methods of green plants and their later maintenance measures.

3. Digital Garden Landscape Color Processing Algorithm

The CIEXYZ color space was born to solve the problem of negative values in the CIE1931RGB color space. CIERGB needs to use negative values when matching the color of visible light, which is not only inconvenient to use but also difficult to understand. The three primary colors of X, Y, and Z selected by the CIE do not correspond to visible colors. They are the three primary colors in my imagination. The specific values are derived from the CIE1931RGB system. Among them, all the X, Y, and Z values in CIEXYZ are positive numbers, and the human eye's response to brightness is represented by the Y value. The conversion relationship between CIEXYZ and CIERGB is shown in the following formula:

$$\begin{bmatrix} \overline{x}(\lambda) \\ \overline{y}(\lambda) \\ \overline{z}(\lambda) \end{bmatrix} = \begin{bmatrix} 2.7689 & 1.7517 & 1.1302 \\ 1.0000 & 4.5907 & 0.0601 \\ 0.0000 & 0.0565 & 5.5943 \end{bmatrix} \begin{bmatrix} \overline{r}(\lambda) \\ \overline{g}(\lambda) \\ \overline{b}(\lambda) \end{bmatrix}. \tag{1}$$

After the transformation coefficient is normalized, it is shown in the following formula:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.490 & 0.310 & 0.200 \\ 0.177 & 0.813 & 0.011 \\ 0.000 & 0.010 & 0.9903 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}. \tag{2}$$

It is worth noting that, in practical applications, different color devices have different conversion relationships due to different color characteristics, and these relationships are recorded in the color profile file.

The CIELAB color space is a nonlinear transformation space of the CIEXYZ space, which was developed to solve the inhomogeneity of the chromaticity space in the past. The CIELAB uses L, a, and b , the three different coordinate axes to describe any color in nature, where L represents lightness, the bottom is black, and the top is white. a means red/green, $+a$ means red, $-a$ means green, b means yellow/blue, $+b$ means yellow, and $-b$ means blue. Studies have shown that the prediction of hue in CIELAB space is not accurate, especially in the prediction of blue hue, which will not be described in detail here. The three-dimensional structure of the CIELAB color space is shown in Figure 1:

The conversion formula between the CIELAB color space and the CIEXYZ color space is as follows:

$$\begin{cases} L = 116 f\left(\dfrac{Y}{Y_0}\right) - 16 \\ a = 500\left[f\left(\dfrac{X}{X_0}\right) - f\left(\dfrac{Y}{Y_0}\right)\right], \\ b = 200\left[f\left(\dfrac{Y}{Y_0}\right) - f\left(\dfrac{Z}{Z_0}\right)\right] \end{cases} \tag{3}$$

$$f(a/b) = \begin{cases} \left(\dfrac{a}{b}\right)^{1/3}, a/b > 0.00856 \\ 7.787\left(\dfrac{a}{b}\right)^{1/3} + \dfrac{16}{116}, a/b \le 0.00856. \end{cases}$$

In the following formula (3), XYZ is the sample color tristimulus value, $X_0Y_0Z_0$ is the reference white tristimulus value under the standard light source, and generally the tristimulus value of a D50 light source or D65 light source is used.

The PCS under the ICC specification is responsible for two tasks. One is the chromaticity purpose conversion, and its PCS value is the original chromaticity value. Another task is perceptual purpose transfer, and its PCS value is the perceptual property of the color appearance of the replicated image in the reference viewing environment. Figure 2 shows the role of PCS color space in color management.

PCS link space is generally CIEXYZ and CIELAB. This is because there is a simple linear conversion between CIEXYZ and most of the international standardized RGB spaces such as PAL RGB, NTSC RGB, and sRGB. However, the CIEXYZ space is a space with nonuniform color vision, and the mapping relationship with the printer CMYK space cannot be expressed by analytical expressions. In order to make up for this deficiency, the ICC stipulates that CIEXYZ is used to define the chromaticity value of the original and then converts it into the CIELAB color space to describe the human eye's perception properties under observation conditions. The role of the PCS color space under the ICC standard in the color management system is shown in Figure 3.

It should be pointed out that there is inhomogeneity in the hue of the CIELAB color space, conversion errors will inevitably occur during color gamut mapping, and the color difference formula based on CIELAB can only calculate color blocks, but not calculate the color difference of complex space images.

CIELAB, CIEXYZ, or CIECAMO2 are all based on simple color blocks to describe color, and none of them can meet the prediction of image color appearance related to visual adaptation and visual spatial and temporal

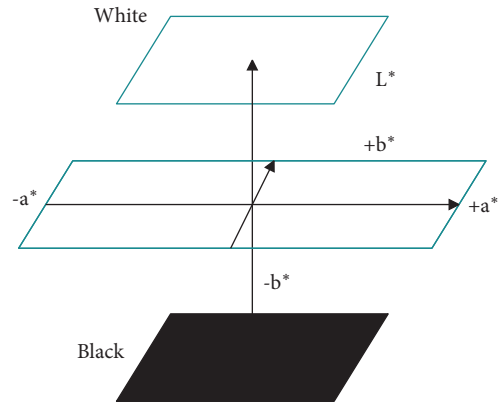


Figure 1: CIELAB color space.

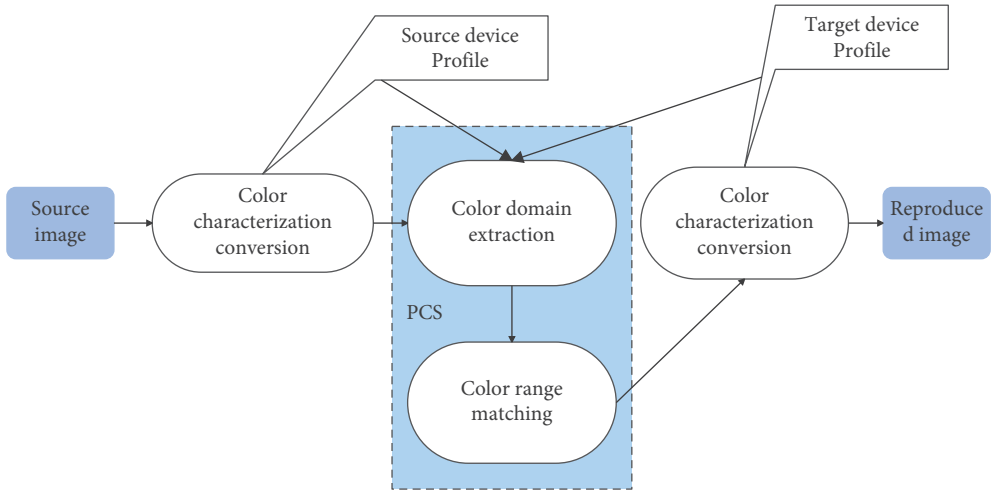


Figure 2: The role of PCS in the color management system.

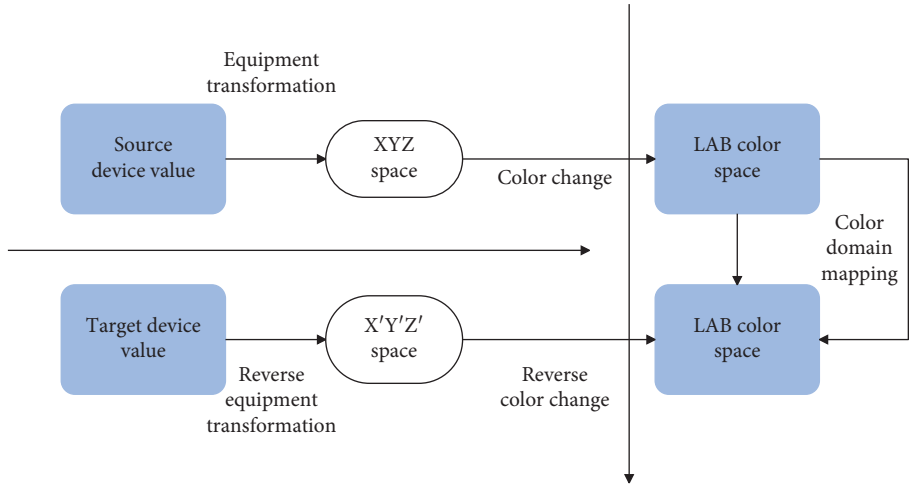


Figure 3: PCS color space under the ICC standard.

characteristics. However, whether it is a color electronic image or a printed product, it cannot be a single color block, so PCS should be undertaken by an image color appearance model. The image color appearance model iCAM is established on the basis of CIECAM02, which takes into account that the human eye changes its perception of white point with the difference of spatial frequency. Therefore, after using CSF to simulate the human eye filtering process,

the maximum stimulus point of the image is used as the reference white. The IPT (Intensity Protan Tritan) color space is both a uniform color space and an opposite color space. Its main advantage is that the prediction of hue is more accurate than in other color spaces in the past, and it can be used in the color reproduction process to improve the reproduction quality of printed matter. iCAM finally transforms the color into the IPT opposite color space, which not only simplifies the transformation method of CIECAMO2 but also predicts the hue more accurately. Figure 4 shows the role relationship of the iCAM color appearance model as the PCS link space in the color management system.

In addition to the above-mentioned PCS color space selection method based on color appearance, there is also a spectrum-based color management and replication technology, as shown in Figure 5. Metamerism is ubiquitous in color reproduction, and if PCS takes the form of spectral reflection, two spectrally matched colors will maintain the same appearance in any lighting environment. In addition, the spectral data, as the original data of color generation, retains the most information and the greatest flexibility, realizes the accurate prediction of color, and can fundamentally eliminate the fundamental defects of traditional printing and color management technology.

The spectrum-based color management method is still in the theoretical research stage, and the specific implementation requires professional equipment and technical personnel. There is still a long way to go before it can be widely used in practice. The main difficulty is that the digital channels of color physical devices cannot be too many, so the spatial conversion between the spectral data of dozens of channels and the digital drive of the device is not an injective relationship. The acquisition of spectral data, how to realize the color gamut description of high-dimensional spectral data, color gamut matching, and color correction, data processing of multispectral images, and how to store, compress, transmit, and the display is the focus and difficulty of research.

The human visual system is a very complex system. When it perceives external color stimuli, the size, structure, shape of the stimulus itself, the external environment, and the state of the observer can all affect it. Therefore, it is impossible to accomplish the purpose of color management only by establishing the tristimulus value model of color.

When two color samples with the same tristimulus value, under different observation environment, background, sample size, sample shape, etc., the human visual perception is different. Moreover, different backgrounds will have different color perceptions, as shown in Figure 6.

In general, the color changes toward the complementary color of the background color; that is, if the background is darkened, the color will be brighter. If the background is redder, the color looks greener; the yellower the background, the bluer the color feels, which is called the color appearance phenomenon. There are many kinds of color appearance phenomena, such as simultaneous contrast, amplification, Hunt effect, Stevens effect, Abney effect, etc., which will not be introduced in detail here. Chromatic adaptation

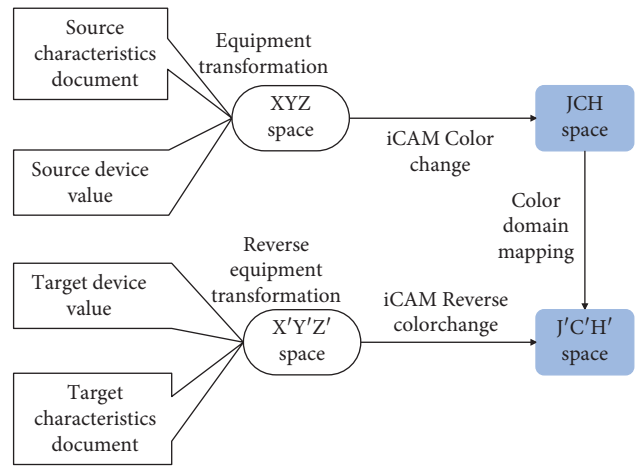


Figure 4: The conversion process of iCAM image color appearance model as PCS space.

transformation appears to solve the color appearance phenomenon of color perception under different light sources or observation conditions, and its transformation parameters are based on a large number of corresponding color data sets.

