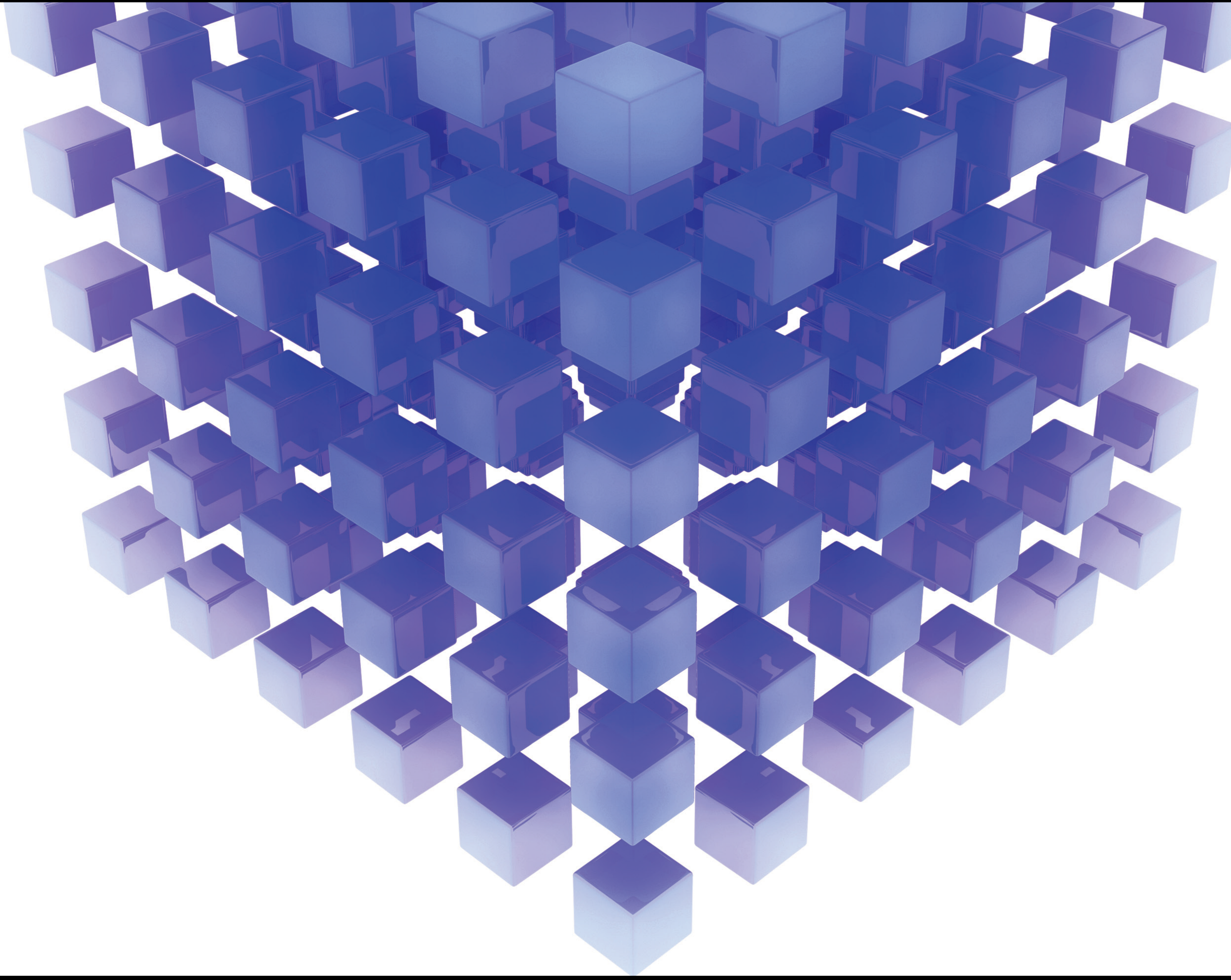
Mathematical Problems in Engineering

Advanced Mathematical Algorithms in Data Processing from Multiple Sensors

Lead Guest Editor: Baiyuan Ding
Guest Editors: Fazal Ijaz Muhammad and Gohar Ali



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Retraction

Retracted: Analysis of Realistic Problems and Practical Paths of "Three-Wide Education" in Higher Education Based on Text Analysis and Mining

Mathematical Problems in Engineering

Received 26 September 2023; Accepted 26 September 2023; Published 27 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

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

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

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

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Retraction

Retracted: Discrete Dynamic Modeling Analysis of College Students' Ideological and Political Education Based on Particle Swarm Optimization Algorithm

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Mathematical Problems in Engineering
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Retraction

Retracted: Dynamic Modeling and Analysis of Innovative Development Model and Ideological and Political Education Based on Big Data

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Retraction

Retracted: The Basic Principles of Marxism with the Internet as a Carrier

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Retraction

Retracted: An Analysis of the Historical Process of Cultural Confidence in Ideological and Political Education Based on Deep Learning

Mathematical Problems in Engineering

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Research Article

Research on the Multilabel Data Stream Classification Method Based on Fuzzy Complex Set-Valued Measure Learning

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In the process of modern industrial production equipment developing towards the direction of structure, automation, and intelligence, motor is still the main power output equipment. If the data flow classification occurs during the operation of the motor, it will lead to problems such as the reduction of its operation efficiency and the increase in system energy consumption. In serious cases, it will even cause motor damage, and the overall system equipment will be shut down for maintenance for a long time, resulting in serious economic losses. Therefore, the research on intelligent multilabel data stream classification technology of motor is of great significance to ensure the stability and reliability of efficient operation of production equipment. In order to improve the recognition efficiency and accuracy of ms-1dcnn's multilabel data stream classification method in the environment of variable motor conditions and strong noise interference, a multiscale feature fusion framework is constructed based on the residual network structure. The implementation principles of two kinds of attention mechanism algorithms, squeeze and excitation module and convolution attention module, are studied, respectively. The attention module suitable for one-dimensional residual network is designed and embedded into the residual module to build a multiscale attention residual network model. Finally, the effectiveness and superiority of the proposed model are verified by using the experimental platform data.

1. Introduction

1.1. Research Background and Significance. As important power equipment in various production fields, the motor has the advantages of low price, relatively simple overall structure, relatively reliable, and so on, and undertakes more than 80% of the kinetic energy output in the process of modern industrial and agricultural production [1]. Especially in metallurgy, mining, machining, rail transit, and other industrial production fields, the installed capacity is huge and widely used. Motors and their related power equipment are important assets of enterprises, and their reliability and stability during operation are the key to ensure the safe and stable operation of mechanical equipment for a long time [2]. If the data flow classification of the motor occurs during the operation of the equipment, it will lead to unstable operation, sharp rise in energy consumption, and other conditions. In serious cases, it will even cause damage to the motor and equipment, and then affect the normal operation of the whole equipment. Sudden shutdown and maintenance must be carried out, resulting in problems such as slow production progress and economic losses. The regular maintenance of the motor is usually aimed at the inspection and maintenance of the motor, which has a certain positive significance in reducing the classification rate of the data flow of the motor, but there are problems such as insufficient maintenance, and blind repair [3]. At the same time, the traditional signal processing and threshold judgment methods using sensor signals are not enough in the process of industrial production in a complex environment, and because the early characteristics of data flow classification are weak or disturbed by noise, there are often cases of inadequate response, motor damage, and production pause when data flow classification is found, resulting in huge property losses and even casualties [4]. The development requirements of automation and intelligence of modern industrial equipment have led to the continuous innovation of multilabel data stream classification technology. At this stage, the intelligent multilabel data stream classification method based on signal processing, artificial intelligence, and other technologies has the advantages of high recognition accuracy and strong adaptability and is a hot issue in the field of multilabel data stream classification [5]. In the “made in China 2025” proposed in 2021, equipment intelligent diagnosis technology is listed as one of the important related technologies in the field of intelligent manufacturing, and it is an important technical means to realize the safe and stable operation of intelligent equipment [6, 7]. Therefore, it is of great practical significance to analyze the data flow classification mechanism of a motor and study the relevant intelligent multilabel data flow classification methods for maintaining the safe, stable, and efficient operation of industrial production.

At present, motor multilabel data stream classification technology can generally be divided into three categories: model-based, signal processing and machine learning, and deep learning [8]. At the beginning of the development of multilabel data stream classification technology, people have performed a lot of research on model-based multilabel data stream classification technology, but because it usually needs to build a mathematical model that can accurately reflect the actual running state of the motor, there are obvious defects and great difficulties. The traditional intelligent multi label data stream classification technology based on signal processing and machine learning has a good operability and recognition effect and has been widely used in the field of multilabel data stream classification. In recent years, with the continuous breakthroughs of computer, artificial intelligence, and other information technologies, as well as the requirements of modern industrial development, intelligent multilabel data stream classification technology based on deep learning algorithm has received extensive attention and research. It is a new research hotspot in the field of multilabel data stream classification and is in the process of rapid development [9, 10].

Based on the data of SIQ-MFS mechanical data flow classification test-bed, aiming at a variety of common types of motor data flow classification in the actual production process, this topic uses the motor vibration signal to realize the research on the motor data flow classification method. In the research of traditional intelligent multilabel data stream classification methods, it is usually necessary to analyze the collected data stream classification signals, extract the features that can reflect the classification status of the real data stream and further filter or reduce the dimension of the features through human intervention and finally get the diagnosis results through the pattern recognition algorithm. Based on the analysis of the generation mechanism of motor data stream classification, the EEMD method is used to analyze and extract the characteristics of motor vibration signals, and a feature selection method based on improved and adjusted mutual information is proposed for multilabel data stream classification. Aiming at the problems of a complex process and human intervention in traditional intelligent multilabel data stream classification methods, a one-dimensional convolution multiscale feature fusion framework is constructed, and an end-to-end intelligent motor multilabel data stream classification based on multiscale one-dimensional fuzzy complex value measure learning is proposed. A multiscale residual network model based on attention mechanism is proposed to solve the common problems of variable working conditions and strong noise interference in practical applications. The experimental results show that the proposed method can effectively realize the classification of multilabel data flow of motor, and has a good robustness and diagnostic effect under variable working conditions and noise interference, which is of practical significance to ensure the safe and stable operation of the motor.

1.2. Research Status

1.2.1. Research Status of Motor Multilabel Data Stream Classification Technology. Multilabel data stream classification is an important technical means to ensure the safe and smooth operation of equipment. It is a hot research direction of interdisciplinary and is in the process of continuous development. In the 1960s, through the monitoring of parameters such as current, voltage, vibration frequency, radial speed, and shaft radial flux, the classification characteristics of motor data flow were studied, and the purpose of multilabel data flow classification was achieved by threshold judgment [11]. Based on various measurement sensors, many researchers have adopted different monitoring methods, combined with signal processing, Internet of things and artificial intelligence technology designed a variety of multilabel data flow classification methods for the various parameters and possible operating conditions of mechanical equipment, which has led to the rapid development of equipment multilabel data flow classification technology, and the accuracy and speed of motor multilabel data flow classification have been improved. It plays a great role in promoting the safe operation of the motor [12, 13].

1.2.2. Multilabel Data Stream Classification Method Based on Signal Processing and Machine Learning. At present, in the process of studying the multilabel data stream classification method based on signal processing and machine learning, because the vibration signal of the motor will show complex nonstationary and nonlinear characteristics when it is in the data stream classification state, in order to fully reflect the classification characteristics of the data stream in the signal, it is necessary to use the time-frequency analysis method to analyze the changes of its vibration signal distribution parameters with time. In the process of multilabel data stream classification, time-frequency analysis methods such as short-time Fourier transform, wavelet transform, and Hilbert Huang transform are usually used to analyze vibration signals [14–16], obtain signal sequences that can reflect the time-frequency characteristics of data stream classification types and calculate their different types of statistical characteristics through a variety of methods, so as to build a data stream classification feature set for motor multilabel data stream classification. Huang et al. proposed to use iterative empirical wavelet packet (EWT) to analyze the gearbox data stream classification signal and used the multi iterative mutual information energy entropy to denoise and reconstruct the decomposed signal components. Finally, the sparse filter fuzzy complex value measure learning model is used to extract the effective data stream classification features and realize multilabel data stream classification [17]. Zhaohua and Huang proposed an adaptive frequency window empirical wavelet transform method to segment the signal spectrum through the frequency window and adaptively select the position of the window and then extract the early features of data flow classification by using the empirical wavelet packet [18]. Cheng-Chien et al.first performed EEMD decomposition on the bearing vibration signal, screened the IMF component based on the calculation of the correlation coefficient and combined it with the distance factor and reconstructed the signal, so as to eliminate the noise interference in the original signal and finally realized the multilabel data stream classification through the wavelet packet and the correlation coefficient [19]. Imaouchen et al. proposed to improve the EMD method by adding complementary noise. On the basis of overcoming the problem of modal aliasing, this method can effectively eliminate the noise residue in the algorithm process and improve the calculation efficiency of EEMD. Finally, IMF component reconstruction signals related to data stream classification features are selected, and amplitude and frequency modulation are extracted from the selected IMF by frequency weighted energy operator method for multilabel data stream classification [20, 21]. Among the above time-frequency signal analysis methods, the EMD method has many characteristics, such as intuitive, posterior, and adaptive. It can effectively decompose the nonstationary vibration signal into signal components of different frequencies in turn. It is one of the most commonly used time-frequency analysis methods. However, when the signal to be decomposed contains many discontinuous signals with different frequencies, the mode aliasing problem will appear in EMD decomposition. Therefore, in practical applications, EMD will be improved by noise-aided analysis and other methods [22].

1.2.3. Research Status of Fuzzy Complex Valued Measure Learning. In recent years, because the key problems of the deep learning algorithm in the training process have been solved, it has made outstanding achievements in image, computer vision, natural language processing, and many other fields by virtue of its incomparable advantages with other technologies, as well as a variety of algorithms that are applicable to various scenes and have a variety of different structure types.

Common deep learning algorithms include restricted Boltzmann machine, automatic encoder, and fuzzy complex value measure learning, on this basis, many researchers have proposed a variety of improved algorithms for different problems and scenarios, which greatly promotes the development and improvement of deep learning. Generally, deep learning algorithm is a kind of network structure with multiple hidden layers, which can realize the effective analysis of input data, learn the inherent characteristics and attributes contained therein, establish the mapping relationship between input data and characteristics, have excellent intelligent learning ability and have been widely used in many fields. Among them, fuzzy complex valued measure learning is one of the most widely used deep learning algorithms. Its excellent application potential has been widely valued and caused many scholars to conduct in-depth research [23].

Fuzzy complex value measure learning is convenient for processing a large amount of data and can automatically extract the deep features in the signal and realize the automation and intellectualization of multilabel data stream classification. As an end-to-end fuzzy complex value measure learning model, it overcomes the problems of low efficiency and effect of multilabel data stream classification caused by complex steps and too many human interventions of traditional intelligent multilabel data stream classification methods to a certain extent. Although fuzzy complex set-valued measure learning has many advantages and is a hot topic of current research, its research in the field of multilabel data stream classification is still in the process of continuous development. More and more in-depth research is needed on how to design a fuzzy complex set-valued measure learning structure suitable for multilabel data stream classification and how to improve the problems of variable working conditions and noise interference in the process of multilabel data stream classification [24].

1.3. Research Route.

(1) The whole research of this paper can be divided into two parts: multilabel data stream classification method based on signal processing and deep learning. In the multilabel data stream classification method based on signal processing, the time-frequency signal analysis and the corresponding spectral analysis methods are studied, respectively. Nine time-frequency and frequency-domain statistical features are selected to construct the feature set, and the sensitive features are screened. Finally, the dimension reduction and pattern classification algorithm are used to realize the construction of the motor diagnosis model. In the multilabel data stream classification method based on deep learning, the application of one-dimensional fuzzy complex value measure learning in the field of multilabel data stream classification is studied, and multiscale one-dimensional fuzzy complex value measure learning is constructed for motor multilabel data stream classification. Aiming at the problems of variable working conditions and noise interference of the motor, the attention mechanism and multiscale residual network are used to build a diagnostic model. Finally, the four common motor data flow classifications collected by the SQI-MFS data flow classification experimental platform and the vibration data under a normal motor state are fully verified by experiments [25].

(2) The time-frequency analysis method EMMD of vibration signals is studied, and the time-frequency features are extracted to construct the original

feature set. In view of the low correlation of its features, which cannot accurately reflect the classification state of data flow, and the redundancy between various features, a feature selection method AMISR based on improved and adjusted mutual information is proposed. The adjusted mutual information value obtained after feature clustering analysis is combined with the standard deviation as the feature evaluation index, quantitative analysis of feature sensitivity. On this basis, the LDA dimensionality reduction algorithm is used to map high-dimensional features to low-dimensional space, and the EMMD-AMISR-LDA-SVM model is constructed to realize the classification of motor multilabel data flow. The effectiveness of the proposed method is verified by two groups of comparative experiments.

(3) Aiming at the problems existing in the traditional intelligent multilabel data stream classification method based on signal processing and machine learning, such as complex process, too much intervention, weak generalization ability, and poor adaptability, this paper further studies the multilabel data stream classification method based on one-dimensional fuzzy complex value measure learning by referring to the current popular deep learning method and combining the one-dimensional attribute of vibration signal. The multiscale feature fusion framework is studied, and an end-to-end multiscale one-dimensional fuzzy complex value measure learning data flow classification diagnosis model is proposed. The stability, generalization performance, and anti-noise ability of the model are verified by motor off-duty and noise interference experiments [25].

2. Classification Principle and Signal Analysis of Multilabel Data Flow

2.1. Analysis of Data Flow Classification Mechanism

2.1.1. Classification Mechanism Analysis of Rotor Broken Bar Data Flow. Because the rotor is subjected to thermal, mechanical, and other stresses during operation, it is easy to classify the broken bar data flow of the rotor after long-time operation or frequent start-up and stop operations. Because the system is relatively complex, the vibration parts and corresponding vibration signals produced by different data stream classification types are different [19].

When operating in the state of no data flow classification, the stator current frequency only contains the main frequency components. When rotor bar breaking data flow classification occurs, electromagnetic and mechanical vibration will occur inside, resulting in harmonic components in the spectrum of stator current. Assuming that the power supply frequency is, the fundamental wave of the three-phase synthetic magnetomotive force of the stator current can be expressed as

$$F_1 = K_1 N_1 I_1 \sin(2\pi - p\theta). \quad (1)$$

The phase of the rotor winding can be obtained as $\varphi = \theta - 2\pi f_r t$, then according to the balance relationship between the stator and rotor magnetomotive force, we get

$$\begin{aligned} T_1(t,\theta) = \frac{K_2 N_2 I_2}{2}\{&\cos[2\pi(f_1 + 2f_r)t - 3\theta] \\ &-\cos[2\pi(f_1 - 2f_r)t + \theta]\}. \end{aligned} \quad (2)$$

When the number of pole pairs P is 1, the slip is

$$\begin{aligned} s &= \frac{(f_1 - f_r)}{f_1}, \\ T_1(t,\theta) &= \frac{K_2 N_2 I_2}{2}\{\cos[2\pi(3-2s)f_1 t - 3\theta] \\ &\quad -\cos[2\pi(1-2s)f_1 t - \theta]\}. \end{aligned} \quad (3)$$

It can be seen from the above analysis that when the rotor bar breaking data flow classification occurs, the frequency in the stator current spectrum will be $f_{bp} = (1-2s)f$. The harmonic component is specifically manifested in the periodic fluctuation of the stator current due to imbalance, which causes the periodic vibration of 2sf in rotor torque and speed, resulting in mechanical vibration.

2.1.2. Analysis of Data Flow Classification Mechanism of Stator Winding. Stator winding data flow classification is usually caused by the damage and falling off of the insulation paint on the surface of the conductor due to long-term high-temperature and corrosive operating environment. It is a common type in asynchronous data flow classification.

$$\begin{aligned} F_e &= \frac{f}{p} \times 2p = 2f, \\ f_s &= (1 \pm 2k(1-s))f, \\ f_s &= (n \pm 2k(1-s))f \quad n = 1,2,3\ldots, k = 0,1,2\ldots. \end{aligned} \quad (4)$$

It can be seen from the above analysis that when the stator winding data flow classification occurs, the harmonic component in the stator current is significantly enhanced, resulting in a certain change in the frequency of vibration. Therefore, the vibration signal can be used as an effective data source that can directly reflect the data flow classification state [26].

2.1.3. Bearing Data Flow Classification Mechanism Analysis. When the bearing has local surface type damage, the characteristic frequency that can reflect its own data flow classification state will appear in the data flow classification vibration signal and show the characteristics of periodicity and decreasing amplitude. Therefore, some signal time-frequency analysis methods can be used to obtain the characteristic information from the nonstationary data stream classification vibration signals with complex frequency components, so as to lay a foundation for constructing the data stream classification feature set and realizing the

Table 1: Four kinds of bearing fault characteristic frequency calculation formulas.

Data flow classification type	计算公式	公式编号
Inner circle data flow classification	$f_i = nr/120(1 + d/\mathrm{D}\sin\alpha)$	(8)
Outer ring data flow classification	$f_o = nr/120(1 - d/\mathrm{D}\cos\alpha)$	(9)
Rolling element data flow classification	$f_b = r/120(1 - d/\mathrm{D}\cos\alpha)$	(10)
Cage data flow classification	$f_c = Dr/120\ d[1 - (d/D)^2\cos^2\alpha]$	(11)

accurate multilabel data stream classification. The damage of different structural components of the bearing will lead to different types of bearing data flow classification, and the corresponding theoretical data flow classification characteristic frequencies are also different. The specific calculation formulas of four different bearing data flow classifications are shown in Table 1.

2.2. Vibration Signal Analysis Method. The frequency characteristics of data stream classification vibration signals are time-dependent, so it is necessary to analyze the change of signal frequency with time. Therefore, time-frequency analysis method is needed to obtain local and global information in the time domain and the frequency domain. In this section, the basic principles of empirical mode decomposition and its improved method are introduced in detail, and simple experimental verification is carried out through example signals [27].

2.2.1. Empirical Mode Decomposition. Empirical mode decomposition (EMD), proposed by Huang in 2021, is a part of Hilbert Huang transform. Because of its strong time-frequency analysis ability and adaptive characteristics, it has been widely used in many fields, including multilabel data stream classification. EMD decomposes the original vibration signal into a series of instantaneous frequency effective single component signals and a set of residual signals according to different frequency components. The single component signal is called the eigenmode function component, and each IMF component only contains the local characteristic signals of the same time scale in the original signal. In order to verify that the single component signal obtained is an IMF component, it is usually judged according to the following two conditions:

(1) Within the length of the signal sequence, the number of extreme points and the number of zero crossings are equal or at most the difference is no more than 1.

(2) For any time, the mean value of the local envelope of the signal is 0.

The specific steps of EMD decomposition of the original signal are as follows:

$$\begin{aligned} h_1(t) &= x(t) - m_1(t),\\ r_2(t) &= r_1(t) - c_2(t), \cdots, r_m(t)\\ x(t) &= \sum_{k=1}^{m} c_k(t) + r_m(t). \end{aligned} \tag{5}$$

From the decomposition process of the vibration signal, it can be seen that the sequence in which each IMF component is decomposed corresponds to the height of the component frequency component, that is, the IMF component decomposed first contains the high-frequency component in the signal, which contains obvious and important characteristic information.

2.2.2. Set Empirical Mode Decomposition. Verify the effect of EEMD on suppressing mode aliasing through the simulation signal and set the simulation signal as

$$x(t) = x_1(t) + x_2(t) + n(t). \tag{6}$$

Among them, $x_1(t) = \sin(100\pi t + \pi/2), x_2 2 = \sin(20\pi t)$, $n(t)$. It is intermittent noise signal.

Due to the superposition of intermittent noise signal components in the mixed signal, after EMD decomposition, it can be clearly seen that there are frequency components with greatly different time scales in imf1 to imf4 components, and there is modal aliasing, which fails to achieve the decomposition goal of the EMD algorithm.

By repeatedly using Gaussian white noise in the algorithm flow to smooth the intermittent signals in the signal to be decomposed, the accurate decomposition of signals with different frequency components can be achieved, and the problem of modal aliasing can be effectively suppressed.

3. Feature Selection and the Multilabel Data Stream Classification Method Based on Improved and Adjusted Mutual Information

3.1. Introduction. For the problems of high dimension and feature redundancy of a feature set, two representative dimensionality reduction algorithms, unsupervised principal component analysis (PCA) and supervised linear discriminant analysis (LDA), are studied to realize the mapping from high-dimensional features to low-dimensional feature space, which is convenient for the training and testing of the classification algorithm. Finally, combined with two classical machine learning classification algorithms, support vector machine and limit learning machine, a multilabel data stream classification model is constructed and verified by two groups of comparative experiments. The experimental results show that the model proposed in this chapter can achieve better recognition results.

3.2. Improved Feature Selection Method. Feature selection analyzes various features in the original feature set and uses some algorithms or indicators to select features that can reflect the classification status of data flow, so as to improve the diagnostic performance. Feature selection also reduces the dimension of feature set, avoids model over fitting and accelerates the operation speed of algorithm model. In this section, based on extracting the original feature set from the original signal sample by using the methods of set empirical mode decomposition (EEMD), spectral analysis, and statistical analysis, and clustering it by using the fuzzy C-means algorithm. A feature selection method that introduces the standard deviation into the cluster evaluation index adjusted mutual information (AMI) is proposed. The original features are evaluated quantitatively to select effective features for classification.

3.2.1. Fuzzy C-Means. Fuzzy C-means (FCM) realizes the soft interval division of all sample points in the data set by introducing membership weight, so that samples of the same category gather around the cluster center and has a higher tolerance for ambiguous samples in the sample points. After initializing the cluster center according to the sample data, the cluster center and the membership weight of each sample are iteratively updated by minimizing the objective function. When the position of the cluster center gradually tends to be stable during multiple iterative operations, and its change difference is within the set range, the algorithm update is stopped [28]. The objective function formula of FCM is shown in the following formula:

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m}\left\|x_i - c_j\right\|^2, \quad 1 \le m < \infty. \tag{7}$$

Here, membership degree is U_{ij} and cluster center is C_j. The calculation formula of iterative update is expressed as

$$\begin{aligned} u_{ij} &= \frac{1}{\sum_{k=1}^{C}\left(\left\|x_i - c_j\right\| / \left\|x_i - c_k\right\|\right)^{2/m-1}}, \\ c_j &= \frac{\sum_{i=1}^{N} u_{ij}^{m}\cdot x_i}{\sum_{i=1}^{N} u_{ij}^{m}}. \end{aligned} \tag{8}$$

The termination condition of iteration update is

$$\max_{ij}\left\{\left|u_{ij}^{(k+1)} - u_{ij}^{(k)}\right|\right\} < \delta. \tag{9}$$

Because FCM is an unsupervised algorithm, there is a problem of the validity test. Therefore, it is necessary to evaluate the performance of the algorithm through some clustering evaluation indicators. The commonly used clustering evaluation indicators include entropy, Pearson correlation coefficient, mutual information, and Davies–Bouldin index.

3.2.2. Adjust Mutual Information. Mutual information is used to express the relationship between information. It is a measure of statistical correlation between random variables. Its definition is similar to cross entropy. It is used to measure the consistency of two data distributions and as an evaluation index of data clustering results. Assuming that and are the distributions of samples, the entropy of the two distributions are

$$H(U) = \sum_{i=1}^{|U|} P(i)\log(P(i)), H(V) = \sum_{j=1}^{|V|} P'(j)\log(P'(j)). \tag{10}$$

Then the mutual information between u and V can be expressed as

$$MI(U,V) = \sum_{i=1}^{|U|}\sum_{j=1}^{|V|} P(i,j)\log\left(\frac{P(i,j)}{P(i)P'(j)}\right). \tag{11}$$

The closer the AMI value is to 1, the more consistent the sample point is with the actual category.

$$\text{AMI} = \frac{MI - E(MI)}{\text{mean}(H(U), H(V)) - E(MI)}. \tag{12}$$

3.2.3. Feature Selection Method. The implementation steps of AMISR are as follows.

There are C types of data flow classification. The vibration signals of all states are analyzed by time-frequency analysis and spectral analysis. A total of N signal sample sequences corresponding to each data stream classification type are obtained, and a variety of statistical features are calculated to construct the original feature set $[\mathrm{OF}^1, \mathrm{OF}^2, \ldots, \mathrm{OF}^M]$, then the matrix formed by the mth feature of all n sample signals is shown in the following formula:

$$OF^m = \begin{bmatrix} F_{11}^m & F_{11}^m & \cdots & F_{1N}^m \\ F_{21}^m & F_{22}^m & \cdots & F_{2N}^m \\ \vdots & \vdots & \ddots & \vdots \\ F_{C1}^m & F_{C2}^m & \cdots & F_{CN}^m \end{bmatrix}, \tag{13}$$

$$SD_c^m = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(S_{ci}^m - \overline{S}_c^m\right)^2}, \tag{14}$$

$$\overline{S}_c^m = \frac{1}{N}\sum_{i=1}^{N}\left(S_{ci}^m\right). \tag{15}$$

Then, after calculation, the standard deviations of all C states are constructed in turn, and the standard deviation set of the mth feature is obtained as $[SD_1^m, SD_2^m, \ldots S_D^C]$, and sum it to get

$$\text{SSD}(m) = \sum_{j=1}^{M} SD_j^m. \tag{16}$$

After calculating the AMI value and standard deviation of all m statistical characteristics, the calculation formula of AMISR is defined to obtain the AMISR value sequence, and the calculation method is shown in the following formula:

$$\mathrm{AMISR}(m) = \frac{\mathrm{AMI}(m)}{SD(m)} \quad m = 1, 2, \ldots, M. \tag{17}$$

Through the above analysis process, it can be seen that the larger the AMISR value of the statistical feature, the higher its correlation with the current data flow classification type and has stronger feature expression ability, which indicates that the features screened by AMISR have the advantages of high degree of aggregation and low degree of deviation within the class. Therefore, using AMISR to evaluate the original feature set and screen out highly relevant features is conducive to improving the effect of multilabel data stream classification [29].

3.3. Extreme Learning Machine. Limit learning machine was proposed by Huang–Guangbin and others in 2004. It is a single hidden layer feedforward fuzzy complex set-valued measure learning model. In the training process, the connection weight between the input layer and the hidden layer of ELM and the threshold of hidden layer neurons are generated by a random algorithm, so it is only necessary to set the number of hidden layer nodes without iteratively updating the above parameters. Compared with the traditional feedforward fuzzy complex set-valued measure learning, ELM has a faster training speed and a better generalization performance while ensuring accuracy.

Figure 1 shows the typical structure of ELM, which is usually composed of input layer, hidden layer, and output layer. The neurons between different network layers are fully connected.

Suppose a single hidden layer fuzzy complex set-valued measure learning with L hidden nodes can be expressed as

$$\begin{gathered}
\sum_{i=1}^{L} \beta_i g\left(W_i \cdot X_j + b_i\right) = o_j \quad j = 1, 2, \ldots, N, \\
H\left(W_1, W_2, \ldots W_L; b_1, b_2, \ldots, b_L; X_1, X_2, \ldots X_L\right) \\
= \begin{bmatrix} g\left(W_1 \cdot X_1 + b_1\right) & \ldots & g\left(W_L \cdot X_1 + b_L\right) \\ \vdots & \ldots & \vdots \\ g\left(W_1 \cdot X_N + b_1\right) & \ldots & g\left(W_L \cdot X_N + b_L\right) \end{bmatrix}, \\
\beta = \begin{bmatrix} \beta_1^T \\ \vdots \\ \beta_L^T \end{bmatrix}_{L\times m}, \\
T = \begin{bmatrix} T_1^T \\ \vdots \\ T_N^T \end{bmatrix}_{N\times m}.
\end{gathered} \tag{18}$$

3.4. Support Vector Machine. In the course of decades of development, support vector machine has been improved and perfected many times by hard margin, soft margin, kernel function, and other methods, gradually theorized as a part of statistical learning theory and has been successfully applied in pattern classification tasks in many fields, as shown in Figure 2.

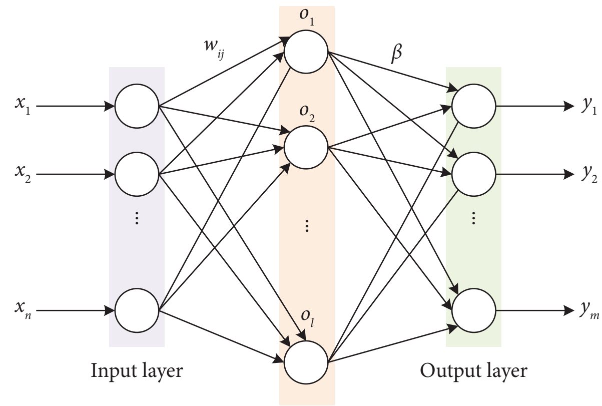

Figure 1: Structure of extreme learning machine.

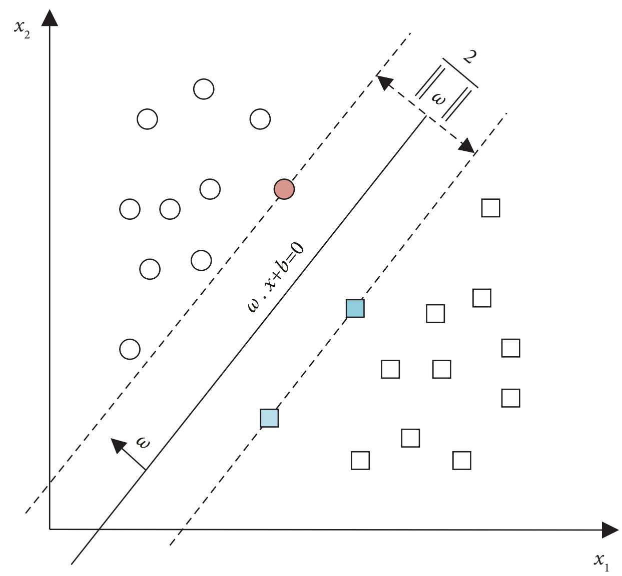

Figure 2: Linear support vector machine partitioning interface.

In order to divide as many sample data as possible correctly, SVM must first obtain the optimal separation hyperplane that maximizes the spacing between different categories of samples.

4. Multilabel Data Stream Classification Method Based on Multiscale One-Dimensional Fuzzy Complex Measure Learning

4.1. Introduction. Traditional intelligent multilabel data stream classification methods based on signal analysis and machine learning usually have the problems of a complex diagnosis process and too much human intervention. Many end-to-end intelligent multilabel data stream classification methods based on deep learning have the advantages of strong feature learning ability, simple diagnosis process, and high recognition accuracy, and gradually become the research hotspot in the field of multilabel data stream classification. As one of the widely used deep learning algorithms, fuzzy complex measure learning has not only made outstanding achievements in image related fields but also many researchers have realized its great research and application potential in the field of multilabel data stream classification.

4.2. Fuzzy Complex Valued Measure Learning Structure. Fuzzy complex valued measure learning (CNN) is a typical and representative deep learning algorithm, which was first proposed by Alexander Waibel et al. In 1987, CNN is a feedforward multilayer fuzzy complex set-valued measure learning model. Its main structure is usually composed of three parts: convolution layer, pooling layer, and full connection layer. The convolution layer and pooling layer mainly perform convolution, pooling, and other operations on the input signals of the network to realize feature learning. Then, the feature map obtained is spread and connected through the full connection layer, and the classification results are output in combination with the softmax function layer.

4.2.1. Convolution Layer. The convolution layer usually contains a set of convolution kernels. Each convolution kernel only convolutes the local area of the input signal or the feature map and then integrates the local features in the next level network to obtain the global feature map. Another main feature of the convolution layer is weight sharing, that is, each convolution kernel must traverse the output of the previous layer, and the weight parameters of any convolution kernel remain unchanged in this process. Weight sharing can effectively reduce the network parameters of the convolution layer, reduce the amount of calculation required for model training and avoid over fitting the model.

4.2.2. Activation Layer. The nonlinear mapping of the input features of the convolution layer is realized through the activation function, and the features in the original multidimensional space are mapped to another space to increase the linear separability of the data.

4.2.3. Pool Layer. Common pooling functions include Max pooling function and average pooling function. Maximum pooling refers to taking the maximum value of the activation value in the local receptive field as the output value, while average pooling refers to taking the average value of the activation value in the local receptive field as the output value. The specific pooling operation is shown in Figure 3, and the filter size is 2×2. The step size is 2.

4.2.4. Full Connection Layer. In the fuzzy complex set-valued measure learning model, the output of the previous layer of the network is spread and connected to realize the mapping from the feature to the sample tag space, forming the input of the full connection layer, and then through the hidden layer using the ReLU function as the activation function, combined with the softmax function to realize the output of the classification results. Its structure is shown in Figure 4.

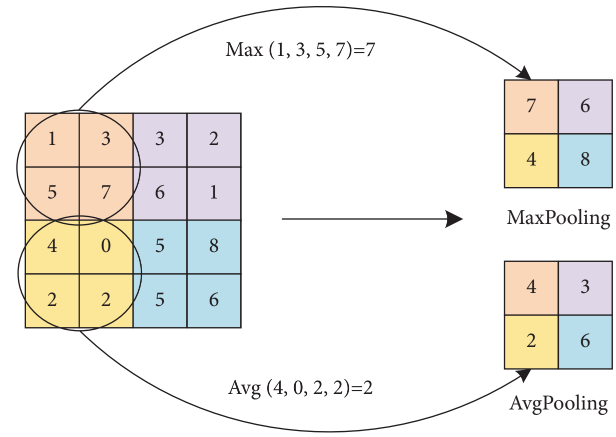

FIGURE 3: Pooling operation diagram.

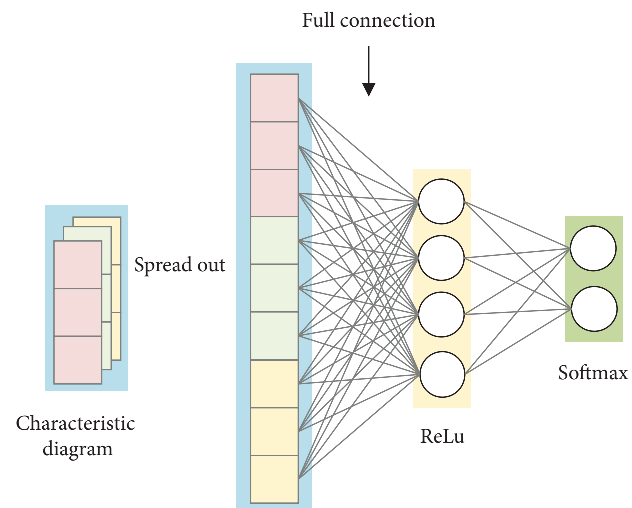

FIGURE 4: Schematic diagram of fully connected layer.

4.2.5. Loss Function. In the learning of fuzzy complex set-valued measure, peers use the loss function to measure the consistency between the output estimated value of the network model and the probability distribution of the target value. The smaller the loss function value is, the better the fitting degree of the network model to the training set samples is, as shown in Figure 5.

4.3. One-Dimensional Fuzzy Complex-Valued Measure Learning Structure. In the field of image, because the large convolution kernel will greatly increase the amount of calculation of network parameters, which is not conducive to the deepening of the model depth and will reduce the computational performance, the two-dimensional fuzzy complex-valued measure learning is usually constructed by stacking multiple small convolution kernels. For example, two 3's are usually used × The convolution layer stack of 3 replaces 1 with 5×5, the receptive field size remains unchanged, but the parameters are greatly reduced. However, for one-dimensional vibration signals, the amount of parameter calculation will increase after the stacking of smaller convolution cores

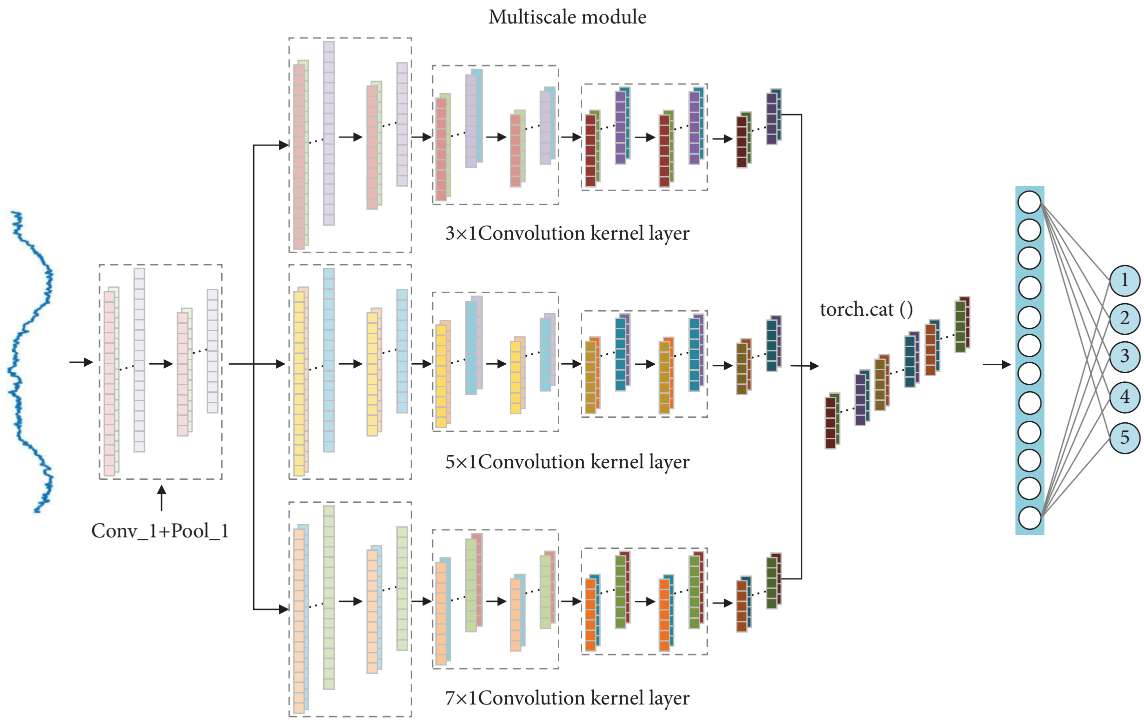

FIGURE 5: Multiscale one-dimensional convolutional neural network structure diagram.