The environmental parameters of the CATO2 model are selected, and then the color adaptation transformation can be performed:

Step 1. First, the tristimulus values XYZ are converted to the cone response space, as shown in the following formula:

$$\begin{bmatrix} R_W \\ G_W \\ B_W \end{bmatrix} = M_{CAT02} \begin{bmatrix} X_W \\ Y_W \\ Z_W \end{bmatrix}, \quad \begin{bmatrix} R \\ G \\ B \end{bmatrix} = M_{CAT02} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}. \tag{4}$$

Among them,

$$M_{CAT02} = \begin{bmatrix} 0.7328 & 0.4296 & -0.1624 \\ -0.7036 & 1.6975 & 0.0061 \\ 0.0030 & 0.0136 & 0.9834 \end{bmatrix}. \tag{5}$$

Step 2. The algorithm calculates the adaptation factor D according to the environmental parameters, as follows:

$$D = F\left[1 - \left(\frac{1}{36}\right) e^{\left(-L_A - 42/92\right)}\right]. \tag{6}$$

Step 3. The algorithm calculates the cone response under the reference white, as follows:

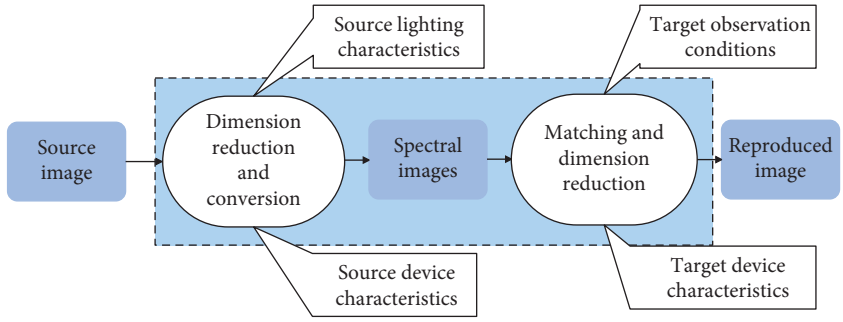


Figure 5: Spectral-based color management.

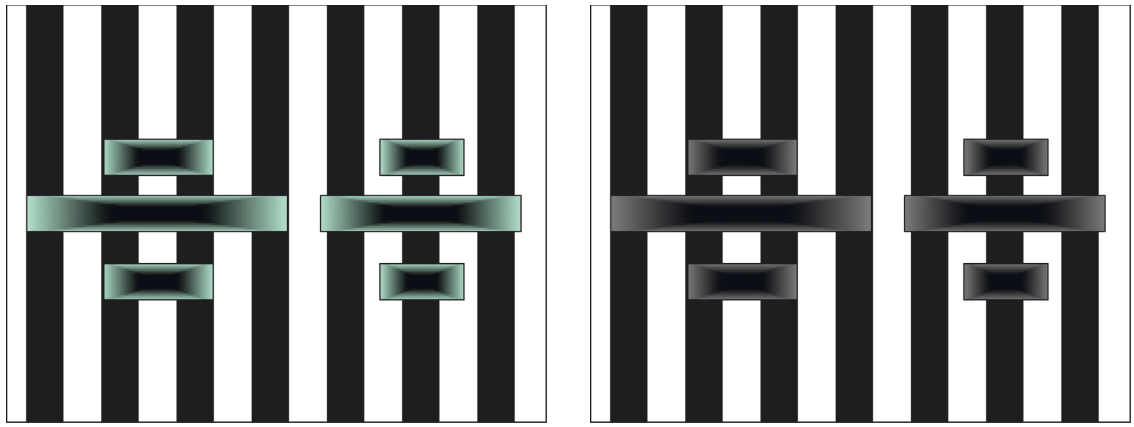


Figure 6: Differences in color perception caused by different backgrounds.

$$R_C = \left[D\left(\frac{Y_W}{R_W}\right) + (1 - D)\right]R,$$

$$G_C = \left[D\left(\frac{Y_W}{R_W}\right) + (1 - D)\right]G, \quad (7)$$

$$B_C = \left[D\left(\frac{Y_W}{R_W}\right) + (1 - D)\right]B.$$

Finally, the inverse transform calculates the corresponding color; that is, the tristimulus value after adaptation, as shown in the following formula:

$$\begin{bmatrix} X_c \\ Y_C \\ Z_C \end{bmatrix} = M_{CAT02}^{-1} \begin{bmatrix} R_C \\ G_C \\ B_C \end{bmatrix}. \quad (8)$$

The color appearance model includes two parts: color adaptation and color appearance attribute space. First, the input *XYZ* tristimulus values are transformed into the cone-responsive color space through color adaptation. Then, the color appearance attribute value is calculated according to the adapted color signal. The forward transformation steps are shown in Figure 7:

(1) *XYZ* tristimulus value changes to human eye pyramidal cell response.

(2) The algorithm inputs environmental parameters and performs color adaptation transformation after cone response.

(3) The algorithm transforms into the color appearance attribute space according to the adaptive cone response.

(4) The algorithm simulates the nonlinear compression of the visual system.

(5) The algorithm calculates various color appearance attributes.

CIELAB space is the simplest color appearance model, and its calculation steps are as follows:

The first step is to enter the corresponding model environment parameters. In the second step, according to the environmental parameters, formula (4) is used to perform color adaptation transformation, and the *XYZ* values are transformed into the vertebral body response space under the reference conditions. The third step is to perform physiological color space conversion. The cone response space after chromatic adaptation transformation is transformed into a cone response HPE space close to the physiological one, and the transformation relationship used is shown in the following formula:

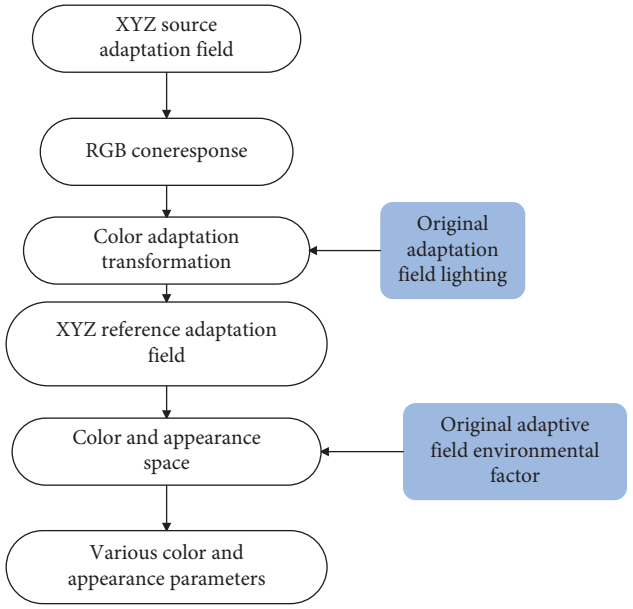


Figure 7: Forward calculation steps of color appearance model.

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = M_H M_{CAT02}^{-1} \begin{bmatrix} R_C \\ G_C \\ B_C \end{bmatrix}. \tag{9}$$

Among them,

$$M_H = \begin{bmatrix} 0.38971 & 0.68898 & -0.07868 \\ -0.22981 & 1.18340 & 0.04641 \\ 0.0000 & 0.0000 & 1.00000 \end{bmatrix}. \tag{10}$$

The fourth step is to simulate the dynamic nonlinear characteristics of the cone response of the human visual system according to the following formula:

$$\begin{aligned} R_a' &= \frac{400\left(F_L R'/100\right)^{0.42}}{27.13 + \left(F_L R'/100\right)^{0.42}} + 0.1, \\ G_a' &= \frac{400\left(F_L R'/100\right)^{0.42}}{27.13 + \left(F_L R'/100\right)^{0.42}} + 0.1, \\ B_a' &= \frac{400\left(F_L R'/100\right)^{0.42}}{27.13 + \left(F_L R'/100\right)^{0.42}} + 0.1. \end{aligned} \tag{11}$$

Finally (the fifth step), according to formula (12)–(16), the correlated color attribute is calculated.

(1) "no color response" A.

$$\begin{aligned} A &= \left[2R'a + G\prime a + \left(\frac{1b\prime}{20}\right)B'a - 0.305\right]N_{bb}, \\ A_W &= \left[2R'aw + G\prime aw + \left(\frac{1}{20}\right)B'aw - 0.305\right]N_{bb}. \end{aligned} \tag{12}$$

(2) Brightness.

$$J = 100\left(\frac{A}{A_w}\right)^{CZ}. \tag{13}$$

(3) Apparent brightness.

$$Q = \left(\frac{4}{c}\right)\left(\frac{J}{100}\right)^{0.5}(A_w + 4)F_L^{0.25}. \tag{14}$$

(4) Temporary amount.

$$t = \frac{e\left(a^2 + b^2\right)^{1/2}}{R\prime a + G\prime a + (21/20)B'a}. \tag{15}$$

(5) Chroma c, visual chroma M, and color saturation s.

$$\begin{aligned} C &= t^{0.9}\sqrt{\frac{J}{100\left(1.64 - 0.29^{*}\right)^{0.75}}}, \\ M &= CF_L^{0.25}, \\ s &= 100\sqrt{\frac{M}{Q}}. \end{aligned} \tag{16}$$

After the above steps, the color appearance attribute conversion analysis based on the CIECAMO2 model can be realized.

The CIECAMO2 model is adopted in the latest windows color management system, WCS. Specifically, when performing color gamut mapping, the JCH space based on the CIECAMO2 color appearance model is used as the PCS link space. The CIACAM02 model is used as the PCS space for color gamut conversion, and the process is shown in Figure 8.

In order to take into account the influence of color appearance perception and color difference resolution, S-CIELAB first transforms the observed image to the opposite color space when processing the image. At the same time, the corresponding classification is carried out, and then the spatial fuzzy characteristics of the human visual system are simulated, and CSF filtering is performed for each classification. Finally, the filtered color values are inversely transformed into the CIEXYZ and CIELAB spaces in turn. The whole process is shown in Figure 9.

The detailed steps of their conversion include the foollowing:

(1) According to formula (17), the algorithm transforms the image color information XYZ into three opposite colors AO_1O_2 as follows:

$$\begin{bmatrix} A \\ O_1 \\ O_2 \end{bmatrix} = \begin{bmatrix} 0.279 & 0.722 & -0.107 \\ -0.449 & 0.290 & 0.077 \\ 0.086 & -0.590 & 0.501 \end{bmatrix}\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}. \tag{17}$$

Among them, the three opposite colors are black-white, red-green, and yellow-blue.

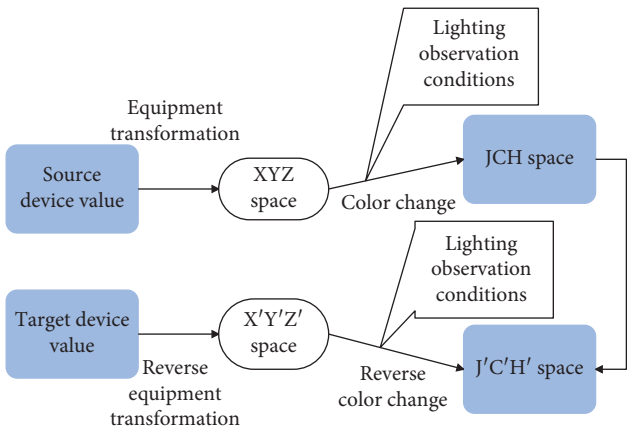


Figure 8: PCS space conversion process based on the CIECAM02 model.

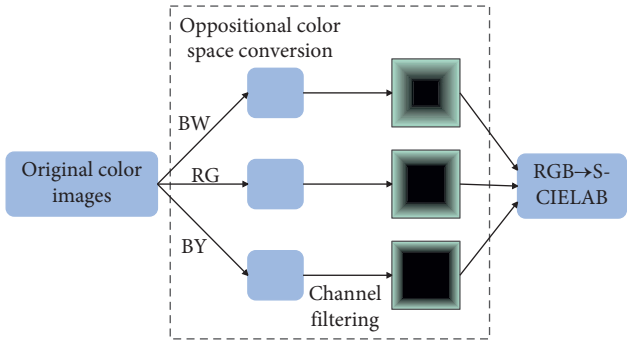


Figure 9: S-CIELAB model flow.

(2) The algorithm performs 2-D convolution calculation on each color component, and its convolution kernel is shown in the following formula:

$$\text{filter} = K \sum_{t} \omega_i E_i. \tag{18}$$

Among them,

$$E_i = k_i \exp\left[\frac{-\left(x^2 + y^2\right)}{\sigma_i^2}\right]. \tag{19}$$

In the above formula, K and K_i are normalization coefficients. Different weights W_i and variable parameter values α_i are obtained through human eye victory experiments.

(3) According to formula (20), the algorithm transforms the color information AO_1O_2 processed by spatial filtering into the CIEXYZ space:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.980 & -1.535 & 0.445 \\ 1.189 & 0.764 & 0.135 \\ 1.232 & 1.163 & 2.078 \end{bmatrix} \begin{bmatrix} A \\ O_1 \\ O_2 \end{bmatrix}. \tag{20}$$

(4) The algorithm transforms CIEXYZ to CIELAB. The specific conversion formula is the same as before, and will not be repeated here.

The main advantage of IPT space is that the prediction of hue is more accurate than other color spaces, so Fairchild calls it the processing space of the iCAM appearance model. The color properties of IPT space and CIELAB space are the same, I stands for lightness, P stands for red/green, and T stands for yellow/blue. However, the value range of IPT is different from that of CIELAB. The value of I is (0, 1), and the value of P and T is {−1, 1}. The input data of IPT is the XYZ value of the observer under the D65 light source and the 2° field of view, and the color space LMS is responded to by the cone cells. The transformation relations used are shown in formulas (21)–(23).

$$\begin{bmatrix} L \\ M \\ S \end{bmatrix} = \begin{bmatrix} 0.4002 & 0.7075 & -0.0807 \\ -0.2280 & 1.1500 & 0.0612 \\ 0.0000 & 0.0000 & 0.9184 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}, \tag{21}$$

$$\begin{aligned} L' &= L^{0.43}; \quad L \geq 0, \\ L' &= -|L|^{0.43}; \quad L < 0, \\ M' &= M^{0.43}; \quad M \geq 0, \\ M' &= -|M|^{0.43}; \quad M < 0, \\ S' &= S^{0.43}; \quad S \geq 0, \\ S' &= -|S|^{0.43}; \quad S < 0, \end{aligned} \tag{22}$$

$$\begin{bmatrix} I \\ P \\ T \end{bmatrix} = \begin{bmatrix} 0.4000 & 0.4000 & 0.2000 \\ 4.4550 & -4.8510 & 0.3960 \\ 0.8056 & 0.3572 & -1.1628 \end{bmatrix} \begin{bmatrix} L' \\ M' \\ S' \end{bmatrix}. \tag{23}$$

The processing process of the iCAM model is similar to that of CIECAMO2, and the input parameters and calculation formulas have not changed, including tristimulus values, adaptive white point, adaptive brightness, and environmental factors. Among them, only the definition of the environmental parameters has changed. After the human eye CSF filtering process is used, the maximum value of the image stimulus is used as the reference white point. This change makes the iCAM model independent of specific viewing conditions when dealing with color, which is not possible with other models. Finally, iCAM converts the color to the IPT color space, which not only greatly simplifies the calculation steps but also improves the accuracy of hue prediction.

The following are the calculation steps of the iCAM model:

The first step is to perform a color-adaptive transformation on the original image and the low-pass filtered image. The CATO2 color adaptation transformation model is adopted, and the specific formula is as follows:

Step 1: First, the model converts the original image and the low-pass filtered image to the cone response space RGB of the human visual system, as follows:

The original image [21].

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = M_{CAT02} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}. \tag{24}$$

Low-pass filtered image.

$$\begin{bmatrix} R_W \\ G_W \\ B_W \end{bmatrix} = M_{CAT02} \begin{bmatrix} X_{LOW} \\ Y_{LOW} \\ Z_{LOW} \end{bmatrix}. \tag{25}$$

The model calculates the adaptation factor, and the adaptation brightness and environmental factors are set according to the external environment:

$$C\ D = F\left[1 - \left(\frac{1}{3.6}\right)e^{\left(-L_A - 42/92\right)}\right]. \tag{26}$$

The cone responses after color adaptation are as follows:

$$\begin{aligned} R_C &= \left[D\left(\frac{Y_W}{R_W}\right) + (1 - D)\right]R, \\ G_C &= \left[D\left(\frac{Y_W}{R_W}\right) + (1 - D)\right]G, \\ B_C &= \left[D\left(\frac{Y_W}{R_W}\right) + (1 - D)\right]B. \end{aligned} \tag{27}$$

Step 2: The adapted cone response $R_cG_cB_c$ is transformed into the IPT color space, first transformed to the corresponding color $X_{D65}Y_{65}Z_{65}$ in the D_{65} reference environment:

$$\begin{bmatrix} X_{D65} \\ Y_{D65} \\ Z_{D65} \end{bmatrix} = M_{CAT02}^{-1} \begin{bmatrix} R_C \\ G_C \\ B_C \end{bmatrix}. \tag{28}$$

Then, CIEXYZ transforms L to IPT, which is a little different from the method mentioned above. The adaptive brightness factor F is added to adjust the nonlinearity in the transformation, as shown in the following formula:

$$\begin{bmatrix} L \\ M \\ S \end{bmatrix} = \begin{bmatrix} 0.4002 & 0.7075 & -0.0807 \\ -0.2280 & 1.1500 & 0.0612 \\ 0.0000 & 0.0000 & 0.9184 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}. \tag{29}$$

The model calculates the luminance factor F_L:

$$\begin{aligned} F_L &= 0.2k^4\left(5F_A\right) + 0.1\left(1 - k^4\right)^2\left(5L_A\right)^{1/3}, \\ k &= \frac{1}{\left(5L_A + 1\right)}, \\ L' &= L^{0.43}; \quad L \geq 0, \\ L' &= -|L|^{0.43}; \quad L < 0, \\ M' &= M^{0.43}; \quad M \geq 0, \\ M' &= -|M|^{0.43}; \quad M < 0, \\ S' &= S^{0.43}; \quad S \geq 0, \\ S' &= -|S|^{0.43}; \quad S < 0. \end{aligned} \tag{30}$$

Its transformation to IPT space is shown in the following formula:

$$\begin{bmatrix} I \\ P \\ T \end{bmatrix} = \begin{bmatrix} 0.4000 & 0.4000 & 0.2000 \\ 4.4550 & -4.8510 & 0.3960 \\ 0.8056 & 0.3572 & -1.1628 \end{bmatrix} \begin{bmatrix} L' \\ M' \\ S' \end{bmatrix}. \tag{31}$$

Step 3: The last step is the color appearance attributes, brightness J, chroma C, hue h, apparent brightness Q, apparent chroma M, and image difference Im as follows:

$$\begin{aligned} J &= I, \\ C &= \sqrt{P^2 + T^2}, \\ h &= \arctan\left(\frac{P}{T}\right), \\ Q &= \sqrt[4]{F_L}J, \\ M &= \sqrt[4]{F_L}J, \\ \Delta\mathrm{Im} &= \sqrt{\Delta I^2 + \Delta P^2 + \Delta T^2}. \end{aligned} \tag{32}$$

4. Garden Landscape Design of Sponge City Residential Area Based on Digital Technology

Figure 10 shows the virtual interface structure of the garden landscape design system in the residential area of the sponge city based on digital technology.

According to the collected environmental landscape information, the location processing of the landscape position to be processed is carried out, and the network technology and infinite network nodes are further used to carry out comprehensive virtual auxiliary processing of the environmental landscape design, so as to improve the efficiency of the environmental landscape virtual design. In the process of 3D simulation of environmental landscape, it is necessary to take into account factors such as regional landscape topography information, vegetation planting information, building appearance, and building feature data, and carry out three-dimensional design and rendering of the scene to achieve multiangle and multidirectional construction, editing, and restoration of landscape information. The specific environmental landscape three-dimensional simulation information processing module is shown in Figure 11.

Figure 12 below shows the effect of the garden landscape design in the residential area of the sponge city.

The model proposed in this paper is simulated by Matlab, and the landscape design effect of the sponge city residential garden landscape design system based on digital technology is counted as shown in Table 1.

From the above research, it can be seen that the garden landscape design of sponge city residential area based on

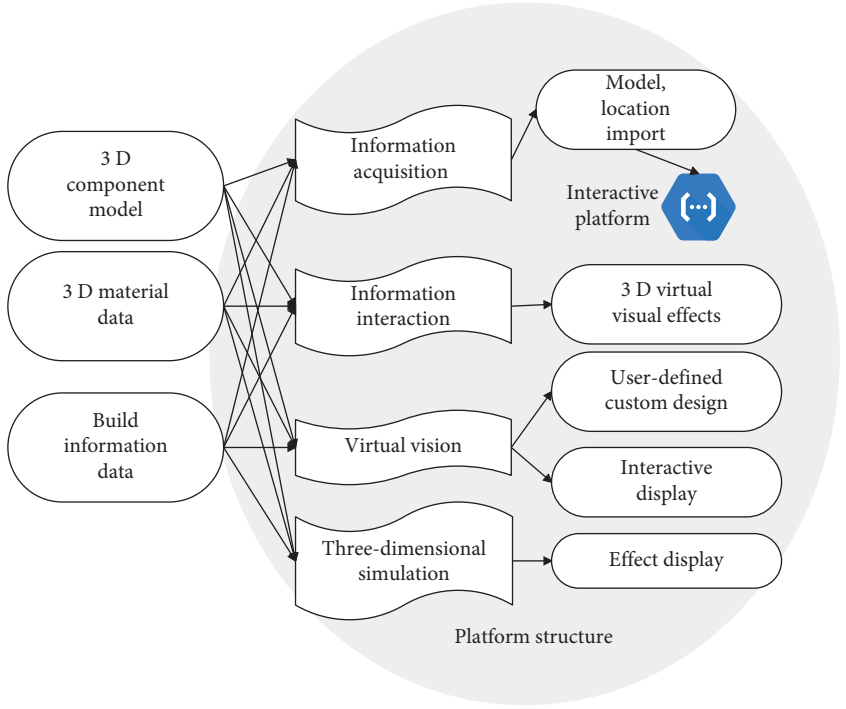


Figure 10: The virtual interface structure of the garden landscape design system in the residential area of the sponge city based on digital technology.

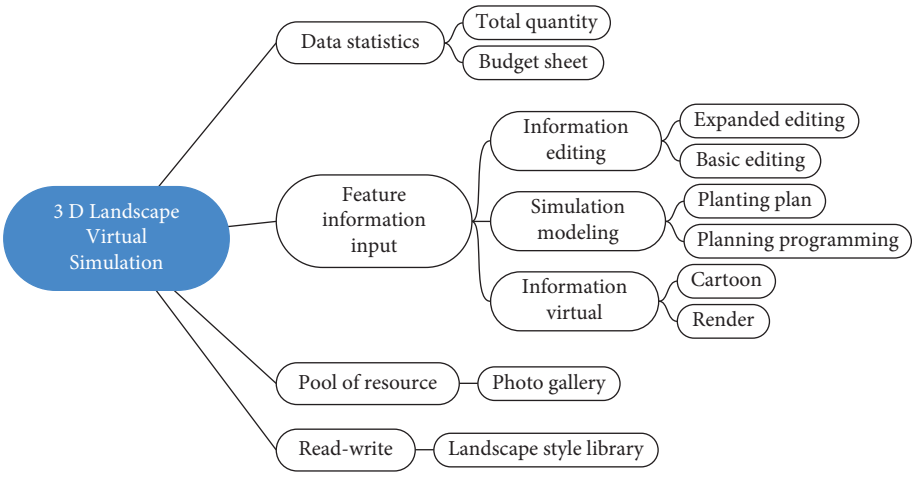


Figure 11: The three-dimensional simulation module of environmental landscape simulation of the garden landscape design system of the sponge city residential area based on digital technology.

Figure 12: Effect diagram of garden landscape design in the residential area of sponge city.

Table 1: The landscape design effect of the garden landscape design system in the residential area of the sponge city based on digital technology.