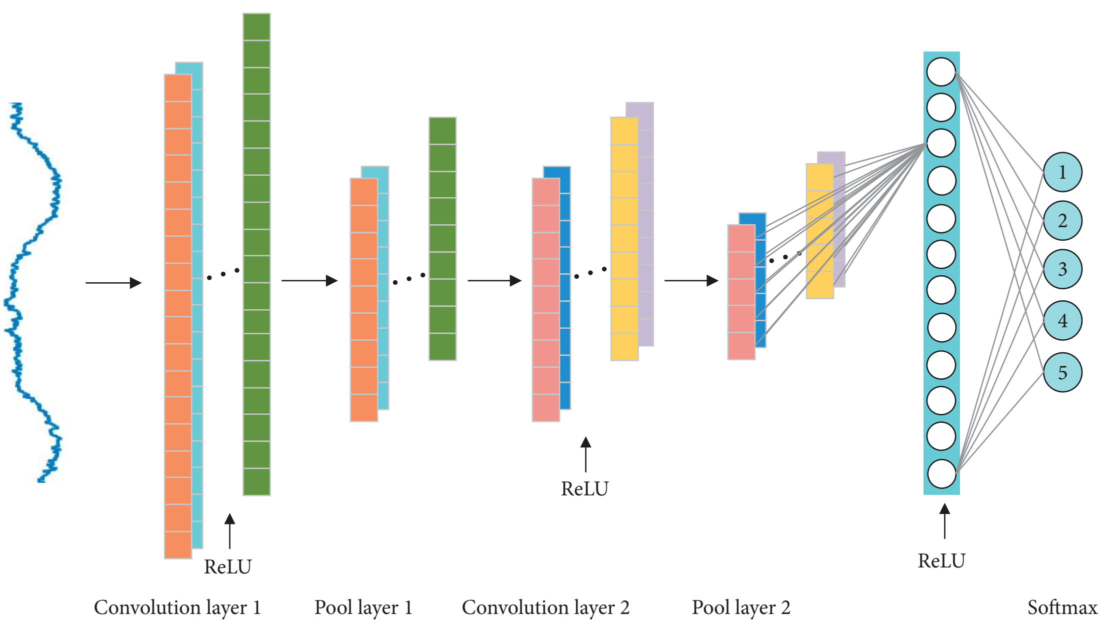

FIGURE 6: Structure of the one-dimensional convolutional neural network.

and convolution layers. Therefore, it is an appropriate method to use the one-dimensional convolution structure to build a multilabel data stream classification model for vibration signals. The common learning structure of one-dimensional fuzzy complex set-valued measures is shown in Figure 6.

4.4. Multiscale Feature Fusion. Fuzzy complex set-valued measure learning has strong feature information extraction and model fitting capabilities. The input data passes through CNN's convolution layer, activation layer, and pooling layer, respectively. The number of feature channels increases and the size of the feature map decreases. At the same time, the feature information extracted by convolution cores of different sizes is also different. Therefore, fusing the features extracted by convolution cores of different sizes can improve CNN's feature expression ability at various levels.

The multiscale fusion framework is constructed by using convolution kernels of different sizes to realize the complementarity of different scale information. Each layer of the multiscale framework is composed of convolution kernels of different sizes. From top to bottom, the size of convolution kernels is 3×1, 5×1, 7×1, and each layer has three groups of the same convolution layer and the pooling layer, which are used to extract the same scale features, and then through a 16×1, and finally through torch Cat() function performs multiscale feature fusion.

5. Summary

Using the vibration data of SQI-MFS mechanical data flow classification test-bed, this paper makes an in-depth study on the current popular intelligent multilabel data flow classification methods and constructs a variety of multilabel data flow classification models and verifies and analyzes them through experiments. The main research contents of the dissertation are summarized as follows.

Empirical mode decomposition (EMD), which is widely used in time-frequency signal analysis is studied, and its shortcomings are clarified. The mixed signal is constructed and tested to verify the decomposition effect of the improved algorithm set empirical mode decomposition (EEMD). After decomposing the vibration signal, it is proposed to use the IMF component and its marginal spectrum and envelope spectrum obtained by Hilbert transform to calculate 9 different statistical features to construct the original feature set.

Aiming at the adaptability of the model to changing conditions and strong noise interference, the ms-1dcnn model is further improved by the residual network and the attention mechanism. The multiscale feature fusion framework and the overall network structure are constructed by using the residual module to improve the efficiency and accuracy of network recognition. Se and CBAM attention modules are introduced and embedded into the residual module, respectively, and a multiscale residual network model based on attention mechanism is proposed. The algorithm not only has good robustness and recognition effect under variable working conditions but also can achieve more than 85% recognition accuracy under the strong noise interference of SNR = −2 db.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the present study.

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Research Article

Computation of Benzenoid Planar Octahedron Networks by Using Topological Indices

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Chemical descriptors are numeric numbers that contain a basic chemical structure and describe the structure of a graph. A graph's topological indices are linked to its chemical characteristics. Biological activity of chemical compounds can be predicted using topological indices. Numerous chemical indices have been developed in theoretical chemistry, including the Zagreb index, the Randić index, the Wiener index, and many others. In this paper, we compute the exact results for the Randić, Zagreb, Harmonic, augmented Zagreb, atom-bond connectivity, and geometric-arithmetic indices for the Benzenoid networks theoretically.

1. Introduction and Preliminary Results

Topological indices, which are particularly useful tools for chemists, are provided by graph theory. In terms of graph theory, vertices represent atoms and edges indicate chemical bonding in a molecular graph [1]. Topological indices such as the ABC index, Wiener index, Randić index, Szeged index, and Zagreb index are highly useful for predicting the bioactivity of chemical compounds.

A graph can be represented by polynomials, numeric numbers, a sequence of integers, or a matrix. All graphs are simple, finite, and connected. All graphs discussed in this article are simple, finite, and connected.

A topological index is a numerical quantity for the chemical graph and it is expressed through chemical graph theory. Interest in topological descriptors has already increased in the computer chemistry sector, and is mostly related with the use of unexpected quantities, the relationship between structure properties, and the relationship between structure quantities.

Topological indices based on distance, degree, and polynomials are some of the most popular forms [2]. Chemical graphs play an important part in theory and theoretical chemistry, and degree-based indices are often utilized in a number of these segments. In this article, we explore at some important topological indices and how they areused to assess benzenoid graphs' chemical activity. Chemists can benefit from these topological indices.the

2. Construction for Benzenoid Planar Octahedron Networks

Step 1: consider a sheet oxide network [3] of dimension n

Step 2: then, place C_6 in each C_3 of oxide network

Step 3: connecting alternating adjacent vertices of C_6 to each opposite vertex, the resultant graph is called benzenoid planar octahedron network BPOH

Step 4: by using the previous algorithm, we can construct the benzenoid dominating planar octahedron network $\mathrm{BDPOH}(r)$ and the benzenoid hex planar octahedron network $\mathrm{BHPOH}(r)$

We defined B to be a network with $V(B)$ as a set of vertices and $E(B)$ as a set of edges in this article, where $\delta(m)$ is the degree of vertex $m \in V(B)$.

The Estrada index is a graph-spectrum-based structural descriptor that was introduced in 2000 by Estrada and is defined as follows [4]:

$$\mathrm{EE}(B) = \sum_{j=1}^{n} e^{\lambda i}. \tag{1}$$

In full resemblance with the Estrada index, Fath-Tabar et al. in [5] introduced the Laplacian Estrada index, which is formalised as follows:

$$\mathrm{LEE}(B) = \sum_{j=1}^{n} e^{\mu i}. \tag{2}$$

Randić index [6] is an oldest degree-based topological index, denoted by $R_{-1/2}(B)$, and was proposed by Milan Randić and is defined as follows:

$$R_{-1/2}(B) = \sum_{mn\in E(B)} \frac{1}{\sqrt{\delta(m)\delta(n)}}. \tag{3}$$

The sum of $(\delta(m)\delta(n))^{\alpha}$ over all the edges $e = mn \in E(B)$ is general Randić index $R_{\alpha}(B)$ [6] and is defined as follows:

$$R_{\alpha}(B) = \sum_{mn\in E(B)} (\delta(m)\delta(n))^{\alpha} \text{ for } \alpha = 1, \frac{1}{2}, -1, -\frac{1}{2}. \tag{4}$$

The Zagreb index, represented by $M_1(B)$ and defined by Gutman and Das [7], is an important topological index:

$$M_1(B) = \sum_{mn\in E(B)} (\delta(m) + \delta(n)). \tag{5}$$

Zhong [8] established the most important harmonic index, which is defined as follows:

$$H(B) = \sum_{mn\in E(B)} \frac{2}{\delta(m) + \delta(n)}. \tag{6}$$

The prominent topological index is augmented Zagreb index which was proposed by Furtula et al. in [9], and it is defined as follows:

$$\mathrm{AZI}(B) = \sum_{mn\in E(B)} \left(\frac{\delta(m)\delta(n)}{\delta(m) + \delta(n) - 2}\right)^{3}. \tag{7}$$

The atom-bond connectivity (ABC) index, proposed by Estrada et al. in [10], is a prominent degree-based topological indicator that is defined as follows:

$$\mathrm{ABC}(B) = \sum_{mn\in E(B)} \sqrt{\frac{\delta(m) + \delta(n) - 2}{\delta(m)\delta(n)}}. \tag{8}$$

Another prominent topological index is the Geometric-arithmetic (GA) index, which was proposed by Furtula in reference [11] and described as follows:

$$\mathrm{GA}(B) = \sum_{mn\in E(B)} \frac{2\sqrt{\delta(m)\delta(n)}}{\delta(m) + \delta(n)}. \tag{9}$$

3. Primary Results of Benzenoid Networks

In this article, the general Randić, first Zagreb, H, AZI, ABC, and GA indices are studied and closed equations for these indices for the benzenoid planar octahedron networks are given. The ABC and GA indices, also their derivatives, are now the subject of substantial research, see [12, 13] topological indices and their invariants in different graph families for more information.

3.1. Results for the Benzenoid Planar Octahedron Network. We construct some degree-based topological indices of the benzenoid planar octahedron network, denoted by $B_1(r)$, in this section. We calculate the general Randić $R_{\alpha}(B)$ for $\alpha = \{1, -1, 1/2, -1/2\}$, first Zagreb, H, AZI, ABC, and GA indices for benzenoid planar octahedron network in this section.

In the following theorem, we calculate the general Randić index for the benzenoid planar octahedron network.

Theorem 1. *Let $B_1(r)$ be the benzenoid planar octahedron network, then its general Randić index is equal to the following equation:*

$$R_\alpha(B_1(r)) = \begin{cases} 2340r^2 - 528r, & \alpha = 1, \\ 12(21 + 6\sqrt{6})r^2 + 12(2\sqrt{3} - 8)r, & \alpha = \dfrac{1}{2}, \\ \dfrac{185}{32}r^2 + \dfrac{11}{16}r, & \alpha = -1, \\ \dfrac{3}{4}(19 + 4\sqrt{6})r^2 + \dfrac{1}{4}(-6 + 6\sqrt{2} + 8\sqrt{3} - 4\sqrt{6})r, & \alpha = -\dfrac{1}{2}. \end{cases} \tag{10}$$

Proof. Let $B_1(r)$ be the benzenoid planar octahedron network BPOH(r) as shown in Figure 1, with $r \geq 2$ and $B_1(r)$ edge set divided into five divisions based on the degree of end vertices. The first edge partition $E_1(B_1(r))$ has $36r^2$ edges, having $\delta(m) = \delta(n) = 3$. The second edge division $E_2(B_1(r))$ has $12r$ edges, having $\delta(m) = 3$ and $\delta(n) = 4$. The third edge division $E_3(B_1(r))$ has $36r^2 - 12r$ edges, having $\delta(m) = 3$ and $\delta(n) = 8$. The fourth edge division $E_4(B_1(r))$ has $12r$ edges, having $\delta(m) = 4$ and $\delta(n) = 8$. The fifth edge division has $18r^2 - 12r$ edges, having $\delta(m) = \delta(n) = 8$.

$$R_\alpha(B) = \sum_{mn \in E(B)} (\delta(m)\delta(n))^\alpha. \tag{11}$$

For $\alpha = 1$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_1(B) = \sum_{j=1}^{5} \sum_{mn \in E_j(B)} \delta(m) \cdot \delta(n). \tag{12}$$

We can achieve the following result by using Table 1 edge division:

$$\begin{aligned} R_1(B) &= 9|E_1(B_1(r))| + 12|E_2(B_1(r))| + 24|E_3(B_1(r))| + 32|E_4(B_1(r))| + 64|E_5(B_1(r))|, \\ &\Rightarrow R_1(B) = 2340r^2 - 528r. \end{aligned} \tag{13}$$

For $\alpha = 1/2$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_{1/2}(B) = \sum_{j=1}^{5} \sum_{mn \in E_j(B)} \sqrt{\delta(m) \cdot \delta(n)}. \tag{14}$$

We can achieve the following result by using the Table 1 edge division:

$$\begin{aligned} R_{1/2}(B) &= 3|E_1(B_1(r))| + 2\sqrt{3}|E_2(B_1(r))| + 2\sqrt{6}|E_3(B_1(r))| + 4\sqrt{2}|E_4(B_1(r))| + 8|E_5(B_1(r))|, \\ &\Rightarrow R_{1/2}(B) = 36(7 + 2\sqrt{6})r^2 + 12(-8 + 4\sqrt{2} + 2\sqrt{3} - 2\sqrt{6})r. \end{aligned} \tag{15}$$

For $\alpha = -1$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_{-1}(B) = \sum_{j=1}^{5} \sum_{mn\in E_j(B)} \frac{1}{\delta(m)\cdot\delta(n)},$$

$$R_{-1}(B) = \frac{1}{9}\left|E_1(B_1(r))\right| + \frac{1}{12}\left|E_2(B_1(r))\right| + \frac{1}{24}\left|E_3(B_1(r))\right| + \frac{1}{32}\left|E_4(B_1(r))\right| + \frac{1}{64}\left|E_5(B_1(r))\right|, \tag{16}$$

$$\Rightarrow R_{-1}(B) = \frac{185}{32}r^2 + \frac{11}{16}r.$$

For $\alpha = -1/2$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_{-1/2}(B) = \sum_{mn\in E_j(B)} \frac{1}{\sqrt{\delta(m)\cdot\delta(n)}},$$

$$R_{-1/2}(B) = \frac{1}{3}\left|E_1(B_1(r))\right| + \frac{1}{2\sqrt{3}}\left|E_2(B_1(r))\right| + \frac{1}{2\sqrt{6}}\left|E_3(B_1(r))\right| + \frac{1}{4\sqrt{2}}\left|E_4(B_1(r))\right| + \left|\frac{1}{8}\right|E_5(B_1(r))\right|, \tag{17}$$

$$\Rightarrow R_{-1/2}(B) = \frac{3}{4}(19 + 4\sqrt{6})r^2 + \frac{1}{4}(-6 + 6\sqrt{2} + 8\sqrt{3} - 4\sqrt{6})r.$$

The first Zagreb index of the benzenoid planar octahedron network is computed in the following theorem. □

Theorem 2. *For the benzenoid planar octahedron network $B_1(r)$, the first Zagreb index is equal to the following equation:*

$$M_1(B_1(r)) = 900r^2 - 96r. \tag{18}$$

Proof. Let $B_1(r)$ denote the bezenoid planar octahedron network. The following is the result of using the edge division from Table 1. As a result of equation (5), we have

$$M_1(B) = \sum_{mn\in E(B)} (\delta(m) + \delta(n)) = \sum_{j=1}^{5} \sum_{mn\in E_j(B)} (\delta(m) + \delta(n)),$$
$$M_1(B_1(r)) = 6\left|E_1(B_1(r))\right| + 7\left|E_2(B_1(r))\right| + 11\left|E_3(B_2(r))\right| + 12\left|E_4(B_1(r))\right| + 16\left|E_5(B_1(r))\right|. \tag{19}$$

We get following result by doing calculation:

$$\Rightarrow M_1(B_1(r)) = 900r^2 - 96r. \tag{20}$$

□

Theorem 3. *Let $B_1(r)$ be the benzenoid planar octahedron network $r \geq 2$; then, we have*

$$H(B_1(r)) = \frac{915}{44}r^2 + \frac{269}{154}r,$$
$$\mathrm{AZI}(B_1(r)) = \frac{46302245}{16464}r^2 - \frac{314431744}{38587}r,$$
$$\mathrm{ABC}(B_1(r)) = \frac{1}{4}(36\sqrt{6} + 9\sqrt{14} + 96)r^2 + \frac{1}{2}(6\sqrt{5} + 4\sqrt{15} - 3\sqrt{14} - 6\sqrt{6})r,$$
$$\mathrm{GA}(B_1(r)) = \frac{18}{11}(33 + 4\sqrt{6})r^2 + \frac{3}{154}(429\sqrt{3} - 112\sqrt{6} - 616)r. \tag{21}$$

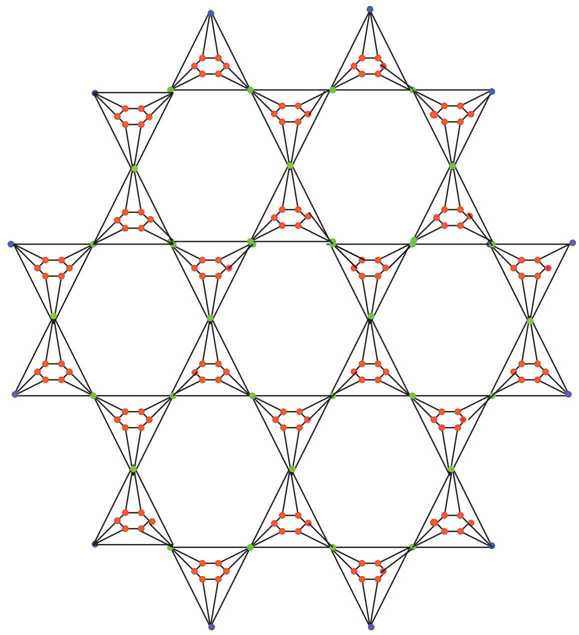

Figure 1: Benzenoid planar octahedron network BPOH(2).

Table 1: Edge division of benzenoid planar octahedron network $(B_1(r))$ based on the sum of the degrees of each edge's end vertices.

$(\delta(m), \delta(n))$, where $mn \in E(B_1)$	Number of edges	$(\delta(m), \delta(n))$, where $mn \in E(B_1)$	Number of edges
$E_1 = (3,3)$	$36r^2$	$E_4 = (4,8)$	$12r$
$E_2 = (3,4)$	$12r$	$E_5 = (8,8)$	$18r^2 - 12r$
$E_3 = (3,8)$	$36r^2 - 12r$		

Proof. We get the required result by finding the edge division in Table 1, and then, applying the definition. It follows from equation (6) that

$$H(B) = \sum_{mn\in E(B)} \frac{2}{\delta(m)+\delta(n)} = \sum_{j=1}^{5} \sum_{mn\in E(B)} \frac{2}{\delta(m)+\delta(n)},$$
$$H(B_1(r)) = \frac{1}{3}|E_1(B_1(r))| + \frac{2}{7}|E_2(B_1(r))| + \frac{2}{11}|E_3(B_1(r))| + \frac{1}{6}|E_4(B_1(r))| + \frac{1}{8}|E_5(B_1(r))|. \tag{22}$$

By doing the calculation, we obtained the following result:

$$H(B_1(r)) = \frac{915}{44}r^2 + \frac{269}{154}r. \tag{23}$$

Equation (7) can be used to compute the augmented Zagreb index as follows:

$$\mathrm{AZI}(B) = \sum_{mn\in E(B)} \left(\frac{\delta(m)\delta(n)}{\delta(m)+\delta(n)-2}\right)^3 = \sum_{j=1}^{5} \sum_{mn\in E(B)} \left(\frac{\delta(m)\delta(n)}{\delta(m)+\delta(n)-2}\right)^3,$$
$$\mathrm{AZI}(B_1(r)) = \frac{1}{3}|E_1(B_1(r))| + \frac{1}{2\sqrt{3}}|E_2(B_1(r))| + \frac{1}{2\sqrt{6}}|E_3(B_1(r))| + \frac{1}{4\sqrt{2}}|E_4(B_1(r))| + \frac{1}{8}|E_5(B_1(r))|. \tag{24}$$

By doing the calculation, we obtained the following result:

$$\mathrm{AZI} = \frac{46302245}{16464}r^2 - \frac{314431744}{38587}r. \tag{25}$$

Equation (8) can be used to compute the atom-bond connectivity index as follows:

$$\begin{aligned}\mathrm{ABC}(B) &= \sum_{mn\in E(B)} \sqrt{\frac{\delta(m)+\delta(n)-2}{\delta(m)\cdot\delta(n)}} = \sum_{j=1}^{5}\sum_{mn\in E_j(B)} \sqrt{\frac{\delta(m)+\delta(n)-2}{\delta(m)\cdot\delta(n)}},\\ \mathrm{ABC}(B_1(r)) &= \frac{2}{3}\left|E_1(B_1(r))\right| + \frac{\sqrt{15}}{6}\left|E_2(B_1(r))\right| + \frac{\sqrt{6}}{4}\left|E_3(B_1(r))\right| + \frac{\sqrt{15}}{4}\left|E_4(B_1(r))\right| + \frac{\sqrt{14}}{8}\left|E_5(B_1(r))\right|.\end{aligned} \tag{26}$$

By doing the calculation, we obtained the following result:

$$\Rightarrow \mathrm{ABC}(B_1(r)) = \frac{1}{4}(36\sqrt{6} + 9\sqrt{14} + 96)r^2 + \frac{1}{2}(6\sqrt{5} + 4\sqrt{15} - 3\sqrt{14} - 6\sqrt{6})r. \tag{27}$$

Equation (9) can be used to compute the geometric-arithmetic index as follows:

$$\mathrm{GA}(B) = \sum_{mn\in E(B)} \frac{2\sqrt{\delta(m)\delta(n)}}{(\delta(m)+\delta(n))} = \sum_{j=1}^{6}\sum_{mn\in E_j(B)} \frac{2\sqrt{\delta(m)\delta(n)}}{(\delta(m)+\delta(n))}. \tag{28}$$

By doing the calculation, we obtained the following result:

$$\begin{aligned}\mathrm{GA}(B_1(r)) &= \left|E_1(B_1(r))\right| + \frac{4\sqrt{3}}{7}\left|E_2(B_1(r))\right| + \frac{4\sqrt{6}}{11}\left|E_3(B_1(r))\right| + \frac{2\sqrt{2}}{11}\left|E_4(B_1(r))\right| + \left|E_5(B_1(r))\right|,\\ \Rightarrow \mathrm{GA}(B_1(r)) &= \frac{18}{11}(33 + 4\sqrt{6})r^2 + \frac{3}{154}(429\sqrt{3} - 112\sqrt{6} - 616)r.\end{aligned} \tag{29}$$

□

3.2. Results for the Benzenoid Dominating Planar Octahedron Network. We construct some degree-based topological indices of the benzenoid planar octahedron network, denoted by $B_2(r)$. We compute the general Randić $R_\alpha(B)$ for $\alpha = \{1, -1, 1/2, -1/2\}$, first Zagreb, H, AZI, ABC, and GA indices for benzenoid dominating planar octahedron network in this section.

We compute the general Randić index for benzenoid dominating planar octahedron network in the following theorem.

Theorem 4. *Let $B_2(r)$ be the benzenoid dominating planar octahedron network, and then, its general Randić index is equal to the following equation:*

$$R_\alpha(B_2(r)) = \begin{cases} 7020r^2 - 8076r + 2868, & \alpha = 1, \\ 108(7+2\sqrt{6})r^2 + 12(-79+8\sqrt{2}+4\sqrt{3}-22\sqrt{6})r + 12(29-4\sqrt{2}-2\sqrt{3}+8\sqrt{6}), & \alpha = \frac{1}{2}, \\ \frac{555}{32}r^2 - \frac{511}{32} + \frac{163}{32}, & \alpha = -1, \\ \frac{9}{4}(19+4\sqrt{6})n^2 + \left(3\sqrt{2}+4\sqrt{3}-11\sqrt{6}-\frac{183}{4}\right)n + \left(\frac{63}{4}-3\sqrt{2}-2\sqrt{3}+4\sqrt{6}\right), & \alpha = -\frac{1}{2}. \end{cases} \tag{30}$$

Proof. Let $B_2(r)$ be the benzenoid planar octahedron network BPOH(r) as shown in Figure 2, with $r \geq 2$ and B_2 edge set divided into five divisions based on the degree of end vertices. The first edge division $E_1(B_2(n))$ has $108r^2 - 108r + 36$ edges, having $\delta(m) = \delta(n) = 3$. The second edge division $E_2(B_2(n))$ has $24r - 12$ edges, having $\delta(m) = 3$ and $\delta(n) = 4$. The third edge division $E_3(B_2(r))$ has $108r^2 - 132r + 48$ edges, having $\delta(m) = 3$ and $\delta(n) = 8$. The fourth edge division $E_4(B_2(r))$ has $24r - 12$ edges, having $\delta(m) = 4$ and $\delta(n) = 8$. The fifth edge division $E_5(B_2(r))$ has $54r^2 - 78r + 30$ edges, having $\delta(m) = \delta(n) = 8$.

$$R_\alpha(B) = \sum_{mn \in E(B)} (\delta(m)\delta(n))^\alpha. \tag{31}$$

For $\alpha = 1$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_1(B) = \sum_{j=1}^{5} \sum_{mn \in E_j(B)} \delta(m) \cdot \delta(n). \tag{32}$$

We can achieve the following results by using the edge division in Table 2.

$$\begin{aligned} &R_1(B) = 9|E_1(B_2(r))| + 12|E_2(B_2(r))| + 24|E_3(B_2(r))| + 32|E_4(B_2(r))| + 64|E_5(B_2(r))|, \\ &\Rightarrow R_1(B) = 7020r^2 - 8076r + 2868. \end{aligned} \tag{33}$$

For $\alpha = 1/2$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_{1/2}(B) = \sum_{j=1}^{5} \sum_{mn \in E_j(B)} \sqrt{\delta(m) \cdot \delta(n)}. \tag{34}$$

We can achieve the following results by using the edge division in Table 2.

$$\begin{aligned} &R_{1/2}(B) = 3|E_1(B_2(r))| + 2\sqrt{3}|E_2(B_2(r))| + 2\sqrt{6}|E_3(B_2(r))| + 4\sqrt{2}|E_4(B_2(r))| + 8|E_5(B_2(r))|, \\ &\Rightarrow R_{1/2}(B) = 108(7+2\sqrt{6})n^2 + 12(-79+8\sqrt{2}+4\sqrt{3}-22\sqrt{6})n + 12(29-4\sqrt{2}-2\sqrt{3}+8\sqrt{6}). \end{aligned} \tag{35}$$

For $\alpha = -1$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_{-1}(B) = \sum_{j=1}^{5} \sum_{mn\in E_j(B)} \frac{1}{\delta(m)\cdot\delta(n)},$$

$$R_{-1}(B) = \frac{1}{9}\left|E_1(B_2(r))\right| + \frac{1}{12}\left|E_2(B_2(r))\right| + \frac{1}{24}\left|E_3(B_2(r))\right| + \frac{1}{32}\left|E_4(B_2(r))\right| + \frac{1}{64}\left|E_5(B_2(r))\right|, \tag{36}$$

$$\Rightarrow R_{-1}(B) = \frac{555}{32}n^2 - \frac{511}{32} + \frac{163}{32}.$$

For $\alpha = -1/2$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_{-1/2}(B) = \sum_{mn\in E_j(B)} \frac{1}{\sqrt{\delta(m)\cdot\delta(n)}},$$

$$R_{-1/2}(B) = \frac{1}{3}\left|E_1(B_2(r))\right| + \frac{1}{2\sqrt{3}}\left|E_2(B_2(r))\right| + \frac{1}{2\sqrt{6}}\left|E_3(B_2(r))\right| + \frac{1}{4\sqrt{2}}\left|E_4(B_2(r))\right| + \frac{1}{8}\left|E_5(B_2(r))\right|, \tag{37}$$

$$R_{-1/2}(B) = \frac{9}{4}(19 + 4\sqrt{6})n^2 + \left(3\sqrt{2} + 4\sqrt{3} - 11\sqrt{6} - \frac{183}{4}\right)n + \left(\frac{63}{4} - 3\sqrt{2} - 2\sqrt{3} + 4\sqrt{6}\right).$$

The first Zagreb index of the benzenoid dominating planar octahedron network is computed in the following theorem. □

Theorem 5. *For the benzenoid dominating planar octahedron network $B_2(n)$, the first Zagreb index is equal to the following equation:*

$$M_1(B_2(r)) = 2700r^2 - 2892r + 996. \tag{38}$$

Proof. Let $B_2(n)$ be the bezenoid dominating planar octahedron network. The following is the result of using the edge division from Table 2. As a result of equation (5), we have

$$M_1(B) = \sum_{mn\in E(B)} (\delta(m) + \delta(n)) = \sum_{j=1}^{5} \sum_{mn\in E_j(B)} (\delta(m) + \delta(n)),$$
$$M_1(B_2(r)) = 6\left|E_1(B_2(r))\right| + 7\left|E_2(B_2(r))\right| + 11\left|E_3(B_2(r))\right| + 12\left|E_4(B_2(r))\right| + 16\left|E_5(B_2(r))\right|. \tag{39}$$

By doing the calculation, we obtained the following result:

$$\Rightarrow M_1(B_2(r)) = 2700r^2 - 2892r + 996. \tag{40}$$

□

Theorem 6. *Let $B_2(r)$ be the benzenoid dominating planar octahedron network $r \geq 2$; then, we have*

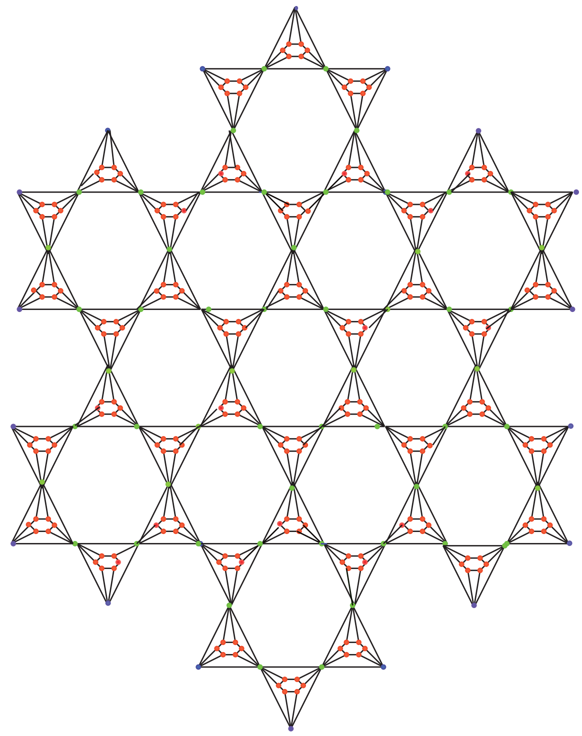

Figure 2: Benzenoid dominating planar octahedron network BDPOH(2).

Table 2: Edge division of benzenoid dominating planar octahedron network $(B_2(r))$ based on the sum of the degrees of each edge's end vertices.

$(\delta(m), \delta(n))$, where $mn \in E(B_2)$	Number of edges	$(\delta(m), \delta(n))$, where $mn \in E(B_2)$	Number of edges
$E_1 = (3,3)$	$108r^2 - 108r + 36$	$E_4 = (4,8)$	$24r - 12$
$E_2 = (3,4)$	$24r - 12$	$E_5 = (8,8)$	$54r^2 - 78r + 30$
$E_3 = (3,8)$	$108r^2 - 132r + 48$		

$$\begin{aligned}
H(B_2(r)) &= \frac{2745}{44}r^2 - \frac{1649}{28}r + \frac{5867}{308},\\
\mathrm{AZI}(B_2(r)) &= \frac{46302245}{5488}r^2 - \frac{62151841433}{6174000}r + \frac{22394249779}{6174000},\\
\mathrm{ABC}(B_2(r)) &= \frac{1}{4}(288 + 108\sqrt{6} + 27\sqrt{14})r^2 + \frac{1}{4}(-288 + 24\sqrt{5} - 132\sqrt{6} - 39\sqrt{14} + 16\sqrt{15})r\\
&\quad + \frac{1}{4}(96 - 12\sqrt{5} + 48\sqrt{6} + 15\sqrt{14} - 8\sqrt{15}),\\
\mathrm{GA}(B_2(r)) &= \left(162 + \frac{432\sqrt{6}}{11}\right)r^2 + \left(-186 + 16\sqrt{2} + \frac{96\sqrt{3}}{7} - 48\sqrt{6}\right)r + 66 - 8\sqrt{2} - \frac{48\sqrt{3}}{7} + \frac{192\sqrt{6}}{11}.
\end{aligned} \tag{41}$$

Proof. We get the required result by finding the edge division in Table 1, and then, applying the definition. It follows from equation (6) that

$$H(B) = \sum_{mn\in E(B)} \frac{2}{\delta(m)+\delta(n)} = \sum_{j=1}^{5} \sum_{mn\in E(B)} \frac{2}{\delta(m)+\delta(n)},$$
$$H(B_2(r)) = \frac{1}{3}|E_1(B_2(r))| + \frac{2}{7}|E_2(B_2(r))| + \frac{2}{11}|E_3(B_2(r))| + \frac{1}{6}|E_4(B_2(r))| + \frac{1}{8}|E_5(B_2(r))|, \tag{42}$$

By doing the calculation, we obtained the following result:

$$H(B_2(r)) = \frac{2745}{44}r^2 - \frac{1649}{28}r + \frac{5867}{308}. \tag{43}$$

Equation (7) can be used to compute the augmented Zagreb index as follows:

$$\mathrm{AZI}(B_2(r)) = \sum_{mn\in E(B)} \left(\frac{\delta(m)\delta(n)}{\delta(m)+\delta(n)-2}\right)^3 = \sum_{j=1}^{5} \sum_{mn\in E(B)} \left(\frac{\delta(m)\delta(n)}{\delta(m)+\delta(n)-2}\right)^3,$$
$$\mathrm{AZI}(B_2(r)) = \frac{1}{3}|E_1(B_2(r))| + \frac{1}{2\sqrt{3}}|E_2(B_2(r))| + \frac{1}{2\sqrt{6}}|E_3(B_2(r))| + \frac{1}{4\sqrt{2}}|E_4(B_2(r))| + \frac{1}{8}|E_5(B_2(r))|. \tag{44}$$

By doing the calculation, we obtained the following result:

$$\mathrm{AZI} = \frac{46302245}{5488}r^2 - \frac{62151841433}{6174000}r + \frac{22394249779}{6174000}. \tag{45}$$

Equation (8) can be used to compute the atom-bond connectivity index as follows:

$$\begin{aligned}\mathrm{ABC}(B) &= \sum_{mn\in E(B)} \sqrt{\frac{\delta(m)+\delta(n)-2}{\delta(m)\cdot\delta(n)}} \\ &= \sum_{j=1}^{5} \sum_{mn\in E_j(B)} \sqrt{\frac{\delta(m)+\delta(n)-2}{\delta(m)\cdot\delta(n)}},\end{aligned}$$
$$\mathrm{ABC}(B_2(r)) = \frac{2}{3}|E_1(B_2(r))| + \frac{\sqrt{15}}{6}|E_2(B_2(r))| + \frac{\sqrt{6}}{4}|E_3(B_2(r))| + \frac{\sqrt{15}}{4}|E_4(B_2(r))| + \frac{\sqrt{14}}{8}|E_5(B_2(r))|. \tag{46}$$

By doing the calculation, we obtained the following result:

$$\begin{aligned}\Rightarrow \mathrm{ABC}(B_2(r)) &= \frac{1}{4}(288 + 108\sqrt{6} + 27\sqrt{14})r^2 + \frac{1}{4}(-288 + 24\sqrt{5} - 132\sqrt{6} - 39\sqrt{14} + 16\sqrt{15})r \\ &+ \frac{1}{4}(96 - 12\sqrt{5} + 48\sqrt{6} + 15\sqrt{14} - 8\sqrt{15}).\end{aligned} \tag{47}$$

Equation (9) can be used to compute the geometric-arithmetic index as follows:

$$\begin{aligned}\mathrm{GA}(B) &= \sum_{mn\in E(B)} \frac{2\sqrt{\delta(m)\delta(n)}}{(\delta(m)+\delta(n))}\\ &= \sum_{j=1}^{5}\sum_{mn\in E_j(B)} \frac{2\sqrt{\delta(m)\delta(n)}}{(\delta(m)+\delta(n))}.\end{aligned} \tag{48}$$

By doing the calculation, we obtained the following result:

$$\begin{aligned}&\mathrm{GA}(B_2(r)) = |E_1(B_2(r))| + \frac{4\sqrt{3}}{7}|E_2(B_2(r))| + \frac{4\sqrt{6}}{11}|E_3(B_2(r))| + \frac{2\sqrt{2}}{11}|E_4(B_2(r))| + |E_5(B_2(r))|,\\ &\Rightarrow \mathrm{GA}(B_2(r)) = \left(162 + \frac{432\sqrt{6}}{11}\right)r^2 + \left(-186 + 16\sqrt{2} + \frac{96\sqrt{3}}{7} - 48\sqrt{6}\right)r + \left(66 - 8\sqrt{2} - \frac{48\sqrt{3}}{7} + \frac{192\sqrt{6}}{11}\right.\end{aligned} \tag{49}$$

□

3.3. Results for Benzenoid Hex Planar Octahedron Network. We construct some degree-based topological indices of the benzenoid planar octahedron network, denoted by $B_3(r)$, in this section. We compute the general Randić $R_\alpha(B)$ for $\alpha = \{1, -1, 1/2, -1/2\}$, H, AZI, ABC, and GA indices for benzenoid hex planar octahedron network in this section.

We compute the general Randić index for benzenoid hex planar octahedron network in the following theorem.

Theorem 7. *Let $B_3(r)$ be the benzenoid hex planar octahedron network, then its general Randić index is equal to the following:*

$$R_\alpha(B_3(r)) = \begin{cases} 2340r^2 + 1752r - 30, & \alpha = 1,\\ 36(7+2\sqrt{6})r^2 + 24(7+\sqrt{6}+\sqrt{10}+\sqrt{15})r + 6(2\sqrt{10}-5), & \alpha = \frac{1}{2},\\ \frac{185}{32}r^2 + \frac{175}{25}r + \frac{24}{25}, & \alpha = -1,\\ \left(\frac{57}{4} + 3\sqrt{6}\right)r^2 + \left(\frac{72}{5} + 3\sqrt{\frac{2}{5}} + 8\sqrt{\frac{3}{5}} + \sqrt{6}\right)r + \frac{6}{5}(-1+\sqrt{10}), & \alpha = -\frac{1}{2}.\end{cases} \tag{50}$$

Proof. Let $B_3(r)$ be the benzenoid hex planar octahedron network BHPOH(r) as shown in Figure 3, with $r \geq 2$ and $B_3(r)$ edge set divided into seven divisions based on the degree of end vertices. The first edge division $E_1(B_3(r))$ has 12 edges, having $\delta(m) = 2$ and $\delta(r) = 5$. The second edge division $E_2(B_3(r))$ has $36r^2 - 36r$ edges, having $\delta(m) = \delta(n) = 3$. The third edge division $E_3(B_3(r))$ has $24r$ edges, having $\delta(m) = 3$ and $\delta(n) = 5$. The fourth edge division $E_4(B_1(r))$ has $36r^2 + 12r$ edges, having $\delta(m) = 3$ and $\delta(n) = 8$. The fifth edge division $E_5(B_3(r))$ has $12r - 6$ edges, having $\delta(m) = 5 = \delta(n)$. The sixth edge division $E_6(B_3(r))$ has $12r$ edges, having $\delta(m) = 5$ and $\delta(n) = 8$. The seventh edge division $E_7(B_3(r))$ has $18r^2$ edges, having $\delta(m) = \delta(n) = 8$.

$$R_\alpha(B) = \sum_{mn\in E(B)} (\delta(m)\delta(n))^\alpha. \tag{51}$$

For $\alpha = 1$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_1(B) = \sum_{j=1}^{7}\sum_{mn\in E_j(B)} \delta(m)\cdot\delta(n). \tag{52}$$

We can obtain the following results by using the edge division in Table 3.

$$\begin{aligned}&R_1(B) = 10|E_1(B_3(r))| + 9|E_2(B_3(r))| + 15|E_3(B_3(r))| + 24|E_4(B_3(r))| + 25|E_5(B_3(r))| + 40|E_6(B_3(r))| + 64|E_7(B_3(r))|,\\ &\Rightarrow R_1(B) = 2340r^2 + 1752r - 30.\end{aligned} \tag{53}$$

For $\alpha = 1/2$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$R_{1/2}(B) = \sum_{j=1}^{7} \sum_{mn \in E_j(B)} \sqrt{\delta(m)\cdot\delta(n)}. \tag{54}$$

We can achieve the following result by using the edge division in Table 3.

$$\begin{aligned} R_{1/2}(B) &= \sqrt{10}|E_1(B_3(r))| + 3|E_2(B_3(r))| + \sqrt{15}|E_3(B_3(r))| + 2\sqrt{6}|E_4(B_3(r))| + 5|E_5(B_3(r))| + 2\sqrt{10}|E_6(B_3(r))| + 8|E_7(B_3(r)|, \\ \Rightarrow R_{1/2}(B) &= 36(7+2\sqrt{6})r^2 + 24(7+\sqrt{6}+\sqrt{10}+\sqrt{15})r + 6(2\sqrt{10}-5). \end{aligned} \tag{55}$$

For $\alpha = -1$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$\begin{aligned} R_{-1}(B) &= \sum_{j=1}^{7} \sum_{mn \in E_j(B)} \frac{1}{\delta(m)\cdot\delta(n)}, \\ R_{-1}(B) &= \frac{1}{10}|E_1(B_3(r))| + \frac{1}{9}|E_2(B_3(r))| + \frac{1}{15}|E_3(B_3(r))| + \frac{1}{24}|E_4(B_3(r))| + \frac{1}{25}|E_5(B_3(r))| + \frac{1}{40}|E_6(B_3(r))| + \frac{1}{64}|E_7(B_3(r))|, \\ \Rightarrow R_{-1}(B) &= \frac{185}{32}r^2 + \frac{175}{25}r + \frac{24}{25}. \end{aligned} \tag{56}$$

For $\alpha = -1/2$

The general Randić index $R_\alpha(B)$ formula from equation (4) is used as follows:

$$\begin{aligned} R_{-1/2}(B) &= \sum_{mn \in E_j(B)} \frac{1}{\sqrt{\delta(m)\cdot\delta(n)}}. \\ R_{-1/2}(B) &= \frac{1}{\sqrt{10}}|E_1(B_3(r))| + \frac{1}{3}|E_2(B_3(r))| + \frac{1}{\sqrt{15}}|E_3(B_3(r))| + \frac{1}{2\sqrt{6}}|E_4(B_3(r))| + \frac{1}{5}|E_5(B_3(r))| \\ &\quad + \frac{1}{2\sqrt{10}}|E_6(B_3(r))| + \frac{1}{8}|E_7(B_3(r))|, \\ \Rightarrow R_{-1/2}(B) &= \left(\frac{57}{4} + 3\sqrt{6}\right)r^2 + \left(\frac{72}{5} + 3\sqrt{\frac{2}{5}} + 8\sqrt{\frac{3}{5}} + \sqrt{6}\right)r + \frac{6}{5}(-1+\sqrt{10}). \end{aligned} \tag{57}$$

The first Zagreb index of the benzenoid hex planar octahedron network is computed in the following theorem. □

Theorem 8. *For the benzenoid planar octahedron network $B_3(r)$, the first Zagreb index is equal to the following equation:*

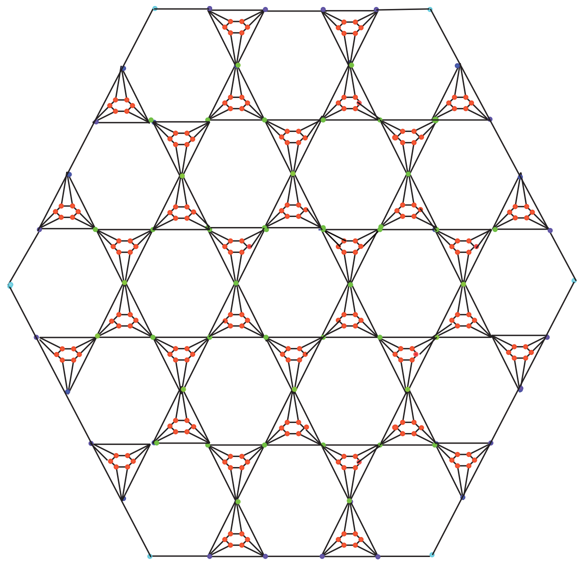

FIGURE 3: Benzenoid hex planar octahedron network BHPOH(2).

TABLE 3: Edge division of benzenoid hex planar octahedron network $(B_3(r))$ based on the sum of the degrees of each edge's end vertices.

$(\delta(m), \delta n)$, where $mn \in E(B_3)$	Number of edges	$(\delta(m), \delta(n))$, where $mn \in E(B_3)$	Number of edges
$E_1 = (2,5)$	12	$E_5 = (5,5)$	$12r - 6$
$E_2 = (3,3)$	$36r^2 - 36r$	$E_6 = (5,8)$	$12r$
$E_3 = (3,5)$	$24r$	$E_7 = (8,8)$	$18r^2$
$E_4 = (3,8)$	$36r^2 + 12r$		

$$M_1(B_3(r)) = 900r^2 + 816r + 24. \tag{58}$$

Proof. Let $B_3(r)$ be the bezenoid hex planar octahedron network. The following is the result of using the edge division from Table 3. As a result of equation (5), we have

$$\begin{aligned}
M_1(B) &= \sum_{mn\in E(B)} (\delta(m) + \delta(n)) \\
&= \sum_{j=1}^{7} \sum_{mn\in E_j(B)} (\delta(m) + \delta(n)),
\end{aligned}$$

$$M_1(B_3(r)) = 7|E_1(B_3(r))| + 6|E_2(B_3(r))| + 8|E_3(B_3(r))| + 11|E_4(B_3(r))| + 10|E_5(B_3(r))| + 13|E_6(B_3(r))| + 16|E_7(B_3(r))|. \tag{59}$$

By doing the calculation, we obtained the following result:

$$\Rightarrow M_1(B_3(r)) = 900r^2 + 816r + 24. \tag{60}$$

□

Theorem 9. *Let $B_3(r)$ be the benzenoid hex planar octahedron network $r \geq 2$; then, we have*

$$H(B_3(r)) = \frac{915}{44}r^2 + \frac{17466}{715} + \frac{78}{35},$$

$$\mathrm{AZI}(B_3(r)) = \frac{46302245}{16464}r^2 + \frac{38645819}{23958} + \frac{2697}{32},$$

$$\mathrm{ABC}(B_3(r)) = \left(24 + \frac{9\sqrt{14}}{4} + 9\sqrt{6}\right)r^2 + \frac{3}{5}(40 + 8\sqrt{5} + 5\sqrt{6} + 8\sqrt{10} + \sqrt{110})r + \left(6\sqrt{2} - \frac{12}{\sqrt{5}}\right), \tag{61}$$

$$\mathrm{GA}(B_3(r)) = \left(54 + \frac{144\sqrt{6}}{11}\right)r^2 + \left(48 + \frac{48\sqrt{6}}{11} + \frac{48\sqrt{10}}{13} + 6\sqrt{15}\right)r + \left(\frac{24\sqrt{10}}{7} - 6\right).$$

Proof. We obtained the required result by finding the edge division in Table 3, and then, applying the definition. It follows from equation (6) that

$$H(B) = \sum_{mn\in E(B)} \frac{2}{\delta(m) + \delta(n)} = \sum_{j=1}^{7} \sum_{mn\in E(B)} \frac{2}{\delta(m) + \delta(n)},$$

$$H(B_3(r)) = \frac{2}{7}|E_1(B_3(r))| + \frac{1}{3}|E_2(B_3(r))| + \frac{1}{4}|E_3(B_3(r))| + \frac{2}{11}|E_4(B_3(r))| + \frac{1}{5}|E_5(B_3(r))| + \frac{2}{13}|E_6(B_3(r))| + \frac{1}{8}|E_7(B_3(r))|. \tag{62}$$

By doing the calculation, we obtained the following result:

$$H(B_3(r)) = \frac{915}{44}r^2 + \frac{17466}{715} + \frac{78}{35}. \tag{63}$$

Equation (7) can be used to compute the augmented Zagreb index as follows:

$$\mathrm{AZI}(B_3(r)) = \sum_{mn\in E(B)} \left(\frac{\delta(m)\delta(n)}{\delta(m) + \delta(n) - 2}\right)^3 = \sum_{j=1}^{7} \sum_{mn\in E(B)} \left(\frac{\delta(m)\delta(n)}{\delta(m) + \delta(n) - 2}\right)^3.$$

$$\mathrm{AZI}(B_3(r)) = 8|E_1(B_3(r))| + \frac{729}{64}|E_2(B_3(r))| + \frac{125}{8}|E_3(B_3(r))| + \frac{512}{27}|E_4(B_3(r))| + \frac{15625}{512}|E_5(B_3(r))| + \frac{6400}{1331}|E_6(B_3(r))| + \frac{32768}{343}|E_7(B_3(r))|. \tag{64}$$

By doing the calculation, we obtained the following result:

$$\mathrm{AZI} = \frac{46302245}{16464}r^2 + \frac{38645819}{23958}r + \frac{2697}{32}. \tag{65}$$

Table 4: Numerical computation for BPOH(r).

$[r]$	R_1	$R_{1/2}$	R_{-1}	$R_{-1/2}$	M_1	H	AZI	GA	
4	35328	6672.47	95.25	352.119	14016	339.714	12402.7	877.399	1109.05
5	110964	10482.4	147.969	548.141	22020	528.62	29565.1	10482.4	1736.48
6	55860	15149.1	212.25	787.36	31824	759.117	52352.1	15149.1	2503.97
7	81072	20672.4	288.094	10969.78	43428	1031.2	80763.8	20672.4	3411.53

Equation (8) can be used to compute the atom-bond connectivity index as follows:

$$\begin{aligned}
\mathrm{ABC}(B) &= \sum_{mn\in E(B)} \sqrt{\frac{\delta(m)+\delta(n)-2}{\delta(m)\cdot\delta(n)}} \\
&= \sum_{j=1}^{7} \sum_{mn\in E_j(B)} \sqrt{\frac{\delta(m)+\delta(n)-2}{\delta(m)\cdot\delta(n)}}, \\
\mathrm{ABC}(B_3(r)) &= \frac{\sqrt{2}}{2}\left|E_1(B_3(r))\right| + \frac{2}{3}\left|E_2(B_3(r))\right| + \frac{\sqrt{10}}{5}\left|E_3(B_3(r))\right| + \frac{\sqrt{6}}{4}\left|E_4(B_3(r))\right| + \frac{2\sqrt{2}}{5}\left|E_5(B_3(r))\right| \\
&\quad + \frac{\sqrt{110}}{20}\left|E_6(B_3(r))\right| + \frac{\sqrt{14}}{8}\left|E_7(B_3(r))\right|.
\end{aligned} \tag{66}$$

By doing the calculation, we obtained the following result:

$$\Rightarrow \mathrm{ABC}(B_3(r)) = \left(24 + \frac{9\sqrt{14}}{4} + 9\sqrt{6}\right)r^2 + \frac{3}{5}\left(40 + 8\sqrt{5} + 5\sqrt{6} + 8\sqrt{10} + \sqrt{110}\right)r + \left(6\sqrt{2} - \frac{12}{\sqrt{5}}\right). \tag{67}$$

Equation (9) can be used to compute the geometric-arithmetic index as follows:

$$\mathrm{GA}(B) = \sum_{mn\in E(B)} \frac{2\sqrt{\delta(m)\delta(n)}}{(\delta(m)+\delta(n))} = \sum_{j=1}^{7} \sum_{mn\in E_j(B)} \frac{2\sqrt{\delta(m)\delta(n)}}{(\delta(m)+\delta(n))}. \tag{68}$$

By doing the calculation, we obtained the following result:

$$\begin{aligned}
\mathrm{GA}(B_3(r)) &= \frac{2\sqrt{10}}{5}\left|E_1(B_3(r))\right| + \left|E_2(B_3(r))\right| + \frac{\sqrt{2}}{2}\left|E_3(B_3(r))\right| + \frac{2}{\sqrt{11}}\left|E_4(B_3(r))\right| + \frac{\sqrt{10}}{5}\left|E_5(B_3(r))\right| \\
&\quad + \frac{2}{\sqrt{13}}\left|E_6(B_3(r))\right| + \frac{1}{2}\left|E_7(B_3(r))\right| \\
\Rightarrow \mathrm{GA}(B_3(r)) &= \left(54 + \frac{144\sqrt{6}}{11}\right)r^2 + \left(48 + \frac{48\sqrt{6}}{11} + \frac{48\sqrt{10}}{13} + 6\sqrt{15}\right)r + \left(\frac{24\sqrt{10}}{7} - 6\right).
\end{aligned} \tag{69}$$

Table 5: Numerical computation for BDPOH (r).

$[r]$	R_1	$R_{1/2}$	R_{-1}	$R_{-1/2}$	M_1	H	AZI	ABC	GA
4	12884	15532.1	218.719	810595	32628	781.659	98352.3	2025.63	1633.58
5	137988	25327.4	358.844	1332.23	54036	1284.24	164219	3335.75	2678.18
6	207132	38087.6	533.656	1983.46	80844	1911.6	246959	4972.66	3980.99
7	290316	53481.0	743.156	2764.27	113052	2663.73	346573	6936.36	5542

Table 6: Numerical computation BHPOH (r).

$[r]$	R_1	$R_{1/2}$	R_{-1}	$R_{-1/2}$	M_1	H	AZI	ABC	GA
4	44418	844.3	120.98	447.945	176888	432.668	51533.9	1128.76	1756.31
5	67230	12695.2	179.891	667.275	26604	644.2	78457.9	1682.49	2624.51
6	94722	17802.8	250.365	929.801	37320	897.433	111007	2345.15	3664.84
7	126894	23767.2	332.401	1235.53	49836	1192.2	149180	3116.74	4877.3

To compare topological indices numerically for BPOH, BDPOH, and BHPOH, we calculated all of the indices for different values of r. Tables 4–6 clearly show that when the value of r increases, all indices increase in ascending order. □

4. Conclusion

In this paper, we computed the required results of Randić, Zagreb, Harmonic, augmented Zagreb, atom-bond connectivity, and geometric-arithmetic indices for BPOH, BDPOH, and BHPOH. We also discovered all of the networks, numerical computations. These key insights lay the groundwork for understanding the underlying topologies of the following networks, which are useful from a variety of chemical and pharmaceutical perspectives. In the future, we want to create some networks and then analyse their topological indices to learn more about their underlying topologies.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Incremental Mining Method of Warehouse Operation Process in Production Enterprises Based on Swarm Intelligence

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In order to improve the scheduling ability of production enterprise warehouse operation, an incremental mining algorithm of production enterprise warehouse operation process based on swarm intelligence algorithm is proposed. The particle swarm optimization method is used to sample the environmental information of the warehouse operation area of the production enterprise, and the collected data of the warehouse operation area of the production enterprise are dynamically weighted, and the shortest path optimization control is carried out. Particle swarm optimization (PSO) is used to detect the shortest path for incremental mining and block search of warehouse operation process in production enterprises, and the pheromone feature quantity of incremental mining of warehouse operation process in production enterprises is extracted. Through the adaptive optimization process of incremental mining of warehouse operation process of production enterprises, incremental mining and shortest optimization control of warehouse operation process of production enterprises are realized. The simulation results show that the optimization ability of incremental mining of warehouse operation process of production enterprises using this method is better, which improves the response ability of warehouse operation of production enterprises and reduces the time cost of delivery.

1. Introduction

In recent years, with the rising of land cost, material cost, and labor cost in China, industrial automation and intelligence have become the development trend of enterprises. At the present stage, full market competition and rising costs make the profit margin of the food industry smaller and smaller, which forces enterprises to continuously reduce operating costs, seek profits from operations, and seek development in the direction of automation and intelligence. As the "third profit source" of warehousing enterprises, properly handling the efficiency of warehousing links will provide new profit growth points for enterprises and become the key power to promote the development of enterprises. It is necessary to study the incremental mining model of the warehouse operation process of production enterprises and combine the optimal design of the warehouse operation process of production enterprises to realize the warehouse operation process planning of production enterprises. However, in the long run, through incremental mining and planning design of warehouse operation process of production enterprises, the labor cost, storage cost, and management cost can be reduced, and the space utilization rate of warehouses can be improved. Effectively improving the efficiency of warehouse operation is conducive to building an advanced logistics system that meets the needs of enterprises and improving the production management level of enterprises, thus effectively helping enterprises to reduce the cost of warehouse management and logistics operation and further improve their operating efficiency [1]. In recent years, the state has issued a series of policies and plans to encourage enterprises to explore an automated warehousing system that is in line with their own development reality [2]. Relevant departments have also actively issued policies to encourage enterprises to promote the development of warehousing and logistics business, which provides a strong policy guarantee for enterprises [3]. With the continuous development of automation technology and information technology, the operation efficiency, labor productivity, and production benefit of the automated warehouse have been greatly improved by adopting advanced control means such as computers and high-efficiency output equipment and sorting equipment. An automated warehouse is generally composed of a goods access machine, storage mechanism, conveying equipment, sorting system, and control device. Comprehensive consideration of the industry characteristics, demand and investment cost of the business, automatic sorting system, and conveyor system are the most widely used automatic equipment for warehousing operation [4]. The flexibility, expansibility, and efficiency of warehouse management directly affect the overall competitiveness of the whole logistics and supply chain and then affect the timeliness and correctness of market distribution, replenishment, and old goods cleaning of production enterprises. Therefore, in the fierce market competition, the market share and sales performance of sportswear companies, the overall profitability of the company, and the ability of modern warehousing operation management play a decisive role. How to build a modern new warehouse operation management system, enhance the core competitiveness of enterprises, and reduce the overall cost of enterprises has become a problem that production enterprises must face and pay attention to in the development of the whole [5].

To solve the above problems, this paper proposes an incremental mining algorithm for the warehouse operation process based on a swarm intelligence algorithm. Swarm intelligence algorithm includes genetic algorithm, particle swarm optimization algorithm, and many other algorithms. Among them, the particle swarm optimization algorithm is simple and easy to implement, without many parameters to be adjusted. Therefore, this paper adopts the particle swarm optimization method to collect and optimize the environmental information sampling in the warehouse operation area of production enterprises. And the shortest path planning method is used to analyze the warehouse operation characteristics of production enterprises, and the global evolution game characteristic quantity of the warehouse operation process of production enterprises is analyzed. Particle swarm optimization (PSO) is used to carry out adaptive optimization in the incremental mining process of the warehouse operation process of production enterprises, and the incremental mining of the warehouse operation process of production enterprises is realized. Finally, the simulation test analysis is carried out, and the validity conclusion is obtained, which shows the superior performance of this method in improving the incremental mining planning ability of warehouse operation process of production enterprises.

2. Particle Swarm Optimization Theory

Particle swarm optimization is a kind of swarm intelligence algorithm, which is designed by simulating the predation behavior of birds. Assuming that there is only one piece of food in the area, the task of the flock is to find this food source, that is, the optimal solution in the general optimization problem. During the whole searching process, birds let other birds know their position by passing their own information to each other. Through such cooperation, they can judge whether they have found the optimal solution or not, and at the same time, they can pass the information of the optimal solution to the whole flock. Finally, the whole flock can gather around the food source; that is, the optimal solution is found, and the problem converges. Particle swarm optimization simulates birds in a flock of birds by designing a massless particle. Particles have only two attributes: speed and position, with speed representing the speed of movement and position representing the direction of movement. Each particle searches for the optimal solution separately in the search space and records it as the current individual extremum, sharing the individual extremum with other particles in the whole particle swarm, and finding the optimal individual extremum as the current global optimal solution of the whole particle swarm. All particles in the particle swarm adjust their speed and position according to the current individual extremum found by themselves and the current global optimal solution shared by the whole particle swarm.

The idea of particle swarm optimization is relatively simple, which mainly includes 1. initializing particle swarm; 2. evaluating particles, that is, calculating the fitness value; 3. finding the individual extreme value; 4. finding the global optimal solution; 5. modifying the speed and position of particles. The specific operation process is shown in Figure 1.

3. 3D Information Sampling and Optimization Control of Incremental Mining of Production Warehouse Operation Process

3.1. Production Enterprise Warehouse Operation Process Incremental Mining of Three-Dimensional Information Sampling. In order to realize the incremental mining of production enterprise warehouse operation process based on swarm intelligence algorithm, the optimization control of incremental mining of production enterprise warehouse operation process is carried out, and the road network model of production enterprise warehouse operation is established [6–8]. A 5-tuple is used to represent the road network of incremental mining of production enterprise warehouse operation process, an edge in the directed graph, as shown in the following formula:

$$\text{Edge} = \{\text{StartID}, \text{EndID}, c_a, x_a, t_a\}, \tag{1}$$

where c_a represents the road characteristics of incremental mining of warehouse operation process in production enterprises, x_a represents the dynamic characteristics of vehicle operation in the process of incremental mining of production enterprise warehouse operation process, *Edge* represents the directed edge of production enterprise warehouse operation in a, StartID represents the ID of dynamic distribution of roads in incremental mining of

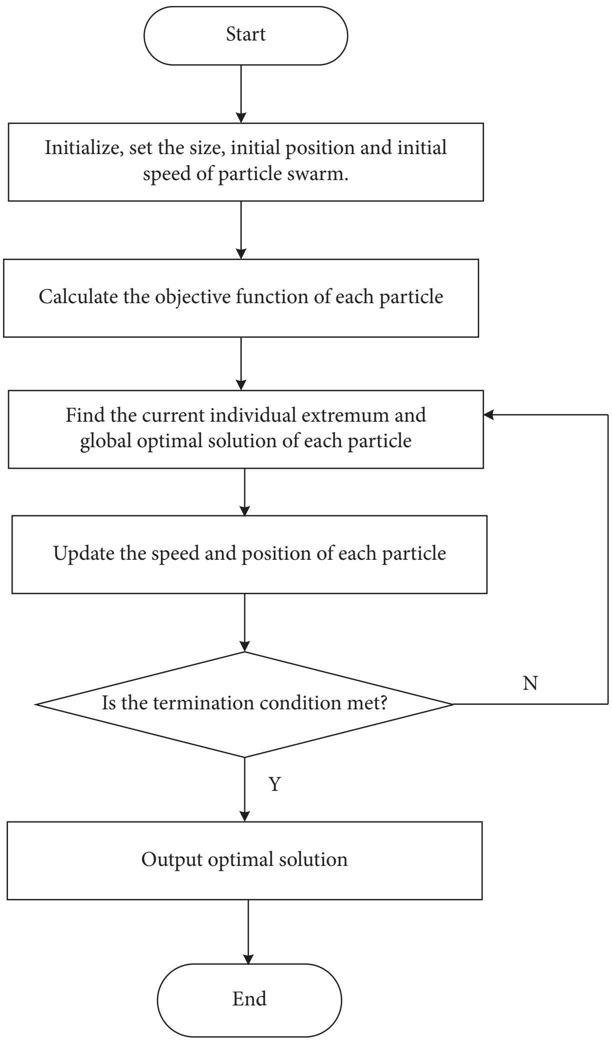

Figure 1: Particle swarm optimization process.

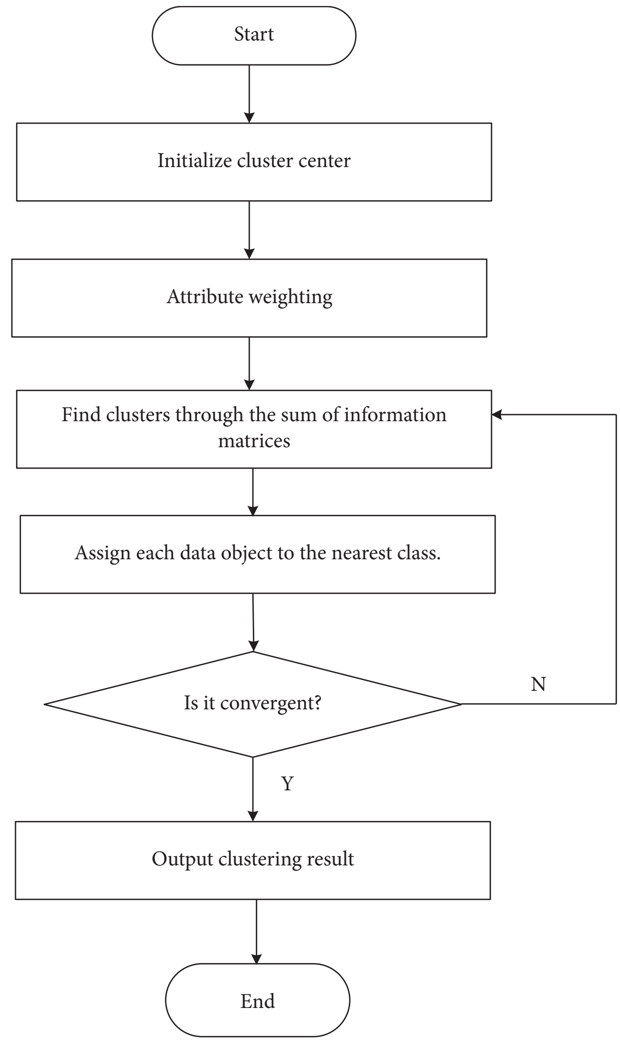

Figure 2: Clustering process of warehouse operation information.

production enterprise warehouse operation process, and EndID represents the ID of the directed end node. According to the road network model of incremental mining of production enterprise's warehouse operation process, the road environment information is sampled, and the information clustering of production enterprise's warehouse operation is completed according to the communication range and the relative distance relationship of the sensor nodes. The specific operation process is shown in Figure 2.

The shortest path of the production enterprise's warehouse operation is concentrated, and the number of nodes of the production enterprise's warehouse operation is represented [9]. The set of edges is shown in the following formula:

$$E = \{e_1, e_2, e_3 \dots e_M\}, \tag{2}$$

where $e_1, e_2, e_3 \dots e_M$ represents the node mode of production enterprise warehouse operation. According to the node distribution, different production enterprise warehouse operation scheduling channels are constructed, and the incremental mining model of the production enterprise warehouse operation process is established [10–12]. The spatial planning function of production enterprise warehouse operation is shown in the following formula:

$$t_a = t_a^0\left[1 + J\left(\frac{x_a}{(c_a - x_a)}\right)\right], \tag{3}$$

where J is the load of the warehouse operation channel of production enterprises, t_a^0 is the modified adaptive coefficient, and c_a is the congestion coefficient of the warehouse operation of production enterprises. The least-square programming method is adopted to optimize the warehouse operation and path of production enterprises, so as to improve the incremental mining ability of the warehouse operation process of production enterprises [13].

3.2. Optimization Algorithm for Warehouse Operation of Production Enterprises

3.2. Optimization Algorithm for Warehouse Operation of Production Enterprises. Establish a grid block planning and detection model of path space area in the warehouse operation area of production enterprises, adopt particle swarm optimization (PSO) shortest path optimization detection method to carry out incremental mining and block search of the warehouse operation process of production enterprises, and carry out information fusion of incremental mining of warehouse operation process of production enterprises [14–16]. The load of incremental mining of warehouse operation process of production enterprises is shown in the following formula:

$$[\nabla F(x)]_j = \frac{\partial F(x)}{\partial x_j} = 2\sum_{i=1}^{N} v_i(x)\frac{\partial v_i(x)}{\partial x_j}. \tag{4}$$

In the above formula, $F(x)$ represents the ambiguity function of incremental mining of the production enterprise warehouse operation process, and $v_i(x)$ is the spatial distribution function of the shortest path of the production enterprise warehouse operation process [17, 18]. Using similarity information optimization method, incremental mining of production enterprise warehouse operation process is carried out to improve the incremental mining ability of production enterprise warehouse operation process, and the physical information fusion parameters of incremental mining of production enterprise warehouse operation process are obtained as shown in the following formula:

$$\begin{aligned}\left[\nabla^2 F(x)\right]_{kj} &= 2\sum_{i=1}^{N}\left[\frac{\partial v_i(x)}{\partial x_k}\cdot\frac{\partial v_i(x)}{\partial x_j} + v_i(x)\frac{\partial^2 v_i(x)}{\partial x_k \partial x_j}\right] \\ &= 2J^T(x)J(x) + 2S(x),\end{aligned} \tag{5}$$

where $J(x)$ is the parameter distribution set of production enterprise warehouse operation process, $S(x)$ is the tracking error of production enterprise warehouse operation process data group, and x_k and x_j are the characteristic quantities of production enterprise warehouse operation model. Using the fuzzy information clustering method, the incremental mining of the production enterprise warehouse operation process is carried out [19, 20], and the path control model is obtained as shown in the following formula:

$$l(v_v) = l(av) + l(cv) + l(bv), \tag{6}$$

where A, B, and C are sorting speed and efficiency parameters, respectively. By counting the production efficiency parameters of the i-th scheme, a comprehensive evaluation is made on the layout scheme of the warehouse operation network of production enterprises, and the scheduling evaluation function in the investment cost distribution nodes v_a, v_b, and v_c is expressed as shown in the following formulas:

$$l(v_a) = l(ba) + l(ca), \tag{7}$$

$$l(v_b) = l(ab) + l(cb), \tag{8}$$

$$l(v_c) = l(ac) + l(bc), \tag{9}$$

where $l(ac)$, $l(bc)$, $l(ab)$, $l(cb)$ are the inertia parameters of the warehouse operation of production enterprises in the. Under the influence of many uncertain factors, the particle swarm optimization detection method of shortest path is used for incremental mining of warehouse operation process of production enterprises to improve the block search ability.

4. Incremental Mining of Warehouse Operation Process of Production Enterprises

Based on the three-dimensional information sampling and optimization control of incremental mining of the warehouse operation process of the above-mentioned production enterprises, the particle swarm optimization method is used to schedule the warehouse operation process of production enterprises, incrementally mine information, and extract pheromone features. By giving the spatial planning matrix of the shortest path of warehouse operation in the production enterprise, the error measurement of path planning is obtained. Fuzzy control error realizes incremental mining of warehouse operation process in production enterprises.

4.1. Particle Swarm Optimization Algorithm for Incremental Mining of Production Warehouse Operation Process. Particle swarm optimization (PSO) shortest path optimization detection method is adopted to conduct parallel scheduling in the incremental mining process of production enterprise's warehouse operation process, and pheromone feature quantity of incremental mining of production enterprise's warehouse operation process is extracted.

The particle swarm state parameter of incremental mining of production enterprise's warehouse operation process is $X_i(t) = (x_{i1}(t), x_{i2}(t), \ldots, x_{iD}(t))$. In the path distribution coordinate system, Hama optimization distribution for incremental mining of production enterprise warehouse operation process is as follows: parallel optimization control algorithm, and the shortest distribution distance T_0, U_0, V_0 is obtained.

According to the parallel control model of the shortest path of warehouse operation in production enterprises, the individual pheromone of the ant colony is T_6^1, and the fuzzy fusion parameter is $p^1 = (p_x^1, p_y^1, p_z^1)^T$. The fuzzy parameter is T_1, U_1, V_1, and the shortest path is taken as the optimization objective function, so that the fuzzy information of warehouse operation of production enterprises is T_6^1, and the fuzzy parameters of intelligent planning of the shortest path of warehouse operation of production enterprises are shown in the following formula:

$$\begin{aligned} &\Delta x = \left(p_x^1 - p_x^0\right)/n \quad \Delta T = (T_1 - T_0)/n \\ &\Delta y = \left(p_y^1 - p_y^0\right)/n\,; \ \Delta U = (U_1 - U_0)/n. \\ &\Delta z = \left(p_z^1 - p_z^0\right)/n \quad \Delta V = (V_1 - V_0)/n \end{aligned} \tag{10}$$

Selecting different index weights, the particle swarm optimization parameter $x_i, y_i, z_i,\ T_i, U_i, V_i\ (i = 1, 2, \ldots, 6)$, which is used to optimize the shortest path of warehouse operation in production enterprises, is obtained. According to the fuzzy control method, particle swarm optimization is carried out, and the particle swarm control equation of warehouse operation of production enterprises is shown in the following formula:

$$ {}^{i-1}T_i = \begin{bmatrix} c\theta_i & -s\theta_i & 0 & a_{i-1} \\ s\theta_i c\alpha_{i-1} & c\theta_i c\alpha_{i-1} & -s\alpha_{i-1} & -d_i s\alpha_{i-1} \\ s\theta_i s\alpha_{i-1} & c\theta_i s\alpha_{i-1} & c\alpha_{i-1} & d_i c\alpha_{i-1} \\ 0 & 0 & 0 & 1 \end{bmatrix}, \tag{11} $$

where S represents the positioning error of the shortest path optimization of production enterprise warehouse operation, c represents the optimization parameters of incremental mining of production enterprise warehouse operation process, the particle star index coefficient is $P_0, P_1, P_2, \cdots, P_n$, and the spatial change matrix of incremental mining of production enterprise warehouse operation process is ${}_0^6T_0, {}_0^6T_1, \cdots, {}_0^6T_n$, and the optimized parallel ant colony optimization function is shown in the following formula:

$$ {}_0^6T = {}_0^1T_1^2T_2^3T_3^4T_4^5T_5^6T, \tag{12} $$

where ${}_0^1T_1^2T_2^3T_3^4T_4^5T_5^6T$, respectively, represents the optimization dynamic parameters of incremental mining of warehouse operation process of production enterprises and finds out the optimization parameters of incremental mining of warehouse operation process of production enterprises. Combined with the fuzzy optimization method, intelligent planning and design of the shortest path of warehouse operation of production enterprises is carried out.

4.2. Production Enterprise Warehouse Operation Process Incremental Mining. The particle swarm optimization (PSO) algorithm is used to mine the warehouse operation process increment of production enterprises. Given the spatial planning matrix of the shortest path of warehouse operation of production enterprises, the error measurement parameters of path planning are as shown in the following formula:

$$ l = \frac{1}{N_0} \int_{T_i}^{T_f} \int_{T_i}^{T_f} \tilde{x}(t) \tilde{h}(t,u) \tilde{x}(u) \mathrm{d}u \mathrm{d}t, \tag{13} $$

where N_0 is the incremental parameter of warehouse operation, $\tilde{x}(t)$ is the optimization correlation state coefficient, $\tilde{h}(t,u)$ is entropy, and $\tilde{x}(u)$ is mutual information. By adopting the adaptive optimization method, the incremental mining of warehouse operation process is carried out, and a fuzzy control model of incremental mining of warehouse operation process composed of decision variables is obtained, which is expressed as shown in the following formula:

$$ \begin{aligned} &\min F(x) = \left(f_1(x), f_2(x), \ldots, f_m(x)\right)^T, \\ \text{s.t.} \quad & g_i \le 0, \quad i = 1, 2, \ldots, q, \\ & h_j = 0, \quad j = 1, 2, \ldots, p, \end{aligned} \tag{14} $$

where $f_1(x), f_2(x), \ldots, f_m(x)$ represents the target state function of incremental mining of the production enterprise's warehouse operation process, and q and p, respectively, represent the distribution weight of the production enterprise's warehouse operation process. The shortest path optimization of the production enterprise's warehouse operation is carried out by using the least square programming method, and the similarity information of incremental mining of the production enterprise's warehouse operation process is obtained as shown in the following formula:

$$ \eta = \frac{a}{a+b+c} \cdot \frac{E[M_A] + E[M_B]}{E[V_A] + E[V_B]}, \tag{15} $$

where M_A and M_B are the load of extracting and storing all kinds of complex goods, and V_A and V_B are the rate of incremental mining of warehouse operation process of production enterprises. The measurement model of incremental mining of warehouse operation process of production enterprises is constructed, and the measurement equation is as shown in the following formula:

$$ E[M_A] = E[V_A] = \sum_{i=0}^{\infty} i(1-p)^i p = \frac{1-p}{p}, \tag{16} $$

where p is the group optimization coefficient of incremental mining of production enterprise warehouse operation process, and the shortest optimization function of the shortest path of production enterprise warehouse operation is established, which is expressed as shown in the following formula:

$$ \begin{cases} A = \dfrac{\partial^2}{\partial f^2} [D_s(f,\mu)]_{\substack{f_{0k} \\ \mu_{0k}}}, \\ B = \dfrac{\partial^2}{\partial \mu^2} [D_s(f,\mu)]_{\substack{f_{0k} \\ \mu_{0k}}}, \\ C = \dfrac{\partial^2}{\partial f\, \partial \mu} [D_s(f,\mu)]_{\substack{f_{0k} \\ \mu_{0k}}}. \end{cases} \tag{17} $$

In the above formula, τ is the location information in the process of incremental mining of warehouse operation process of production enterprises, f is the frequency characteristic quantity of the shortest path distribution of warehouse operation of production enterprises, t is the time parameter, and $D_s(f,\mu)$ is the output state objective function of incremental mining. To sum up, the particle swarm optimization algorithm is adopted to carry out adaptive optimization in the process of incremental mining of warehouse operation process of production enterprises, and the optimal design of incremental mining of warehouse operation process of production enterprises is realized.

5. Simulation and Result Analysis

In order to test the application performance of this method in incremental mining of production enterprise warehouse operation process, a simulation experiment is conducted. The experiment is based on the Matlab simulation platform.

5.1. Experimental Setup. Three machines are used to build the Hadoop cluster environment. The operating system of each node is Ubuntu12.04. The configuration of each machine is shown in Table 1.

In the environment of Table 1, the number of spatial distribution nodes of production enterprise warehouse operation is set as 80, the shortest response time is 14 s, and the index weight is $\lambda = (2322,\ 0.645,\ 4.643,\ 154.144,\ 4.355,\ 7.277)$. The map size of the production enterprise warehouse operation area is 1400×1400 pixels, and the spatial node distribution of the production enterprise warehouse operation process path is shown in Table 2.

Table 1: Experimental environment.

Standard	To configure
CPU	Intel i5 3.2 GHz
OS	Ubuntu12.04 64 bit
Disk	500 GB
IDE	Eclipse
Hadoop	Hadoop1.0.2

Table 2: Spatial node distribution of warehouse operation process path in production enterprises.

Warehouse operation node	X	Y
1	349.378512	441.342975
2	345.247107	310.585124
3	340.452893	56.895041
4	343.365289	151.780165
5	346.028099	313.273554
6	336.011570	302.182645
7	339.979339	134.050413
8	347.376860	118.854545
9	339.444628	54.920661
10	353.229752	287.767769

5.2. Examples of Warehouse Operation of Production Enterprises. In the scheduling of the warehouse operation process of production enterprises, first of all, we will sort out the details of the SKUs of goods that need to be shipped in large quantities or have a large inventory in the next quarter or month, so that WMS system can allocate a fixed Home Location before the order is generated, and take a part of inventory from VNA to replenish it to the Home Location. Set the minimum safety stock for the Home Location. Once the remaining stock of the zero-picking location is less than the safety stock quantity, the WMS system triggers VNA's picking task and the zero-picking location's replenishment task. After VNA completes the corresponding picking task, the zero picking personnel will replenish the inventory. In this way, once the order comes, the zero picking inventory demand can be mostly picked directly from the prereplenished inventory.

Second, when the WMS system allocates the location of Home Location, set the system allocation rule, so that the products of the same type and the same material are distributed in consecutive adjacent positions, so that customer orders can better realize that the products of the same material or SKU are in the same zero-picking carton. Because the system has precalculated the contents of the zero-picking carton during the production and shipment plan, it can be understood that most of the goods in the same zero-picking carton can be picked at adjacent locations, thus shortening the road effort of picking, and the more the quantity of picking per unit time, thus improving the picking production efficiency.

Third, because we have set up safety stock for the zero-picking locations, most of the demand for zero-picking quantity can be picked directly from these locations. However, there will still be some cases where the stock on the preallocated zero-picking locations is not enough. This is why we should not blindly replenish the goods at these zero-picking locations, because the actual location size is fixed, and there is not enough storage space for excessive replenishment. In this case, when the quantity of demand for some goods in actual order is greater than the inventory in the zero-picking position, we ask WMS to assign a Free Seat and ensure that the products replenished to the zero-picking position can be completely picked in the current picking task, so that once the zero-picking position is empty, this position can be used by another goods, thus improving the utilization rate of the position.

5.3. Analysis of Experimental Results. According to the experimental setup in section 5.1 and the example in section 5.2, the method in this paper is used to mine the operation process information. First, the working environment coordinates of the warehouse operation of the production enterprise are obtained, as shown in Figure 3.

In the environment shown in Figure 3, the warehouse operation of production enterprises is carried out, and the optimization path is obtained as shown in Figure 4.

According to the optimization path of warehouse operation of production enterprises shown in Figure 4, the optimization planning of warehouse operation of production enterprises is carried out. According to the walking mode of picking goods from the retail area, there are mainly three ways, namely, after the pickup truck is built, first go to Free Seat to pick goods, then go to Home Location to pick goods, and finally, send them to the packaging station for packaging; Or after building the car, go directly to Free Seat to pick the goods, and then send them to the packaging station for packaging; Or after building the car, go directly to Home Location to pick the goods and finally send them to the packaging station for packaging. The optimized planning model is shown in Figure 5.

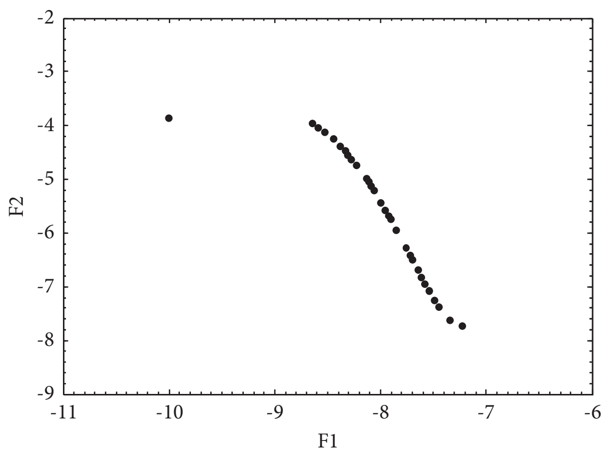

FIGURE 3: Working environment coordinates of warehouse operation of production enterprises.

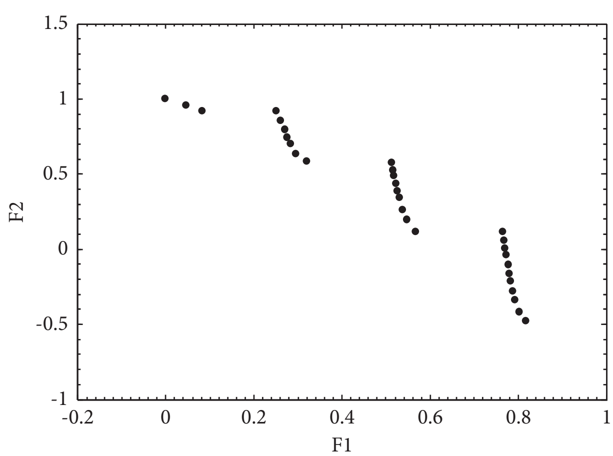

FIGURE 4: Optimization path of warehouse operation of production enterprises.

Analysis of the above simulation results shows that the optimization ability of incremental mining of production enterprise warehouse operation process is better, and the response ability of production enterprise warehouse operation is improved. The simulation results of path deviation correction of warehouse operation process in testing enterprises are shown in Figures 6–8.

According to the analysis in Figure 8, for the three sets of test function sets, using multiple information fusion of main feature information and iterative recovery matching method, the probability of local search to improve the search to the global optimal solution is increased, so as to achieve dynamic real-time correction of access paths. The improved crossover operator reduces meaningless operations, makes effective use of fine-grained cloud data features, and improves the incremental mining ability of the warehouse operation process of production enterprises.

In order to verify the time efficiency of this algorithm in incremental mining of warehouse operation process of production enterprises, the time required for mining this

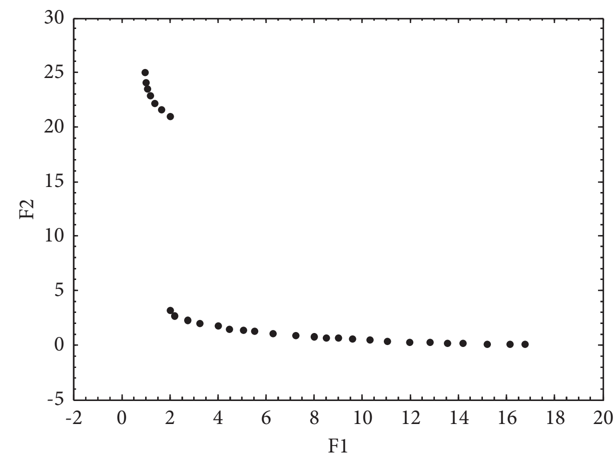

FIGURE 5: Results of optimal planning for warehouse operation of production enterprises.

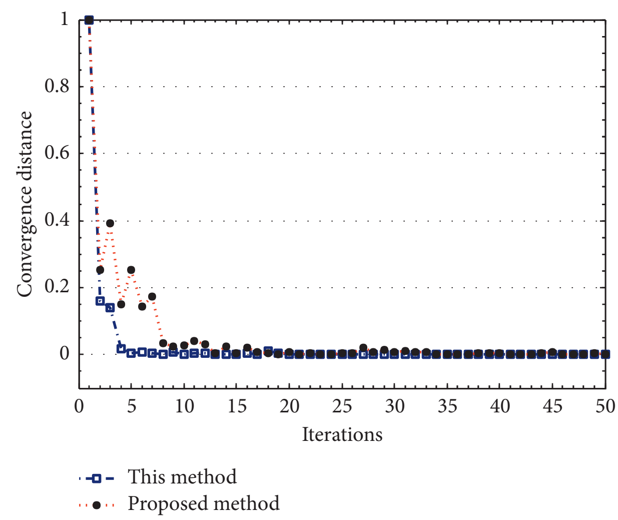

FIGURE 6: Comparison of convergence of warehouse operation of production enterprises of test function 1.