Num	Landscape Design
1	90.65
2	90.19
3	83.14
4	89.41
5	83.97
6	81.42
7	81.35
8	80.86
9	85.75
10	82.02
11	81.79
12	83.43
13	88.91
14	81.30
15	87.77
16	88.12
17	88.78
18	87.47
19	88.74
20	79.30
21	80.41
22	82.25
23	87.60
24	80.80
25	89.82
26	84.73
27	80.39
28	84.18
29	85.50
30	86.12
31	83.55
32	83.10
33	79.71
34	80.86
35	89.20
36	83.38
37	88.66
38	82.61
39	81.80
40	90.73
41	89.28
42	82.24
43	82.67
44	90.55
45	82.64
46	90.09
47	86.32
48	86.53
49	84.58
50	79.34
51	83.70
52	89.97
53	80.44
54	88.06
55	86.14
56	82.08
57	80.67
58	83.82
59	81.50
60	86.77
61	88.48
62	81.32
63	86.26
64	80.30
65	80.98
66	83.96

digital technology proposed in this paper can meet the needs of sponge city garden landscape design.

5. Conclusion

In the process of urban construction, a large number of hard impermeable pavements are used, so that more and more natural land is replaced by impervious pavement, and the original permeable layer of natural precipitation is cut off, interrupting the original urban water cycle. There are many environmental problems in cities, such as massive loss of rainwater resources, serious runoff pollution, and increased risk of flood disasters. The traditional urban stormwater management adheres to the planning concept of "come quickly and go quickly," while the municipal drainage system quickly drains the rainwater, which forms an obvious contradiction. On the one hand, due to the excessive exploitation of groundwater, the groundwater level has dropped, resulting in a serious water shortage in the city. On the other hand, urban rainwater is not used reasonably, and a large amount of discharge causes waste and even damages the urban ecological environment. This paper combines digital technology to carry out the garden landscape design of the residential area of the sponge city, and conducts the research on it through the intelligent system. The research results show that the garden landscape design of sponge city residential area based on the digital technology proposed in this paper can meet the needs of sponge city garden landscape design.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The research was supported by the 2017 Youth Project for Humanities and Social Science Research of the Ministry of Education and funded by the results of the "LID Landscape Model Study in Sponge City Construction" (No. 17YJC760077).

References

[1] K. Janečková Molnárová, Z. Skřivanová, O. Kalivoda, and P. Sklenička, "Rural identity and landscape aesthetics in exurbia: some issues to resolve from a Central European perspective," *Moravian Geographical Reports*, vol. 25, no. 1, pp. 2–12, 2017.

[2] C. L. Lin, "Establishing environment sustentation strategies for urban and rural/town tourism based on a hybrid MCDM approach," *Current Issues in Tourism*, vol. 23, no. 19, pp. 2360–2395, 2020.

[3] M. Das and A. Das, "Dynamics of urbanization and its impact on urban ecosystem services (UESs): a study of a medium size town of West Bengal, eastern India," *Journal of Urban Management*, vol. 8, no. 3, pp. 420–434, 2019.

[4] D. Ramsey and C. D. Malcolm, "The importance of location and scale in rural and small town tourism product development: the case of the Canadian Fossil Discovery Centre, Manitoba, Canada," *The Canadian Geographer/Le Géographe canadien*, vol. 62, no. 2, pp. 250–265, 2018.

[5] F. Drummond and J. Snowball, "Cultural clusters as a local economic development strategy in rural small-town areas: sarah baartman district in South Africa," *Bulletin of Geography. Socio-Economic Series*, vol. 43, no. 43, pp. 107–119, 2019.

[6] I. Abreu, J. M. Nunes, and F. J. Mesias, "Can rural development be measured? design and application of a synthetic index to Portuguese municipalities," *Social Indicators Research*, vol. 145, no. 3, pp. 1107–1123, 2019.

[7] J. A. González Díaz, R. Celaya, F. Fernández García, K. Osoro, and R. Rosa García, "Dynamics of rural landscapes in marginal areas of northern Spain: past, present, and future," *Land Degradation & Development*, vol. 30, no. 2, pp. 141–150, 2019.

[8] T. Pinto-Correia, M. Almeida, and C. Gonzalez, "Transition from production to lifestyle farming: new management arrangements in Portuguese small farms," *International Journal of Biodiversity Science, Ecosystem Services & Management*, vol. 13, no. 2, pp. 136–146, 2017.

[9] Z. Yi, Z. Fei, and L. Ruiqin, "The path of rural revitalization in rapidly urbanizing areas: taking southern jiangsu as an example," *China City Planning Review*, vol. 27, no. 4, pp. 24–33, 2018.

[10] M. Antic, D. Santic, M. Kašanin-Grubin, and A. Malic, "Sustainable rural development in Serbia-relationship between population dynamicss and environment," *Journal of Environmental Protection and Ecology*, vol. 18, no. 1, pp. 323–331, 2017.

[11] M. Cecchini, I. Zambon, A. Pontrandolfi et al., "Urban sprawl and the 'olive'landscape: sustainable land management for 'crisis' cities," *Geojournal*, vol. 84, no. 1, pp. 237–255, 2019.

[12] E. W. Kaindoa, M. Finda, J. Kiplagat et al., "Housing gaps, mosquitoes and public viewpoints: a mixed methods assessment of relationships between house characteristics, malaria vector biting risk and community perspectives in rural Tanzania," *Malaria Journal*, vol. 17, no. 1, pp. 298–316, 2018.

[13] W. Hulko and J. Hovanes, "Intersectionality in the lives of LGBTQ youth: identifying as LGBTQ and finding community in small cities and rural towns," *Journal of Homosexuality*, vol. 65, no. 4, pp. 427–455, 2018.

[14] C. Herrero-Jáuregui, C. Arnaiz-Schmitz, L. Herrera et al., "Aligning landscape structure with ecosystem services along an urban–rural gradient. Trade-offs and transitions towards cultural services," *Landscape Ecology*, vol. 34, no. 7, pp. 1525–1545, 2019.

[15] V. Ferretti and E. Gandino, "Co-designing the solution space for rural regeneration in a new World Heritage site: a Choice Experiments approach," *European Journal of Operational Research*, vol. 268, no. 3, pp. 1077–1091, 2018.

[16] O. le Polain de Waroux, S. Cohuet, D. Ndazima et al., "Characteristics of human encounters and social mixing patterns relevant to infectious diseases spread by close contact: a survey in Southwest Uganda," *BMC Infectious Diseases*, vol. 18, no. 1, pp. 172–187, 2018.

[17] M. Keane and Y. Chen, "Entrepreneurial solutionism, characteristic cultural industries and the Chinese dream," *International Journal of Cultural Policy*, vol. 25, no. 6, pp. 743–755, 2019.

[18] C. Chen, R. LeGates, and C. Fang, "From coordinated to integrated urban and rural development in China's megacity regions," *Journal of Urban Affairs*, vol. 41, no. 2, pp. 150–169, 2019.

[19] H. N. Ngugi, F. M. Mutuku, B. A. Ndenga et al., "Characterization and productivity profiles of Aedes aegypti (L.) breeding habitats across rural and urban landscapes in western and coastal Kenya," *Parasites & Vectors*, vol. 10, no. 1, pp. 331–348, 2017.

[20] A. D. Beyene, A. Mekonnen, B. Randall, and R. Deribe, "Household level determinants of agroforestry practices adoption in rural Ethiopia," *Forests, Trees and Livelihoods*, vol. 28, no. 3, pp. 194–213, 2019.

[21] J. Stojanović, V. Kokotović Kanazir, and M. Stojanović, "Does small town with touristic function have demographic potential?" *Journal of the Geographical Institute "Jovan Cvijic," SASA*, vol. 67, no. 2, pp. 145–162, 2017.

Hindawi
Mobile Information Systems
Volume 2023, Article ID 9834707, 1 page
https://doi.org/10.1155/2023/9834707

Retraction

Retracted: The Construction and Empirical Research of College English Multimodal Teaching from the Perspective of New Media

Mobile Information Systems

Received 8 August 2023; Accepted 8 August 2023; Published 9 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.

References

[1] S. Cao, R. Chen, H. Liu, and R. Shi, "The Construction and Empirical Research of College English Multimodal Teaching from the Perspective of New Media," *Mobile Information Systems*, vol. 2022, Article ID 7582536, 12 pages, 2022.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 7582536, 12 pages
https://doi.org/10.1155/2022/7582536

Research Article

The Construction and Empirical Research of College English Multimodal Teaching from the Perspective of New Media

Shuting Cao,[1] Rui Chen ,[2] Haiyuan Liu,[2] and Ruolin Shi[2]

[1]*Department of Scientific Research Management, Cangzhou Normal University, Cangzhou 061001, China*
[2]*Department of Foreign Languages, Cangzhou Normal University, Cangzhou 061001, China*

Correspondence should be addressed to Rui Chen; chenrui@caztc.edu.cn

Received 22 February 2022; Revised 12 April 2022; Accepted 30 April 2022; Published 21 May 2022

Academic Editor: Wen Zhou

In order to analyze the multimodal discourse in college English teaching, this paper proposes a multimodal discourse method for college English teaching based on the new media context. The basic structure of the questionnaire is analyzed from four dimensions; secondly, students are selected as the survey samples to understand the students' true feelings about English subjects and teachers' teaching, and the questionnaires are analyzed according to the three dimensions of the student's questionnaire structure. Supported by the theory of "complex dynamic development" and "second language motivational self-system," case tracking of three English majors was carried out. Data analysis shows that under the condition of multimodal language input, the learning motivation of individual learners in the second language classroom presents a relatively stable dynamic development trend, as well as nonlinear dynamic development characteristics in a specific period. College English teaching has been improved by the method raised in this research.

1. Introduction

With the development of information technology, great changes have taken place in the way people live and learn. Particularly, the development of modern educational technology represented by multimedia technology changed the way students learn so that students' learning status changed from passive to active; learners can choose their own learning methods and learning content using information technology. Multimedia is a carrier of information storage and transmission that integrates various media forms; it includes various media information such as image, text, video, sound, and so on. In the process of learning, students can use multimedia technology to receive information and acquire more and wider knowledge, as shown in Figure 1. Therefore, multimedia technology has been widely used in the teaching of various subjects [1]. In college English teaching, how to improve teaching efficiency through multimedia technology, improving the teaching effect brings new challenges to the research on the teaching mode, teaching process, and teaching evaluation of this course. In the era of new media, various media influence the thoughts and behaviors of college students extensively and deeply, facing the status quo of the absence of media literacy education in higher education, and aiming at the multimodal characteristics of information representation in the new media era.

2. Literature Review

In the 1990s, Western researchers put forward the theory of multimodal discourse analysis, that in addition to language communicative competence, other symbolic resources (e.g., images, videos, animations, etc.) and means also have the function of realizing communication. Based on the theory of multimodal discourse analysis, many experts and scholars put forward a multimodal teaching model. Multimodal teaching mode refers to the embedding of voice, image, text, and other media into English teaching, which makes English learning get rid of the traditional blackboard writing and note-taking mode; it is a comprehensive application related to modern teaching equipment and computer network. This

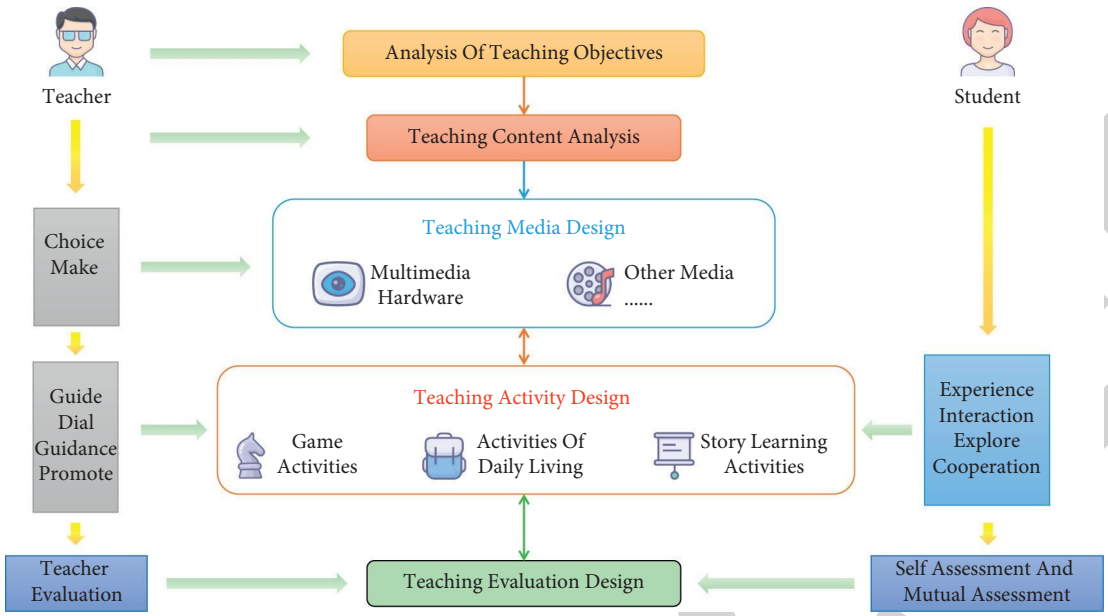


Figure 1: Design model of multimedia technology-assisted teaching.

model can not only mobilize the atmosphere of teachers and students in the classroom, but also stimulate students' enthusiasm for vocabulary learning by stimulating their senses, such as sight and hearing, and arouse interest in further learning English vocabulary, thus helping to deepen their memory of vocabulary and improve the practical application ability of language so that learners can understand and master the content to be learned in a relaxed environment. In view of this, taking multimodal theory as the theoretical basis of research, on this basis, the multimodal teaching mode is introduced into the English vocabulary teaching in senior high schools, exploring its effect on college English vocabulary teaching has become a topic of great research value.