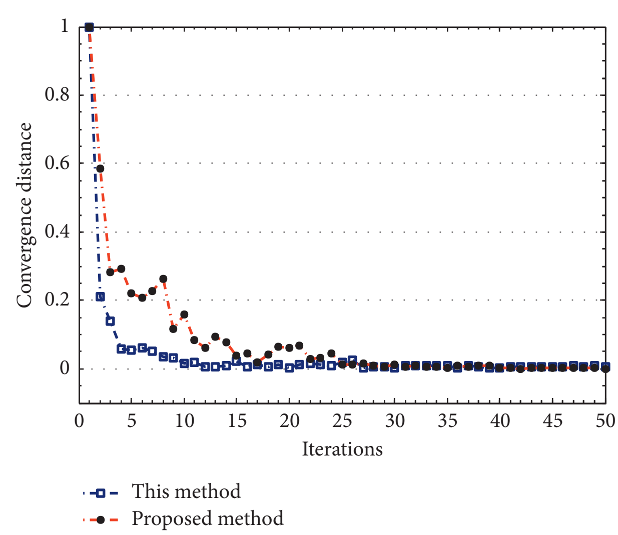

FIGURE 7: Test function 2: comparison figure of convergence of warehouse operation correction in production enterprises.

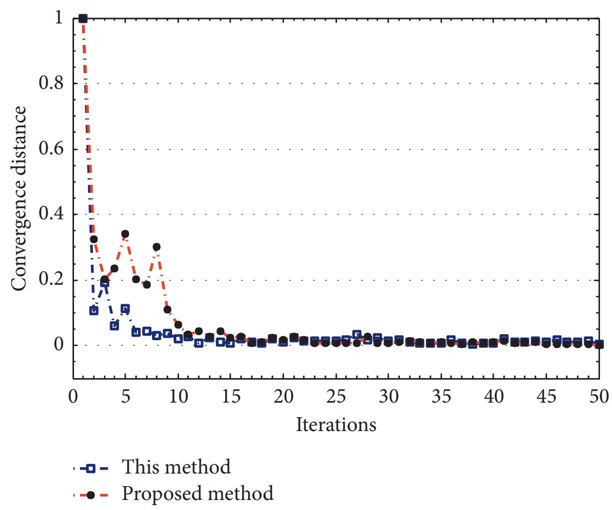

FIGURE 8: Test function 3: comparison diagram of convergence of warehouse operation correction in production enterprises.

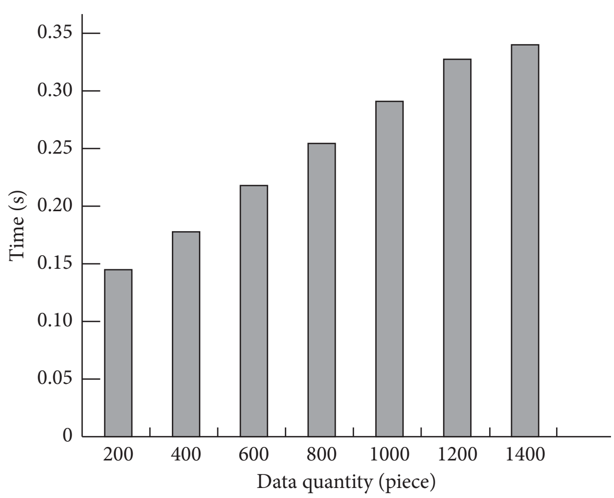

FIGURE 9: Mining time of this algorithm under the number of warehouse operation data of different production enterprises.

algorithm under different numbers of warehouse operation data of production enterprises is studied, and the results are shown in Figure 9.

According to the analysis of Figure 9, with the increase in the amount of warehouse operation data of production enterprises, the time-consuming of algorithm deduplication mining is on the rise. When the amount of data reaches 1400, the mining time-consuming is only 0.33 s. The experimental results show that the algorithm in this paper has a high efficiency of incremental mining of warehouse operation process of production enterprises.

6. Conclusions

This paper presents an incremental mining algorithm of the warehouse operation process based on the swarm intelligence algorithm. The particle swarm optimization method is used to sample the environmental information of the warehouse operation area of the production enterprise. Through dynamic weighting and shortest path optimization control, incremental mining and partition block search of warehouse operation process in production enterprises are realized. Particle swarm optimization algorithm is used to carry out adaptive optimization in the process of incremental mining of warehouse operation process of production enterprises, so as to realize incremental mining of warehouse operation process of production enterprises. The warehouse operation process of a production enterprise is taken as an example to verify. The analysis shows that the optimization ability of incremental mining of production enterprise warehouse operation process using this method is good, which improves the response ability of production enterprise warehouse operation. When the amount of data reaches 1400, the mining time is only 0.33 s, and the execution time is small.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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Research Article

Nonlinear Hypothesis Generation Strategy of Management Accounting Data Mining

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Management accounting plays a greater role in providing business decisions for enterprises. As the core technology of big data processing, data mining technology can process a large amount of complex, structured, and unstructured information very efficiently. In this paper, the nonlinear system is taken as the research object, and the obtained system data is directly used. In the framework of divide and conquer strategy, multi-model method is combined with data clustering and a local modeling algorithm to study the nonlinearity of management accounting data mining. Through online adaptive estimation of parameters, aiming at the zero dynamic problem of the non-minimum phase system, through the decoupling matrix analysis of the nonlinear system, the state of the original strategy is dynamically extended to make the estimated parameters asymptotically approach the true value. The estimated parameters are applied to the nonlinear hypothesis strategy to achieve the goal of linearization control. It is assumed that the generation strategy is applied to the mining of different related types of rules without manually setting parameters, which greatly improves the efficiency of rule discovery. Through case analysis, this paper demonstrates the feasibility of applying nonlinear hypothesis strategy of data mining technology to management accounting and puts forward the relevant application process framework. The validity and feasibility of nonlinear hypothesis strategy data mining technology in management accounting are verified.

1. Introduction

The goal of management accounting is to make full use of relevant information by management accounting, to play the role of management accounting in analyzing the past, controlling the present, and planning the future, providing strong support for enterprise-related decision-making and improving the management system and control framework of the enterprise [1]. In order to effectively realize the corporate strategy, this means that management accounting will play a greater role in enhancing the core competitiveness and value creativity of the enterprise and injecting new vitality into the enterprise in the current economic downturn [2].

In the era of big data, management accounting needs to perform the function of providing decision-making information for business management [3]. One of the most important professional differences between management accounting and strategic management, human resource management, marketing management, and so on is "measurement," otherwise, management accounting will be mixed with other management. For example, although the concept of "customer value" commonly used in marketing management is very useful for marketing management, it is difficult to measure customer value in practice, and few or even no enterprises can calculate customer value. [4]. As the core technology of the big data era, data mining technology is to mine data through new systems, new tools, and new models, and extract data from massive data to support their own decisions [5]. Using data mining technology to effectively and accurately discover key data in the field of management accounting can help enterprises reduce cost management, improve product quality and service quality and seek and discover more information about upstream and downstream industry chains and markets [6]. Providing a more comprehensive and effective decision-making basis for decision-makers of enterprises has very important practical significance for enterprises to improve their strategic competitiveness and complete industrial upgrading and strategic transformation [7].

This paper uses data mining to study the related theory of management accounting, analyzes the current situation, some problems and future developments, decoupling the nonlinear hypothesis generation strategy and adopts linear algebra theory and dynamic expansion algorithm [8]. Combining analysis, the use of the dynamic expansion algorithm is to construct a nonlinear hypothesis generation strategy to achieve the purpose of mining management accounting data [9]. This paper studies the impact of data mining on management accounting and the application of data mining technology in management accounting [10]. The impact of data mining on management accounting function in the big data era includes that data mining technology can effectively improve the cost control of management accounting. The core function of management accounting in functional enterprises is to control the cost effectively. In the enterprise's business activities, every link is closely related to cost control. The enterprise prepares the implementation plan or annual budget to effectively control the enterprise's cost. The case analysis demonstrates the feasibility of applying data mining technology to management accounting and proposes a relevant application process framework [11, 12].

A large number of data are quickly integrated and summarized to find the most accurate data information. For users of data mining technology, it saves a lot of time. It reduces the intermediate links of data processing, so that relevant personnel of the enterprise can extract and use data information more quickly. At the same time, the application of data mining technology can also process and analyze accounting data in real time, thus, making it easier for enterprise managers to make better use of accounting related information. For example, for the inventory management of an enterprise, relevant custodians can regularly study and analyze the past inventory quantity and market demand. Then through the use of data mining technology, we can accurately analyze it and roughly determine the inventory quantity of the enterprise. Try to avoid inventory squeeze and reduce the economic loss to the enterprise. In the era of big data, in order to achieve more stable development and improve their competitiveness, enterprises need to define the market.

2. Management Accounting and Data Mining

2.1. Theoretical Analysis of Management Accounting. Management accounting is an important branch of accounting. It mainly serves the internal management needs of enterprises. It aims to improve the economic benefits of enterprises [13]. Through the use of relevant information, organic integration of financial and business activities plays an important role in enterprise planning, decision-making, control, and evaluation [14]. Management accounting is an important part of corporate accounting, and its role in business management activities is more and more important [15]. It is the most effective tool for strategic, business, and financial integration. Moreover, as management accounting is increasingly valued by management, its role has not been limited to the financial field. The management of procurement, sales, production, and even the planning of the entire enterprise process belongs to the scope of management accounting [6, 16]. The improvement of cost control function of management accounting is promoted. The most important function of management accounting in enterprises is to control the cost effectively and accurately. And in the business activities of enterprises, every link is closely related to the cost control of enterprises. At the same time, in the process of preparing the implementation plan or preparing the annual budget, the enterprise aims to better control the enterprise cost. Based on the big data era, if the cost is controlled only through planning or budget, it will not fully meet the needs of enterprise cost control. Therefore, enterprises can make full use of the data mining technology to mine and analyze a large amount of data information, thus, making the conclusions more accurate and reasonable. And learn more experience and lessons from them and lay a good foundation for the smooth development of cost control.

Management accounting can provide comprehensive and effective business information to the decision-making level so that enterprises can use the limited resources to maximize the value of the enterprise [17]. This requires not only the daily financial information of the enterprise but also the internal comprehensive management information that suits the characteristics of the enterprise and the development of the industry [18, 19]. They behave in a variety of ways, with financial and nonfinancial information, quantitative and nonquantitative information, actual and projected information, historical and future information, structured and unstructured information, internal and external information, tangible and intangible, and other information [20]. Figure 1 shows the theoretical analysis framework of management accounting.

Management accounting is the business management service for enterprises. Its main role is to provide managers with comprehensive and effective information for them to make optimal decisions. It is another important factor in management accounting to study important indicators and their changes in relevant information. To calculate function through the relevant data model, to obtain the relevant business data of the enterprise under the existing conditions and predict the future business conditions, mainly including the financial status forecast, cost forecast, profit forecast, operational benefit forecast, cash flow of the enterprise forecasting, and other aspects, so as to provide effective and reliable information for business decision-making, management decision-making is correct or not, need to be judged through continuous feedback, management accounting through regular and irregular assessment, and evaluation of business conditions for managers provide appropriate feedback.

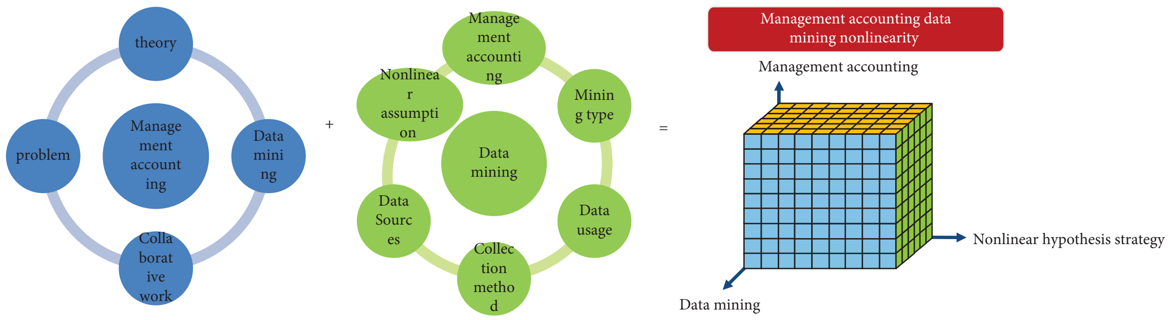

Figure 1: Management accounting theory analysis framework.

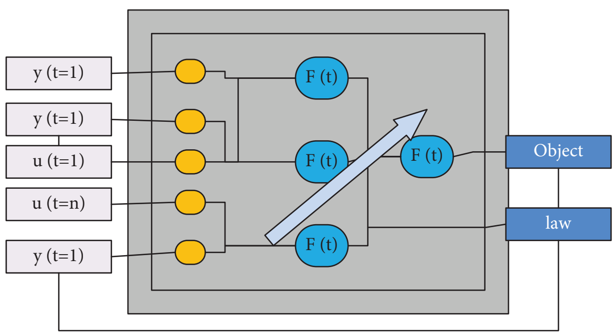

Figure 2: Data mining management accounting adaptive control system block diagram.

2.2. Application of Data Mining in Management Accounting. The impact of big data on management accounting is profound and huge. In the face of the current massive data, traditional management accounting often adopts a single processing method, and it has not been able to fully exert its important role in business decision-making. Data mining uses integrated technology to play a very important role in various disciplines such as database processing, mathematical statistics, and artificial intelligence. The technology will be managed in terms of data search, processing, analysis, and utilization. Accounting provides effective data, enabling management accounting to make powerful decisions in corporate forecasting, decision making, budgeting, accounting, control, analysis, and assessment. Figure 2 shows the block diagram of data mining management accounting adaptive control system.

Process-based, total, real-time data processing has become a core requirement for data value mining. If you want to get this data, you need to use data analysis tools, such as commonly used attribution analysis, regression analysis, trend analysis, fuzzy matching, decision tree, and so on. The algorithm used for mining analysis tools is more complicated. The amount of data and calculation involved in the analysis is generally large. The establishment of big data warehouse is conducive to the realization of enterprise information sharing.

Data mining technology can be applied to many aspects of management accounting, so that management accounting can cover more business information, so that it can reflect the business situation objectively and multi-dimensionally. At the same time, the information provided by management accounting is no longer limited to financial information, but also includes the information needed for internal management, which helps the internal and external management of the enterprise, promotes strategic management and carries out strategic management of business operations and business structure. Analyze and realize the improvement of value chain management in combination of "control management before event analysis and post-event accounting evaluation" to realize the combination of management accounting and economic benefits the way it is. This is the impact of data mining on management accounting in terms of data storage, either through cloud storage or remotely. Based on the cloud storage service, the data informatization platform is built and can be customized on demand to meet the needs of management accounting for data storage and reading in the era of big data.

2.3. Nonlinear Adaptive Control. The feedback linearization control of nonlinear systems is to achieve complete linearization or precise linearization of affine nonlinear systems through differential homeomorphic transformation (i.e., nonlinear coordinate transformation) and nonlinear state feedback which is one of the best options for linear control. Due to the generation and application of feedback linearization theory, the nonlinear system control theory has been greatly developed. Some conclusions about the geometrical description of linear control systems have been promoted in parallel in nonlinear system control. In essence, the linearization control of affine nonlinear systems rely on the exact cancellation of nonlinear terms in nonlinear systems known to mathematical models. However, for an actual system, it is often difficult to obtain an accurate mathematical model of the system due to modeling errors or different ways of operating the system. If a nonlinear system that fails to accurately know the mathematical model directly implements linearization control using nonlinear state feedback, the abovementioned exact cancellation cannot be established, which may lead to the failure of the nonlinear control strategy. Therefore, for a non-linear system that does not accurately know the mathematical model, it is necessary to design a robust control scheme to deal with the parameter uncertainty in the mathematical model of the nonlinear system. Because the mathematical modeling of the system is not accurate or the parameters change during the operation of the system, there are many uncertain factors in the nonlinear system. Therefore, when designing the controller for the nonlinear system, the uncertainties of the system and the external interference must be considered. Robust control has been widely used in linear systems. It can also overcome the uncertainty of nonlinear systems and ensure that nonlinear closed-loop systems have good dynamic quality and strong robustness. When the nonlinear system is uncertain or subject to external disturbances, the performance index of the nonlinear system can be analyzed by the robust control theory. In addition, in the case of considering uncertainties or external disturbances, according to the Lyapunov function, the nonlinear robust controller can also be designed using the robust control theory. Because the robust control can deal with the uncertainty of the nonlinear system and restrain the external disturbance of the system well, the robust control is widely used in various research fields and has achieved good results.

3. Nonlinear Hypothesis Strategy of Management Accounting

3.1. Nonlinear Adaptive Control. The nonlinear hypothesis is often the smallest phase system. Because the minimum phase system has many excellent properties, one of them is that it can be calmed by feedback. The so-called minimum phase system is that the zero dynamic of the system is an asymptotically stable system. Consider a single-input and single-output nonlinear system with a relative order r.

$$\left\{\begin{array}{c} \hat{x} = f(x) + g(x)u \\ y = h(x) \end{array}\right\}. \tag{1}$$

Coordinate transformation is written as

$$\hat{z} = \vartheta(x) = L_f h(x), \quad i = 1, r. \tag{2}$$

It can be written as

$$\begin{cases} \hat{z_i} = z_{i+1}, \quad i = 1 \ldots r, \\ \hat{z_r} = b(z) + a(z)u, \\ \widehat{z_{r+1}} = q_{r+1}(z) + p_{r+1}(z), \\ \ldots\ldots \\ y = z_i. \end{cases} \tag{3}$$

If the system is zero dynamic, then we get

$$\eta_i = q_0(\eta) - \frac{b(0,\eta)}{a(0,\eta)} p(0,\eta). \tag{4}$$

If it is locally asymptotically stable, the strategy is called a nonlinear minimum phase strategy.

But in actual engineering, the nonlinear hypothesis strategies we encounter are not all minimum phase systems but most of the points are non-minimum phase systems. This section presents a control strategy for non-minimum phase hypotheses based on state feedback methods.

3.2. Nonlinear Hypothesis Strategy. For block decoupling problems with some nonlinear strategies, regular static state feedback cannot be used to achieve decoupling purposes. This also shows the importance of using the differential geometry method, especially the geometric infinite structure to study the static decoupling problem of nonlinear systems, and the algebraic infinite structure is still not an effective tool for the static decoupling problem. However, the algebraic method is more suitable for the dynamic feedback problem of nonlinear systems, namely the dynamic block decoupling problem.

The minimum-order dynamic decoupling feedback problem can be discussed by constructing the root of the nonlinear hypothesis strategy. The dynamic expansion algorithm or the Singh algorithm can be used to construct the root of the nonlinear system. The root of the nonlinear system can be used to achieve the dynamics of the nonlinear hypothesis strategy.

Feedback decoupling is proposed. The dynamic expansion algorithm is used below to construct the root of the nonlinear hypothesis strategy.

From the analysis of the previous dynamic expansion algorithm, the strategy has been constructed in step k.

$$\begin{cases} x_k = f_k(x_k) + g_k(x_k)u_k, \\ y = h(x_k). \end{cases} \tag{5}$$

The state of the integrator added at each step is

$$A_{\text{ij}} = \sum_h \text{span}_x \left\{ d_x \sum_{i=1}^{k} \sum_{i \neq j} \frac{\partial y_k}{\partial z_i} dz_i \right\}. \tag{6}$$

Then

$$A^K \subset \sum_{J=1}^{K} E_k^j \cap \sum_{i \neq j} E_k^j. \tag{7}$$

The decoupling problem of nonlinear hypothesis strategies is discussed by using the dynamic expansion algorithm and linear algebra theory. The dynamic expansion theory is used to construct the subspace of the vector space E in the nonlinear hypothesis strategy. From the perspective of linear algebra, the dynamic expansion algorithm is essentially a construction method of the subspace E base. The dynamic expansion algorithm and linear algebra theory are used to construct the root of the nonlinear system. The dynamic decoupling feedback problem is discussed by constructing the root. The process of finding the root of the nonlinear system is to decouple the nonlinear system in the dynamic state feedback. The process can find those input partitions that only affect the current output.

3.3. Management Hypothesis Nonlinear Hypothesis Strategy Model Framework. According to the basic principles of management accounting, the application of nonlinear hypothesis strategy in data management technology in enterprise management accounting is used to construct a process framework based on data mining. The construction of the process framework aims to achieve the following

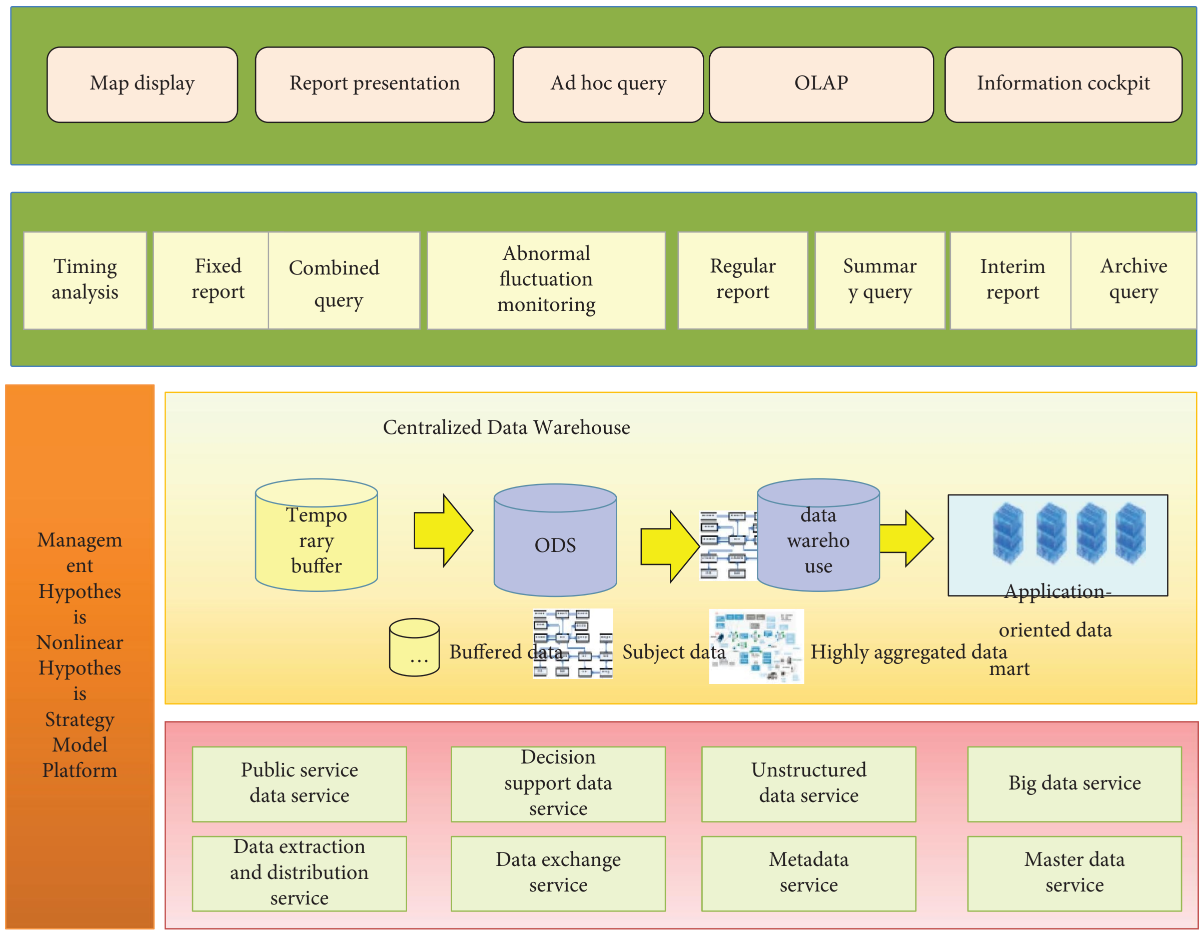

Figure 3: Management hypothesis of the hypothetical strategy model framework.

objectives: to explore effective ways for enterprises to make full use of information in the era of the knowledge economy, to deepen the understanding of data and information; to guide the application of data mining technology in management accounting and to improve the decision-making relevance of management accounting. To enhance the competition of enterprises Figure 3 shows the management assumptions of the hypothetical strategic model framework.

3.3.1. Define the Problem. Defining the problem reveals problems encountered in business management and conducts in-depth analysis. For example, why income will decline, what methods can be used to increase income, what factors are involved in improving income, how competitors do, and they have no similar problems. After analyzing the problem, understanding the problem will be more profound, the collection of information will be more systematic and the source will be more effective.

3.3.2. Identify the Source of Information. After clarifying the above issues, you can determine what information you need to look for from those aspects. For information sources, it can be roughly divided into two categories: internal information and external information.

3.3.3. Data Collection and Organization. Through the abovementioned information source, data collection can be performed, but the collected information is often fragmented and scattered information, and there will be a lot of noise, which requires the use of information sorting techniques, such as typical data cleaning.

3.3.4. Data Mining. After the process, data mining can be performed. The commonly used algorithms for data mining are described in the foregoing and will not be repeated here. However, it should be noted that data mining must be closely related to the basic principles of management accounting and the purpose of solving the problem. It cannot be mined for data. After all, the amount of data is very large, and each time it is mined, it will generate quite a lot of information. The initial digging target will lose the direction of decision-making because of too much data.

3.3.5. Analysis and Expression of Results. Data mining leads to corresponding data, and in the face of problems that need to be solved, it needs to be combined with the characteristics of the enterprise and the business environment for analysis to arrive at a more reasonable

Table 1: Business scale list.

Project	Number of people	Deposit size	Loan size	Number of public settlement accounts	Per capita water flow	Financial accounting customer
End of 2013	26	80673 ten thousand	3500 ten thousand	1367 household	651	1220 household
End of 2015	19	163199 ten thousand	27049 ten thousand	1886 household	1251	2770 household

Table 2: List of job configurations.

Post setting	year 2013	year 2015
Front desk teller	Private counter	Cash business counter
	Full-time cash teller	Cancel
	Public counter	Non-cash counter
Mid-stage teller	For public accountants	Maintenance of public account and product maintenance
	Signing a contract for public products	
	Management of public foreign exchange business	International business executive
	Reviewing the public account	Cancel
	Review of public foreign exchange business	Cancel
	Review the public front office business	Cancel
	Exchange of posts	Increase the number of hits, transfer business
	Fight against the public	Cancel
	Business trip	Cancel
	Public finance payment business	Cancel
	Print the classification of public customers	Cancel
Lobby manager	1 person	1 person

solution. The results of data mining can be data or presented in clear charts or tables.

4. Instance Verification

4.1. Instance Data. Table 1 shows the share of branch business departments at the end of 2013 and the scientific theory and relevant data at the end of 2015. A branch of China Construction Bank Beijing Branch has 68 employees and has 8 business outlets. At the end of 2015, the personal deposit scale of the branch business department reached 163.199 million yuan, the scale of public deposits broke 10 billion, and the number of public settlement accounts was more than 2,000. In recent years, a branch has focused on the development goals of "comprehensive outlets, integrated tellers, and integrated marketing teams," constantly improving service quality, and under the concept of service-driven efficiency, highlighting the assessment of individual employees' comprehensive contributions and giving play to everyone's advantages and characteristics, forming a distinct team characteristics.

In 2013, the branch combined with the characteristics of its own business and personnel characteristics, through the scientific theory of relevant data, on the premise of ensuring that the accounting business is not affected, actively explore the "lower and lower, process reengineering" program to reposition the post. Reengineering, that is, reducing the fixed cost of counter accounting personnel, digging deeper customers who contribute value, reallocating resources, placing more costs on valuable customers, increasing revenue, and making 20% more customers create 80% of their profits. With the help of data mining technology, through a large number of research and analysis of all the data of this branch in recent years, a set of effective programs has been proposed (see Table 2).

Therefore, the sub-branch cooperated with relevant departments to use data mining technology to mine relevant data, mainly through the following and the steps are taken as follows:

(1) Business understanding: Business understanding is primarily about diagnosing the bank's current business conditions in order to determine what data is needed, which businesses will generate revenue, which customers will create profits, and which will not
(2) Data acquisition: Bank customers are divided into public customers and private customers. For public customers, they refer to corporate customers. For private customers, they refer to personal customers. Therefore, the data obtained is divided into public and private.
(3) Data preprocessing: Data mining requires a lot of data processing, so data quality is particularly important. Data preprocessing is a preparation work before data mining, which plays a vital role in the quality of data mining. The object of data mining includes not only some financial data of customers, such as asset size, credit status, and profitability, but also some non-financial data, such as the frequency of business transactions, whether it is the card-issuing households, complaint rate, and satisfaction.

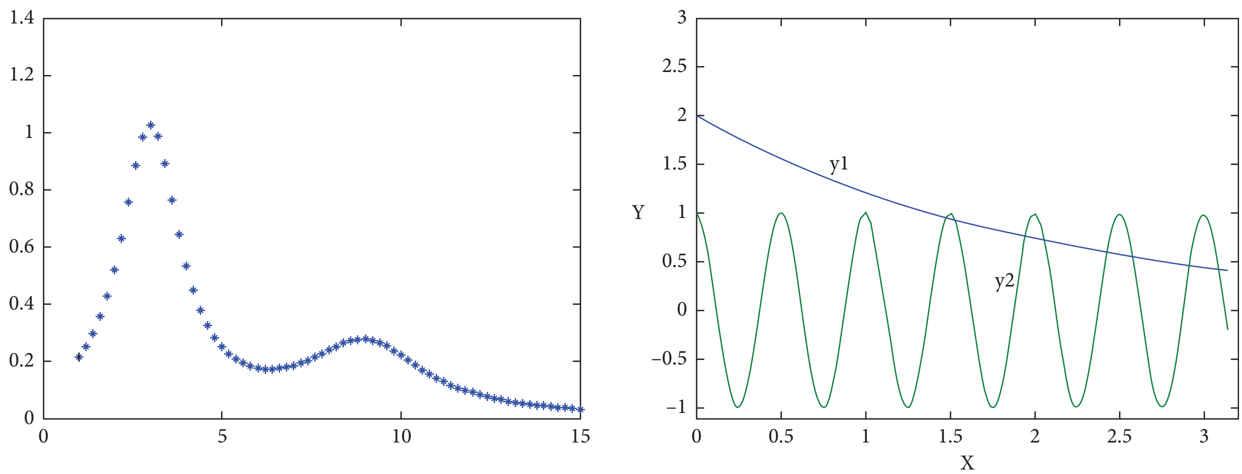

Figure 4: Nonlinear hypothesis strategy verification process diagram.

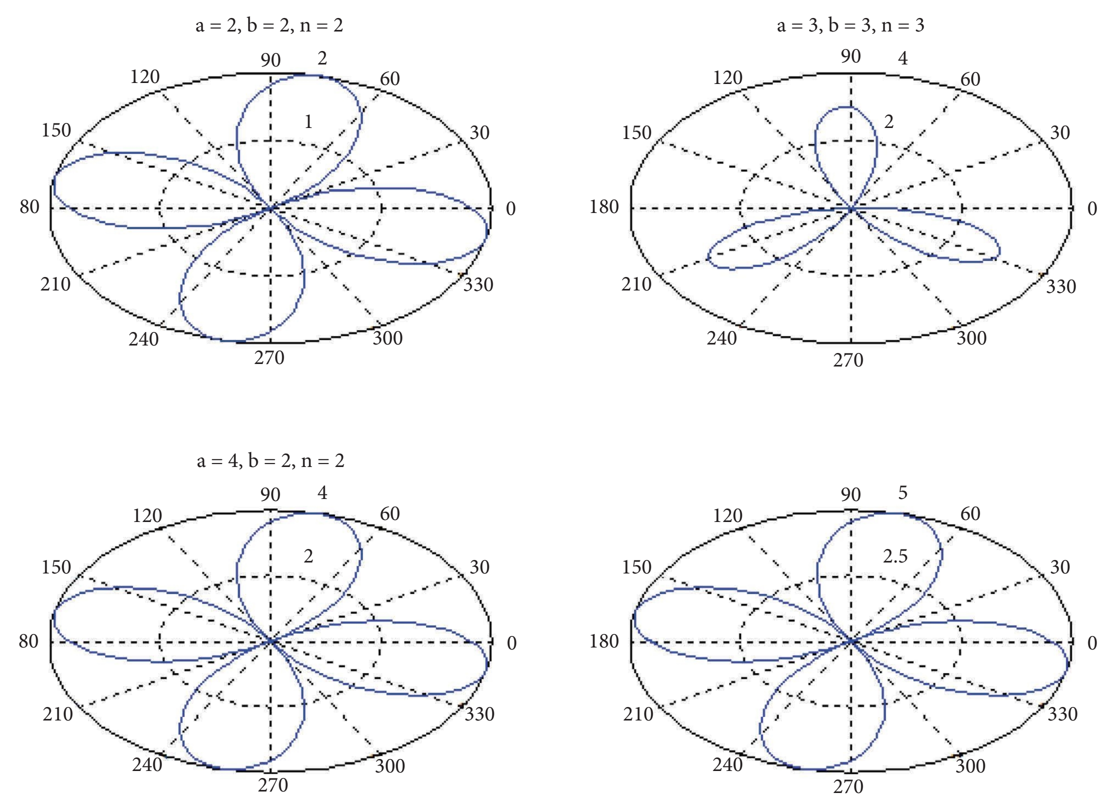

Figure 5: Control chart of the nonlinear hypothesis strategy model in management accounting data mining.

These data are not only complex and large but may also contain a lot of repetitive and useless information, so it is important to clean, integrate, and convert the data into a standardized process.

(4) Data mining: The non-linear hypothesis strategy is used for data mining. Through data mining technology, data is collected and organized to form a huge database. According to many factors affecting cost and income in management accounting, customers are classified according to different contribution values, and different customer groups are obtained. Different marketing strategies stimulate potential consumption; at the same time, different cost allocations are made according to different levels of customers, and income is increased under effective cost control, which increases profits and enhances its core competitiveness.

Among them, the nonlinear hypothesis strategy verification process is as follows.

It can be seen from Figure 4 and Figure 5 that the estimated parameter asymptotically tends to the true value through the nonlinear hypothesis estimation of the parameter, thus completing the complete linearization hypothesis control based on the nonlinear state feedback, realizing the rotational speed and the rotor. Both theoretical derivation and computer simulation prove the feasibility and effectiveness of this method in managing accounting data mining applications.

5. Conclusion

In this paper, state feedback is given, and an adaptive control scheme based on linearization is developed. Through online adaptive estimation of parameters, aiming at the zero dynamic problem of the non-minimum phase system, through the decoupling matrix analysis of the nonlinear system, the state of the original strategy is dynamically extended to make the estimated parameters asymptotically approach the true value. The estimated parameters are applied to the nonlinear hypothesis strategy to achieve the goal of linearization control. Through case analysis, this paper demonstrates the feasibility of applying the nonlinear hypothesis strategy of data mining technology to management accounting and puts forward the relevant application process framework. The validity and feasibility of the nonlinear hypothesis strategy data mining technology in management accounting are verified. Through the nonlinear hypothesis estimation of the parameters, the estimated parameters asymptotically approach the true value. Thus, the complete linearization assumption control based on nonlinear state feedback is completed, and the speed and rotor are realized. Theoretical derivation and computer simulation have proved the feasibility and effectiveness of this method in the application of management accounting data mining. However, the study still has some limitations. The research lacks the establishment of sales, cost, and capital prediction models. In future research, it is necessary to scientifically and accurately predict various indicators of the enterprise as the basis for decision-making.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest regarding this work.

Acknowledgments

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Research Article

Application of Video Feedback System to Technical Analysis and Diagnosis of Throwing Athletes

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Throwing sports have high technical difficulties and requirements. The traditional learning and training methods require athletes to start from observation and imitation and constantly repeat mechanized training. Athletes have no intuitive comparison and understanding of the overall situation of their own movement technology. Video feedback systems can make up for the shortcomings of traditional methods, so that athletes can more intuitively observe the problems of their own actions. Therefore, this paper puts forward the application research of technical analysis and diagnosis of throwing athletes based on video feedback system, and uses random forest regression algorithm to construct video feedback system. The comparative experimental results show that the students who study and train the movement technology through the video feedback system have higher performance in javelin throwing than the students in the control group, and the performance improvement range is higher. The javelin throwing movement technology is closer to the requirements of the standard movement, which can reduce the wrong movements of javelin throwing. It is more conducive for students to achieve better javelin throwing results.

1. Introduction

In throwing events, whether it is a solid ball or other events, power is the basis of throwing. When throwing, the athlete should upload the strength of the lower limbs to the upper limbs, and then transfer it from the upper limbs to the arms. At the last moment, the maximum force generated by the whole body is applied to the missile. That is to say, it needs a strong explosive ability in throwing. Only when the explosive force reaches the limit and works perfectly on the projectile, can it reach a long distance. Therefore, in daily training, athletes must strengthen the practice of strength quality if they want to have good strength. In the process of training, we should grasp the characteristics of training and take targeted training. In throwing events, we should arrange appropriate training plans according to the characteristics of the events, and determine the training content by the training items. In throwing events, the most important thing in the competition is the longest distance that the athletes can throw. How to throw the missiles farther requires athletes to have better strength and speed.

Throwing sports in track and field have high technical difficulties and requirements. It is a great challenge for athletes to master or improve their skills and achievements in a short time. In the traditional track and field teaching, the main teaching means is that athletes understand, learn, and practice through the explanation and demonstration of coaches or teachers [1]. In teaching and training, coaches pay more attention to the physical exercise and repeated imitation of sports. In the process of a large number of mechanical training, athletes do not have a comprehensive and detailed understanding and cognition of their throwing techniques and movements. Once they develop wrong throwing movements, it is difficult to correct and change [2, 3]. With the reform of physical education, the traditional physical education teaching methods cannot meet the needs of athletes' training. It is of great significance to seek new physical education teaching methods combined with modern teaching means and technology to analyze and diagnose physical education teaching and athletes' technology [4]. Video feedback technology is a new educational concept, which mainly analyzes and diagnoses the movement and technology through video teaching in the process of teaching and training, and assists other training of athletes, so that athletes can refine the training content, observe their throwing technical movements, and improve and correct them in time [5, 6]. At the same time, it is conducive for coaches to better understand the technical state of sports, better analyze and diagnose athletes' throwing technology, and formulate targeted guidance suggestions and evaluation indicators [7].

This paper puts forward the application research on the technical analysis and diagnosis of throwing athletes based on video feedback system. The random forest regression method is used to construct the video feedback system model to analyze and diagnose the throwing athletes' technology. This paper is mainly divided into three parts. The first part expounds the application and research status of video feedback system in physical education teaching. The second part constructs the throwing athlete technology analysis system based on video feedback. The third part analyzes the experimental results and corresponding analysis of throwing mobilization technology based on video feedback system.

This paper is mainly divided into five parts. The first part analyzes the research background of throwing in track and field. The second part expounds the application and research status of video feedback system in physical education teaching. In the third part, a throwing athlete technology analysis system based on video feedback is constructed. The application principle of video feedback system in athletes' technical analysis is analyzed. The fourth part analyzes the experimental results and corresponding analysis of throwing mobilization technology based on video feedback system. The parameters of the video feedback system model based on random forest regression algorithm are optimized. Finally, the full text is summarized. Frequency feedback system can deepen athletes' cognition of throwing technology, reduce the probability of wrong actions, and effectively correct problematic actions.

2. Related Work

With the development of modern technology, video feedback technology has been paid more and more attention and applied. It is mainly based on feedback teaching, transforming the form of language feedback into the form of video feedback, and has been applied in the field of medicine and physical education [8]. In the field of physical education, video feedback technology is widely used in sports such as taekwondo, swimming, martial arts, aerobics, and table tennis. There are also some corresponding studies in track and field [9]. Video feedback teaching first photographed and recorded students' sports practice process through camera technology, and then made students observe and recognize their shortcomings in the practice process through continuous return visit to the camera content, and then improved their actions through multiple correction, projection, and comparison [10, 11]. On this basis, some scholars use three-dimensional camera equipment to record students' tennis classroom performance and feedback the recorded information to students, so as to enrich the teaching content and improve the teaching effect [12]. Other scholars have moved audiovisual technology into hurdle technology teaching, combined with teachers' explanation and collective feedback mechanism, so that students can master hurdle technology faster, impose cognitive thinking, and break the limitations of thinking [13]. Other scholars have emphasized the continuous shooting of the video feedback system, and believe that its continuous shooting can intuitively record and show the action details with strong complexity and continuity in Taekwondo, so that students and teachers can observe and find problems in the action more carefully, so as to make targeted correction and practice [14, 15]. Some scholars have conducted experimental analysis on the application of video feedback system in volleyball teaching. It is concluded that video feedback system helps students understand the essentials of action technology in the initial stage of volleyball learning. Through the freeze frame and slow playback of technical action video, students can observe and learn more intuitively and form a clear image. In the advanced stage of students' learning volleyball technology, video feedback can help students find their own problems and correct them in time [16, 17]. In addition, some scholars proposed the combination of bilateral feedback teaching method and video feedback system, which was applied to Javelin teaching and training, and found the movement transfer characteristics through the study of double limb training [18]. Other scholars applied the video feedback system to the field of action correction in throwing teaching, and analyzed the athletes' action error prone points and corresponding correction methods in combination with the athletes' throwing characteristics, learning state, psychological situation, and other factors [19, 20].

To sum up, the application of video feedback technology in physical education has been widely recognized. With the development of modern technology, it has gradually changed from video technology to modern mobile devices, such as mobile phones and computers, to record the teaching and training process, and then combined with the corresponding data analysis technology and software. It can effectively analyze and correct the problems and deficiencies of athletes and students in the process of sports, so as to improve students' innovative thinking and comprehensive ability, strengthen teaching effect, promote physical education teaching reform, and lay the foundation for the rapid development of physical education.

3. Technical Analysis System of Throwing Athletes Based on Video Feedbacks

3.1. Application Principle of Video Feedback Systems in Athlete Technical Analysis. The technical analysis of throwing athletes is essentially the analysis of athletes' action skills, and action skills are a kind of action mode with certain consolidation, automation, and perfection [21]. In the process of action, people include all kinds of actions that need the actions of different parts such as hands and feet. Therefore, when people learn new actions, the coordination between different parts is relatively poor. Only through contact can they consolidate and master the action skills, so as to realize the action automation [22]. According to relevant theories, the formation process of athletes' motor skills can be divided into four stages. The first stage is the initial stage of motor skills learning, in which athletes have a preliminary interest in throwing games; the second stage is the generalization stage, in which athletes will learn some primary skills of throwing; the third stage is the consolidation stage, in which athletes improve their motor skills through continuous learning and practice; and the fourth stage is the automation stage, that is, athletes can master the learned motor skills [23]. According to the four stages of the formation of motor skills, athletes' motor technology learning objectives can be divided into three different levels, namely cognitive level, emotional level, and motor skill level. Among them, the level of motor skills can be further divided into seven different angles, namely perception, set, mechanical action, guiding reflection, complex external reflection, adaptation, and innovation. Video feedback includes mechanical action, guiding reflection, complex external reflection, adaptation, and so on [6]. As shown in Figure 1, the application process of video feedback system in technical analysis of throwing athletes is shown.

The application of video feedback system in technical analysis and diagnosis of throwing athletes is to help athletes better understand the problems existing in their own movement skills and correct them in time, so as to improve their mastery of throwing technology and learning efficiency. Therefore, the application of video feedback system in technical analysis and diagnosis of throwing athletes should conform to the level of motor skill formation process and learning objectives, and also combine the following principles. The first principle is the comprehensive principle, that is, the coach should consider the basic situation of all athletes when formulating learning and practice objectives for throwing athletes. Different athletes have different degrees of learning and understanding of throwing skills [24].

The second principle is the principle of teaching students in accordance with their aptitude and timely motivation, that is, different athletes have differences in learning ability, personality characteristics, physical advantages, and ways of thinking. Watch the technical action videos of excellent throwing athletes from different angles, so as to deepen the athletes' comprehensive understanding of action technology and effectively find their own problems. When the coach explains the essentials of the throwing action, he should not only demonstrate the action, but also comprehensively explain the knowledge related to the action, so that the athletes can understand the principle of the throwing action. Intuition not only requires the demonstration action of the coach to make the athletes initially form the action image of the action, but also allows the athletes to observe their own actions through the video feedback system. The third principle is the intuitive principle, that is, when athletes learn and practice throwing movements, they can deepen their understanding of movement skills through their own sensory system and intuitive and vivid movement performance.

Therefore, in the process of training, we should emphasize teaching students in accordance with their aptitude, determine goals according to the characteristics of different athletes, and use different feedback languages to provide effective and targeted guidance to different athletes, so as to optimize the effect of athletes' learning and training. At the same time, we should also establish athletes' self-confidence, stimulate learning interest and enthusiasm, and timely affirm and encourage athletes. The fourth principle is the heuristic principle, that is, cultivate athletes' independent thinking and autonomous learning ability through video feedback system, let athletes find problems and put forward solutions through video observation and group discussion, and the coach gives certain guidance and reminder at the right time, so as to improve athletes' understanding and application ability of throwing skills.

3.2. Construction of the Video Feedback System Model Based on Random Forest Regression Algorithm. Decision tree can easily deal with the interaction of features and is nonparametric, so there is no need to worry about outliers or whether the data is linearly separable. Before using the maximum number of votes or the average value to predict, you want to establish the number of subtrees. Generally speaking, the more the number of subtrees, the better the performance, and more stable the accuracy of prediction, but it will also slow down the calculation process. Random forest regression algorithm, or RFR algorithm in short, is an integrated learning algorithm based on decision tree. It has high accuracy and can avoid the shortcomings of single prediction or classification model. In the random forest regression algorithm, each decision tree will take the equal probability random sampling method to extract the corresponding training data from the original data. The training data of each individual classifier is different, and the majority or average of all individual classification results is the final result of the random forest regression algorithm. As shown in Figure 2, the principle diagram of random forest regression algorithm is shown.

The combination model of a group of decision subtrees constituting the random forest regression algorithm is $\{h(x,\theta_t), t = 1, 2, \ldots, T\}$, in which the random variable is θ_t and obeys the independent and identical distribution, the independent variable is x, and the number of decision trees is T. Take the mean value of each decision tree as the regression prediction result, as shown in the following:

$$\overline{h}(x) = \frac{1}{T}\sum_{t=1}^{T}\{h(x,\theta_t)\}, \tag{1}$$

where $\{h(x,\theta_t)\}$ is the output about x and θ.

Randomly select the training set vectors x and y, and the interval function is shown as follows:

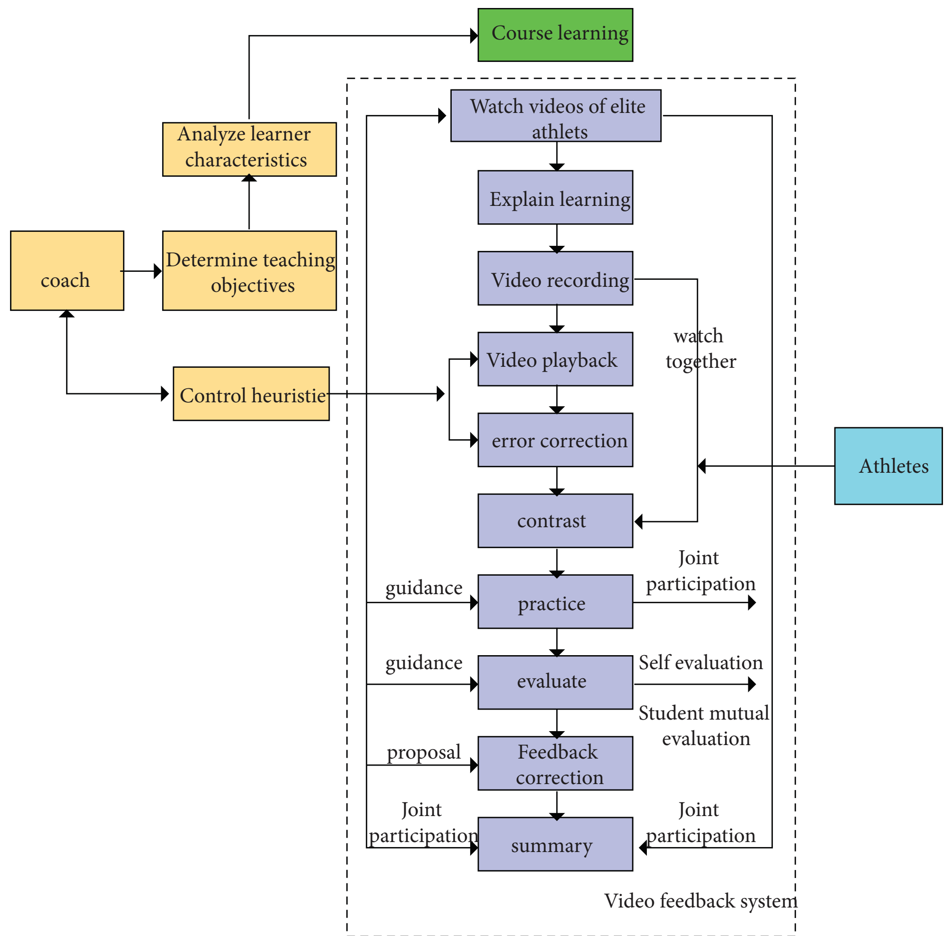

Figure 1: Application process of the video feedback system in technical analysis of throwing athletes.

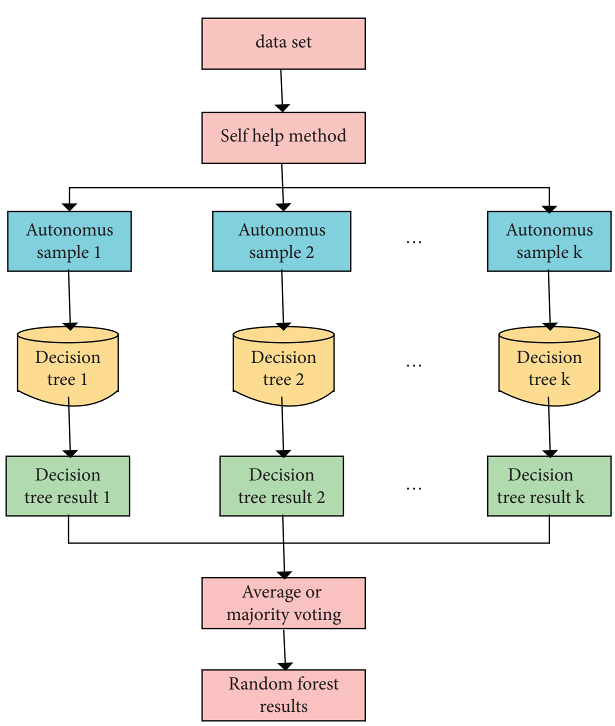

Figure 2: Schematic diagram of random forest regression algorithm.

$$mg(x, y) = av_t I(h(x, \theta_t) = y) - \max_{j \neq y} av_t I(h(x, \theta_t) = j). \tag{2}$$

The exponential function is expressed as I, and the corresponding classification result in the training set x is expressed as y.

In order to avoid the over fitting problem in the decision tree model, bagging and random subspace are integrated into the random forest regression algorithm. Bagging idea can increase the number of regression decision subtrees constructed by randomization, and keep them independent of each other. In the idea of random subspace, both the nodes between decision trees and their own nodes have different feature subsets. At the same time, the independence and diversity of decision trees can improve the randomness of node splitting of random forest regression algorithm. A reasonable and effective sampling can generate a decision tree, which contains a training set that can relatively reflect the business logic. You can also stop the growth of trees in advance by pruning or postprune the generated tree according to certain rules. Because of the overfitting of the training set, the validation set data can be corrected and the above operations can be repeated. From the bottom-up processing nodes, delete those nodes that can maximize the accuracy of the verification set until further pruning is harmful.

A plurality of training samples are randomly selected from the original samples, and the number of training samples is the same as that of the original samples. Then the regression decision tree T is constructed for each training sample, and the average value of each decision tree is taken as the final result. If the original sample is expressed as S and the number of samples is expressed as N, the probability ε of not being extracted in each sample is shown as follows:

$$\varepsilon = \left(1 - \frac{1}{N}\right)^N. \tag{3}$$

When $N \longrightarrow \infty$, we have

$$\varepsilon = \left(1 - \frac{1}{N}\right)^N \approx \frac{1}{e} \approx 0.368. \tag{4}$$

According to (4), 36.8% of the samples taken each time will not be taken, that is, out-of-bag data (OOB).

According to the generalization error of the model, the prediction ability of the model to the data outside the training set can be judged. The randomly selected training vector set is (X, Y) and the training sets are independent of each other. The $h(X)$ mean-square error output is shown as follows:

$$\mathrm{PE}^* = E_{X,Y}(Y - h(X))^2. \tag{5}$$

When the number of regression decision trees reaches enough, (7) can be obtained according to (6) and $t \longrightarrow \infty$ condition:

$$h_t(X) = h(X, \theta_t), \tag{6}$$

$$E_{X,Y}\left(Y - \overline{h}(X, \theta_t)\right)^2 \longrightarrow E_{X,Y}(Y - E_\theta h(X, \theta))^2 = \mathrm{PE}_b^*, \tag{7}$$

where E_θ represents the mathematical expectation and θ_t represents the random variable of the t decision tree.

The average generalization error of each regression decision tree $h(X, \theta)$ is shown in the following:

$$\mathrm{PE}_c^* = E_\theta E_{X,Y}(Y - h(X, \theta))^2. \tag{8}$$

If the regression decision subtree is unbiased for all random variables θ, that is, as shown in the following:

$$\mathrm{EY} = E_X h(X, \theta). \tag{9}$$

Then, (10) can be obtained:

$$\mathrm{PE}_c^* \leq \overline{\rho}\mathrm{PE}_b^*, \tag{10}$$

where $\overline{\rho}$ represents the correlation coefficient of the residual.

The data partition purity of random forest regression tree is measured by square error, and the data set D is divided into m subset, namely $D_1, D_2, \ldots, D_m$. The optimal output value is shown as follows:

$$\widehat{c}_m = \mathrm{ave}(y_i | x_i \in D_m), \tag{11}$$

where ave represents the average value of output variables corresponding to all input variables in the subset.

When dividing v different continuous values in attribute B, after sorting the values in a certain order, select the focus of two adjacent values as the location of the possible splitting point of the attribute. Therefore, $v - 1$ methods can be obtained to divide the data set D into two different subsets, as shown in the following:

$$D_1(B, s) = \left\{x | x^{(B)} \leq s\right\}, \tag{12}$$

$$D_2(B, s) = \left\{x | x^{(B)} > s\right\}. \tag{13}$$

As shown in (14) and (15), it is the square error of the subset after division:

$$\mathrm{SE}_1 = \sum_{x_i \in D_1(B,s)} (y_i - c_1)^2, \tag{14}$$

$$SE_2 = \sum_{x_i \in D_2(B,s)} (y_i - c_2)^2. \tag{15}$$

The optimal splitting attribute B and splitting point satisfy

$$\min_{B,s}\left(\min_{c_1}(\mathrm{SE}_1) + \min_{c_2}(\mathrm{SE}_2)\right). \tag{16}$$

The output value of the divided subset is shown in the following:

$$\widehat{c}_1 = \mathrm{ave}(y_i | x_i \in D_1(B, s)), \tag{17}$$

$$\widehat{c}_2 = \mathrm{ave}(y_i | x_i \in D_2(B, s)). \tag{18}$$

4. Experimental Results of Technical Analysis and Diagnosis of Throwing Athletes Based on the Video Feedback System

4.1. Model Parameter Optimization of the Video Feedback System Based on Random Forest Regression Algorithm. Random forest is a compositional supervised learning method. In the random forest, we generate multiple prediction models at the same time, and summarize the results of the model to improve the accuracy of the prediction model. Random forest algorithm (prediction and regression) mainly includes the following three aspects. (1) Randomly take n sample units from the original data and generate a decision or regression tree. (2) Randomly select $m < m$ variables at each node and take them as candidate variables for dividing nodes. The number of variables at each node should be consistent. (3) Finally, integrate the results of each decision or regression tree to generate predictive values. The advantages of random forests include: (1) When the data set is not verified, the out-of-pocket prediction error can be calculated (the category corresponding to the sample points not used in the spanning tree can be estimated by the generated tree, and the out-of-pocket prediction can be obtained by comparing it with the real category). (2)

Random forest can calculate the importance of variables. (3) Calculate the distance between different data points for unsupervised classification.

The video feedback system model based on random forest regression algorithm has two main parameters: the number of regression decision subtrees and the number of randomly selected feature splits. In this paper, the estimation of out-of-pocket data is used to estimate a single regression decision subtree, and its mean value is the generalization error of the model. Asshown in Figure 3, when the number of feature selections for randomly selected feature segmentation is 2 and 11, respectively, the data error and training time will change accordingly. It can be seen from the data in the figure that the variation trend of out-of-bag data error is different with the increase of the number of regression decision-makers. When the number of regression decision-makers is less than 20, the out-of-bag data error shows a sharp downward trend; when the number of regression decision-makers is greater than 20 and less than 60, the variation trend of out-of-bag data error is slow decline; and when the number of regression decision-makers is greater than 60, the out-of-bag data error is close to the convergence state. In addition, the training time of the model increases with the increase of the number of regression decision-makers.

Considering the error, efficiency and actual demand, the optimal value of the number of regression decision-makers is 60. Under this condition, the variation of out-of-bag data error and model running time with the number of feature selection is shown in Figure 4. It can be seen from the results in the figure that when the number of feature selection increases, the training time of the model is fluctuating and rising as a whole. The out-of-bag data error shows a downward trend. The decline speed is fast in the early stage, and then gradually becomes slow. When the number of feature selection increases to more than 18, the change range of out-of-bag data error is small, and the increase range of training time becomes larger. Therefore, the optimal value of feature selection is 18.

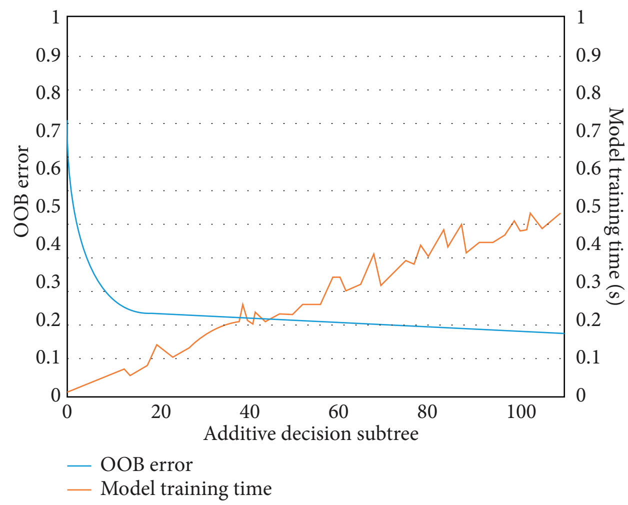

Figure 3: Changes of OOB error and model training time with the number of regression decision makers.

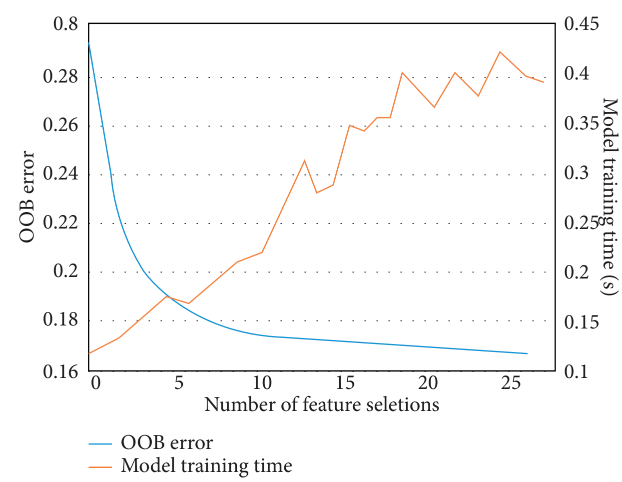

Figure 4: The variation of OOB error and model running time with the number of feature selections.

4.2. Technical Evaluation of Throwing Athletes Based on the Video Feedback System. In this paper, forty students from a sports university are divided into two groups for Javelin technology analysis and diagnosis control experiment. As shown in Figure 5, the average values of the body shape and physical quality of the two groups of students before the experiment are compared. As shown in Figure 6, the corresponding t and P values are shown. It can be seen from the data in the figure that there is no significant difference in body shape and physical quality between the experimental group and the control group, which is in line with the conditions of the control experiment.

After eight times of javelin throwing technical analysis and diagnosis, the students in the experimental group mainly observe, learn, compare, and correct the javelin throwing movements through the video feedback system. The results of the two groups were compared after the second, fifth, and eighth javelin throwing technical analysis and diagnosis, as shown in Tables 1–3.

As shown in Figures 7 and 8, there are three visual comparative changes of the two groups of standard achievement and technical achievement, respectively.

As can be seen from Figures 7 and 8, the three scores of the experimental group are higher than those of the control group in terms of both standard scores and technical scores, and the gap between the two groups is gradually increasing. In terms of performance change range, the performance change range of the experimental group is greater than that of the control group. This shows that the students in the experimental group can more effectively learn the javelin technical action through the video feedback system, improve the quality of action technology, reduce the generation of wrong action, effectively correct the existing action problems, understand and master the javelin action technology, and further improve the overall javelin throwing performance. The research needs to determine the respective

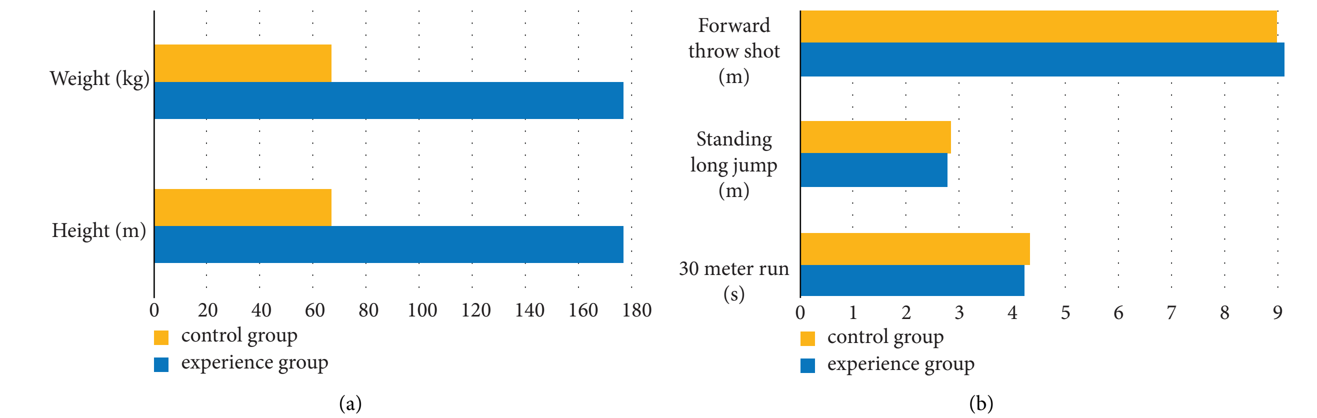

Figure 5: Before the experiment, the comparison of the average value of the body shape and physical quality of the two groups of students.

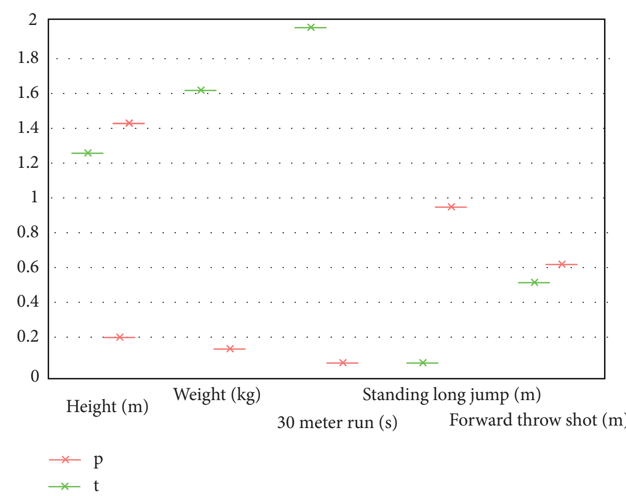

Figure 6: Before the experiment, the corresponding T and P values of the body shape and physical quality of the two groups of students.

Table 1: After the second javelin throwing technical analysis and diagnosis, the results of the experimental group and the control group were compared.

	Experience group	Control group	t	P
Achievement of standard throwing javelin in place (m) $\overline{x} \pm s$	19.94 ± 2.583	19.12 ± 1.791	1.628	0.109
Technical achievements of side throwing javelin in situ (points) $x \pm s$	68.55 ± 5.327	68.36 ± 6.059	0.409	0.678

Table 2: After the fifth javelin throwing technical analysis and diagnosis, the results of the experimental group and the control group were compared.

	Experience group	Control group	t	P
Achievement of javelin throwing in short run-up (m) $\overline{x} \pm s$	32.45 ± 3.755	77.23 ± 5.118	3.832	0.015
Technical results of javelin throwing in short run-up (points) $x \pm s$	29.32 ± 2.660	72.19 ± 3.203	3.514	0.020

Table 3: After the eighth javelin throwing technical analysis and diagnosis, the results of the experimental group and the control group were compared.

	Experience group	Control group	t	P
Complete shooting achievement (m) $\overline{x} \pm s$	41.28 ± 4.115	84.15 ± 5.150	7.241	0.017
Complete shooting technical achievements (points) $x \pm s$	32.8 ± 3.195	78.74 ± 3.610	3.665	0.10

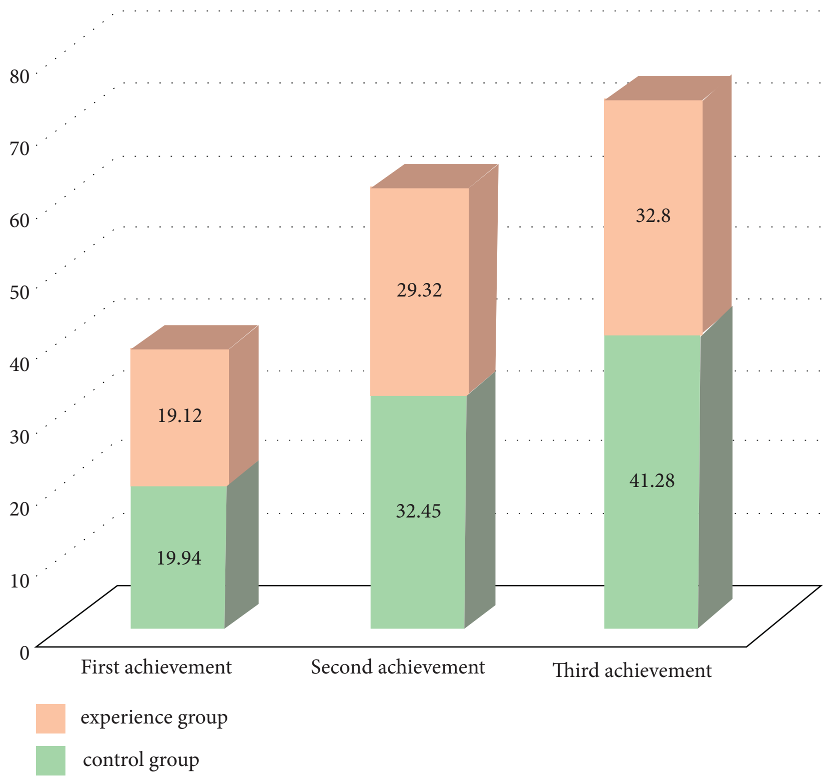

Figure 7: The results of the experimental group and the control group were compared and changed three times.

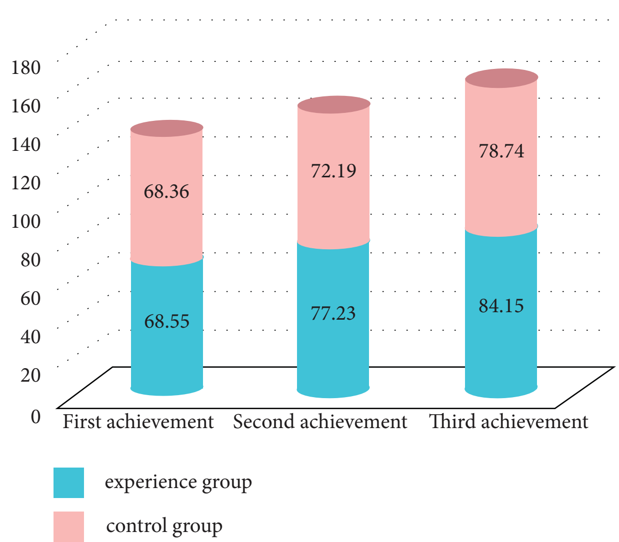

Figure 8: The technical scores of the experimental group and the control group were compared for three times.

ranges of the superparameters of the random forest model, and then we will determine the final optimal value of each superparameter in these ranges. In other words, we now delimit a large range for each superparameter that needs to be selected. Then, in the later stage, the optimization algorithm will be used to search within this range of each superparameter. After determining the respective ranges of each superparameter, then we will combine them separately. Compare the model results obtained by each combination of superparameter values, so as to determine the optimal combination of superparameters.

As shown in Figures 9 and 10, the technical analysis and comparison results and corresponding T and P values of javelin throwing in the experimental group and the control group are shown. The video feedback system mainly analyzes the angle, height, deviation angle, and the distance between the centers of gravity of the javelin. It can be seen from the results in the figure that the mean and standard deviation of the deviation angle of the experimental group are 25.08 and 4.068, respectively, and the mean and standard deviation of the deviation angle of the control group are 28.63 and 3.974, respectively, and the corresponding P value is less than 0.05, that is, there is an obvious difference between the deviation angle of the experimental group and the control group. The deviation angle can reflect the good and bad force in the longitudinal axis direction at the moment of throwing javelin, which has a great impact on the performance of javelin throwing. Therefore, compared with the control group, the deviation angle of the experimental group is smaller, which indicates that the students in the experimental group perform better in the longitudinal axis direction at the moment of throwing javelin.

The greater the distance between the body and the center of gravity of the javelin, the better the athletes can surpass the equipment. The average distance between the centers of gravity of the students in the experimental group is 71.09 cm, and the average distance between the centers of gravity of the students in the control group is 68.48 cm, with standard deviations of 1.278 and 1.654, respectively. From the P value

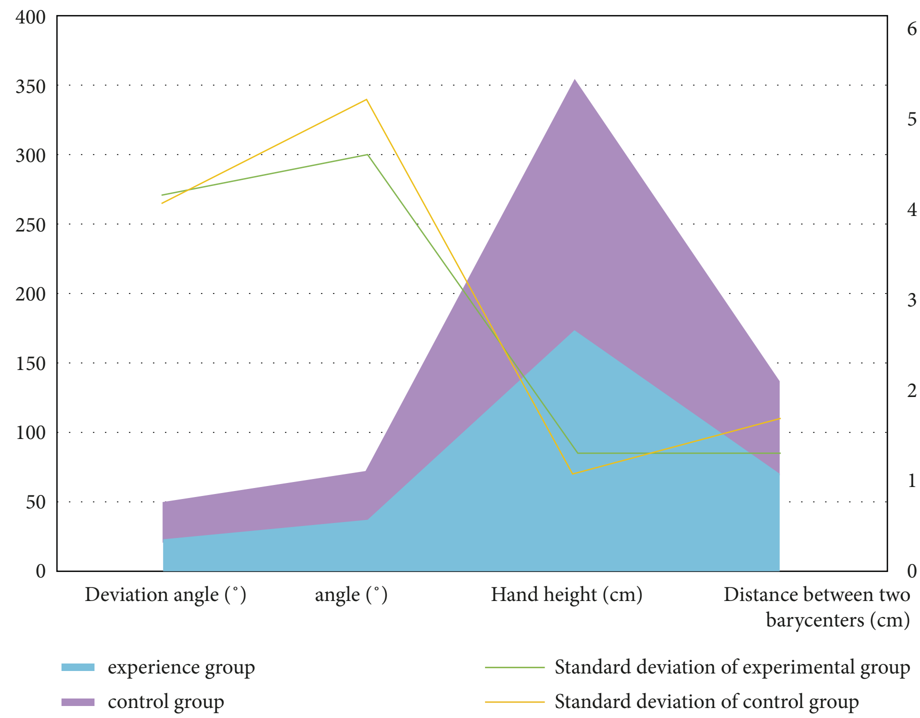

Figure 9: Analysis and comparison of javelin throwing techniques between the experimental group and the control group.

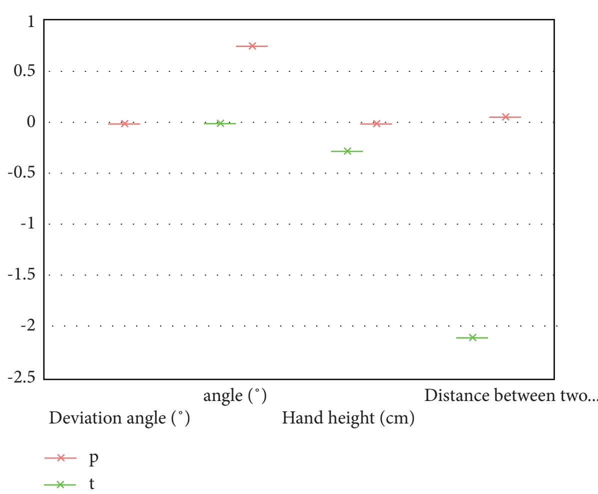

Figure 10: The corresponding T and P values of javelin throwing techniques in the experimental group and the control group.

results, there is no significant difference between the two groups, but the standard deviation of the students in the experimental group is smaller and the average value is higher, That means that the students in the experimental group surpass the equipment to complete better.

The position of these two figures has been adjusted. The test of T is a two-sided test. As long as the absolute value of T is greater than the critical value, the original hypothesis will not be rejected. P value is the probability of sample observations or more extreme results when the original hypothesis is true. If the P value is very small, it indicates that the probability of the occurrence of the original assumption is very small. If it occurs, according to the principle of small probability, we have reason to reject the original assumption. The smaller the P value is, the more sufficient the reason we reject the original assumption is. The release height and angle of javelin throwing are important factors that directly affect the final result of javelin throwing. Under the same conditions, the higher the release height and the closer the angle is to the best angle 32°, the better the final result. The hand heights of the experimental group and the control group were 174.48 cm and 173.65 cm, respectively, and the P value was less than 0.05, indicating that there were significant differences in hand heights between the two groups. The P value of the release angle of the two groups is greater than 0.05, that is, there is no significant difference in the release angle of javelin throwing between the two groups, but from the perspective of standard deviation, the standard deviation of the angle of the experimental group is smaller, the degree of dispersion is lower, and the gap between the students' release angle and the best angle is smaller.

5. Conclusion

Throwing sports have high requirements for athletes' movements and skills, while the traditional way of learning and training is mainly based on coaches' demonstration and explanation, and then athletes continue to carry out mechanized training. However, this training method is easy to cause athletes' throwing skills, action errors, lack of understanding of action skills, and so on. Video feedback system is the combination of modern equipment and feedback teaching theory, which can help athletes find the problems in the training process in time and correct them in time. Therefore, this paper proposes the application of video feedback system to the technical analysis and diagnosis of throwing athletes. Based on the formation principle of throwing athletes' action technology and the application principle of video feedback system, the random forest regression algorithm is used to construct the video feedback system. The experimental results show that the video feedback system can effectively help students improve their javelin throwing performance, and its performance growth rate is much higher than the traditional learning and training methods. At the same time, from the technical analysis results of javelin throwing movement, it is concluded that the javelin throwing movement formed by students' learning and correction through the video feedback system is more conducive to obtain higher throwing results, the javelin release angle is closer to the standard angle, and the release height, deviation angle, and center distance are more conducive to students' better throwing results. It further shows that the video feedback system can deepen the athletes' cognition of throwing skills, reduce the probability of wrong movements, and effectively correct the problematic movements. The video feedback system in this paper needs to be further improved. It is not discussed that students' forehand shots are prone to irregular movements, so as to analyze the throwing technology of athletes from more angles. With the development of modern equipment and technology, video feedback system can be gradually developed from single-line feedback system to multiangle feedback system in the future. Therefore, further research is needed.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

Acknowledgments

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Research Article

Application of Factor Analysis in Image Modeling Design of Environmental Protection Gold Stove

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In order to design an environmentally friendly gold furnace that considers both traditional cultural elements and modern decorative elements, this paper puts forward the application of factor analysis in the image modeling design of an environmentally friendly gold furnace. Firstly, the elements of lines, colors, and patterns were extracted by factor analysis. By using the hierarchical structure model and factor analysis, the synchronous parameter fusion model of image modeling design factors of the environmental protection gold furnace is constructed to fuse the output reliability parameters of image modeling of the environmental protection gold furnace and adjust them adaptively. The factor analysis and process control of image modeling of environmental protection golden stoves are carried out using the method of differential feature analysis. Then, the Atlas and image Kanban are analyzed, and the image design factors of the environmental protection golden stove are excavated. Finally, the concepts of cultural space and cultural time are introduced. Based on the study of historical and material materials, the overall comparative analysis is carried out from three aspects: shape, color, and pattern. Combined with the extracted target image and the excavated design factors, the image modeling design of the environmental protection gold furnace is effectively carried out, providing design methods and sample references for the innovative design of the environmental protection gold furnace. The experimental results show that the mining design factors can effectively analyze the problems existing in the modeling design of the current environmental protection gold furnace, with a low bit error rate and strong practicability.

1. Introduction

The images brought to people by products are complex and diverse, and the degree of people's demand for different images also varies. Simulating animal behavior through the algorithm mathematical model of distributed parallel information processing has certain advantages for the mapping processing of patterned knowledge and has the characteristics of fuzzy association. At the same time, it can learn new knowledge to continuously improve its knowledge structure [1, 2]. Due to its unique nonlinear information processing technology, it effectively improves the processing ability of intuitive information. It is often used to establish the complex relationship between input and output variables and has been successfully applied to the image modeling design of the environmental protection golden furnace and other fields [3, 4]. In order to obtain the optimal modeling combination, it is necessary to sort the modeling images. The key step is establishing the image weight, which is of great significance in realizing the multi-image design of product modeling.

Reference [5] proposed a forward fading surface modeling idea and method based on CATIA software as a three-dimensional platform and NURBS surface construction theory. Firstly, the drawing is analyzed to determine the modeling characteristics and attributes of the hood fading surface. Secondly, the characteristic line surface method and control point surface adjustment method are used to complete the modeling design of the tapered surface of the engine cover, and the design process and points for attention are described. Finally, through surface assembly and other surface quality evaluation methods, the designed surface is well connected with other parts of the front wall of the school bus and meets the requirements of surface smoothness, which can provide an effective theoretical basis for subsequent engineering design. Reference [6] proposed applying the genetic algorithm to industrial product modeling design in a virtual reality environment. Through the hierarchical product modeling structure, the product modeling gene code is designed, and the fitness function is used to evaluate the individual fitness to determine the individual fitness of the code. The evolution of the product modeling design scheme is supported by the genetic operator. After meeting the conditions of manual participation, the design scheme is evaluated manually in the virtual reality environment until the scheme satisfactory to users is produced. Reference [7] proposed an intelligent modeling design method based on the product image database using image processing technology based on deep learning to inspire designers to develop new products and optimize the product design process. Firstly, the crawler technology is used to capture the product image from the shopping website, and the image processing algorithm is used to remove the repeated and chaotic image. Then, analyze the objective features contained in the image, classify and label the image using multilabel learning technology, and form a multilevel flexible classification product image database with labels that can be updated in real time. The database can help designers use labels for retrieval. A new image similar to the original image but different is generated using the generative confrontation network technology for style transfer learning. Finally, experienced designers participate in the design and get a new scheme sketch. Reference [8] takes the design project of the Chinese Zodiac rat tea set as an example and puts forward a design method of cultural and creative products based on Chinese Zodiac culture. Firstly, it demonstrates the typicality and particularity of the Chinese Zodiac mouse in the Chinese Zodiac culture and concludes that the design method of cultural and creative products of the Chinese Zodiac mouse has strong applicability. Under the symbolic trivalent model proposed by Pierce, through investigation and collection of the cultural content of the zodiac mouse, we can screen out the cultural meaning with high recognition and positive content. Combined with the biological form of “mouse” and the functional appeal of the tea set, choose a reasonable product image to convey the meaning of zodiac culture.

The above research has conducted beneficial discussions on product modeling design from different aspects [9], which provides a theoretical basis for the image modeling design of the environmental protection golden stove. Therefore, this study establishes the relationship system between the two cultures based on cultural space and cultural time and constructs the image modeling design method of environmental protection Golden stove using perceptual engineering and factor analysis methods.

2. Application of Factor Analysis in Image Modeling Design of Environmental Protection Gold Stove

2.1. Image of Environmental Protection Golden Furnace. The lion dragon is a mythical lion that Buddha considered very patient and took as a mount. Therefore, the censer is often decorated with a lion dragon. Censers shaped and decorated with lion dragons were so popular that the “lion dragon” was often used later as a synonym for censers. The lion dragon has a rough shape, and its cheeks are plump with the gorgeous pattern depiction of the lion’s body and the ups and downs of the skeleton shape [10]. With dynamic facial features and skeleton components, it forms a folk art that combines the beauty of spirit, shape, and state.

The lion dragon has a rough appearance, a high and sloping forehead, bright eyes, a wide mouth, a garlic nose, and full and plump cheeks with a gorgeous depiction of the lion’s body and the undulating skeleton shape. With controllable dynamic facial features and skeleton components such as round lips, open teeth, vibrating tongue, and sharp ears, it forms folk art integrating the beauty of spirit, shape, and state.

2.2. Factor Analysis. Factor analysis is mainly an exploratory technique used to analyze data and have a general understanding of them before analysts conduct multivariate data analysis. It is a very necessary process. In multiple regression, factor analysis can help determine whether there is collinearity or conditional index and can also be used to deal with collinearity. The advantage of factor analysis is that a few factors are used to describe the relationship between many indicators or factors. In other words, several closely related variables are grouped into the same category, and each category of variables becomes a factor, reflecting most of the information of the original data with fewer factors. Using this research technology, we can easily find out the main factors affecting the image modeling of the environmental protection golden furnace and their influence. In this study, the modeling, color, and pattern factors are mainly analyzed.

2.2.1. Modeling Factor Analysis. This paper collects numerous physical objects and picture data for sorting and analysis, summarizes the characteristics of its typical samples with the method of chart analysis, and introduces the symbols that can express the cultural connotation into the design of environmental protection gold stove [11, 12] to enhance the interactive experience of consumers on Folk culture so that consumers can arouse the thinking association of a regional culture from the visual experience of the first sense to the actual use process.

The extraction process of modeling elements is as follows.

Use Photoshop to truly and completely draw the original detail modeling of the environmental protection gold furnace:

(1) In the realistic method, through the first line extraction, select the front and side view of the environmental protection gold furnace.

(2) In the simplified method, many patterns are involved in the environmental protection gold furnace, and the contents of the decorative parts of different patterns are extremely complex. When used in the

element design of the environmental protection gold furnace, copying all the original patterns in the modeling design of the environmental protection gold furnace is unnecessary. Therefore, we should mainly grasp the key characteristics of patterns. Through the second line extraction, the outline of the environmental protection gold furnace is simplified and abstracted, and the complex decorative lines are subtracted to remove the redundant decorative details.

(3) The reconstruction method takes the abstract and simplified face contour as the basic element, further geometrically simplifies the elements, and then rotates, repeats, and stretches the geometric pattern elements of the shadow play.

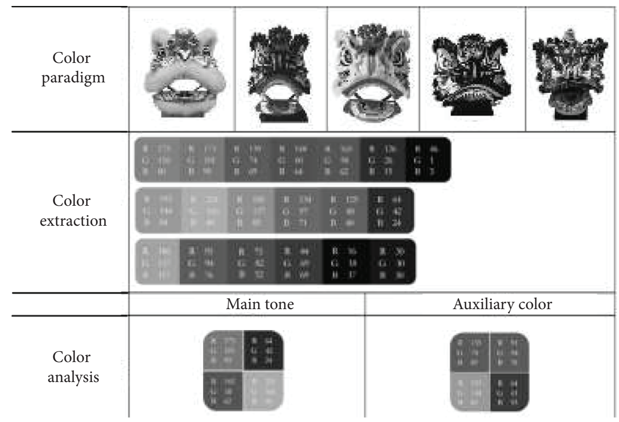

Figure 1: Color factor analysis.

2.2.2. Color Factor Analysis. China's color culture integrates the color views of Confucianism, Taoism, Buddhism, and vulgarity and embodies the philosophical thought of "the unity of heaven and man." This view of color is based on metaphysics, which is intuitive, psychological, subjective, and empirical. The color of the lion dragon golden stove does not aim to imitate and reproduce real things. It does not depend on objective images but surpasses the real lion. The environmental protection golden stove draws the color of the character's face from the traditional opera. The character of different characters is reflected in the color proportion and decorative color of red, black, and white. Among them, most of Liu Bei's lions are yellow-faced golden lions, with white fluffy and colored lion bodies. The overall color matching is light and lively. Guan Gongshi is decorated with black toothbrush whiskers on the base of red, which represents loyalty and righteousness in Facebook, reflecting a certain aggressiveness. The contrast of red and black colors produces a striking visual impact, increases the lion's head weight as a martial lion, and gives people a sense of awe without anger. The color of Zhang Feishi is mainly black and white, with white lines on a black background or green edges in a gray pattern. It shows a sense of integrity, bravery, and even recklessness and vividly reflects the rugged and powerful physique of the environmental protection gold stove and the mighty and handsome spirit (Figure 1) [13].

2.2.3. Pattern Factor Analysis. Ornamentation is a spiritual entity to express people's deep-seated ideas or abstractions [14]. Folk people have always described the lion dragon pattern as "tiger eyes and cheeks on both sides, forehead and top reaching the sky." The lion dragon's forehead is decorated with a cloud head Ruyi pattern, also known as "pig nose soul." With the spread of Buddhism and the integration of local and foreign cultures, Ruyi has gradually become a decorative object and pattern shape containing the aesthetic spirit of the Chinese nation and auspicious implication [15]. The Ruyi pattern on the forehead of the lion dragon also expresses people's expectations for auspiciousness and peace. The most frequent pattern in the lion dragon is the Tang grass pattern around the lion's mouth. Different from the traditional flower and grass patterns that collect a variety of flowers and plants, Tang grass patterns form regular and upward growing grass leaves after certain deformation and artistic processing to imitate the beard of the lion, which not only enriches the formal beauty of the lion dragon but also includes the Creator's worship of nature, with special cultural connotation. Other patterns, such as the grass tail pattern from the cheeks on both sides to the curling up at present, the tiger stripe on the back of the lion dragon's head, the bamboo basket pattern marking the name of the making master, the dot pattern in groups corresponding to the grass tail pattern, and the small spot pattern on the lion dragon's ear, decorate the lion's head, forming a gorgeous, vivid, auspicious, and powerful charm (Figure 2) [16].