Vocabulary teaching activities were carried out smoothly. Zou and Huang's research analyzes two theories of the impact on college English vocabulary teaching: semantics and pragmatics [2]. Pan and Zhang investigated the role of corpus in English vocabulary teaching and proposed to establish the concept of word frequency to help learners better acquire vocabulary, conducive to the improvement of their vocabulary use ability [3]. Pealver and Urbieta analyzed the methods of English vocabulary teaching from three different perspectives: lexicology, stylistics, and pragmatics [4]. Kawa analyzed the importance of context in English vocabulary teaching, and at this level, combined with the research and development trend of English vocabulary teaching, providing suggestions for the development of English vocabulary teaching [5]. Belgrimet and Rabab'Ah analyzed the relationship between the number of collocation misuses and vocabulary acquisition strategies; research shows that in classroom teaching, using effective strategies for teaching can help improve the level of learners' vocabulary collocation [6]. Djatmika et al. studied the synergy between multimodalities in the second language teaching model and the complementarity of different symbols in multimodal discourse; they believe that within a text, discourse, language, and visual modalities are mutually complementary relationships, and the complementarity is achieved through linguistic and visual modalities of various modalities [7]. Purwaningtyas, based on constructing a multimodal theory, expand the application scope of multimodal discourse analysis to teaching discourse and teaching practice; the applicable object of this theory is increased [8]. Luca introduced the research method of multimodal discourse in detail, including picture display method, language description method, image, and text combination method, drawing method, and so on, in-depth discussion on the application of multimedia and network information technology in the field of language teaching, and discussed a variety of symbolic forms to assist language teaching methods [9]. Tandiana et al. studied the allocation of multimodal and interactive resources in the use of interactive whiteboards by teachers and discussed the principles of design and use of interactive whiteboards in teaching; the application and interrelationship of modern media technology in multimodal teaching is analyzed [10]. Hakokõngäs et al. studied the effects of multimodality on second language learners; the study shows that multimodal combined teaching can help learners learn languages better; on this basis, the principles of multimodal curriculum design and the method of computer-assisted teaching are constructed [11].

Based on current research, combining the core concepts of foreign media literacy education with the theory of multimodal discourse analysis, construct a multidimensional analysis framework of flat multimodal media discourse in the teaching of media literacy in college English courses. The author's research explores the multimodal discourse analysis approach of media literacy education and provides a reference for peer researchers to conduct in-depth research.

3. An Empirical Study of Multimodal Discourse Analysis in College English Teaching in the Context of New Media

3.1. New Media Context. In recent years, the term "new media context" is increasingly used by researchers; with the help of any search engine, you can see many papers on related topics, for example, "information dissemination in the context of new media," "TV program innovation in the context of new media," "broadcasting Countermeasures in the New Media Context," "Film Marketing in the New Media Context," "Brand Communication in the New Media Context," "Advertising Communication Strategies in the New Media Context," "Crisis Communication and Coping Strategies in the New Media Context," and so on. However, upon closer inspection, it is not difficult to find that most of these studies generally equate the word "context" with "background," "era," and "environment"; however, the "context," especially the "new media context," is not necessarily defined. From the point of view of academic research, this cannot but be said to be a pity. The word "context" comes from the Greek "Contextre," which is "Context" in English, which means "interwoven" [12]. "Context" is a linguistic concept that refers to the interweaving of various words; emphasis is on the meaning of a word or sentence, which is determined by the segment or dialogue in which it exists.

3.1.1. The Results and Analysis of College English Teaching in the Context of New Media

(1) The questionnaire survey on students' understanding of English multimodal teaching and classroom participation shows the following:

(a) The application of multimodal teaching methods in English classrooms still needs to be improved. More than 70% of the students in 3 classes were satisfied or very satisfied with the teachers' use of visual modal teaching methods in the classroom; 69% of the students expressed uncertainty or dissatisfaction with the use of auditory modality and other modal means in the teacher's teaching [13].

(b) Students' understanding of English multimodal teaching is not comprehensive enough. More than 50% of students believe that multimodal teaching is visual modal teaching, that is, the use of PPT teaching courseware in the classroom. Only 20% of students understand multimodal teaching. In addition to teaching using visual modalities, other modalities are also used in combination.

(2) Investigation on the relationship between teachers' classroom multimodal teaching and students' English learning enthusiasm is carried out.

Through questionnaire survey and face-to-face interviews, it is found that teachers' flexible use of multimodal teaching has an important impact on students' learning enthusiasm [14]. 82% of students said they liked the colorful teaching methods in the classroom. More than 37% of students expect teachers to provide more interactive opportunities in the classroom, such as group discussions, role-playing, and so on.

3.1.2. Problems and Countermeasures in College English Teaching Practice in the Context of New Media. Multimodal college English classroom teaching requires teachers to constantly update their educational concepts, using new teaching theories to guide classroom teaching:

(1) Combined with situational teaching, making full use of multimodality to mobilize students' enthusiasm in classroom teaching should be combined with specific situations to mobilize the enthusiasm of students [15]. Teachers should make full use of new media resources in the classroom and comprehensively use PPT courseware with video and audio; at the same time, they should pay attention to the use of auditory modalities such as oral expression, speed of speech, and intonation, as well as the teacher's body language; the use of tactile modalities such as facial expressions and other modalities provides students with a rich learning environment and enhances their interest in learning.

(2) Promote personalized learning and guide students correctly. Actively guide students in their spare time according to their own interests, with the help of computers, mobile phones, campus networks, electronic reading rooms, MP5, and other media for training and learning, as a supplement to multimodal teaching [16]. The new media resources are vast, and the learning form of online life allows students to broaden their horizons, but in the face of so much information, students will inevitably be confused. Teachers should help students in time and guide them to use navigation methods to avoid time-consuming and low-efficiency situations.

(3) Carry out diversified teaching evaluation and adjust multimodal teaching methods in time. Classroom multimedia teaching, as well as audiovisual channels such as mobile phones, computers, and online classes that students use after class, provides more choices for foreign language teaching evaluation methods. Teachers should, based on student feedback and assessment results, timely adjust multimodal teaching methods to achieve better teaching effect [17].

3.2. Multimodality. Kress and van Leeuwen define multimodality as all channels and mediums involved in communication; in addition to traditional language symbols, it also includes notation systems for colors, images, music, technology, and more. Multimodal discourse refers to the use of multiple sensory systems, such as hearing, sight, touch, and so on, through language communication, the phenomenon of using image symbols, sound symbols, action symbols, and other means to communicate. In the process of

communication, communication can not only be achieved through language, it can also be achieved through various methods such as speech speed, intonation, tone and other sound aspects, body movements, expressions, and other physical aspects. Therefore, communication is not only carried out through a single sense, but using multiple senses at the same time.

3.2.1. Multimodal Theory. In the 1990s, a new theory, multimodal theory, emerged in Western countries, also called multimodal discourse analysis theory; although its research history at home and abroad is only more than 20 years, theoretical research and practical research on multimodal theory go hand in hand; a lot of research results have been obtained. "Multimodality" has attracted the attention of linguists. In recent years, scholars have paid more and more attention to this new theory; it has become a term widely used by linguists and scholars at home and abroad. It is also based on functional grammar theory, including more nonverbal factors such as body movements, sounds, images, and so on into the research scope; several studies have been carried out on the relationship between modalities and media. Published papers and books complete the theory of multimodal discourse analysis, providing research methods and theoretical basis for the study of multimodal discourse analysis theory. A framework for multimodal discourse analysis, based on analyzing the theory of multimodal discourse analysis, through the interpretation and analysis of the theoretical framework of systemic functional linguistics, is proposed [18]. The diagram vividly shows the logical relationship of the various elements in the theory. Under the framework of multimodal discourse analysis theory, there are five levels:

(1) Cultural level: it includes two parts, one is the potential of choice of discourse mode, and the other is ideology. This level is the key level of the multimodal synthesis theoretical framework.

(2) Context level: interpersonal communication is affected by contextual factors, which include discourse category, discourse tone, and discourse form.

(3) Meaning level: it expresses what kind of meaning people say words have, which can express different meanings in different occasions, and is restricted by the contextual environment in the context level.

(4) Form level: it includes form and relationship, and the form mainly includes language, image perception, sound perception, and feeling; the relationship is complementary and noncomplementary. "Each modality has its own formal system." The meaning level and the formal level are collectively referred to as the content level.

(5) Expression level: the main introduction media is expressed by language and nonlanguage. Among them, language includes accompanying language and pure language; nonlanguage includes body language and nonbody language.

3.2.2. Multimodal Discourse Analysis. Multimodal discourse analysis is a discourse analysis method that emerged in the 1990s, and its emergence is closely related to the diversification of meaning representation in the new media era. The so-called multimodality (multimodality) refers to the design of symbolic products or events, the use of multiple symbolic modalities, and how they can be integrated. The symbol mode mentioned above not only refers to traditional language symbols, also including nonverbal symbols such as images, animations, colors, movements, sounds, layouts, and so on. There are three orientations of multimodal discourse analysis methods: the sociosemiotic approach, the systems functional linguistics approach, and the interactive sociology approach. Among them, the social semiotics orientation is based on Hodge and Kress's social semiotics theory. Hodge and Kress believe that there is a "motivation" relationship between the signifier and the user of the sign; the generation of motivation is closely related to people's social environment, and other symbol systems outside the language system can also construct meaning. Therefore, the generation and understanding of any symbolic meaning cannot be separated from other symbolic systems; the meaning of the text must be interpreted within a broader context established by various sign systems. Based on this, scholars have conducted research on various modal and multimodal texts such as images, music, movements, film and television works, space design, children's picture books, and classroom teaching. Multimodal discourse analysis theories and methods were introduced in the early 2000s; since then, scholars have mainly carried out research from two aspects: theoretical development and discourse analysis practice. In recent years, scholars have begun to pay attention to the teaching of multiple reading and writing related to the theory of multimodal discourse analysis, from the construction of the learning model for the cultivation of multiple reading and writing skills, the teaching of multiple reading and writing, research on the impact of college students' reading comprehension, multicultural literacy, and critical literacy [19]. However, there is still a lack of research on media literacy teaching based on multimodal discourse analysis theory.

3.2.3. The Importance of Multimodal Discourse Analysis in College English Teaching

(1) New requirements for cultivating compound talents for the society: since the 1990s, the reform of college English teaching is in full swing, and a variety of teaching modes emerge in an endless stream, such as task-based teaching mode, situational teaching mode, and so on. Although each of the above teaching modes has its own advantages, most of them only emphasize the reading and writing of the language and ignore other modalities; it has not achieved close integration with modern educational technology; therefore, it cannot really meet the new requirements of the current society for cultivating compound talents. With the rapid development of information technology and the mutual penetration

of global cultures, college English teaching can no longer be limited to the traditional practice of relying on language to express meaning; instead, the teaching mode should be transformed from single modal to multimodal; this requires teachers to comprehensively use new multimodal expressions such as sounds, actions, and pictures in actual teaching to stimulate students' interest in learning, build a more reasonable information exchange mode, and complete dynamic communication activities with students in specific situations; in this way, compound talents with comprehensive application ability in English are gradually cultivated.