In addition, the mirror in the center of the lion's forehead is called "Tianting." There are plush tassel balls around the mirror for decoration, and the modeling combination of tassel balls and Tianting is also absorbed from the headdress of the Cantonese opera character "crown prince helmet." From the simplification of the northern lion to the magnificence of the southern lion, we can see that, under the influence of history, culture, and environment, the prosperity of opera culture and bamboo binding technology have promoted the integration of Guangdong regional culture and the image of classic lion dance, forming a unique environmental protection golden furnace.

3. Image Modeling Design of Environmental Protection Golden Furnace with Cross-Cultural Integration

3.1. Cultural Space and Cultural Time. The (finite or infinite) place where objects exist and move, and cultural space is an abstract concept. Cultural time is a concept corresponding to the sequence of things in people's view. Time has no corresponding entity, and it is just a concept designated to facilitate people to logically establish their understanding of things. However, this concept can correspond to the difference between the sequence of two things, so it has practical significance. Culture is all human spiritual activities and their products in terms of economy and politics, a very broad and humanistic concept. In short, culture is the

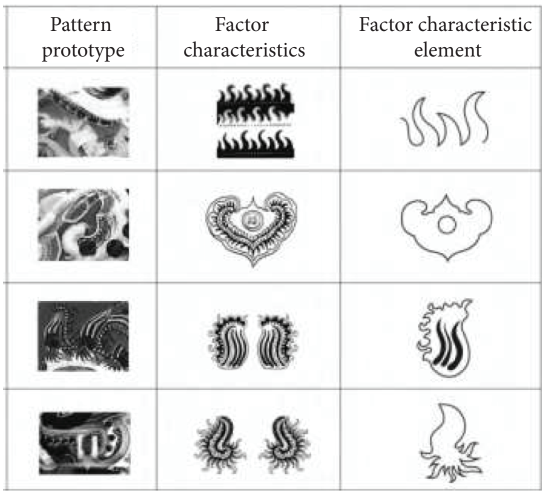

Figure 2: Pattern factor analysis.

general term for the forms of human life factors in the region: clothing, crown, culture, things, food, housing, and transportation, among others.

All matter in the universe is in the process of alternating time and space, and culture is no exception. The emergence of cultural space is obtained through cultural practice. The existing creation can be divided into three forms: 1) to recreate some cultural spaces that have become "ruins"; 2) to create new space according to the theme of a certain culture; and 3) to transform one kind of cultural space into another.

The ideological framework of cultural space and cultural time is shown in Figure 3. It represents cultural space vertically and cultural time horizontally.

In space, the environmental protection gold furnace is affected by three elements: human, function, and environment. In terms of time, what affects the environmental protection gold furnace is the life cycle and the evolution history of its similar environmental protection gold furnace. Herein, culture is regarded as a composite whole, and its space refers to the place where traditional cultural activities are held regularly or the expression forms of traditional culture are displayed intensively. The human, function, and environment elements will change over time. Therefore, the cultural space will evolve until it evolves into another similar cultural space, resulting in multiculturalism. The establishment of the concepts of cultural space and cultural time can recognize the emergence, development, and change of culture as a whole.

The relationship between culture and design is closely linked [17]. Starting from cultural space and cultural time, let the form design of the environmental protection gold furnace achieve reasonable integration, and improve the cultural recognition and identity of the environmental protection gold furnace form. In order to blend phenomenon of different cultures in space and time. This study extracts the image from one culture according to the actual needs, determines the target image, and then excavates the modeling design factors for the target image from another culture to realize the image modeling design of environmental protection golden stove with cross-cultural integration.

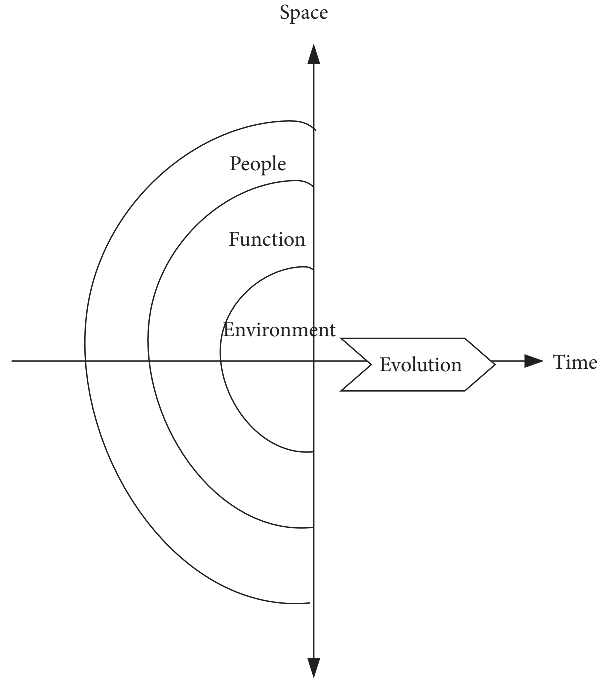

Figure 3: Ideological framework of cultural space and cultural time.

3.2. Design Factor. Factor design is a kind of experimental design. In order to investigate the main effect and interesting interaction effect of the image modeling factors of the environmental protection gold furnace, all or part of the factors are processed to perform the experiment so that the effects to be investigated are not mixed. It is composed of combinations of different factors at different levels. The factor design is used to calculate two or more factors at the same time, and AHP is used to mine the design factors of the environmental protection gold furnace. Firstly, the hierarchical structure model is established to analyze and group the factors contained in the target problem and clarify the hierarchical relationship. Secondly, list the analysis Atlas and classify the samples with similar attributes. Finally, according to the constructed image Kanban, users can judge the elements in the hierarchy and determine their relative importance to obtain the relatively important modeling design factors in the image modeling of the environmental protection golden furnace.

3.2.1. Cultural Hierarchy Model. The gene concept was first proposed in biology and then applied to design to extract the internal and external characteristics of design objects. Among them, culture-related design genes are called culture factors. According to the above research, the most influential factors in image modeling of the environmental protection golden furnace are color and pattern [18, 19], which are carried out by the analytic hierarchy process. The hierarchical analysis structure of image modeling of the environmental protection gold furnace is shown in Figure 4.

According to the hierarchical analysis structure in Figure 4, the image modeling factor analysis of the environmental protection golden furnace is realized. There are M

environmental protection golden furnace image modeling nodes $A_1, A_2, \ldots, A_n$, and the information degree of each environmental protection golden furnace image modeling node is expressed as f, respectively. At the same time, the final position of N environmental protection golden furnace image modeling factors is $B_1, B_2, \ldots, B_N$. The fuzziness detection method fuses the output reliability parameters of environmental protection golden furnace image modeling information [20]. The j component is as follows:

$$[F(x)]_j = \frac{F(x)}{x_j}\sqrt{2\sum_{i=1}^{N} v_i(x)\frac{v_i(x)}{x_j}}. \tag{1}$$

In the previous formula, $v_i(x)$ is the change trend of image modeling of the environmental protection gold furnace, $F(x)$ is the fuzzy scheduling function of image modeling of the environmental protection gold furnace, and $v_i(x)$ is the difference function. By using the factor analysis method, the difference function of image modeling factor analysis of the environmental protection gold furnace is expressed as follows:

$$F(x) = J^T(x) \div 2v(x). \tag{2}$$

In the previous formula, $J^T(x)$ is the value function of factor analysis and $v(x)$ is the equilibrium parameter. In the interval of a real number field, when $d = 4, s_c = 3/2$, the automatic adjustment of design factors is carried out through fuzzy adaptive adjustment [21], and the statistical characteristic distribution matrix $J(x)$ of image modeling design factors of environmental protection golden furnace is output as follows:

$$J(x) = \begin{pmatrix} v_1(x)x_1 & v_1(x)x_2 & \cdots & v_1(x)x_n \\ v_2(x)x_1 & v_2(x)x_2 & \cdots & v_2(x)x_n \\ \vdots & \vdots & \ddots & \vdots \\ v_n(x)x_1 & v_n(x)x_2 & \cdots & v_n(x)x_n \end{pmatrix}. \tag{3}$$

In the previous formula, $v_n(x)$ is the scheduling component of the image modeling design factor of the environmental protection gold furnace and x_n is the joint characteristic solution. The differential feature analysis method is used to analyze the image modeling factor of environmental protection golden furnace, define the regularity index $s_c = d - 1/2$ of image modeling of environmental protection golden furnace, consider the load information of image modeling of environmental protection golden furnace, establish the comprehensive architecture model of image modeling of environmental protection golden furnace, and obtain the space planning function expression of factor analysis as follows:

$$Q = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}, \tag{4}$$

$$\text{Subject to}\left\{ \sum_{j=1}^{m} X_{ij} = a_i, \quad i = 1,2,3\ldots n, \sum_{i=1}^{m} X_{ij} = b_i, j = 1,2,3\ldots m, X_{ij} \geq 0, \quad i = 1,2,3\ldots n, \quad j = 1,2,3\ldots m. \right. \tag{5}$$

In previous formulas, C_{ij} is the joint cross-correlation quantity, X_{ij} is the detection coefficient of environmental protection golden furnace image modeling, a_i is the scheduling coefficient, and b_i is the output load. Therefore, the load balancing parameters of image modeling of the environmental protection gold furnace are obtained, and the differential feature analysis method is used to conduct image modeling factor analysis and process control of the environmental protection gold furnace, which lays the foundation for subsequent Atlas analysis.

3.2.2. Construction of Analytical Atlas. In order to analyze the image modeling of the environmental protection golden furnace and better understand things through images, Atlas refers to systematic classification editing. The charts used to explain things are drawn or photographed according to the image modeling of the environmental protection golden furnace. The analysis Atlas is constructed to interpret the color and pattern factors of the image modeling of the environmental protection golden furnace. Color is a unique symbol of a culture [22, 23]. The main colors of the lion dragon golden stove are green, white, black, gold, and blue. Among them, gold, green, and blue are mainly the colors produced by the impact of the environment. Gold represents the desert and is the symbol of the living environment. Green represents life. Blue is the color of the sky, representing freedom. White and black represent purity and solemnity. The pattern appeared as a decorative element in the early stage, but it became one of the main visual elements in the later stage. The plant patterns are decorative elements based on people's yearning for nature. It is the abstraction and deformation of plants. Geometric patterns are produced to fill the gap in decoration. The structure of the analysis spectrum is shown in Figure 5.

Figure 5 shows that the main structure in the analysis Atlas is the analysis total node, divided into multiple target nodes, providing a reference for understanding the development history of environmental protection gold furnaces and mining design factors of pattern characteristics.

3.2.3. Excavation Design Factors. By selecting 10 experts with rich knowledge of the development history and pattern characteristics of the environmental protection gold furnace,

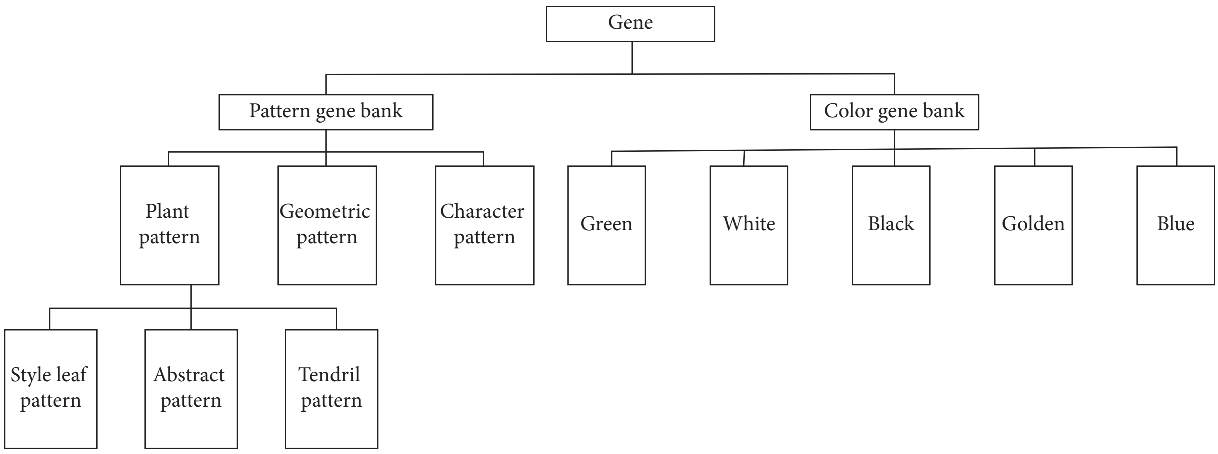

Figure 4: Analytic hierarchy process structure.

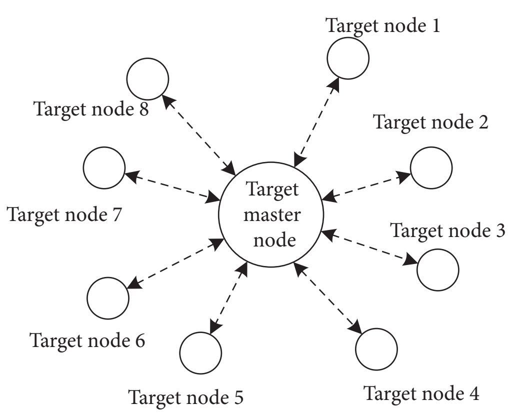

Figure 5: Structural diagram of the analytical spectrum.

we solicited design factors. The theoretical basis is that, in order to reduce the uncertainty of factor selection when designing the image modeling of the environmental protection gold furnace, it is necessary to use AHP to decompose the fuzzy design factors into specific and detailed environmental protection gold furnace design factors and obtain the relative importance scores of each factor through a qualitative assignment. Firstly, 10 experts were asked to send the summary of design factors provided by the experts to the experts' mailbox through open-ended answers. The experts retained and deleted the selected design factors and described in detail the specific reasons for retaining or deleting the design factors. After sorting out the design factors retained by the experts, the design factors of the image modeling design of the environmental protection golden stove were obtained and evaluated, as shown in Table 1.

Table 1: Design factors of environmental protection gold furnace.

Variable	Content	Score
$X1$	Green	10
$X2$	White	10
$X3$	Black	10
$X4$	Golden	10
$X5$	Blue	10
$X6$	Style leaf pattern	10
$X7$	Abstract pattern	10
$X8$	Tendril pattern	10
$X9$	Geometric pattern	10
$X10$	Character pattern	10

3.2.4. Factor Analysis. SPSS 22.0 statistical software is used to conduct factor analysis on the design factors of image modeling of the environmental protection golden furnace [24, 25]. Bartlett and KMO's sphericity are used to test the factors. The test result is that the KMO value is 0.58 greater than 0.5, the Bartlett sphericity test value is 358.541 (degree of freedom is 195), and the significant difference result is $p < 0.01$. The above results show a good linear relationship between the factors. The above design factors can be used to carry out factor analysis, proving that the ranking results of the factor analysis method have satisfactory consistency. Among them, the analysis factor is the most important factor. When designing the image modeling of the environmental protection golden furnace, we should pay special attention to the product form.

3.2.5. Association Rule Analysis. Association rules are a common method of data mining [26]. Through association rules, we can effectively mine the dependence and association between one thing and other things.

Input the factors obtained from the factor analysis into the software SAS 9.3 for correlation analysis, set the support threshold in the software to 10% and the support to 90%, and finally obtain five strong correlation design factors affecting the image modeling design of environmental protection golden furnace. Find out all frequency sets, and the frequency of these itemsets is at least the same as the predefined minimum support. Then, the strong association rules are generated from the frequency set, and these rules must meet the minimum support and minimum reliability. After that, use the found frequency set to generate the desired rules, and generate all rules that only contain the items of the set, of which there is only one item on the right of each rule.

Herein, the definition of the middle rule is used. Once these rules are generated, only the rules that are greater than the minimum reliability given by the user will be left, thereby completing the application of factor analysis in the image modeling design of the environmental protection golden furnace.

4. Result Analysis

In order to verify the effect and feasibility of the application method of factor analysis in the image modeling design of environmental protection gold stove, the experiment was designed, which was verified by the results of factor analysis, association rule analysis, and image modeling design of environmental protection gold stove. The experimental design was based on four principles, namely, the principle of comparison, the principle of consistency of experimental conditions, the principle of randomization, and the principle of repeatability.

4.1. Factor Analysis Results. To determine the multiobjective image is to locate the various image needs of users for the product. Firstly, collect the image vocabulary and make a questionnaire, then statistically analyze the representative images, and finally determine several images as the target images. Product modeling evolutionary design needs to set decision variables, that is, the change range of product modeling parameters. Generally, appropriate change values are set according to specific problems. The final result of factor analysis is extracted by principal component analysis, as shown in Table 2.

According to the analysis results in Table 2, the eigenvalues of seven factors in the obtained correlation coefficient matrix are higher than 1. The cumulative variance contribution rate can be as high as 76.916%. The factor analysis results show that the information contained in the above 10 variables can be well explained by seven factors: $X1$, $X2$, $X3$, $X4$, $X6$, $X7$, and $X8$.

4.2. Association Rule Analysis. Set the relevant parameters of product multi-image modeling evolutionary design, including rules and confidence. According to the previous analysis, the number of individual serial numbers in the strong correlation design factor is set to 5. The seven factors obtained are analyzed by association rules. The analysis results of association rules are shown in Table 3.

The results of the association rule analysis in Table 3 show that the image modeling design of the environmental protection golden furnace can be evaluated by $X7$ and $X6$.

4.3. Image Modeling Design of Environmental Protection Golden Furnace. Based on the above analysis results, the image modeling design of the environmental protection gold furnace is carried out by integrating the design factors of image modeling of the environmental protection gold furnace with a modern cultural image. The design of the furnace is completed through the cooperation of the existing design team and the image of the furnace. The schematic diagram of the design results is shown in Figure 6.

Figure 6 shows that the shape of the gold furnace is complete after adding the design factor. In the process of image modeling design of the environmental protection gold furnace, the design requirements such as manufacturing process, cost, and product appearance are comprehensively considered. While focusing on product appearance modeling, we should also consider multiple perceptual images contained in the product appearance to meet the emotional needs of large user groups for the image modeling of the environmental protection golden furnace to the greatest extent. Therefore, the comprehensive consideration of multiple images is more in line with design thinking.

In order to further verify the effect and feasibility of the method in this paper, comparative experiments are designed. The image modeling design data of the environmental protection golden stove will have problems such as data loss, noise interference of the transmission channel, and digital synchronization, which will affect the accuracy of the image modeling design of the environmental protection golden stove. The bit error rate represents the index to measure the accuracy of the modeling design within the specified time. The smaller the bit error rate, the higher the efficiency of the modeling design and the better the performance.

The method in this paper can effectively realize the reliability control of the image modeling design of the environmental protection golden furnace. The effect of the modeling design is good, and the balance is strong. The bit error rate of the modeling design under different methods is detected. The methods in [5, 6] are compared with the methods in this paper. The comparison results are shown in Figure 7.

Figure 7 shows that comparing the methods in [5] with those in [6], the method selected in this paper has a low bit error rate in the image modeling design of the environmental protection gold furnace. The main reason is that this method designs the hierarchical analysis structure of image modeling of environmental protection gold furnace, realizes the analysis of image modeling factors of environmental protection gold furnace, obtains the load balance parameters of image modeling of the environmental protection gold furnace, and adopts the differentiation feature analysis method. The image modeling factor analysis and process control of the environmental protection golden stove help reduce the bit error rate to a certain extent. Based on this, the design thinking of image modeling of the environmental protection gold furnace based on factor analysis has a good effect.

5. Discussion

Taking the Suanni design as an example, it can be realized from the following aspects.

5.1. Proper Deletion of Modern Decorative Elements. The image design from the traditional lynx to the

Table 2: Eigenvalues and contribution rate of correlation coefficient matrix.

Common factor	Characteristic value	Factor contribution rate (%)	Cumulative variance contribution rate (%)
$X1$	3.521	8.185	8.185
$X2$	4.185	8.679	16.864
$X3$	3.054	8.032	24.896
$X4$	5.945	9.517	34.413
$X5$	0.654	6.352	40.765
$X6$	2.845	7.854	48.619
$X7$	1.625	7.564	56.183
$X8$	1.425	7.165	63.348
$X9$	0.894	6.584	69.932
$X10$	0.987	6.984	76.916

Table 3: Strong correlation design factor analysis results.

Serial number	Rule	Confidence
1	$X1, X3 \longrightarrow X7$	0.985
2	$X2, X4 \longrightarrow X6$	0.953
3	$X3, X4 \longrightarrow X6$	0.934
4	$X2, X6 \longrightarrow X7$	0.921
5	$X7, X8 \longrightarrow X6$	0.911

Figure 6: Finished product drawing of gold furnace modeling design.

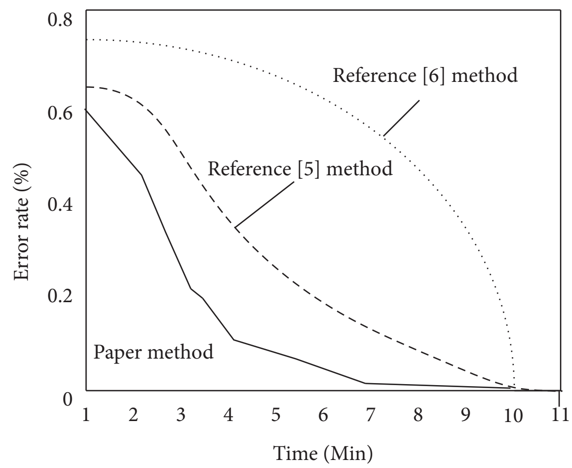

Figure 7: Comparison results of the bit error rate.

environmental protection golden stove retains the traditional element characteristics of the lynx, but at the same time, it also adds some parts and finally integrates into an image design with modern trend characteristics and rich details of traditional creation methods. Among them, the most obvious ones are chains and bells that hang from the eyebrows and extend to the beard. The addition of these decorative elements adds a metallic feel to the image of the environmentally friendly gold stove. The curves and movements of the two chains on the lion's head are not purely symmetrical, and the angle of the bell and the tassel also changes slightly, as if swinging to one side. Lotus addition is balanced up and down by the spread of the beard underneath, making the pattern clumpy. The tongue stud, eyebrow stud, and other accessories are hip-hop elements to make the lion more playful. There are many replacement decorative elements in the image modeling of the environmental protection gold furnace, such as replacing the traditional Suanni sole horn with a duck hat, which is full of modern breath. The "sky eye" is used to replace the mirror between the eyebrows, ingeniously filling the spare space in the round mirror. The English letters on the forehead replace the original traditional pattern to establish a perspective relationship in the plane, making the shape of the forehead more full. People identify that pompoms, tongue, and cheeks are identical decors and drooping whiskers. On the basis of not affecting the recognition of the traditional lynx, it also made a slight deletion, which made the image modeling design of the environmental protection golden stove not always add innovation, but also appropriately deleted the complicated details, making the visual effect lighter and more agile.

5.2. From "Heart" to "Rational" Color Design. Color has the power to take the lead. The psychology that people of different ages or sexes produce of color differs. The color design of the brand image is an important visual element to convey brand connotation, form recognition, and establish a public image. The color of HEA Suanni is mainly red, yellow, and orange. Among them, the white fluffy part has shown the most anterior and dynamic organ shape of eyes and mouth, which can express the charm, and has highlighted the lion's facial features covered by the fluffy. The black contour line is the border line that divides the large surface and distinguishes the facial features. From the color combination of facial features, accessories, and whole blocks in the image modeling of the environmental protection gold stove, through the extraction of the RGB value of color, put color coordinates into the relevant conclusion: red, yellow, and orange with the largest face area constituting a "vigorous" sense of spirit. Decorative red, yellow, and orange accessories form an "active, strong" sense of movement. The eye color of the red, black, and yellow composition is a "dynamic, enterprising" temperament. The mouth ministry that the orange, black, and red tricolor forms has an "energetic" spark. These seemingly "heart" and casual use of colors are important elements that reflect the brand's young and energetic positioning. Through rational color screening, the visual effect is harmonious and unified but does not lose its level; it vividly and intuitively conveys the brand spirit.

5.3. Creation of Lines of Spatial Dimension. The image of the environmental protection gold furnace imitates the knife marks of woodcut prints on the lines. Among them, the stop and turn of the square and square are just right. Both ends of the lines show the trend of picking on the thin and thin, and the middle is flat and powerful, with no lack of virtual and real changes, so that the image of the lion breaks away from the monotonous, rigid, and stiff alienation. Through the arrangement of different thicknesses and densities, the lines create a sense of spatial hierarchy and dimensional change of the facial features in the two-dimensional plane. The thick lines and small color blocks regularly arranged around the nose form a backward and weakened visual perception. The smooth edges erase the overly realistic sense of fuzz. The eyes and mouth should use long lines to outline and describe in order to form a large structural division and then use a dense and appropriate line arrangement to make the Suanni facial expression more prominent and present in the front as the visual center. Other accessories are relatively weak, forming a scattered space, which makes the image of the environmental protection gold furnace richer and more interesting.

6. Conclusion

Through the extraction, comparative analysis, and sorting out of the image modeling factors of the environmental protection gold furnace, the detailed characteristics of the pattern on the environmental protection gold furnace can be expressed through exaggeration and personification in the design to express the vivid and artistic spirit of the image. By integrating methods, "take the essence of traditional culture, (and) remove its elaborate secondary decoration" appropriately into the modern decorative elements, forming a combination of new and old designs. Using colors that highlight cultural characteristics and form brand memory points to design in order to form the visual guide of the image. The use of lines with virtual, real, dense, and varying lengths creates the depth of spatial levels in visual language, enriching the original two-dimensional plane design dimension. The research shows that the error rate of the design method is low, and the design thinking of image modeling of the environmental protection gold furnace based on the factor analysis method has a good effect.

The above research has achieved certain results, and the following aspects can be further explored in the next research:

(1) Data visualization is an important way of presenting data information. In the process of the visual practice of image modeling of the environmental protection golden furnace, we should consider the characteristics of data and the psychological needs of the audience and build a visual level based on the efficiency of information transmission, which can be studied in depth.

(2) The application of visual elements in the visualization of image modeling data of the environmental protection golden furnace can be combined with various theories.

(3) The data age is the leading trend of current and future social development. Under this trend, the design of image modeling of the environmental protection golden furnace should also follow the trend of the times, inject new content of the new era, and develop it forward.

Data Availability

The raw data supporting the conclusions of this article will be made available from the author, without undue reservation.

Conflicts of Interest

The author declares that they have no conflicts of interest regarding this work.

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Research Article

Study on Music Emotion Recognition Based on the Machine Learning Model Clustering Algorithm

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In recent years, the explosive growth of online music resources makes it difficult to retrieve and manage music information. To efficiently retrieve and classify music information has become a hot research topic. Thayer's two-dimensional emotion plane is selected as the basis for establishing the music emotion database. Music is divided into five categories, the concept of continuous emotion perception is introduced, and music emotion is regarded as a point on a two-dimensional emotional plane, together with the two sentiment variables to determine its location. The artificial labeling method is used to determine the position range of the five types of emotions on the emotional plane, and the regression method is used to obtain the relationship between the VA value and the music features so that the music emotion classification problem is transformed into a regression problem. A regression-based music emotion classification system is designed and implemented, which mainly includes a training part and a testing part. In the training part, three algorithms, namely, polynomial regression, support vector regression, and k-plane piecewise regression, are used to obtain the regression model. In the test part, the input music data is regressed and predicted to obtain its VA value and then classified, and the system performance is considered by classification accuracy. Results show that the combined method of support vector regression and k-plane piecewise regression improves the accuracy by 3 to 4 percentage points compared to using one algorithm alone; compared with the traditional classification method based on a support vector machine, the accuracy improves by 6 percentage points. Music emotion is classified by algorithms such as support vector machine classification, K-neighborhood classification, fuzzy neural network classification, fuzzy K-neighborhood classification, Bayesian classification, and Fisher linear discrimination, among which the support vector machine, fuzzy K-neighborhood, and the accuracy rate of music emotion classification realized by Fisher linear discriminant algorithm are more than 80%; a new algorithm "mixed classifier" is proposed, and the music emotion recognition rate based on this algorithm reaches 84.9%.

1. Introduction

Music is an artistic experience and an entertainment method that expresses people's thoughts and emotions and reflects real life by using music as the medium and carrier of expression [1]. So far, the main way people perceive music is still through hearing, but the expression of music and the transmission of emotional information is not limited to acoustic situations [2]. In modern society, people sing, dance, and experience music with the help of high-tech sound, light, electricity, etc., to achieve wonderful audio-visual effects and emotional interaction, such as music evenings and music fountains. It can be seen that from ancient times to the present, these behaviors reflect people's desire to interact synchronously through multisensing modes such as hearing, vision, and touch, perceive the pitch, loudness, duration, and timbre of musical sounds, and experience the rhythm, melody, harmony, and timbre of music [3]. Computers cannot "hear" music like humans but they can extract content features such as spectrum, rhythm, and mel-frequency cepstrum coefficients (MFCC) by performing audio processing on music. Classification and retrieval of music are known as content-based music retrieval technology. However, due to the complex and unknown mechanism of human perception of music and the generation mechanism of emotion, pure machine classification makes subjective music emotion classification more difficult because of its objectivity, and emotion classification has not achieved the same accuracy as style classification. Exactly which features can express musical emotion more accurately, how to automatically analyze the extracted features, and which classification method can obtain higher accuracy are all issues worthy of study.

At present, with the improvement of people's material living standards year-by-year, people have put forward higher requirements for spiritual life. The pursuit of material civilization and spiritual civilization is the internal driving force of social progress. The way of information dissemination is moving from the era of "multimedia" to the era of "all media" [4]. It is the multimedia that disseminates information with images but pursues the experience of "all-media" information based on "audio-visual-tactile" multisensing channels. People with normal hearing function hope to experience music synchronously and interactively through the "listening-visual-tactile" multisensing channels, which can further increase the immersion of perceiving music [5]. People with hearing disabilities cannot "hear" music but they also desire to experience the emotion of music, receive music education, and perform music. The results of modern psychological research have shown that music perception is a cognitive activity coordinated by multiple sensory systems and is not limited to hearing. With appropriate stimulation, vision and touch can also perceive music through synesthesia [6]. In 2007, the research results of Edward et al. showed that the parts of the brain used by hearing-impaired people to process tactile information are the same as those used by normal people to process auditory information, which means that hearing-impaired people can use the tactile sensation of body skin to perceive music and can experience music like a normal person. These research results have laid a physiological and psychological foundation for the related research on "tactile auxiliary or alternative auditory perception of music" [1]. At present, a simple music player dedicated to the deaf has appeared on the market, which converts the rhythm of the music into vibration and emits light through LEDs. The color and brightness of the light change with the rhythm, and you can experience music through vibration or light changes. These music players do not yet meet the needs of hearing-impaired groups.

Technology is based on two or three perceptions of hearing, vision, and touch to experience music synchronously and interactively, involving the intersection and integration of various disciplines and technologies, including musicology, aesthetics, art, cognitive psychology, psychophysics, mechanical engineering, multimedia technology, signal processing, pattern recognition, intelligent control, virtual reality, instrument science, and other related disciplines [7]. At present, the related technologies of multisensory interactive music experience based on "listening-visual-tactile" have become a research hotspot at home and abroad. Related research has been carried out [8].

Music is the language and art of emotion, and emotion is the essential feature of music. Modern psychological research shows that the nonsemantic organizational structure of music vibrating with sound waves has a direct isomorphic relationship with human emotions and will activities [9]. Emotional experience is a series of emotional reactions caused by appreciating works, and the expression and perception of emotions are increasingly important as a means of human-human interaction and human-computer interaction [10]. Scholars at home and abroad have proposed a variety of emotion modeling methods. One type of view holds that emotion is composed of discrete basic emotions, the most representative being the OCC (Ortony, Clore, Collins) emotion model established by Ortony et al. and the Hevner emotion ring model proposed by Hevner et al. Behaviors, views on things, etc., define 22 basic emotions. The Hevner model is divided into 8 categories and uses 67 adjectives to describe musical emotions [11]. The other is the emotional model based on dimensional space theory, which considers that emotions are distributed in a certain space composed of several dimensions, a specific emotion can be mapped to a specific position in a continuous space, and the similarities and differences between different emotions can be measured according to the distance from each other in the dimensional space; different emotions are not independent, but continuous, which can achieve smooth conversion [12]. The most representative dimensional emotional model is the three-dimensional emotional model proposed by Wundt in 1907, another three-dimensional emotional model established by Plutchik in 1980, and the two-dimensional annular emotional model proposed by Russell in 1980 [13]. Russell's two-dimensional ring emotion model divides emotion into two dimensions, namely, pleasure and arousal. Pleasure is divided into positive and negative poles, and motivation is divided into low intensity and high intensity. In 1989, Thayer proposed a two-dimensional energy-stress model based on the Russell emotional model. The energy dimension is consistent with the arousal in the Russell model; the stress dimension represents valence [14]. Valence is a physiological or psychological pleasure response to external stimuli, with positive and negative directions. It can be seen that both the Thayer effective model and the Russell affective model reflect two aspects of valence and motivation and can map emotion to the "valence-incentive" emotional plane, so it can also be called "valence-incentive" [15]. The third type is the emotional model based on cognitive mechanisms, such as the EM emotional model, the Roseman emotional model, the EMA emotional model, and the salt and pepper emotional model [16]. The Hevner emotion ring model, the Russell emotion model, and the Thayer emotion model are widely used in music emotion recognition; based on the Hevner emotion ring model [17], the music emotion can be classified and the music emotion type corresponds to the adjective in the Hevner emotion ring model; based on the Russell or Thayer two-dimensional emotional model of music, the specific emotion of music can be mapped as a point in the emotional plane of "valence-incentive" (the horizontal axis corresponds to the effect value, the vertical axis corresponds to the incentive value), and the regression and classification of music emotions can be achieved by applying machine learning methods [18].

Due to differences in cultural background, age, gender, personality, and musical preferences, as well as the influence of external factors such as the perceived environment, people's descriptions of musical emotions to the same song may vary from person to person, and the adjectives that describe musical emotions themselves have a considerable degree of ambiguity [19]. Due to the subjectivity and ambiguity of music emotion, it is a very challenging task to accurately identify music emotion [20]. Another difficulty in identifying music emotion based on audio signal features is that there is a semantic level gap between music features and emotional cognition, so it is very difficult to accurately identify music emotion. The psychological process of music cognition can be described in four levels as follows: the physical layer, perceptual layer, musical layer, and semantic layer [21]. After comprehensively perceiving or judging all the characteristics of the physical layer, perceptual layer, music layer, and semantic layer and then identifying the emotional cognition of music through reasoning and thinking, it will be affected by people's cultural background, age, gender, personality, music preferences, and perceived environmental factors [22]. Since 2000, music emotion recognition has become a hot research topic at home and abroad. From MIDI format symbol music to audio format music emotion recognition, from western classical music to modern pop music, researchers have done a lot of work. The methods of music emotion recognition mainly include emotion classification and emotion regression [23].

Based on the Hevner emotional ring model and the Russell two-dimensional emotional model, the music emotion is classified. The more the classification, the lower the recognition rate of the music emotion. The researchers applied the machine learning algorithm to classify the music emotion into cheerful, angry, sad, and calm. Based on the method of audio signal processing, extract the energy, melody, harmony, time domain, frequency domain, and other dimensional features of music, through machine learning methods, including the support vector machine, the Gaussian mixture model, the neural network, and the K-nearest neighbor algorithm categorize the emotion of music [24]. Another way of music emotion recognition is to regress music emotion based on the Russell or Thayer emotion model through the regression method; the emotion of music corresponds to a point in the "valence-motivation" emotion plane [25]. Emotion, which can accurately calculate the effective value and incentive value corresponding to the music emotion, overcome the shortcomings of the classification method that is not precise enough to identify the music emotion and can track the changes of the music emotion in the "valence-incentive" emotional plane [26].

In our study, extract the energy, melody, time domain, frequency domain, and harmony of the five dimensions of perceptual music, and use the machine learning-based method to treat music emotion recognition as a regression problem. To realize the recognition of music emotion, a new classification algorithm is proposed to improve the recognition rate of music emotion. The mapping relationship of the emotional attributes of music in the emotional plane of "valence-motivation" is discussed, and the schemes of music emotional regression and classification are proposed, respectively; the characteristics of music energy, beat, time domain, frequency domain, and harmony are extracted. The method of machine learning realizes the regression and classification of music emotion and proposes a new music emotion classification method "Hybrid Classifier," which improves the emotion recognition rate, gives the experimental results of emotion recognition for each regression and classification method, and gives the results of emotion recognition. The experimental results are discussed and analyzed.

First, the mapping relationship of music emotional attributes in the emotional plane of "valence-motivation" is discussed, and the schemes of music emotional regression and classification are proposed, respectively. A variety of machine learning methods are used to achieve music emotion regression and classification, and a new music emotion classification method "Hybrid Classifier" is proposed to improve the emotion recognition rate. Finally, the emotion of each regression and classification method is given. The experimental results are identified, and the experimental results are discussed and analyzed.

2. Data Source and the Method

This paper selects the music emotion database from MediaEvaP4ˆ as the material for music emotion recognition research. MediaEval is an organization dedicated to providing test standards for the evaluation of new algorithms for multimedia access and retrieval. Members of the organization research topics such as speech recognition, multimedia content analysis, music, and audio analysis, user information analysis, and audience emotional responses. The music emotion database mainly contains 1000 English music files in mp3 format downloaded from Free Music Archive (http://freemusicarchive.org/, FMA) [27]. The files are numbered from 1 to 1000. However, due to some redundancy in the initial collection process, a list of files to filter out redundancy is provided in the database annotation file. After filtering out the redundancy, there are 744 music files in the actual database, among which 619 and 125 music files are marked for training and testing of the music emotion regression model, respectively [1]. The length of each music file in the database is 45s, and the sampling rate is 44100 Hz. The annotation file contains information such as the song name of each song and also contains the static and dynamic excitation and valence values of 2 Hz in the range [−1, 1] given by 10 participants, and standard deviation information is based on MediaEva music emotion database; the paper carried out the music emotion recognition research according to the framework of Figures 3 and 4 [28].

Computer-based music emotion recognition mainly refers to the use of modern signal processing technology to achieve music feature extraction and machine learning methods to achieve music emotion regression or classification [29]. Commonly used machine learning methods include supervised, semisupervised, and unsupervised machine learning methods [30]. At present, semisupervised and unsupervised methods still have the disadvantage of unsatisfactory recognition effect. Most of the studies reported in the literature use supervised machine learning methods to realize music emotion recognition [31]. Therefore, the discussion on computer music emotion recognition in this study is based on the supervision of machine learning. A typical computer music emotion recognition model framework is shown in Figure 1. The model framework mainly includes two parts, namely, model training and unknown type of music emotion prediction. In the model training, the music signal of known music emotion is converted into one-to-one correspondence features through signal preprocessing and feature extraction; c and emotion labels [32]. The training data set of $v(x) > 0$; the machine learning algorithm trains the classification or regression model with the minimum classification error or minimum mean square error as the objective function for the input training data set. In the stage of emotional prediction of an unknown type of music, it mainly predicts the emotional attributes of music; after the music signal of unknown emotional type undergoes signal preprocessing and feature extraction similar to that in model training, a test data set JC containing only music feature vectors is generated, and then input x into the regression or classification model generated in the model training phase to achieve the prediction output of music emotion. Analysis of the computer music emotion recognition model framework shows that the music emotion attribute of the training data needs to be predicted in the model training, so the music emotion subjective scoring method is often used in the preparation of the training data set [33]. At the same time, due to the individual uniqueness and subjectivity of music emotion, the "training data set" obtained by the subjective evaluation method is used for the training of the music emotion recognition model, which can effectively generate a music recognition system with individual preferences.

Music signal preprocessing and feature extraction are the first steps towards realizing music emotion recognition [34]. This step mainly includes music signal framing, signal windowing function processing after framing, feature calculation in each sliding window, and original feature space projection or feature selection for dimensionality reduction [35]. The music signal is a continuous time-series nonstationary signal, so the signal needs to be framed. Since the dynamic annotation of the MediaEval music emotion database gives the mean and standard deviation of V and A of 2 Hz, that is, an annotation is given every 0.5 s from the beginning of the music file 15 s, the sliding length of each frame is 0.5 s, 50% window length overlapping rectangular windows to frame each music file in the database [36]. Feature extraction and statistics are performed on the music signals in each frame, respectively, and a local feature data set corresponding to the dynamic V and A annotations in the database can be obtained. Further statistical processing of 60 frames of data in each file can obtain the global feature data set corresponding to the static V and A annotations of the entire music file.

Windowing the music signal is to do a dot product directly with the window function $W_M(n)$ on the music time series as follows:

$$W_M(n) = \begin{cases} W(n), & 1 \leq n \leq M, \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

Commonly used window functions include rectangular window, triangular window, Hanning window, Hamming window, and Gaussian window. The Gibbs effect and spectral leakage will appear when the rectangular window is used to truncate the signal for spectral analysis. The rest of the window functions can be better improved in the spectral analysis. The paper adopts the Hanning window function, as shown in equation (2), to realize the window processing of the music short-time frame signal.

$$\omega(n) = 0.5\left[1 - \cos\left(\frac{2\pi n}{(M+1)}\right)\right]. \tag{2}$$

The Hanning window of 1024 points (~22 ms) is superimposed on the signal, respectively, and the windowed signal can be further processed, such as short-time Fourier spectrum, and Mel frequency cepstral coefficient (MFCC) calculation.

After the feature extraction is performed on the music signal in this paper, the total dimension of the obtained feature data set (all feature spaces) is 548 dimensions.

On one hand, it is difficult to find an accurate regression model or classification plane to identify music emotion in high-dimensional space, and on the other hand, it will greatly increase the computational complexity of the algorithm. Therefore, this study also discusses the spatial projection based on principal component analysis and the relief-based algorithm. Feature selection features the dimensionality reduction method.