(2) An effective supplement to the main mode of classroom teaching discourse: language has been an important research field in academia for a long time; similarly, the language of teachers and students in English classroom teaching is also the focus of classroom discourse research [20]. However, in today's booming digital multimedia, the dominant role played by a single language modality is gradually diminishing. On the contrary, other complex and diverse communicative modalities, to varying degrees, auxiliary language modalities complete the meaning construction of English classroom discourse and promote its development to a deeper level of semiotics [21]. In English classroom teaching, teachers can complete classroom tasks through the comprehensive use of multiple modalities; for example, in basic word explanation, spoken language and text are the main modalities for realizing the meaning of the utterance, but it fails to provide students with vivid visual information related to words or example sentences; moreover, this single-modal teaching mode can easily lead to students' dislike of learning, but if teachers can skillfully combine other multimodal forms in the process of explaining words, such as PPT picture display, video clip playback, and so on, with language mode; then, students can directly feel the fun of word learning, and their impression and understanding of words will naturally be effectively strengthened; this fully reflects the positive role of the main mode of multimodal collaborative classroom discourse.

3.2.4. Multimodal Interactive College English Teaching Mode. In today's vigorous advocacy of multimodal teaching concepts and flipped classroom teaching methods, the multimodal interactive college English teaching mode has become an important development direction. Multimodal interaction in teaching mode refers to the interaction between teachers and students in classrooms, extracurricular activities, and online learning environments make full use of visual, auditory, tactile, and other senses to carry out English interactive activities between students, teachers, students, and human and machine. The purpose of this model is to allow students to complete different learning tasks using multiple senses under the guidance and coordination of

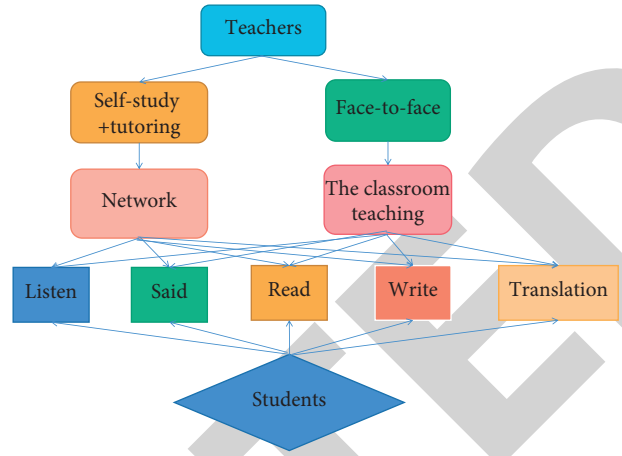


Figure 2: Multimodal interactive college English teaching mode.

teachers to acquire the ability to apply English. In the interactive process, the role of teachers is to guide, promote, and coordinate, while students, as the main body of activities, through exploration, practice, and cooperation, learning by doing and exploring, completing the cognition and externalization of language usage rules [22]. The core of multimodal interactive teaching lies in the word "moving," which emphasizes the joint participation of teachers and students in the teaching process, enhances students' awareness of participation and self-learning, and turns teachers' one-way explanation activities to students into active two-way classroom activities. In the classroom, there are various forms of multimodal interactive English teaching, and the corresponding teaching mode can be designed according to the teaching content; common teaching modes include situational group discussions, preclass speeches on self-selected topics, two-person dialogues on designated topics, and role-playing storylines. After class, interact with the students in the group and cooperate to complete the tasks assigned by the teacher. At the same time, students should preview the text, self-study vocabulary and sentence pattern module content on the online learning end, and carry out multimodal interactive learning of man-machine. The composition of the multimodal interactive college English teaching mode is shown in Figure 2.

3.3. The Main Problems Existing in College English Teaching at This Stage

(1) The base is thin. The educational level of teachers in the College English Teaching Department is generally low, the proportion of senior professional titles is small, minority bilingual teachers occupy a certain proportion, and there are too many young female teachers. In teaching, it is shown as follows: the teaching burden is heavy, the experience is insufficient, and the individual students vary greatly. Students are from colleges and universities in the Xinjiang Uygur Autonomous Region, including ethnic minority students, local Han students, and

students from the mainland. College English teachers should give full play to the role of multimedia in teaching while changing their teaching concepts and mobilize students' hearing, vision, and other perceptions to achieve the teaching purpose of cultivating diverse talents. In order to better stimulate students' interest in learning, the single mode of oral communication should be changed, using more means to facilitate teaching. The multimodal teaching mode can not only meet the needs of social development, but also be more beneficial to the cultivation of college students' ability of multiple reading and comprehensive application of English.

(2) The task of teaching and scientific research is heavy. From the current survey of teachers, it is found that teachers have an average of 12 lessons per week, most teachers undertake five to six courses, and the task of preparing lessons is heavy. In addition, it also undertakes homework correction and tutors' students in various extracurricular activities, competitions, and exams. According to the survey, nearly 85% of teachers said they spent most of their time in preparing lessons, writing and printing lesson plans, and making courseware everyday. From this, the traditional college English teaching mode can no longer meet the needs of teaching at this stage, and the change of teaching mode is imminent.

(3) The teaching method is single. The traditional college English teaching is mainly based on teacher teaching; in the process of large class teaching, the number of classes is relatively large, and the interaction between teachers and students is limited, teachers do not consider the activities of teachers and students when preparing lessons. English teaching is a kind of simple and repetitive work in a sense, which seriously reduces teachers' enthusiasm for teaching and students' learning.

(4) Students' enthusiasm is not high. Affected by the large class teaching, the course progress and the number of hours are continuously compressed, so teachers can only be busy displaying courseware in the limited class hours; there are fewer opportunities for nonverbal behavioral interaction, and teacher-student interaction is limited. Even if a certain teaching activity is carried out, its form is relatively simple, and the enthusiasm of students to participate in the classroom is not high.

4. Analysis of Survey Results

4.1. Analysis of Teacher Questionnaire Survey Results. In order to better understand the application of multimodal discourse analysis theory in college English discourse teaching and whether teachers understand multimodal discourse analysis theory, a total of 23 questionnaires were distributed to English teachers in four universities in city A, and 23 were recovered, with a recovery rate of 100% and 100% valid questionnaires. According to the basic structure of the teacher questionnaire, the questionnaire will be specifically analyzed according to four dimensions [23].

4.1.1. Basic Information of Teachers. According to Table 1, the author found that the current primary school English teachers are still female, and the teachers under the age of 30 are the main ones. Secondly, the current school English teachers are mainly undergraduates, accounting for 82.61%, only 13.04% hold a master's degree, and teachers under the age of 30 have a bachelor's degree. Finally, for teaching years and professional titles, we can draw the results from Table 1: educational qualifications, teaching years, and professional titles are basically positively related to the development trend.

4.1.2. Current Situation of Discourse Teaching. According to Figure 3, it is found that more than 50% of teachers believe that discourse teaching is very important in college English teaching; no teacher thinks that discourse teaching is not important. So, we can conclude the following: discourse teaching occupies an important position in college English teaching.

According to Figures 4 and 5, we found that the most popular teaching method used by teachers in discourse teaching is the task-based teaching method. Grammar-translation method and multimodal teaching method have low usage rates. At the same time, the teachers who choose the grammar-translation method are between 22 and 35 years old, and their education is a university degree [24, 25]. In addition, each English teacher will choose the task-based teaching method to design and implement teaching activities.

The results of the questionnaire survey are shown in Figures 6 and 7; when teaching discourse, most teachers pay more attention to the layout of the article or the communicative function of the discourse. Therefore, the author uses age and education as independent variables to conduct cross-analysis with this question; we found that the degree is undergraduate, and teachers between the ages of 22 and 35 believe that in discourse teaching, more attention should be paid to grammar and vocabulary in discourse.

According to Figures 8 and 9, the author found that, at present, more than 17.39% of college English teachers always use different teaching activities to teach English; among them, task-based activities are the most popular among teachers. Teachers often use different teaching activities to help students improve the ability to use texts so that students can better understand the meaning of texts. Although 4.39% of teachers occasionally use a variety of teaching activities, it is worth affirming that teachers are aware of the significance of using different teaching activities to help students understand the meaning of texts [26].

4.2. Analysis of Student Questionnaire Survey Results. In order to have a more comprehensive understanding of the current discourse teaching of college English teachers, as well as the specific effects of teaching, to help teachers

Table 1: Statistics of basic information.

	Gender	Teaching grade	Age	Education	Teaching age
Teacher A	Woman	Freshman	46–50	College	26 years
Teacher B	Woman	Sophomore	46–50	Postgraduate	24 years
Teacher C	Woman	Junior year	30–35	Undergraduate	10 years

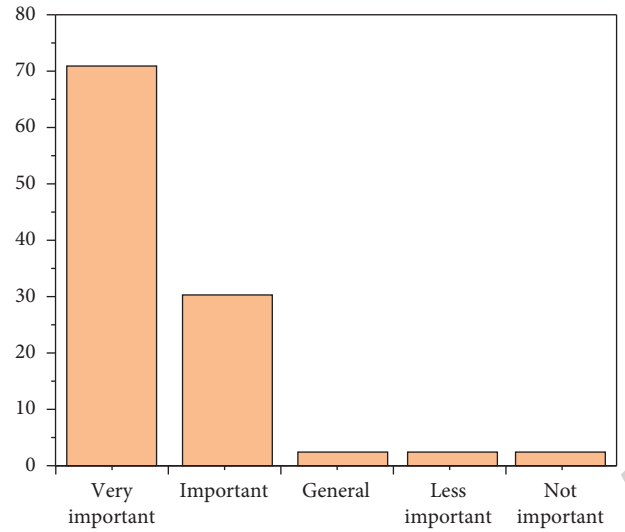


Figure 3: The status of discourse teaching in English teaching.

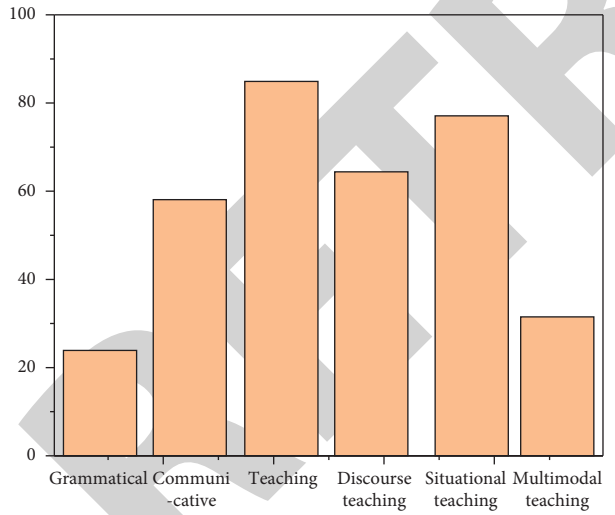


Figure 4: Statistics of the application of pedagogy in discourse teaching.

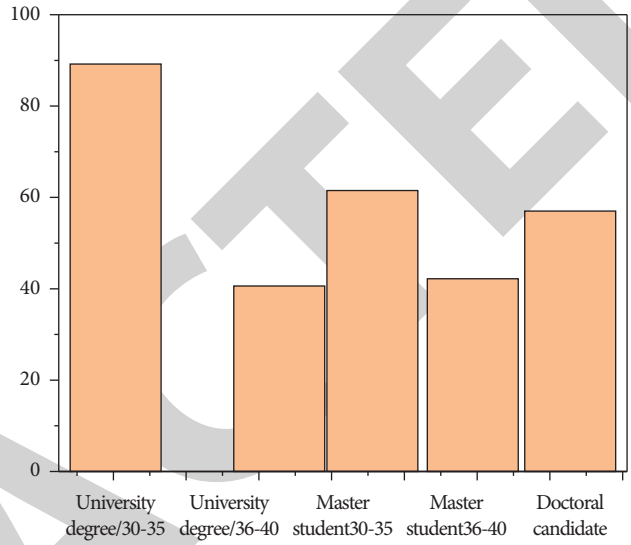


Figure 5: Cross-analysis of teachers' educational background and age and discourse teaching methods.