Principal component analysis (PCA) is an effective method for processing, compressing, and extracting information in samples based on a variable covariance matrix, which can effectively reduce the number of features containing noise or redundancy and is a common dimensionality reduction method. The core idea of PCA is to project the n-dimensional features into mutually orthogonal k-dimensional ($k < n$) features under the principle of preserving the maximum variance based on the assumption that the signal has a large variance and the noise has a small variance. The k-dimensional feature is also called a pivot. Let the sample feature matrix $X = \{x_1, \ldots, x_n\}$, x_i is a column vector. First, matrix B is obtained by subtracting the mean of each column by column; second, the covariance matrix C of B is computed as follows:

$$\begin{aligned} C &= E[B \otimes B] \\ &= \frac{1}{N} \sum B \cdot B^*. \end{aligned} \tag{3}$$

Third, the eigenvalues V and column eigenvectors D of matrix C are computed as follows:

$$[V, D] = eig(C). \tag{4}$$

Fourth, we sort V and D, calculate the contribution rate and cumulative contribution rate of each eigenvalue in V

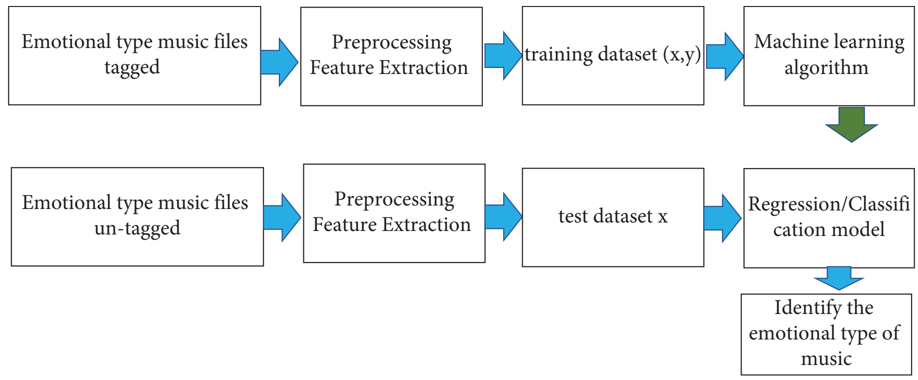

Figure 1: Computer music emotion recognition model framework.

after sorting, and select the rearranged k-column eigenvectors $W_{n\times k}$ corresponding to the eigenvalues whose cumulative contribution rate is greater than the threshold T; finally, the final PCA dimensionality reduction data is $Y = B * W$.

In this study, the transformation matrix W whose cumulative energy threshold T of the first k eigenvalues in V is greater than 90% is selected for eigenspace PCA dimension reduction. The original data set containing 548-dimensional features was dimensionally reduced using the PCA dimensionality reduction method, the threshold was set to 90% of the energy, and the final feature dimension after dimensionality reduction was 139-dimensional.

The Relief algorithm was first proposed by Kira and Rendell in 1992, and now it generally refers to a series of algorithms including Relief, ReliefF, and RReliefF. The Relief algorithm is one of the commonly used feature selection weight algorithms, which has the advantages of high operating efficiency and no restrictions on data types. The core idea of the algorithm is to assign weights related to categories to features. Based on the ability of features to distinguish close-range samples, the features with larger weights are finally selected to form a feature subset to represent the original feature set, and the classification is discarded. Small-weight features have less contribution. The Relief algorithm randomly selects a sample from the training set D and then follows the distance metric of formula (5) to find the nearest neighbor sample H from the samples of the same class and R and find the nearest neighbor sample M from the samples of different classes from R.

$$d = \frac{1}{2}\left(\|R - M\| - \|R - H\|\right). \tag{5}$$

Then, we update the weight of each feature according to the rule 6 as follows: if the distance between the sum and M is less than the distance between the sum and M, it means that the feature is beneficial to distinguishing the nearest neighbors of the same and different classes and then increase the feature weight; conversely, if the distance between a feature and M is greater than the distance between M and M, indicating that the feature has a negative effect on distinguishing the nearest neighbors of the same class and different classes, the weight of the feature will be reduced. The above process is repeated m times, and finally, the average weight of each feature is obtained. The larger the weight of the feature, the stronger the classification ability of the feature, and the weaker the classification ability of the feature. The iterative formula for the weights of the algorithm process is as follows:

$$w[A] = w[A] - \frac{\operatorname{diff}\left(A, R_i, H\right)}{m} + \frac{\operatorname{diff}\left(A, R_i, M\right)}{m}, \tag{6}$$

where A is the dimension scalar of the feature, and $\operatorname{diff}(A, I_1, I_2)$ is defined as follows:

$$\operatorname{diff}\left(A, I_1, I_2\right) = \begin{cases} 1 \operatorname{value}\left(A, I_1\right) = \operatorname{value}\left(A, I_2\right), \\ 0, \text{otherwise}. \end{cases} \tag{7}$$

The improved Relief algorithm uses the average of the k nearest neighbors to replace the single nearest neighbor in the weight iteration, which reduces the influence of noise on the weight to a certain extent and makes the final feature selection more accurate. The weight update formula of the Relief algorithm is as follows:

$$\begin{aligned} w[A] = w[A] &- \frac{\sum_{j=1}^{n} \operatorname{diff}\left(A, R_i, H_j\right)}{k \times m} \\ &+ \sum_{C \neq \operatorname{class}\left(R_i\right)} \frac{p(C)}{1 - p\left(\operatorname{class} R_i\right)} \frac{\sum_{j=1}^{k} \operatorname{diff}\left(A, R_i, M_j(C)\right)}{k \times m}, \end{aligned} \tag{8}$$

where $p(C)$ is the prior probability of each class estimated from the training set; $1 - p(\operatorname{class} R_i)$ represents the sum of the probabilities of misclassification.

The RReliefF algorithm uses probability to express the rules that clearly distinguish between two classes. This probability can be estimated by establishing a model that predicts the relative distance between the two classes. The iterative formula for the weights of the RReliefF algorithm can be expressed as follows:

$$w[A] = \frac{P_{\operatorname{diff}(C)|\operatorname{diff}(A)} P_{\operatorname{diff}(A)}}{P_{\operatorname{diff}(C)}} - \frac{\left(1 - P_{\operatorname{diff}(C)|\operatorname{diff}(A)}\right) P_{\operatorname{diff}(A)}}{1 - P_{\operatorname{diff}(C)}}, \tag{9}$$

where

$$\begin{aligned}P_{\text{diff}(A)} &= P(\text{different value of A}|\text{mearest instances}),\\P_{\text{diff}(C)} &= P(\text{different value of A}|\text{mearest instances}),\\P_{\text{diff}(C)|\text{diff}(A)} &= P(\text{diff.prediction}|\text{diff.valuue of A andnearest instances}).\end{aligned} \tag{10}$$

In this study, the Relief feature selection algorithm is used to perform feature selection on the 548-dimensional original feature set. We select the ones with a weight greater than 0 and finally determine that the feature dimensions used for the training and prediction of the regression model of music emotional effect value (V) and incentive value (A) are 276 dimensions and 258 dimensions, respectively.

Regression is an analytical method used to predict changes in unknown dependent variables by determining the correlation between dependent variables and some independent variables, establishing regression equations, and adding extrapolation. The existing regression theories can be used to predict the V and A values of music in the emotional plane of music signal features.

Let X_i be the feature set of a certain piece of music after signal preprocessing and feature extraction and y_i be the emotional attribute of music (V or A value); the process of training an optimal regressor $r()$ is to give N inputs $(X_i, y_i), i \in \{1, 2, \ldots, N\}$, to achieve the smallest mean square error e between the predicted output and y_i as follows:

$$e = \frac{1}{N}\sum_{i=1}^{N}\left(y_i - r(X_i)\right)^2. \tag{11}$$

Since the V and A values are real numbers in the range of [−1, 1] in the emotional coordinate space, two regression models can be established according to the existing regression theory to predict the V value and the A value. In the regression model, the true values of V and A can be obtained by subjective scoring. Due to the use of the public database of MediaEval, the annotated V and A values are regarded as true values in the paper; Shi is the feature set after feature extraction, with a total of 548 dimensions. However, in order to obtain the best regression effect, specific analysis must be carried out for specific problems [37]. Therefore, in this paper, algorithms such as multivariate adaptive regression, support vector regression, and radial basis function regression are used to realize the V and A value regression of music emotion, respectively, and the optimal regression algorithm and regressor are selected by comparison.

3. Results and Discussion

3.1. Music Emotion Regression Model Training and Prediction Scheme. In music emotion recognition, regression and classification are the two main methods. Unlike classification, which only needs to distinguish emotions such as joy, anger, sadness, and calmness, the goal of music emotion regression is to identify more accurate music emotions. It regards the emotional plane as a continuous space and identifies V-A through the regression model. The emotional state is represented by each point in the emotional plane (find out the mapping between music and specific coordinate positions in the V-A emotional plane).

The training and prediction framework of the emotional regression model is shown in Figure 2. The framework uses machine learning methods to achieve regression model training and then can predict the V and A values of music emotions. Specifically, it includes training and evaluating the model through the training data under the rules of the regression algorithm and using the trained regression model parameters for the music emotion prediction of the test data; the V and A values of the predicted music emotion with the manually calibrated V and A values are compared to test the accuracy of music emotional regression.

Multivariate adaptive regression splines (MARS) is a high-dimensional data regression method with good generalization ability proposed by Friedman of Stanford University in 1991 for nonlinear problems. Its goal is to predict a continuous output variable from a large number of independent samples; support vector machine (SVM) was first proposed by Vapnik, and he further developed a series of machine learning algorithms that can realize nonlinear mapping of output feature vector to high-dimensional feature space. When SVM is used for classification problems, it is called support vector classification (SVC). When SVM is used for regression problems, it is also called support vector regression (SVR). Unlike SVC, the purpose of SVR is to find a function that can achieve the smallest deviation e from the true value y of the input training data set. At the same time, the function should be as flat as possible. Radial basis function regression (RBFR) can be regarded as a surface fitting problem in a high-dimensional space, and it is an effective regression method.

In this study, the mean absolute error (MAE), the regression value accuracy (A_c), and the sentiment classification accuracy (A_c of classification) are used as the evaluation criteria for the music sentiment classification system based on three different regression methods.

The mean absolute error is the average of the absolute values of the squares of the differences between all observations and the mean. The mean error makes the dispersion absolute value, so that the errors will not be canceled by positive and negative, so compared with the mean error, the mean absolute error can better reflect the error between the predicted value and the observed value. Value range for

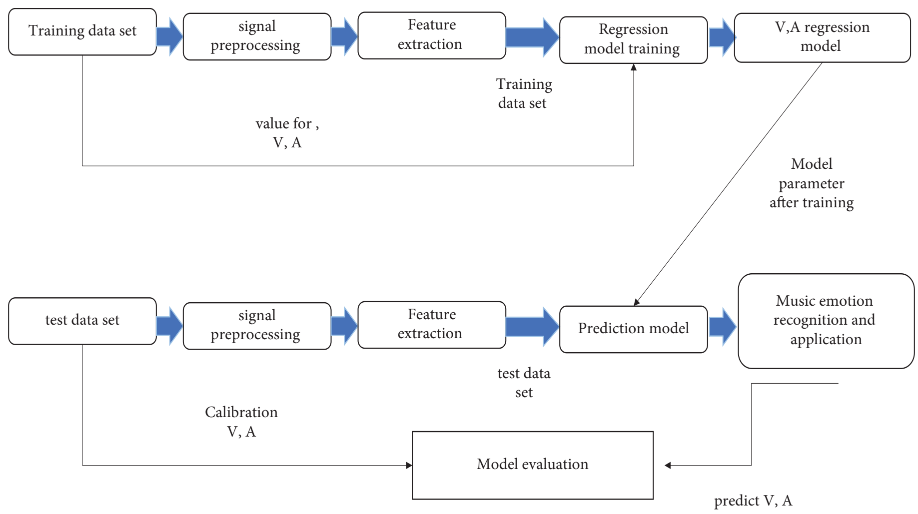

Figure 2: Music emotion regression model training and prediction framework.

accuracy of regression values (Ac of Arousal, Ac of Valence) can be divided into three (Table 1).

In order to check the regression effect of the VA value separately, the VA value is divided into three categories according to the value range of the VA value, and the accuracy of the regression value is determined by the accuracy of the category. If the predicted value is in the same range as the observed value, the classification is correct; otherwise, it is wrong.

The accuracy of sentiment classification is determined by whether the predicted value and the observed value are in the same sentiment category and is used to observe the classification effect of the entire classification system. The experimental evaluation results are shown in Table 2.

Figure 3 shows the distribution of the manually labeled values and predicted values of RBFR regression V and A. It can be seen that the predicted values have obvious regionality.

From Table 2, it can be concluded that the effectiveness of nonlinear regression (support vector regression and RBFR) is significantly improved compared with linear regression (polynomial regression), which indicates that there is an obvious nonlinear relationship between music feature vectors and emotional variables. Compared with RBFR, support vector regression has higher prediction accuracy for the arousal value, and the latter has higher prediction accuracy for the valence value, which may be related to the different decision relationship between different sentiment variables and eigenvectors.

Based on this, since the regression models of the VA values are obtained separately, there is no correlation between the two. In this study, support vector regression and RBFR are combined in the subsequent experiments, and support vector regression is used to obtain the arousal regression model, respectively. RBFR obtains the valence regression model and then observes the classification accuracy of the music emotion classification system, which has a certain improvement compared with the two methods alone, as shown in Table 3.

Table 1: Arousal, valence value range.

	Valence		Arousal
Cluster 1	[−0.6,0.6]	Cluster 1	[0.4,1]
Cluster 2,4	[0.2,1]	Cluster 2,5	[0,0.6]
Cluster 3,5	[-1,-0.2]	Cluster 3,4	[−0.6,0]

3.2. Comparison of the Results of the Regression Method and the Pattern Recognition Method. After the comparison and analysis of the efficiency of the three regression models, a regression-based music emotion classification system is finally formed by the combination of support vector regression and RBFR regression. In order to verify the effectiveness of the system, the text is also classified on the same music database using the support vector machine method to classify the music emotion.

When SVM is used for classification, the method of “one pair and the rest” is adopted, and 5 classifiers need to be trained. Each classifier distinguishes the current training category from other categories. When testing, the probability that the input test data belongs to each category is calculated and its maximum probability as the category of the data is taken. The comparison of the accuracy obtained by SVM classification and the regression method is shown in Table 4.

From Table 4, it can be concluded that the accuracy of the regression method is increased by 14% compared with the SVM method, which proves the effectiveness of the regression method. In addition, it can be found from the above table that the accuracy rates of categories 2, 3, and 4 are higher than those of categories 1 and 5, indicating that the feature vectors of categories 2, 3, and 4 can better express this category, and clearly compare it with other categories. The categories are distinguished, while the features 1 and 5 are not clear enough, and it is easy to divide them into other categories. Further research is needed on the selection of features.

Table 2: Efficiency of various regression algorithms.

	MAE of valence	MAE of arousal	Ac of valence (%)	Ac of arousal (%)	Ac of classification (%)
MARS	0.2826	0.2776	61.4	70	56
SVM	0.2333	0.2173	71	82	63
RBFR	0.1987	0.1803	72.4	80	64

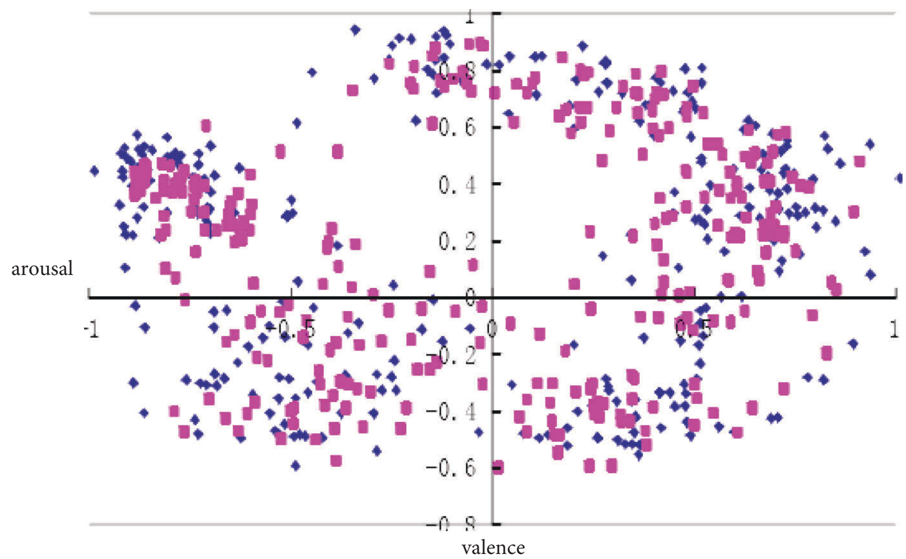

Figure 3: The distribution of the manually labeled values and predicted values of RBFR regression V and A. Pink rectangle is the prediction value and blue rectangle is manually labeled values.

Table 3: Comparison of RBFR combined with support vector regression and used alone.

	Ac of valence (%)	Ac of arousal (%)	Ac of classification (%)
SVR	71	81	63
RBFR	72	80	64
Combined	72	81	68

3.3. Analysis of the Experimental Results of Music Emotion Classification. The MediaEval database used in this study does not clearly mark the "music emotion type," but the V and A values of the music emotion attribute are marked in detail. The study defines the emotion type of music according to the coordinate quadrant of the mapping point of V and A in the "V-A emotion plane." The emotion type of music defines four following categories: I, II, III, and IV, representing cheerfulness, anger, sad, and calm musical emotions, respectively. At the same time, in order to overcome the influence of subjective scores, in the MediaEval database, the samples whose coordinates determined by the V and A values in the annotation are less than 0.05 from the origin are excluded; 125 sample data are randomly selected as the test sample set during the experiment, and the remaining data are used as the training sample set was independently repeated 10 times. Similar to music sentiment regression, this study performs PCA dimensionality reduction and Relief feature selection on all the extracted music features, and conducts sentiment classification experiments in all feature spaces, PCA feature spaces, and Relief feature spaces, respectively.

In this study, support vector machines, fuzzy neural networks, K-neighborhood, fuzzy K-neighborhood, Bayesian, linear discriminant analysis, and the proposed hybrid classification algorithm were used to train sentiment classification models, respectively. SVM adopts RBF kernel function, and relevant parameters are determined by optimization; K parameter in KNN is 8; FKNN adopts Gaussian function as fuzzy function; Bayes classification and LDA classification are realized by MATLAB built-in functions, respectively. At the same time, the paper also conducts model training and testing on the hybrid classifier proposed in this paper as shown in Figure 4, and each independent classifier adopts the above corresponding configuration. Finally, the experiment gives the results of music sentiment classification by multiple classifiers and compares the results of the hybrid classifier and the independent classifier.

After PCA dimension reduction, the feature dimension is 139 dimensions. The Relief feature selection algorithm is used to select the original data; if the weight is greater than 0.01, the feature dimension used for classification model training and prediction is finally determined to be 166 dimensions. The classification experiment results are shown in

Table 4: Comparison of SVM classification and regression classification.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Sum
Total songs	80	80	80	80	80	400
SVM correct number	32	41	50	56	28	207
Regression correct number	40	52	61	69	40	262
SVM accuracy rate	40%	51%	63%	70%	35%	52%
Regression accuracy number	50%	65%	76%	86%	50%	66%

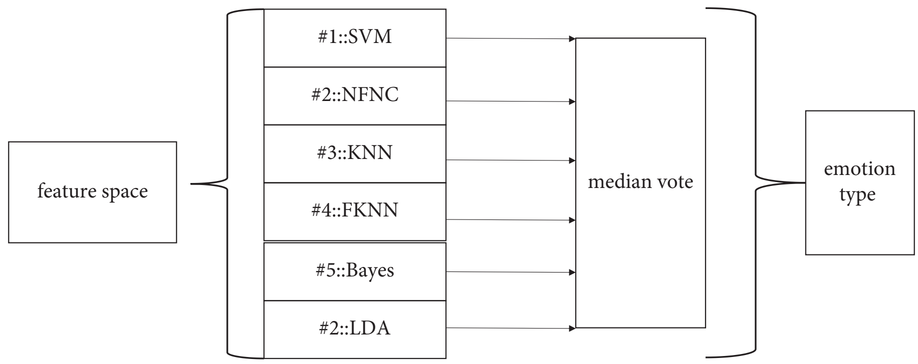

Figure 4: Mixed classifier structure diagram.

Table 5. It can be seen from the experimental results that the hybrid classifier model proposed in this paper has achieved the best music emotion recognition effect in all feature spaces, PCA feature spaces and Relief feature spaces, and its recognition accuracy is 84.9%, 83.4% and 80.2%, respectively. The experimental results show that using the hybrid classifier proposed in this paper can improve the accuracy of music emotion classification and further reduce the risk of misclassification. The proposed hybrid classifier method is effective.

By comparing the experimental results, it can be found that the classification effects of different classifiers in the three feature spaces have certain differences; music emotion classification also has the characteristics based on special cases, so it is necessary to select the optimal classifier and feature space to realize music emotion recognition task. The experimental results further show that by comparing the results on different feature spaces, it can be seen that the classification accuracy on the PCA feature space has increased or has only a small decrease in classification accuracy compared with the use of all features, so the PCA feature space is more suitable for music emotion [38]. Classification: comparing the recognition results of different classifiers on the same feature space, in addition to the proposed hybrid classifier with the best results, support vector machines, fuzzy K-neighborhood, and linear discriminant analysis all have the best performance in music emotion classification tasks. Good classification ability, in all feature spaces and PCA spaces, the recognition accuracy of these algorithms is greater than 80% under the experimental conditions and MediaEval database music samples. The results of one-time classification using the hybrid classifier on all feature sets show that most of the errors are in the classification between adjacent quadrants. This problem should be paid enough attention in the future music emotion recognition.

Table 5: Experimental results of music emotion classification (average accuracy, %).

	KNN	Bayes	LDA	NFNC	FKNN	SVM	Hybrid
ALL	62	69	80.4	79.3	83	83	85
PCA	62.8	76	81.6	58	82.2	81.1	83.5
Relief	66.8	59	77.4	69	50.3	79.3	80.2

4. Conclusions

In this study, the music emotion recognition was discussed and the mapping relationship of music emotion attributes on the “V-A emotion plane” was analyzed. The focus is on the use of music feature extraction and machine learning methods to achieve music emotion recognition.

Based on the MATLAB signal processing toolbox, sound description toolbox, and music information retrieval toolbox, this paper extracts the features related to music emotion (including energy, rhythm, harmony, time domain, and spectrum and other features). The dimension is 548, and the dimension of music feature space is reduced by the method of principal component analysis space projection and Relief feature selection.

Based on the emotional “valence-incentive” model, this paper applies machine learning algorithms such as multivariate adaptive regression spline method, support vector regression, radial basis function regression, random forest regression, and regression neural network, respectively. In the Relief feature space, the optimal regression results were achieved based on the support vector machine regression method and the random forest algorithm, respectively. The emotional valence and the incentive value R^2 for the statistical values are 29.3% and 62.5%, respectively, which are better than the results reported in the literature.

Based on intelligent algorithms such as support vector machine classification, *K* neighborhood classification, fuzzy neural network classification, fuzzy K neighborhood classification, Bayesian classification, and Fisher linear discrimination, this paper analyzes music in all feature spaces, PCA feature spaces, and Relief feature spaces, respectively. Emotions are classified; among them, the correct rate of music emotion classification realized by support vector machine, fuzzy K neighborhood, and Fisher linear discriminant algorithm is more than 80%; combined with the above intelligent algorithm, a hybrid classifier is proposed, which includes six independent subclassifiers and median voting decision algorithm implemented by the above intelligent classification algorithm; based on the hybrid classifier, in each feature space, the best classification results are achieved on all feature spaces and the recognition accuracy of music emotion on all feature spaces and PCA feature spaces is as high as 84.9% and 83.4%, respectively.

This study implements a music emotion classification system. Compared with traditional methods, the classification performance has been improved to a certain extent, but there are still areas for improvement in the process of learning and experimentation. First of all, although the music emotion database is established according to the emotion classification standard proposed at the International Conference on Music Information Retrieval, the standard is based on English songs. The description of categories in English may be biased in Chinese understanding. The important thing is that there is no broad mass base, and it is only established by students from the same school. Due to the small number of people, the obtained music library does not represent the will of the majority of people in a certain sense. In future experiments, it may be possible to collect the power of everyone on the Internet to build a more unified and convincing music emotion classification library. Using the regression idea to solve the problem of music emotion classification has its advanced nature. The regression algorithm has been researched maturely in a certain sense, but for music characteristics and emotional variables, which is insufficient. In this paper, only the support vector regression and k-plane segmentation regression algorithms are selected, which are more suitable for this system. In the future, further research and experiments can be carried out to obtain better results. In terms of feature selection, this paper selects the cepstral and spectral feature parameters of MFCC and RASTA-PLP to characterize music fragments based on the previous research and does not do further research. For musical emotion, due to its ambiguity and subjectivity, as well as the complexity of the process of human perception of emotion, what factors constitute the difference of musical emotion remains to be studied, and only these two types of characteristics cannot fully express its characteristics. In terms of feature selection, more experiments and screening are needed to obtain more accurate feature expressions in terms of musical emotion.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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Research Article

Intelligent Construction Optimization Control of Construction Project Schedule Based on the Fuzzy Logic Neural Network Algorithm

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At present, the field of construction engineering is limited by various situations, such as complex construction environments and many uncertain factors. Therefore, on the basis of the engineering network diagram, this paper proposes a construction project schedule management method based on the fuzzy logic neural network algorithm. By building a neural network, a large amount of historical data is input, and computers are allowed to calculate the key routes, thus predicting the construction period, and a construction project in a city is taken as an example for simulation experiments. The traditional construction period management scheme expects a construction period of 55 days. The planned construction period optimized by the project management technology integrating fuzzy logic neural network algorithm is 55 days, which is 2 days less than the traditional construction project schedule management technology and will not cause construction period delay. The simulation results show that this algorithm is more accurate and more efficient in calculating the key lines when dealing with large-scale projects, which can help the construction unit to quickly find the optimal strategy and effectively reduce the construction delay and capital loss caused by uncertainty factors.

1. Introduction

Construction project schedule control refers to the preparation of the project schedule according to the overall schedule objectives and the principle of resource optimization formulated at the beginning of the project, and the construction is carried out in accordance with the schedule, according to the work content, procedures, time consumed, and handover relationship of each stage of the construction project. Then, in the process of project construction, it is checked whether the actual progress of the project is consistent with the planned progress. If there is any deviation, it is a process of analyzing the deviation, taking control measures, modifying the plan and continuing to implement it according to the new plan, and so on until the final completion of the project. The most important indicator of project schedule control is the project duration. However, due to the complex construction environment, there are many uncertain factors, which often occur in all stages and posts of construction, and will have a far-reaching impact on the project schedule. Therefore, the on-site control personnel need to analyze those factors that may affect the progress before the project starts, estimate the possible consequences of these factors, and prepare a reasonable and feasible schedule on this basis so that the project can proceed smoothly according to the plan.

Many scholars have conducted a lot of research on project schedule control. Based on the study of many well-known project schedule management cases, this paper analyzes the mutual influence between project objectives, safety, quality and cost, and schedule management and expounds on the characteristics and applicable environment of some basic methods (such as the Gantt chart method, flow construction plan, plan review technology, S-curve method, critical path method, and so on) widely used in on-site schedule management. This method solves the problem that the traditional schedule management method does not consider resource constraints and has been praised by many researchers [2]; Tao and Tam integrate the three objectives of the project: quality, progress, and cost into a system and explore ways to maximize comprehensive benefits [3]; Bhaskaran studied the operability of applying plan review technology to expressway project schedule management [4]; Chen et al. used the latest Group Support System software to track and control the progress [5]. In the research of network planning technology, most of the research focuses on resource-constrained project scheduling problem (RCPSP). Stinson proposed an integer programming model for RCPSP under renewable resource constraints. Since then, many researchers regard this model as a standard model and turn their focus to the solution of this model [6]. For this model, the current solution is mainly achieved through a mathematical programming algorithm. Sood et al. elaborated and solved the problem in detail by using dynamic programming and linear programming, and the solution result is very ideal [7]; Patrick et al. proposed a linear programming model based on primal-dual relationships to solve the RCPSP model, which also achieved good results [8]. In the study of activity time, the critical chain technology uses a fixed value, while the plan review technology determines the duration of the project according to three different types of time: the most optimistic time, the most likely time, and the most pessimistic time of the controller for the project progress, which is also known as the three-point estimation method of time. At first, the three-point estimation method used empirical formulas, but with the deepening of research, many scholars proposed many new methods based on empirical formulas. For example, Newbold summarized seven-time estimation methods and studied their respective variances and expectations of different methods on the premise that the processing time obeyed the triangular distribution [9].

A neural network, also known as an artificial neural network, is an active network composed of simple calculation and processing units (i.e., neurons) as nodes and uses a certain network topology. The artificial neural network can fully approach any complex nonlinear relationship and can learn and adapt to unknown or uncertain systems. All its quantitative or qualitative information is stored in each neuron in the network with equipotential distribution, which has strong robustness and fault tolerance. The parallel distributed processing method is adopted, which makes it possible to carry out a large number of operations quickly [10].

The research of neural networks has a history of more than half a century since the 1940s. In 1943, American psychologist McCulloch cooperated with mathematician Pistt to study the description of objective events in formal neural networks with logical-mathematical tools, put forward the excitation and inhibition neuron model, and initiated theoretical research on neural networks. Psychologist Hbeb proposed the modification rule of neuron connection strength in 1949, and their research is still the basis of many neural network models. In 1957, Rosneblatt proposed the perceptron model, which started almost at the same time as AI, but it did not achieve the great success of AI for more than 30 years and experienced a long depression in the middle [11]. After the 1970s, the research on neural networks was at a low tide. Until the 1980s, practical algorithms for artificial neural networks were obtained, and turing digital computers encountered physical insurmountable limits in the artificial intelligence of analog audio-visual systems, people renewed their interest in artificial neural networks, leading to the revival of neural networks, and the upsurge of neural networks was raised again. At present, the research on neural network theory mainly focuses on network algorithms, performance, and the use of neurophysiological cognitive science to study human thinking and intelligent mechanisms [12]. Application research mainly focuses on the software simulation and hardware implementation of neural networks and the application of neural networks in various fields, such as pattern recognition, signal processing, knowledge engineering, expert systems, optimization combination, robot control, and others [13–15]. The research results include the BP algorithm of multilayer network, the proposal of the network model, and the introduction of the energy function, neural network model of competition and cooperation, Boltzmann and self-organizing feature mapping network model, and so on [16]. Neural networks and schedule management are both hot areas of current research. However, various uncertain factors on the construction site make it difficult for the construction to proceed smoothly according to the original plan, and it is very easy to produce deviations. Therefore, if you want to really have reasonable and efficient progress control, you must give different solutions according to different environments and different factors [17]. The application of the fuzzy earned value method and fuzzy control to the analysis of schedule deviation and case-based reasoning to the formulation of deviation measures is exactly what is needed for schedule control at present. At the same time, the model in this paper can be widely applied to different research fields. Different projects in different fields only need to establish a case base and measure base corresponding to their field, and the model can be used equally.

The main innovations and contributions of this paper include the following points:

(1) Combing the methods and theories of traditional progress control, this paper gives the definition and connotation of project progress management based on the logical neural network algorithm, which lays a foundation for the application of fuzzy control in the field of construction engineering. Through the fuzzy earned value method, the actual data of the construction site is transformed into the input variables of the fuzzy controller, which is convenient for subsequent fuzzy control reasoning.

(2) The process and strategy of scheduled fuzzy control are described. The progress fuzzy controller is constructed, and the strength of control measures is deduced by using fuzzy reasoning technology.

2. Problems Existing in the Progress Management of Existing Construction Projects

It is particularly important for construction enterprises to improve their construction level and efficiency so as to enhance their competitiveness in the industry. From the perspective of the overall development trend of project management, the progress control of the project almost represents the whole project management in the initial development stage of project management [18]. Generally, in the whole life cycle of a project, the construction stage of the project is the most important stage, and whether the progress control of the project construction stage is effective or not is directly related to the success or failure of the project. For construction enterprises, project progress control is a key method to ensure the success of the project [19]. The main reasons are first of all, the construction of a project lasts for a long time, the construction environment is complex, and accidents often occur, resulting in schedule delays; at the same time, the construction process requires a lot of collaboration, and the handover between processes is complex [20]. Usually, a small error will cause a delay in progress. Finally, the final result of the project is not only to complete the construction project on time but also to consider various factors such as quality, cost, and so on [21]. Therefore, project managers need to comprehensively consider various factors to maximize the overall benefits of the project, which will also have an impact on the progress control part.

Based on the analysis of the history, definition, and process of traditional progress control, we can conclude that the current system of construction project progress control is still very imperfect, as shown in the following points:

(1) The mode of schedule control has not yet formed a systematic system and lacks modern management means. Although the traditional progress control method has been implemented for a long time, the truly systematic progress control is still in its infancy, and the corresponding systems and specifications are also quite imperfect [22]. At the same time, the amount of information obtained by the project parties is different, which will also lead to information asymmetry, which will affect the understanding of the project participants. Moreover, an engineering project generally contains a large amount of information. It is time-consuming, laborious, and impractical to rely solely on the project site managers to collect and manage this huge amount of information [23].

(2) The traditional schedule control lacks an accurate control model, and human subjective factors are significant. In essence, progress control means that the construction enterprise controls the construction period of the whole project. However, due to the one-time nature, liquidity, and complexity of the project, as well as various uncertainties that may be encountered in the construction process, the progress will be affected. Therefore, it is difficult to establish a fine and accurate model to control the progress of the construction, and it is more difficult to express it with a mathematical model, which can only be controlled by the subjective experience of the on-site management personnel. This will cause the personal ability of the controller to be directly linked to the control results, which will introduce potential risks to the benefits of the project [24].

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3. Problem Statement and Research Ideas

How to deal with the current situation of nonintelligent progress control in construction enterprises is an important problem to be solved by construction enterprises. After consulting and learning from a large number of theories and literature studies, this paper proposes to integrate the fuzzy logic neural network algorithm technology into the optimization of project schedule control. The fuzzy control model of project progress is a model that integrates the analysis of the causes of progress deviation, the calculation of progress deviation, and the proposal of specific control measures. It includes the following three intelligent control methods: the fuzzy earned value method, fuzzy control, and case-based reasoning, which solves the problem that the influencing factors of schedule control are complex and the calculation model cannot be accurately established. During the construction process of the project, the model continuously collects the corresponding information, uses the quantitative fuzzy earned value method to analyze the progress deviation, and then uses the rules of fuzzy control to solve the control quantity of the project progress [26–28]. This model is to continuously collect corresponding information during the construction of the project and determine the key technical nodes affecting the construction period in combination with the key chain identification technology. The key chain identification technology process is shown in

Figure 1. The quantitative fuzzy earned value method is used to analyze the progress deviation, and then the fuzzy control rules are used to solve the control amount of the project progress. Finally, the final progress deviation control measures are given with the help of case-based reasoning technology. It helps the on-site schedule control personnel to make decisions, thus reducing the possibility of making mistakes due to the inexperience of the on-site schedule control personnel, and provides a new idea for the current construction project schedule control field.

4. Optimization of Construction Project Schedule Management Based on the Fuzzy Logic Neural Network Algorithm

4.1. Logical Neural Network Algorithm. Classical reinforcement learning is a tabular method, which is prone to dimension disaster when dealing with high-dimensional data features. Inspired by deep learning, the combination of the two forms of neural network learning and fuzzy logic neural network algorithms are particularly widely used in deep reinforcement learning. See Figure 2 for the structure of the neural network.

The fuzzy logic neural network algorithm is a classical deep reinforcement learning algorithm based on value function. It combines convolutional neural networks (CNN) with the Q-learning algorithm, takes advantage of CNN's strong representation ability of images, regards video frame data as the state input network in reinforcement learning, and then outputs a discrete action value function from the network, and the agent selects the corresponding action according to the action value function. The convolutional neural network (CNN) and the Q-learning algorithm are shown in Figure 3.

The reason why the fuzzy deep neural network algorithm can better combine deep learning and reinforcement learning is that it introduces three core technologies, namely, objective function, objective network, and experience playback mechanism. The training process is shown in Figure 4.

(1) Objective function: we use convolutional neural network combined with full link as the approximator of action value function to achieve an end-to-end effect. The input is an image, and the output is a finite action value function.

(2) Target network: in order to make the performance of the fuzzy depth neural network algorithm more stable, two network models including CNN are used for learning. First, the network model Q (s, a, w) replaces the predictive Q network to evaluate the value corresponding to the current state action; the second is to use the network model Q (s, a, w') instead of the target Q network to calculate the target value. In this way, the fuzzy depth neural network loss function L (w) under the dual network architecture can be obtained as follows:

$$L(w) = E_{\pi_w}\left[\left(r + \gamma \max_{a'} Q(s', a', w') - Q(s, a, w)\right)^2\right]. \quad (1)$$

In this formula, w represents the network parameters in the loss function, and E represents the mathematical expectation. $r + \gamma \max_{a'} Q(s', a', w')$ represents the target value of Q network optimization, where w'represents the parameters of the target network. Depth Q network updates network parameters based on gradient rules formula loss function can be obtained by deriving the following weight:

$$\nabla_w L(w) = E_{\pi_w}\left[\left(r + \gamma \max_{a'} Q(s', a', w') - Q\ (s, a, w)\right)\nabla Q(s, a, w)\right]. \quad (2)$$

In formula (2), ∇ represents gradient calculation. The structure and initial parameters of the dual network are the same, that is, $w_0 = w'$. After several rounds of iteration, there is $w' = w$. Therefore, the logical neural network algorithm is introduced into the target network, and the target Q value remains unchanged for a period of time, which reduces the possibility of loss value oscillation and divergence during training, fully ensures the training time, and improves the stability of the algorithm.

Experience playback mechanism: the logical neural network algorithm introduces the experience playback mechanism to store the experience migration samples obtained from the interaction between the agent and the environment at each time in the experience pool. After a number of steps, the batch size samples are randomly taken from the experience pool and input into the neural network as discrete data, and then the small batch random semigradient descent method is used to update the network parameters.

4.2. Fuzzy Depth Neural Network Algorithm Q Value Update Method for Project Schedule Management. The key design point of the fuzzy depth neural network model is to update the Q value. According to the characteristics of the project, in order to make the network more stable, this paper designs two neural networks with the same structure but different parameters and updates the actual value and estimated value of Q, respectively, to realize the convergence of the value function. The update process is shown in Figure 5.

At the same time, the fuzzy depth neural network algorithm uses a memory bank to learn from the previous experiences. Each time it is updated, the previous experience will be randomly selected for learning. For this project, the

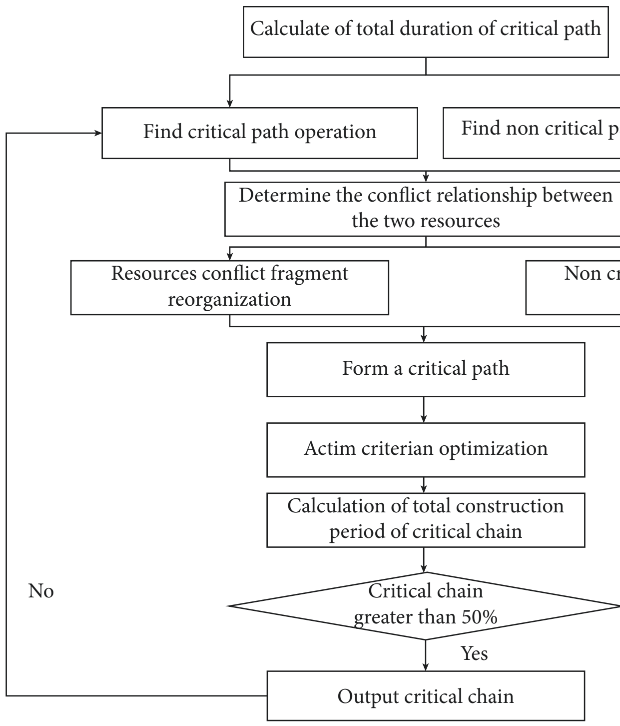

Figure 1: Key chain identification technology process.

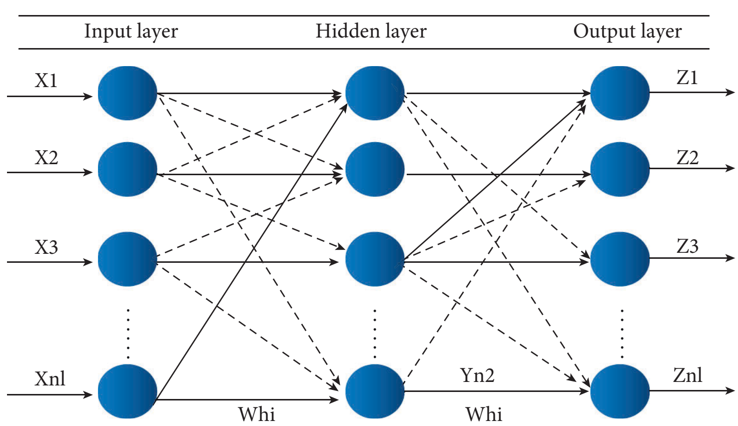

Figure 2: Structure diagram of the neural network.

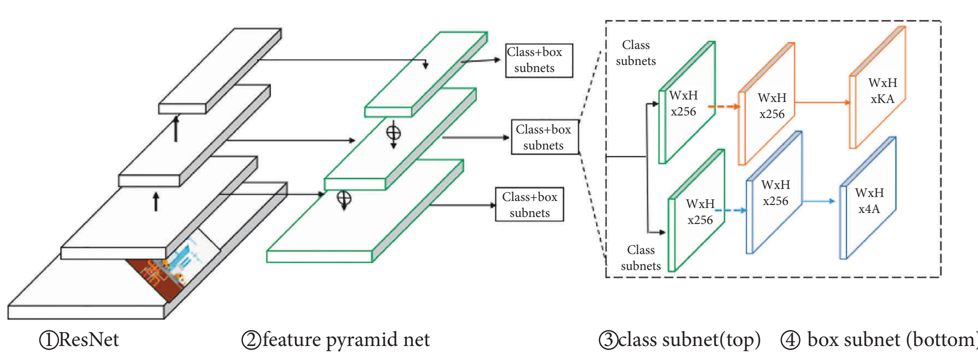

Figure 3: Convolutional neural network CNN and Q-learning algorithm.

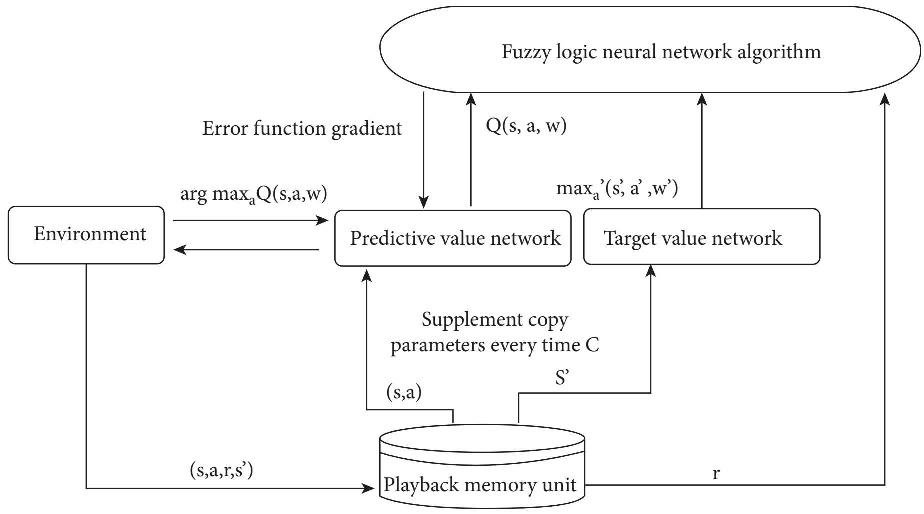

Figure 4: Training process of the logical neural network algorithm.