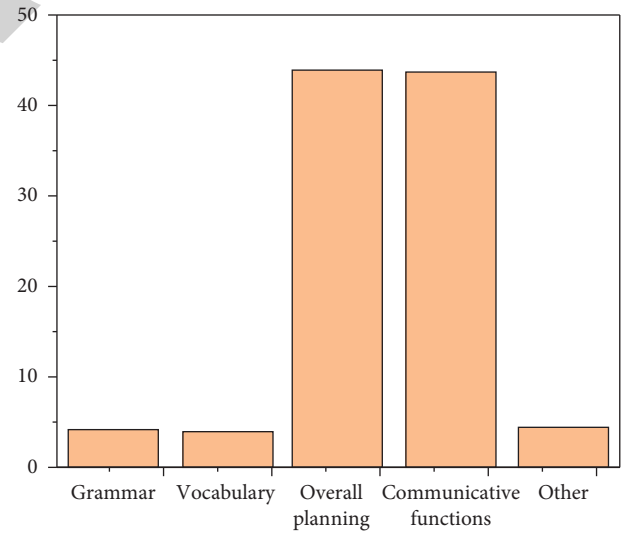


Figure 6: The important content that teachers pay attention to in discourse teaching.

improve teaching, improve students' interest in learning. A sample of students from a university in city A was selected as the student part for investigation. A total of 114 questionnaires were distributed to the students, and a total of 114 were recovered. The recovery rate was 100%, and the valid questionnaires were 100%. Among them, questions 1–3 are basic information, and questions 4–14 are mainly to understand students' real feelings about English subjects and teachers' teaching [27]. The following will analyze the questionnaire according to the three dimensions of the student's questionnaire structure (see Table 2 for details).

4.2.1. Students' Attitude towards English Class. According to Figure 10, we can see that the ratio of male to female students is relatively average, and more than 73% of the students love

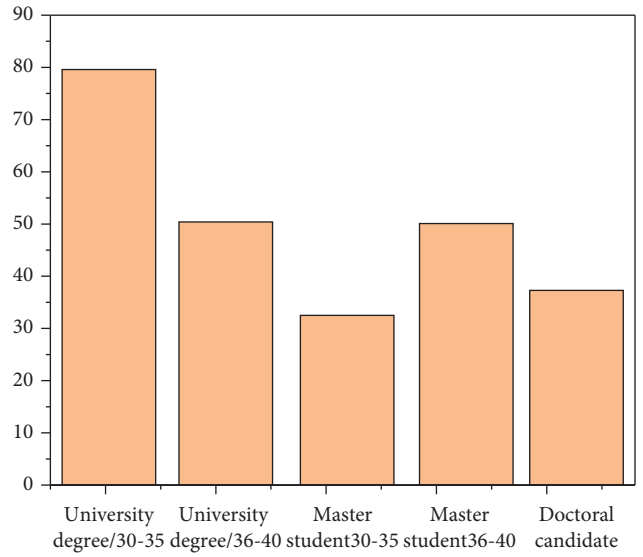


Figure 7: Cross-analysis of teachers' educational background and age and discourse concerns.

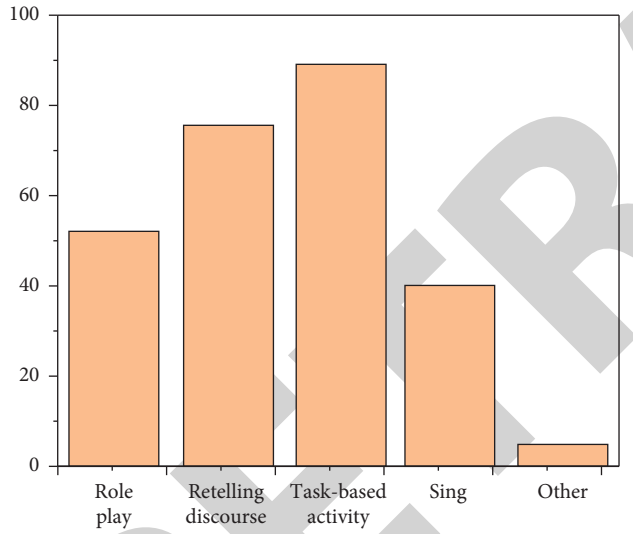


Figure 8: Teachers' commonly used teaching activities in discourse teaching.

English courses. From this, we can roughly infer that most students at the university level prefer English courses [27].

4.2.2. Students' Attitude towards Multimodal English Teaching. According to Figure 11, we can see that 43% of students like to learn English through pictures and other multimodal forms, 32% of students prefer multimodal teaching activities. Therefore, it can be understood that up to 75% of students like to learn English through different forms. Only 5% of students dislike this teaching method.

Through the analysis of the student questionnaires, we know that the children in the compulsory education stage are in the specific operation stage, they prefer more intuitive teaching forms, so more students prefer multimodal

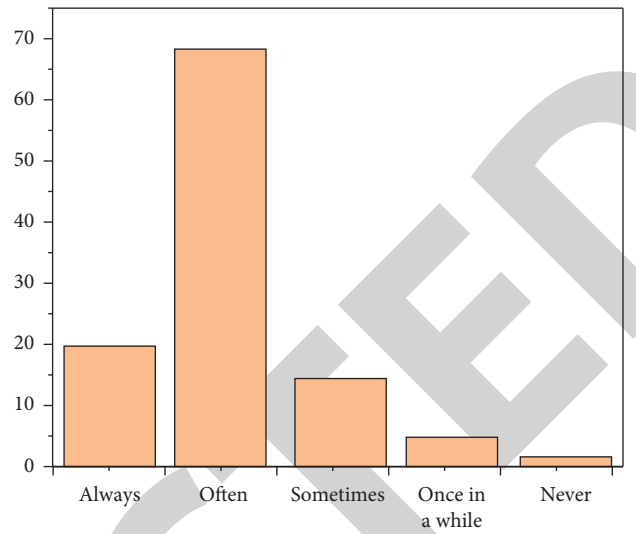


Figure 9: The frequency of teachers' discourse teaching using a variety of teaching activities to help students understand the meaning of discourse.

Table 2: Basic information of students.

Class	Man	Woman	Total people
Class 1	24	16	40
Class 2	25	20	45
Class 3	17	26	43
Total	66	62	128

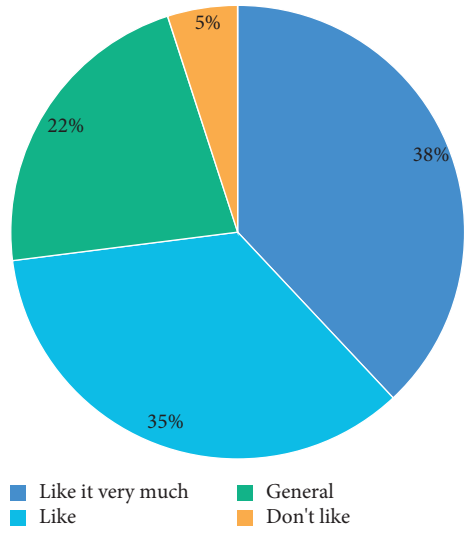


Figure 10: Students' likeness for English classes.

teaching activities to learn English. And Gardner's theory of multiple intelligences also allows us to understand; students hope that teachers in English teaching use multimodal teaching forms as much as possible to attract their own attention, strengthen their own interest in learning, to enhance the enthusiasm and initiative of learning, and then improve the comprehensive language ability.

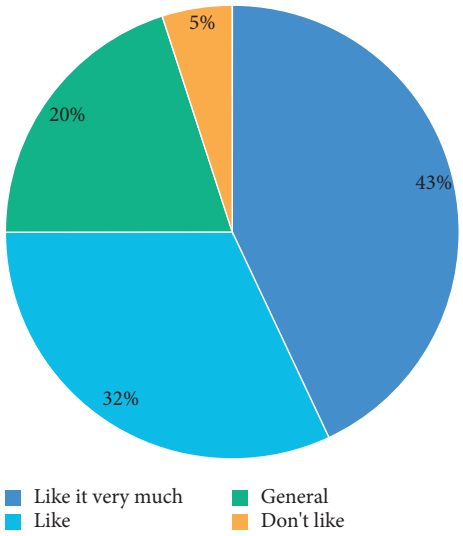


Figure 11: The degree to which students prefer multimodal English lessons.

4.3. Dynamic Trajectory of Second Language Classroom Motivation under the Condition of Multimodal Language Input. The researchers conducted intra-individual and interindividual comparisons of the motivational change trajectories of the three subjects C, M, and W in the three comprehensive English classes (as shown in Figures 12–14); it was found that the subjects' second language classroom motivation showed the relative stability of the dynamic development trend and the characteristics of nonlinear dynamic development in a certain period.

4.3.1. The Relative Stability of Motivation. As shown in Figures 12–14, subject C's motivation changes in the three lessons are all between 80 and 90, the motivation level is high, and the motivation trajectories of multiple nodes are close to the same, the range of change is small. The motivation of subject M in the 3 lessons varies from 55 to 85, and the motivation level is in the middle level and the change range is large. Subject W's motivation changes in the 3 lessons basically ranged from 30 to 40; the motivation level was low and the change range was small. The average value of the dynamic changes of motivation displayed by the three subjects in the three lessons is consistent with the results of the static questionnaire conducted before the experiment, which indicates that the motivation level of the second language learners is relatively stable within a certain period.

In summary, the "future second language self-direction" (including goal orientation and vision and imagery) of the three subjects was the cyclic attractor of their second language classroom motivation system; on the premise of not changing the development direction of motivation and the range of level changes, it plays a major guiding role in the motivational intensity of individual learners, thus contributing to the relatively stable development of L2 motivation.

4.3.2. Development of Nonlinear Dynamic Changes. The development trend of second language motivation is

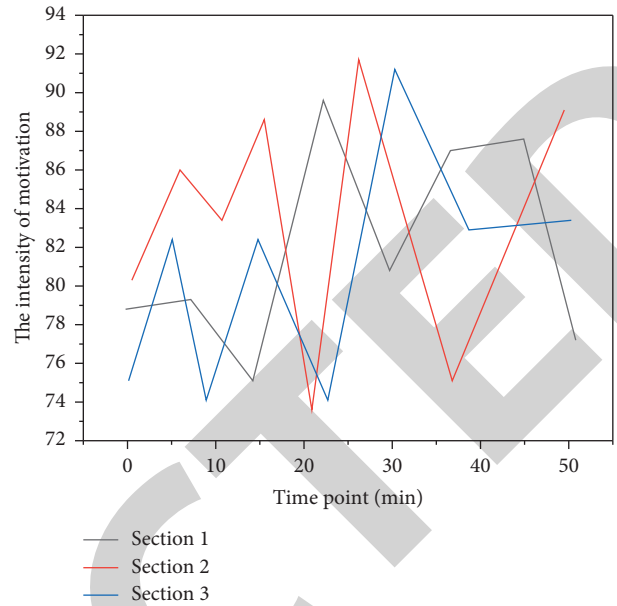


Figure 12: C's motivational change trajectory in 3 lessons.

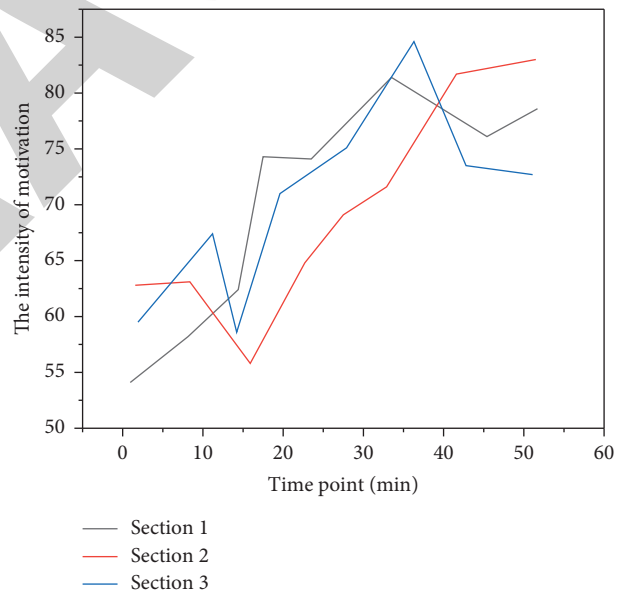


Figure 13: Motivational change trajectory of M in 3 lessons.

relatively stable, but the trajectories of the three subjects' classroom motivation also show the diversity and difference of ups and downs.

As shown in Figure 15, group motivation develops steadily; motivation levels fluctuated between 55 and 65, with no large fluctuations. The motivation levels of the three subjects in Figure 16 all changed significantly. Subject C's motivation remained at a high level; subject M changed most obviously; the level of motivation has been increasing; subject W has been in a low level of motivation. The above results show that the developmental trajectory of group motivation does not coincide with the developmental trajectory of individual motivation. Therefore, the group

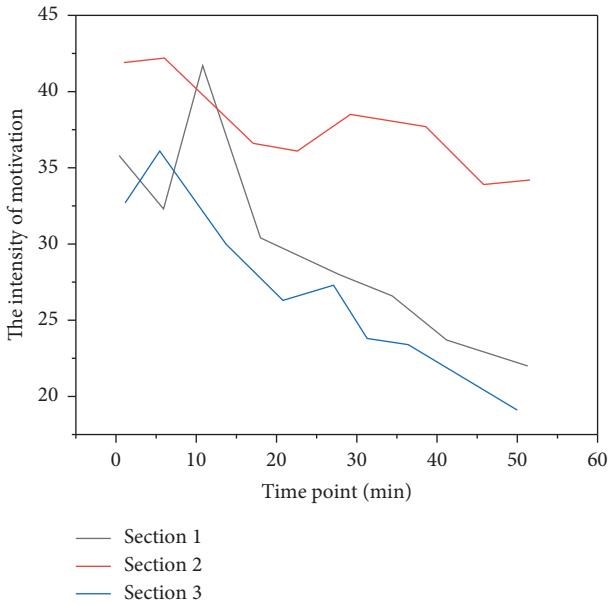


Figure 14: W's motivational change trajectory in 3 lessons.

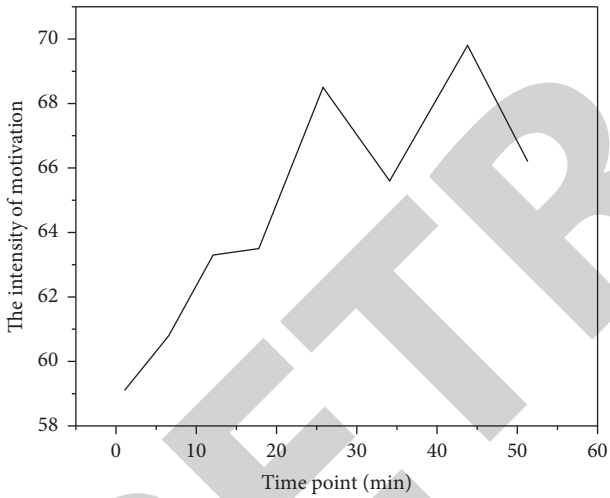


Figure 15: Change track of group motivation in the first lesson.

motivation level cannot represent the specific motivation level of the individual learners in the group and may mask the typical characteristics of individual motivation development.

In addition, the motivational development trajectories of the three subjects in the same session were also constantly changing and distinct. Subject C's motivation level increased steadily during the first 30 minutes of class, but dropped abruptly between 30 and 35 minutes. Subject C explained, "At that time, the teacher asked me to get up to answer a question, and my answer was very unsatisfactory. At that time, I was in a bad mood and struggled for a long time. Later, the teacher led a class discussion session, I was pulled back from the self-blame, and gradually recovered." Subject M's motivation level maintained a substantial increase in the first 30 minutes of the class and reached a steady state after 30 minutes, M explained, "I was in a good mood that day and

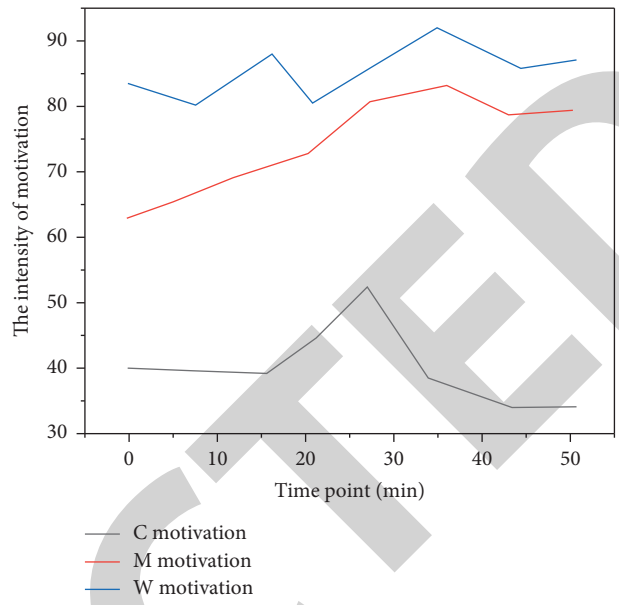


Figure 16: Change track of individual motivation level in the first lesson.

was in good shape before class. The main content of the class revolves around World War II, which is a topic I am very interested in. In the meantime, the teacher also let us enjoy the wartime video of the Battle of Britain, and imitated Churchill's impassioned wartime speech, which is great. Later, the teacher gave some audios and a lot of text materials, which felt a little boring, and at the end of a class, I was a little tired, and my interest was not so high." In contrast, subject W's motivation level changed slightly throughout the class, but it was generally in a downward trend. Additionally, between 10 and 25 minutes of this session, 3 subjects were basically in the stable and improving stage of motivation level (subject C and subject W performed most prominently); during this period, the teachers mainly adopted the classroom design form of audio + video + subtitle language input mode; this shows that multimodal language input has an effective stimulating effect on learners' motivation [28, 29]. From this, the change of learners' individual classroom motivation is mainly due to the influence of classroom environment factors. The design of classroom activities and the form of language input have obvious regulatory effects on learners' short-term learning motivation.

5. Conclusion

The author is supported by the theory of "complex dynamic development concept" and "second language motivation self-system," implemented case tracking for 3 English majors, using the time series method, the personality dynamic method, and the equivalent modeling method to explore the multimodal language input conditions, the dynamic change development characteristics, and situational influencing factors of second language classroom motivation. Research indicates, under the condition of multimodal language

input, the motivation of individual learners in the second language classroom shows the relative stability of the dynamic development trend, and the nonlinear dynamic development characteristics of a specific period. On the one hand, individual learners' future L2 self-direction is a higher-order attractor that maintains the stability of motivation levels. On the other hand, learners' language acquisition level, classroom learning content and input modality, and teacher and peer behaviors are the key situational factors for the dynamic changes of individual learners' classroom motivation [30].

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This work was supported by the Cangzhou Normal University, China.

References

[1] X. Liu, H. Yingjie, Z. Zhen, and J. Thompson, "An empirical study of production-oriented approach in college English writing teaching," *Universal Journal of Educational Research*, vol. 8, no. 11B, pp. 6173–6177, 2020.

[2] Y. Zou and X. Huang, "An empirical study of application of cultural confidence to translation teaching in college English," *International Journal of English Linguistics*, vol. 11, no. 3, 19 pages, 2021.

[3] X. Pan and Z. Zhang, "An empirical study of application of multimodal approach to teaching reading in efl in senior high school," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 15, no. 02, 98 pages, 2020.

[4] E. A. Pealver and A. S. Urbieta, "Multimodal discourse in digital storytelling: an assessment tool proposal," *CALL-EJ*, vol. 22, no. 2, pp. 14–25, 2021.

[5] A. S. Kawa, "Multimodal discourse analysis for teaching English as a second language," *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, vol. 12, no. 2, pp. 279–285, 2021.

[6] S. Belgrimet and G. Rabab'Ah, "A multimodal discourse analysis of English posters in violence awareness campaigns against women," *Theory and Practice in Language Studies*, vol. 11, no. 2, 191 pages, 2021.

[7] D. Djatmika, A. H. Wibowo, S. Sugini, H. Halim, and B. Mohamad, "Multimodal strategies in teaching children with autism: a discourse analysis," *Systematic Reviews in Pharmacy*, vol. 11, no. 2, pp. 219–229, 2020.

[8] T. Purwaningtyas, "Didactic symbol of visual images in efl textbook: multi-modal critical discourse analysis," *Pedagogy Journal of English Language Teaching*, vol. 8, no. 1, 51 pages, 2020.

[9] I. S. Luca, "A multimodal discourse analysis in media," *Romanian Journal of English Studies*, vol. 17, no. 1, pp. 74–80, 2020.

[10] S. T. Tandiana, F. Abdullah, and Y. Saputra, "Learning multimodality through genre-based multimodal texts analysis: listening to students' voices," *Vision Journal for Language and Foreign Language Learning*, vol. 9, no. 2, pp. 101–114, 2020.

[11] E. Hakokõngäs, O. Halmesvaara, and I. Sakki, "Persuasion through bitter humor: multimodal discourse analysis of rhetoric in internet memes of two far-right groups in Finland," *Social Media + Society*, vol. 6, no. 2, 2020.

[12] F. V. Lim, "Investigating intersemiosis: a systemic functional multimodal discourse analysis of the relationship between language and gesture in classroom discourse," *Visual Communication*, vol. 20, no. 1, pp. 34–58, 2021.

[13] C. Schubert, "Multimodal cohesion in persuasive discourse: a case study of televised campaign advertisements in the 2020 us presidential election," *Discourse, Context & Media*, vol. 43, no. 2, Article ID 100537, 2021.

[14] L. Law, "Creativity and power: a systemic functional multimodal discourse analysis of the co-constructed multimodal creativity-power relation in house m," *d. SERIEs*, vol. 7, no. 1, pp. 45–62, 2021.

[15] J. Chen, "Multimodal discourse analysis of judges' footing shifts in criminal courtroom," *Chinese Journal of Applied Linguistics*, vol. 43, no. 1, pp. 5–25, 2020.

[16] B. Hu, "A multimodal discourse analysis of zhaocaimao (lucky cat) constructed by the Chinese communities in South Africa," *African and Asian Studies*, vol. 19, no. 1-2, pp. 99–132, 2020.

[17] S. Y. Kim, "College disability support offices as advertisements: a multimodal discourse analysis," *Discourse Studies*, vol. 23, no. 2, pp. 166–190, 2020.

[18] N. V. Sokolova, "Multimodal it marketing discourse: an integrated approach investigation," *Russian Journal of Linguistics*, vol. 24, no. 2, pp. 366–385, 2020.

[19] D. Iii and T. Y. Lewis, "A multimodal approach to higher order literacy development of low-level efl university students in Japan," *Innovation in Language Learning and Teaching*, vol. 15, no. 2, pp. 1–20, 2020.

[20] L. Mantovan, "E pluribus unum: the detection of political persuasion through discourse analysis," *International Journal of Linguistics*, vol. 12, no. 4, 18 pages, 2020.

[21] X. Mai and Y. Fan, "An empirical study of the willingness to communicate in college English classes from an ecological perspective," *Creative Education*, vol. 12, no. 09, pp. 2056–2065, 2021.

[22] S. Kim, "An empirical study on the effects of google-based activities in the college level English learning," *The Korean Association of General Education*, vol. 14, no. 6, pp. 339–353, 2020.

[23] F. Liu, "An empirical study on the improvement of English reading ability of Chinese college students based on big data——based on the lens grading system," *Journal of Physics: Conference Series*, vol. 1744, no. 3, Article ID 032066, 2021.

[24] C. I. T. Panggabean and A. Asariski, "An analysis of efl students' questions in research on elt class at university of pgri ronggolawe tuban," *English Education Journal of English Teaching and Research*, vol. 6, no. 1, pp. 13–21, 2021.

[25] L. Gui, "An analysis of the strategies for developing students' consciousness of pronunciation and intonation in college English teaching based on the international communication," *E3S Web of Conferences*, vol. 214, no. 3, 01041 pages, 2020.

[26] S. Gao, Q. Cui, and C. Ma, *Modeling and Simulation of Proximity Explosion Damage Probability for Anti-radiation Missile Laser Fuze*, Springer, Berlin, Germany, 2019.