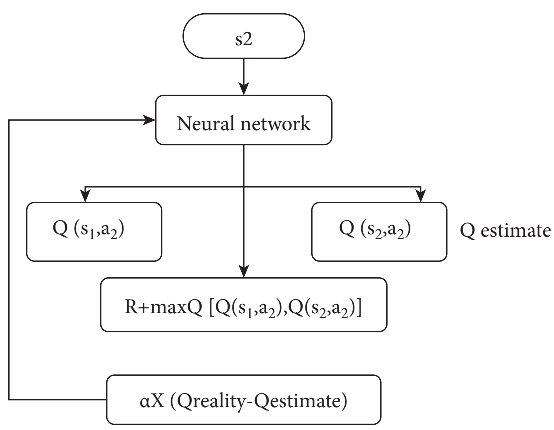

Figure 5: Updating process of the fuzzy depth neural network.

target network is updated with two networks with the same structure but different parameters, which makes the efficiency higher and more stable. In neural network training, instability or training difficulties may occur. To solve this problem, the fuzzy depth neural network adopts a target network and experience playback pool to improve. The loss function used is

$$L(w) = (R + \gamma \max (Q(s\prime, a\prime, w) - Q(s, a, w)))^2. \quad (3)$$

The fuzzy depth neural network algorithm uses two neural networks with the same structure but different parameters. The neural network that predicts the estimated value of Q uses the latest parameters, while the actual value of Q also uses the latest parameters of the neural network, which can make the training process more stable.

4.3. Selection of State and Action. The setting of the state is very important to the influence of the experiment. According to the characteristics of the project, this paper abstracts the events of the project's construction as stated. The data selected in this paper has a total of 21 events, that is, there are 21 states, and the state space is set as S. si indicates the i-th state ($i = 1, 2, 3, \ldots, 21$). The transition between states is represented as an action, A represents action space, and ai indicates the i-th action ($i = 1, 2, 3, \ldots, 21$). There are 21 actions as well as states.

In reinforcement learning, agents gain rewards by constantly interacting with the environment how to find an optimal strategy when interacting with the environment without losing too many rewards in the process of trial and error; we need a good method to balance. Exploration is the agents' continuous trial and error to collect more information and expand the memory bank. It will not bring great rewards in the short term but a long-term return. The use is to make the best choice under the current state according to the current memory bank, obtain immediate rewards, and focus on short-term returns, but this will lead to damage to long-term interests. So, this article combines ε-greedy ($0 < \varepsilon < 1$) select, where, $\varepsilon = 0.9$, that is, the best choice can be made in 90% of cases and random selection in 10% of cases. Through this setting, not only short-term interests but also long-term interests can be guaranteed.

4.4. Setting of Reward Function. The ultimate goal of neural network learning is to maximize the reward obtained. In this experiment, the time taken for the last event to reach the next event is set as the reward value, G is the reward value function, and R represents the immediate reward obtained by the agent after executing action a from the current state S to the next state S. With the immediate reward, we can get the reward value obtained by the last event to the next event in the project as critical path. The reward function is calculated as follows:

$$G = \lambda G_{t+1} + R_{t+1}. \quad (4)$$

In this formula, the total return is equal to the discount reward of the next state plus the immediate reward, where λ is the discount factor. This formula also indicates that the

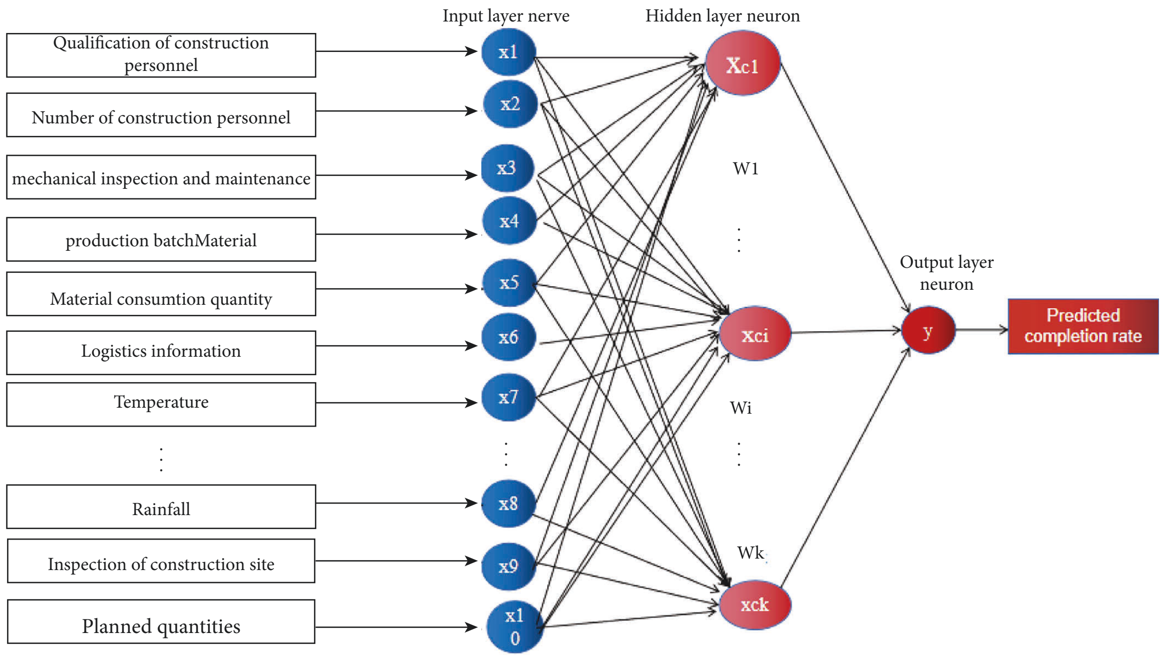

Figure 6: Fuzzy logic neural network work progress prediction model.

greater the reward value obtained from the previous event to the next event in the project, the greater the probability of choosing the optimal path.

The prediction model of engineering project construction progress and completion rate designed in this paper mainly uses the RBF neural network to imitate the information processing ability of biological neural cells. The basic idea of the RBF neural network is to use the radial basis as the hidden units to constitute the hidden layer space, directly mapping the input vector to the hidden layer space, without being connected by the weights. The central point of the RBF neural network is determined first, thus determining the mapping relationship between the systems. The implicit layer space is linearly mapped to the output space, and the output of the neural network is a linear weighted sum of the hidden cell output, while the weight is the tunable parameters in the neural network. This paper uses the fuzzy logic neuron network function, which randomly selects the center point setting method of the RBF's network, and directly selects the sample points as the network center points. During the training process, according to the target error set by the model, new hidden layer nodes are continuously added to the neural network structure, and the center point of the basis function is adjusted until the expected error requirements are met. See Figure 6 for the construction progress prediction model of the fuzzy logic neuron network.

5. Empirical Application of Construction Project Schedule Management Based on the Fuzzy Logic Neural Network Algorithm

5.1. Introduction to Experimental Cases. A construction project in a city needs to be constructed. The project requires a tight completion time, involves a wide range of events, the work is closely intersected, and the technical requirements are high. All departments attach great importance to it and require the construction personnel to quickly find the critical path to complete it. According to historical data and previous project progress, data collection and sorting are carried out, as shown in Table 1.

Table 1: List of logical relationships among various works of the project.

Work	Immediate work	Duration
A	—	2
B	A	4
C	A	3
D	B	2
E	B, C	6
F	B, C	1
G	D	4
H	D, E	3
I	D, E, F	2
J	G, H	6
K	I	1
L	J, K	2
M	L	4
N	L, M	3
O	N	3
P	M, N	2
Q	O	5
R	P	1
S	Q	4
T	Q, R	6
U	S	6
V	S, T	2
W	U, T	4
X	W	3

It can be seen from Table 1 of the project with a total of 21 events that according to the logical relationship between various works, we can get a project activity network diagram, as shown in Figure 7. Using the traditional critical chain method to find the critical path needs a lot of artificial calculation, and they not only have to spend a lot of manpower material resources but also there may be an error. Therefore, this paper uses the fuzzy deep neural network algorithm in deep reinforcement learning to train and find out the key routes so as to predict the construction cycle.

5.2. Simulation Experiment Process. It can be seen from Table 1 that there are 21 events in this project, and the rewards obtained by the transfer of work can be obtained from the logical relationship between each event, forming the reward matrix. This experiment is implemented using the TensorFlow platform, programmed with the Python language, and trained with the fuzzy depth neural network algorithm. First, events are abstracted as states, and the transfer between events is abstracted as actions, which are input into the neural network at the same time, and then processed with the convolutional neural network. The number of convolution cores in two layers is 21 and 42, respectively, and the size of the convolution core is $3 * 3$. In the training process, set the discount factor of Q-learning $\lambda = 1$. The number of iterations $N = 1000$, the size of the experience pool $D = 1000$, the number of samples extracted each time batch = 50, and set the learning rate of neural network $\alpha = 1$. With the setting of these parameters, after inputting the data into the neural network, the neural network will judge and finally output the action value. The Q reward matrix is as follows:

$$Q = \begin{bmatrix}
0&52&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&50&49&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&46&43&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&46&35&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&40&0&41&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&34&40&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&34&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&37&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&32&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&31&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&29&28&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&25&24&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&25&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&22&16&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&15&17&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&15&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&13&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&9&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&7&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&3\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0
\end{bmatrix}. \tag{5}$$

5.3. Simulation Project Progress Results. According to the training results of the fuzzy depth neural network algorithm, we can get the value of each work moving to another work, as shown in Figure 8.

According to the simulation project results, when the Q matrix converges, the agent can learn the key route of the project management progress. It can be seen from this that when the state is 1, the optimal transfer mode is 2, and the corresponding value is 52. When the state is 2, the transferable states are 3 and 4, and the corresponding values are 50 and 49, respectively. When the value is larger, the selection is 50, that is, the transfer mode is 3. By analogy, when the state is 20, the selection is 21, and the corresponding value is 3, so the optimal path is $1 \longrightarrow 2 \longrightarrow 3 \longrightarrow 4 \longrightarrow 6 \longrightarrow 8 \longrightarrow 10 \longrightarrow 11 \longrightarrow 12 \longrightarrow 13 \longrightarrow 14 \longrightarrow 15 \longrightarrow 17 \longrightarrow 19 \longrightarrow 20 \longrightarrow 21$, that is,

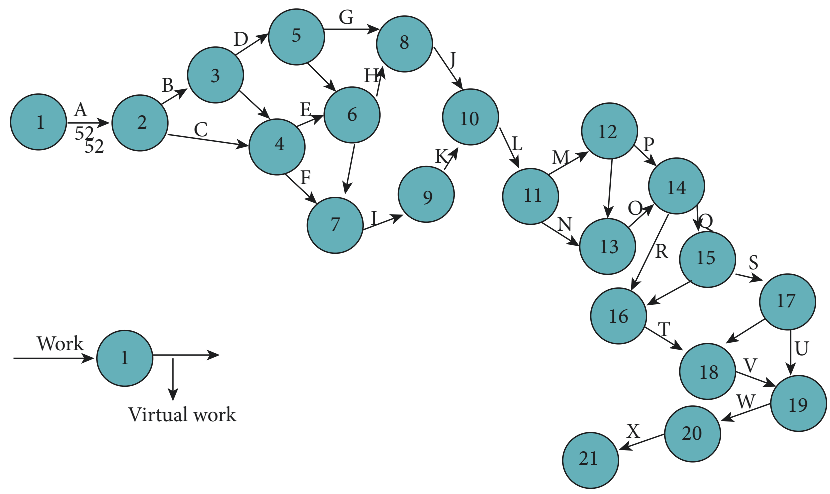

Figure 7: Project activity network diagram.

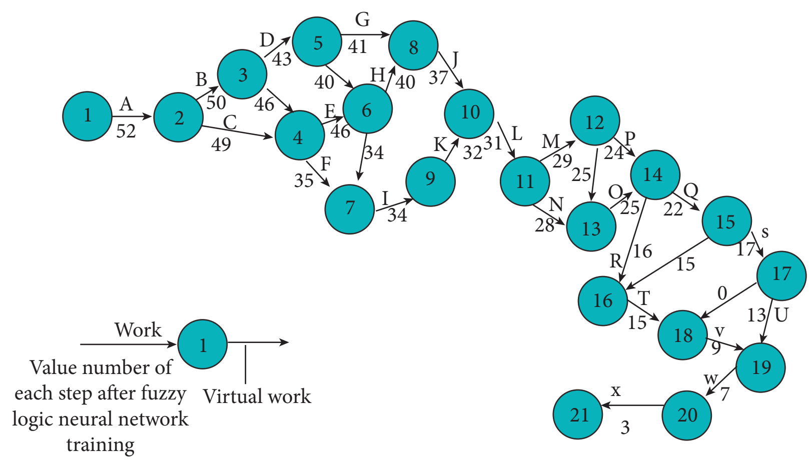

Figure 8: Network diagram of value items at each step after fuzzy depth neural network training.

A⟶B⟶C⟶E⟶H⟶J⟶L⟶m⟶o⟶Q⟶s⟶u⟶w⟶x, so the construction period is 55 days.

The traditional project schedule management technology is based on the critical path. According to the prediction results of the progress completion rate, the construction period of the construction project schedule is 57 days. Compared with the monthly schedule initially prepared, it can be seen that the construction period has been delayed to a certain extent, and the actual construction schedule will be delayed again due to resource constraints and other constraints of the traditional project management technology. The traditional project schedule management does not provide corresponding delay mitigation measures, and the completion period can only be postponed after the schedule is delayed. However, through the intelligent optimization of the construction project schedule integrating the fuzzy logic and neural network algorithm, the dynamic optimization mode of schedule is applied. When the actual construction data information of the smart site platform is updated, the completion rate of the underlying schedule that has not occurred is predicted. At the same time, the process duration of the schedule is estimated based on the prediction results of the completion rate, and then the key chain technology is used for optimization. In the way of high-frequency optimization, in the actual construction process, the project buffer is set for 5 days under accurate guidance. When the utilization rate of the buffer is not more than 2/3, the expected construction period of the key chain identified by the fusion fuzzy logic neural network algorithm is 55 days, which is 2 days less than the traditional construction project schedule management technology and will not cause construction period delay.

The above simulation project schedule results show the accuracy and feasibility of the fuzzy logic neural network algorithm in determining the critical route and construction period in the construction project schedule management. Compared with the traditional schedule management method, the fuzzy logic neural network algorithm reduces the amount of calculation and shortens the time of calculating the optimal path. It further explains the feasibility and rationality of the fuzzy logic neural network algorithm used to explore the construction project progress management.

6. Conclusion

The traditional project schedule management method makes it difficult to calculate the key route when facing the large-scale project. This paper studies this problem, proposes a building project management model based on the fuzzy logic neural network algorithm, explores intelligent schedule management methods, and takes a building project as an example for simulation experiment analysis. The planned duration of the traditional key chain technology of the project is 57 days. The duration of the scheduling process is estimated based on the prediction results of the completion rate and then optimized by the project management technology integrating the fuzzy logic neural network algorithm. The planned construction period is 55 days, which is 2 days less than the traditional construction project schedule management technology and will not cause a construction period delay. Experiments show that this algorithm is more efficient and accurate for calculating the optimal route of the project, which further explains the feasibility and rationality of this algorithm for exploring intelligent construction progress management methods. This paper applies the deep reinforcement learning method to construction progress management and verifies the effectiveness of this method through simulation experiment analysis so that the relevant departments can no longer rely on manual calculation of key routes during project construction, effectively reducing human costs, saving a lot of resources, and also providing some research ideas for some scholars.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

Acknowledgments

The purpose of this study is to serve Hunan's "Three Highlands and Four New Missions", to achieve the innovation and practice of the talent training mode of the engineering construction professional cluster and to obtain the support of the top-level design research on talent training under the natural resource background of the project engineering construction professional cluster, project number 2022G03.

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Research Article

Improvement in Automatic Speech Recognition of South Asian Accent Using Transfer Learning of DeepSpeech2

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Automatic speech recognition (ASR) has ensured a convenient and fast mode of communication between humans and computers. It has become more accurate over the passage of time. However, in majority of ASR systems, the models have been trained using native English accents. While they serve best for native English speakers, their accuracy drops drastically for non-native English accents. Our proposed model covers this limitation for non-native English accents. We fine-tuned the DeepSpeech2 model, pretrained on the native English accent dataset by LibriSpeech. We retrain the model on a subset of the common voice dataset having only South Asian accents using the proposed novel loss function. We experimented with three different layer configurations of model to learn the best features for South Asian accents. Three evaluation parameters, word error rate (WER), match error rate (MER), and word information loss (WIL) were used. The results show that DeepSpeech2 can perform significantly well for South Asian accents if the weights of initial convolutional layers are retained while updating weights of deeper layers in the model (i.e., RNN and fully connected layers). Our model gave WER of 18.08%, which is the minimum error achieved for non-native English accents in comparison with the original model.

1. Introduction

Automatic speech recognition (ASR) is a key component in making human-computer interaction (HCI) hassle-free because it is the most interactive and convenient mode of communication between automated systems and humans [1]. The interaction between human and voice-based systems is mostly accomplished in English language. Some of the common applications of voice-controlled systems in AI world are chatbots, humanoid robots, healthcare systems [2], self-driving cars, surveillance systems, industrial robots, and many more. From these applications, chatbots are the most widely used till date. They are everywhere around us. Regardless of region state or country, everyone is using it. Google Assistant [3], SIRI [4], Cortana [5], and Alexa [6], all of them are helping humans in each step of their daily life [7]. Form booking an appointment for barbers' shop to remainder for daily grocery items. Over half of the world's population now has a mobile phone of which 17% of them are smartphones [8], which means around a billion smartphones and 700 million windows users [9] out there in this world. And all of them are equipped with chatbots. Mobile phones come with SIRI or Google Assistant and Windows users have Cortana.

Similar to chatbots, self-driving cars have similar issues. According to Google Waymo, autonomous vehicles have reached 8 million test miles in July 2018 [10]. This clearly states, how close humans are to bringing 5^{th} level of autonomous vehicles to reality. These autonomous systems are designed to operate through voice commands with English according to the British Council, 1.75 billion people in this world speak English [11]. America has the biggest share with around 268 million native English-speaking people [12], UK is second with 59.6 million speakers [13], Europe is third with collectively 70 million people, who speak English as a native language, [14] and Canada is fourth with 19 million native speakers [15]. Although the abovementioned countries have more population of native English-speaking people, but there are several non-native English speakers, present in these countries as well. Apart from this, there is number of counties, which uses English as a second language and their accent is different than that of native English speakers.

For instance, Pakistan and India are holding the biggest share of non-native English speakers, i.e., around 88.6 million people in Pakistan and 125 million in India speak English as a secondary language [16]. Due to regional differences, South Asians and Gulf countries vocal accent for English is different from native English-speaking countries [17]. This highlights the issue of usability, for the voice-controlled systems with dissimilar accents. Which eventually generates hurdles in the use of discussed human voice-controlled systems. Although ASR is being used widely, it is not flexible enough for non-native English accents—thus, 290 million people are unable to use its applications properly.

The motivation behind this research area is given as follows:

(i) Make more accurate the English ASR for non-native English speakers

(ii) Use existing ASR system's accuracy and make it more robust by adding an additional pipeline for non-native English Speakers.

(iii) Make model learnable for a small amount of data

For the last two decades, Hidden Markov's model (HMMs) and Gaussian mixture models (GMMs) were very effective in improving the recognition accuracies of ASR. However, in recent few years, deep neural network (DNNs) [18] has replaced GMMs although the remaining part of GMM-based recognition architecture is still kept for several experiments. These systems are called hybrid ASR systems [19] because they use classic HMM/GMM-based architecture and after the training, they replace the GMM with DNN. Likewise, recurrent neural networks (RNNs) are used as well in a similar manner for language modeling.

There is a plethora of work regarding ASR. For most of the ASR systems, models are trained using a native English accent. Some of the described models have achieved above 90.0% accuracy. Like Google's model for ASR [20] can be as accurate as the human itself in some cases. They claimed of achieving 95.0% of accuracy. But this model is not performing well for non-native English accents until now. Research and development in ASR continuously getting better [21] with large-scale pieces of training, deeper network architectures, and reduced word error rate (W.E.R) have been providing efficient results for ASR. Microsoft AI and Research Lab published research shows 5.1% W.E.R on 2000 switch-board evaluation set by adding additional acoustic model architecture to their system [22]. They called it CNN-bidirectional long short-term memory networks (CNN-BLSTM). Their work clearly reflects closeness to human efficiency. But the problem still occurs when it comes to South Asian accents.

In deep learning, the learning of the model is directly proportional to the amount of data. The more data model has for training, it learns more and makes general decision boundaries. Sometimes, if the model needs some modification in class labels then it requires training from scratch. The solution to this problem was provided by transfer learning [23]. Through transfer learning, the learning of the model can be transferred to new similar problems with some modifications to the last layers of the model. We can use the trained weights of the model and find the best weights for the last layer, that is, called the classification layer.

Recently, DeepSpeech2 [24] provides a deep learning-based architecture that gave promising results in English and Mandarin languages. The deep speech architecture consists on 1D convolutional layers, RNN layers, and fully connected layers. The DeepSpeech2 architecture gives awesome results for two very different languages. It means it has the capability to learn the features of different languages. So, we decided to evaluate DeepSpeech2 on non-native English speakers and improve the quality of DeepSpeech2 by transfer learning.

The most basic limitation in training these models is the limited available dataset, i.e., non-native English speakers' dataset is limited and not widely available. Consequently, most of the models are unable to recognize non-native English accents. To cover this gap, we proposed a system for the recognition of English language, specifically for non-native English accent speakers. Our system will recognize and generate a transcription of human voice using deep learning model named DeepSpeech2 [25]. Our proposed solution will address the following points to reduce the word error rate (W.E.R) on South Asian accents for English language automatic speech recognition (ASR).

(1) We propose a hybrid model based on DeepSpeech2 with two pipelines that learn both English and non-native English accent.

(2) We propose a novel loss function that optimizes the model's weights better.

(3) We achieve 18.08% for non-native English and 7.0% WER for English accent. 2 [26] model by fine-tuning its model on using non-native English accent dataset.

2. Literature Review

Automatic speech recognition is not new to this era of 4th industrial revolution wave. It all started in the middle of 19th century. In 1950, researchers from bell labs build a system named "Audrey" [27] to recognize a digit for single person [28]. Audrey was a six-foot-high relay rack, capturing considerable power in addition to streams of cable. It was capable of recognizing digits from speech using phonemes.

Although in the 1950s computer systems were not so good, they had limited computational speed and memory. But Audrey was perfect in recognizing digits from 1 to 9 with more than 90% of accuracy [29]. It also produces above 70% accuracy in the case of some selected unknown speakers. But Audrey was not comfortable with unknown voices, which means lesser accuracy. From 1960 to 1970, most of the exploration and phonetic segmentation work was completed. Some major techniques used for ASR in 60 s were brute force approach and template. It was good in results but it is hard to scale. A big breakthrough in that era was speech understanding research (SUR), the project of DARPA [30].

Later on, in the 1980s some of remarkable discoveries were found. First appearance of hidden Markov models (HMM) [31] changed the way of speech recognition. With HMM, neural networks also played their role. Layered feed-forward networks with sigmoid function are used to train the model for speech recognition [32]. A three-layer net was constructed and a back-propagation learning procedure is used to train the network. Results of these neural nets are better than HMMs. Time delay neural network (TDNN) achieved 1.5% of word error rate over HMM's 6.3% of word error rate [33]. With the development of HMM and neural networks, many breakthroughs were achieved. DARPA started new speech projects, HMM become popular. Rabiner at bell labs performs well using HMM, AT&T performed the first large-scale deployment of speech recognition named (voice recognition, call processing) VRCP [34, 35]. Automated systems were deployed, in the late 1990s United Airlines launches an automatic flight information system.

In the last decade of research and development in the area of ASR, sensor networks [36] computer vision [37], and natural language processing grows rapidly. Deep learning innovation played a vital role in it. In a recently published Microsoft research [38], very impressive results had been recorded. LSTM was preferred on RNN-LMs to achieve proficiency in reducing W.E.R. Models were built using CNTK. Human versus machine errors is analyzed, which indicates substantial equivalence. In this research, NIST 2000 dataset was used, which produces 4.9% of word error rate [39]. But NIST 2000 dataset was originally recorded from calls with native English accent. That is why it is not very much accurate with South Asian accent.

Kadyrov et al. [40] proposed an ASR based on spectrogram images of speech signals. They achieved 98.34% accuracy. But they used a self-generated dataset. They did not evaluate the model on different accents of English speakers, we consider the different accents of the English speakers and evaluate them on standard benchmark.

Another method to gain efficiency in automatic speech recognition was through active learning. In it, a gradient-based active learning method was used [41]. Active learning aims to label only the most informative data. It helps in reducing labeling costs. In a result, it outperformed the confidence score method used in ASR. Deep learning approaches have achieved significant accuracies in ASR. CNN is key player in achieving these accuracies. Mostly less than 10 layers CNN architecture is used to design models for learning features. But Yisen Wang proposed deep and wide CNN architecture. This architecture is known as RCNN-CTC, it consists of residual connections and connectionist temporal classification loss function [25]. Resulting in 14.92% W.E.R on WSJ dev93 and 6.52% W.E.R on Tencent chat datasets.

One of the core difficulties in automatic speech recognition is noise. Because real-time speech data are filled with different noises like background noises, sampling rates, and codec distortion. Google recently published research to overcome this issue [42]. They trained their model on 162,000 hours of speech. Their goal is to make a generally robust system. Previously most of the models are domain robust, like noise. Google applied various techniques to ensure the robustness of the system by using multiple codecs for encoding inputs in the presence of background noise [43]. More interestingly their model performs very well in new unseen conditions. Their multidomain model trained on 10 hours of data outperformed a model trained for 700 hours of speech data on a new domain only [44].

The survey of previous ASR methodologies is also described in Table 1.

All of the abovementioned outstanding results provide an overview of ASR history and development. But there is one common problem with all these systems, which is non-native English accents. All datasets, used for those training, are recorded or collected from native English-speaking sources, which are different from South Asian English accents. Our proposed system is for the recognition of English language specifically for the non-native English accent as Asian accent is different from native English language, by reducing the (W.E.R) on South Asian accent. Our framework will perceive and create interpretation of human voice utilizing DeepSpeech2, where a few adjustments are suggested in the system layers.

3. Methodology

This paper makes a contribution toward automatic speech recognition for English language in native English and non-native English accents. This research work is inspired by DeepSpeech2 model for English and Mandarin languages. The whole system architecture is shown in Figure 1. The first step involves the preprocessing of the dataset, the second part is feature extraction from audio signals, and the third part is proposed two pipelined CNN-RNN models. The last stage of the system is the decoder, which is used for post-processing of the predicted transcriptions. Each module of the proposed system is explained below:

3.1. Data Preprocessing. Common voice (CV) dataset was not recorded in a controlled environment, which means that volunteers used their own devices for the recording of CV dataset. The recording was completed with the help of microphones and Internet browsers. Due to the fact that the recording took place in an uncontrolled environment, too much noise was introduced in the background of recorded audio, for instance, the distortion at the beginning of the audio, similar to the noise generated by the microphone,

Table 1: Literature survey of previous methodologies.

Year	Paper	Methodology	Language	Accent	WER
2021	[45]	Unsupervised CNN	English	—	12.83
2021	[46]	RNN encoder-decoder + CTC	English	—	8.3
2021	[47]	Quantifying bias	Dutch	—	16.85
2022	[48]	Transformers	English	—	39.9
2022	[49]	Semisupervised learning	English	—	9.4
2022	Proposed	Multi pipeline feature extractor learning	English	Native + South Asian	7

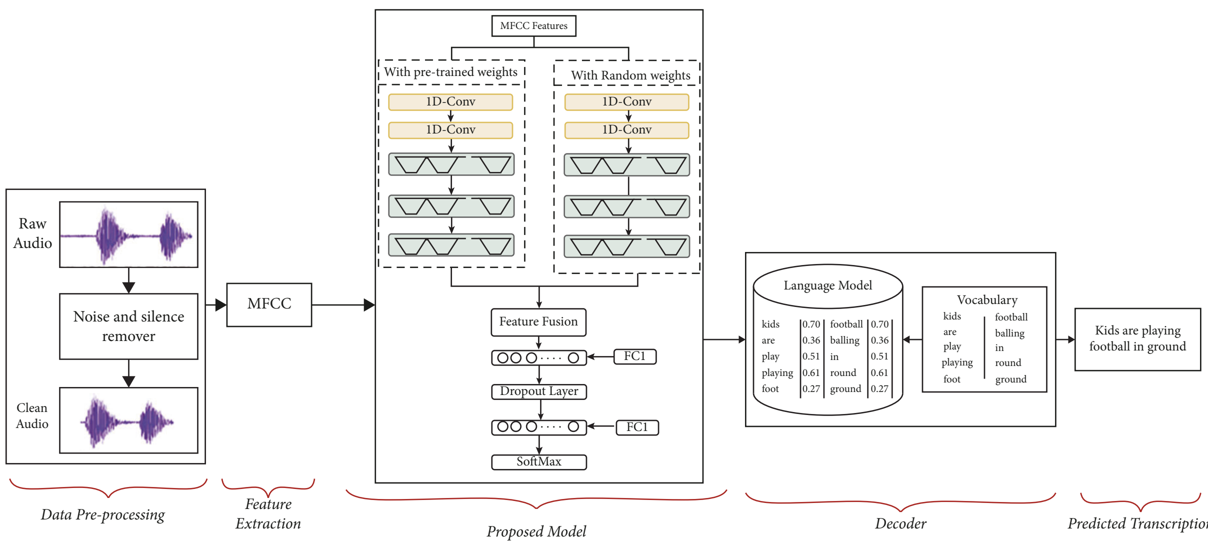

Figure 1: System architecture of the proposed system.

when plugged into the port. Moreover, it has empty gaps (unnecessary silences) between the words and sentences, for example, the speaker starts speaking after 0.5 to 1.5 second delay, and sometimes takes a long stay in between two sentences while reading paragraphs. Thus, CV dataset was useless in raw form and required tons of cleaning and preprocessing. We have cleaned all of South Asian separated audio files by removing the noise and deleting silences between sentences. We employed a self-generated Algorithm 1 to scan each audio file and perform the following activities on it to make sure data are useable for training and prediction. The preprocessing steps include as follows:

(1) Deletion of empty audio files

(2) Elimination of unnecessary silences between the sentences and words

(3) Removal of loud noisy sounds from the beginning of recordings

(4) Extraction of audio file in the FLAC format as per the requirement of network

In order to remove silence and loud noisy sounds, we used zero crossing rate (ZCR) methodology [50]. It is observed that speech section of audio file computes a low zero crossing value and in silent parts, it gives a higher zero crossing value [51]. It is because of the fact that zero crossing count indicates frequency, which is concentrated by energy in the spectrum of voice signals. Vocal sounds are produced by repeated flow of air through the glottis by excitation of the vocal tract, which usually generates a low zero crossing count. Whereas speech other than voice is formed by a narrow vocal tract to cause turbulent airflow that will eventually result in noisy sound and outputs a high zero crossing count.

$$\text{Z.C.R} = \frac{1}{T-1}\sum_{t=1}^{-1} I_R < 0\left(S_t, S_{t-1}\right), \tag{1}$$

where S = Signal, T = Length of Signal, T = time,

After filtering audio files, we saved it to FLAC format because FLAC files are better in audio quality than mp3. The visual representation of audio signal before and after preprocessing is shown in Figure 2.

3.2. Feature Extraction. The MFCC features are used as input for the model. In the last few decades, these features show very excellent results in automatic speech recognition, semantic analysis through speech, gender classification, and emotion recognition through speech. MFCC features are calculated by the given equation as follows:

$$C_n = \sum_{j=1}^{J} \log(E(j))\cos\left[n\left(j - \frac{1}{2}\frac{\pi}{m}\right)\right], \quad \text{for } n = 1, 2, 3, \ldots, k, \tag{2}$$

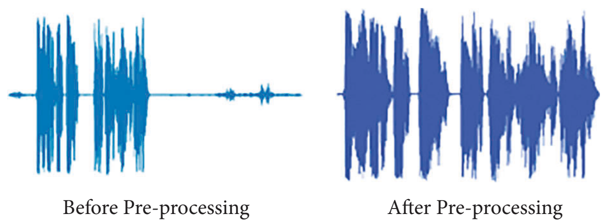

Figure 2: Audio signal processing to remove unnecessary silence and noise.

here $E\ (J)$ is DFT bin energies that are obtained by the following equation:

$$E(J) = \sum W_k(f)|x(f)|^2. \quad (3)$$

The proposed model also implements the attention mechanism to weight the extracted features. The functionality of the attention layer can be expressed through the following equation:

$$C(i) = \sum_{i=1}^{n} a_i f_i, \quad (4)$$

here a_i represents the attention score of ith features and f_i is the actual value of ith feature.

3.3. Proposed Network. The proposed network architecture of DeepSpeech2 has been used with an extra pipeline for non-native English accents and a novel loss function described in the loss function section. The DeepSpeech2 architecture contains two 1D convolution layers, three bidirectional RNN layers, and one fully connected layer. The 1D convolution layers extract the features from the signal by convolving the 1D-kernel over the Mel frequency cepstral coefficients (MFCC) features, where RNN layer is a state full layer, that extracts the temporal information from the features extracted by convolution layers. The fully connected layer then predicts the text using the features extracted by both convolutional and RNN layers. The proposed model consists of two pipelines of convolution layers. These two pipelines are introduced to extract features of English and non-native English accents. As the DeepSpeech2 model was trained on the English accent dataset so, we used the DeepSpeech2 model with its trained weights to extract English accent features. The structure of the second pipeline is same as DeepSpeech2 model having initial DeepSpeech2 weights that are further fine-tuned using non-native English accent dataset.

MFCC features have been used as input for both pipelines of model. First convolution layer contains 32 filters of size $11 \times 41 \times 1$ with a stride size of 3×2. Second convolution layer contains 32 filters of size 11×21 with a stride size of 1×2. Both convolution layers perform padding to avoid the down sampling of data. Three bidirectional RNN layers are stacked followed by convolution layers. The last bidirectional RNN layer of both pipelines out 2,048 features. The features from both pipelines are concatenated and further passed to FC1 layer having 4,096 neurons. Now the

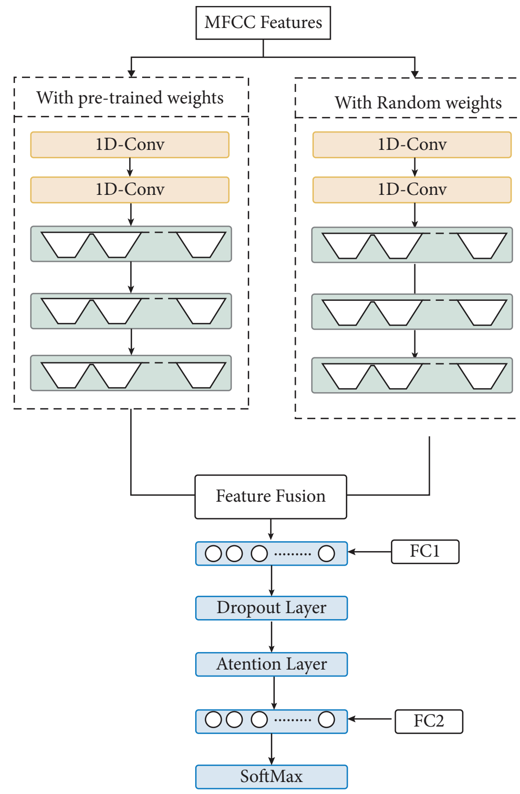

Figure 3: Proposed network architecture.

proposed network extracts double features $(2048 + 2048 = 4096)$ than deep speech features (2048). The excess of features leads the network to overfit. To avoid overfitting dropout layer is used after FC1 layer. An attention layer is also introduced after the dropout layer for weighting the features from English and non-native English accent pipelines. The weighted features are further passed to FC2 layer having a number of neurons equal to vocabulary size. The softmax layer is used to predict the probability of each character. The probabilities of each character can be calculated by the following equation (5):

$$p(c) = \frac{e^c}{\sum_{k=1}^{k} e^c}, \quad (5)$$

here $p\ (c)$ shows the probability of z class and e^c shows the score of z class that is produced by FC2 layer. K represent the size of the vocabulary.

The architecture of the proposed network is shown in Figure 3.

3.4. Decoder. The transcriptions produced by the model are mostly correct without English language constraints like spacing and sentence boundary, etc. To handle this problem a language model is used by Amodei [24]. We extend the vocabulary of LibriSpeech dataset [52] with the common voice dataset's transcriptions. A decoder is developed using a language model and vocabulary that accepts the predicted transcriptions from RNN model and produced the

```
Read CSV of common voice dataset
Choose “Pakistani,” “Indian,” “Dutch,” and “Sri-Lankan” accent rows from country column
Select “filename” columns from CSV file
Create a dictionary for JSON file writing
for i in filename do
flacConvert(i)
SilenceRemover(i)
Duration(i)
Finding transcript with respect to audio file
for lineIndex in range(x) do
transcript = split[lineIndex]
Write JSON file
data = {“audio_filepath”: “1.FLAC,” “duration”: duration, “text”: transcript}
with open(‘json-other-train.txt,” “a”) as outfile:
json.dump(data, outfile)
end for
end for
flacConvert(i) (Convert mp3 -> FLAC)
Calculate audio file length
Calculate audio file sample rates
Calculate duration = audio file length/sample rate
Calculate loudness
Calculate peak amplitude
Splitting audio file into chunks with silence > 0.5 second (considering it silent if quieter than −16 dBFS)
for chunk in enumerate (chunks) do
List.Append(chunk)
end for
```

Algorithm 1: Dataset preprocessing algorithm.

Table 2: Sample transcriptions generated by proposed model and decoded by the language model.

RNN output	Decoder output
Kids are playing foot balling round	Kids are playing football on the ground
She is trying together toys	She is trying to get her toys
Birds flying roups	Birds fly in groups

transcription that satisfies the English language constraints as shown in Table 2.

4. Experiments and Results

In this section, the experimental setup of model training, evaluation measure, and results are discussed.

Table 3: Different configuration settings for non-native English accent pipeline.

Configuration	Freeze layer	Training layer
A	None	Conv, RNN, and FC
B	Conv and FC	RNN
C	Conv	RNN and FC

4.1. Experimental Setup. The training is done for three different layer configurations of the network. In configuration A, the convolutional layer freezes, and learning of RNN layer and FC layers takes place by modifying their weights. Configuration B is made by freezing the convolution layer and FC layer and modifying weights of RNN layer. In configuration C, the RNN and FC layers are frozen and let the convolution layers learn. These three configurations are shown in Table 3.

While training, one pipeline for non-native English accent was trained and the other pipeline was used as is with pretrained weights of the original DeepSpeech2 model. The English accent pipeline was freezed by setting the learning rate 0 for all layers. The proceeding implementation details for non-native English accent pipeline.

The training of model is done using ReLU activation in all of the layers. The proposed loss function as discussed in Section 4.1.1 is used as a criterion. Stochastic gradient descent (SGD) optimizer is used with dynamic learning rate, starting from $l = 1 \times e^{-3}$ with decay rate of $1 \times e^{-1}$. The model is trained for 200 epochs. The experiments are performed on the system having Nvidia’s 1080 Ti GPU having 3584 Cuda cores and 11 GB cud memory. The system contains 16 GB DDR3 RAM and a 2.8 quad-core processor. The total dataset is split in a 70–30 ratio. A total of 70% of the data are utilized for learning the model and the remaining 30% of data are used to evaluate the learning of the model. The model’s architecture is designed and trained on paddle paddle framework. Some of the main python libraries for data manipulation and audio signal processing are used such as Pandas, Numpy, SciKit, and PyAudio.

The model hyperparameters are shown in Table 4.

4.1.1. Loss Function. Most existing ASR models were optimized using some cost functions that take the predicted output y' and ground truth y. The difference y and y' is used to optimize the model parameters. The proposed optimization technique intends to reduce the feature gap between the South Asian and European accents. So, the proposed loss calculation function uses the features of South Asian and European accent audio from FC2 layer, and the mean square difference of these features is used as a loss to optimize the model parameters as shown in the following equation:

$$d(a,e) = \frac{1}{N}\sqrt{(a_1 - e_1)^2 + (a_2 - e_2)^2 + \cdots + (a_i - e_i)^2 + \cdots + (a_n - e_n)^2}, \tag{6}$$

here a is feature vector of South Asian accent and e is feature vector of European accent on the same transcription and N is number of samples. The objective of this loss function is to decrease the difference between the feature vector of South Asian and European accents to reduce the accuracy gap in ASR for South Asian and European accents.

4.2. Dataset. We have used common voice [53] dataset for fine-tuning of DeepSpeech2 [54] models. common voice dataset was recorded for more than 18 languages by Mozilla for the purpose of research. It consists of total 1087 hours of audio files, from which 780 hours were validated with transcription. This dataset was recorded with both male and female voices with the ratio of 47% and 11% at a sampling frequency of 16 kHz. A detailed description of dataset accent according to the region is listed in Table 5.

As stated earlier, we are focusing on non-native English accents, so we used a subset of this dataset by filtering out Pakistani, Indian, Dutch, and Sri-Lankan speaker's recordings, with the help of Algorithm 1. Because accent variation is affected by the geographical area in which the speaker grows up and lives as well as by factors such as social class, culture, education, and working environment. All of these factors have an impact on the accuracy of the automatic speech recognition system. After splitting desired recorded files, we got a total of 10,219 audio files with an average playtime of 5 seconds. Table 6 shows the further splitting of training and testing classes accordingly with respect to gender.

4.3. Evaluation Measures. The model evaluation parameters that we have selected are word error rate (WER), match error rate (MER), and word information rate (WIR).

4.3.1. Word Error Rate. WER is one of the most common evaluation parameters for ASR models and it provides a good comparison between the results of our proposed model and other related work done so far. The WER tells the rate of error in the transcript generated by ASR by comparing it to the original transcript. It can be calculated by the following equation:

$$\text{W.E.R} = \frac{S + I + D}{N}, \tag{7}$$

where N is the total number of words spoken in the original transcript.

$$N = S + D + H, \tag{8}$$

here, S is the number of substitutions. I is the number of insertions, D is the number of deletions, and H is the total number of hits, i.e., correctly transcribed words.

4.3.2. Match Error Rate. Match error rate tells the probability of given input-output word matches being incorrect. It can be calculated by equation.

$$\text{M.E.R} = \frac{S + I + D}{H + S + I + D} = 1 - \frac{H}{N}. \tag{9}$$

Unlike in WER, here N is sum of all four terms.

$$N = H + S + I + D. \tag{10}$$

4.3.3. Word Information Loss. Word information loss gives the probability of any input word is matched with an equal output word and vice versa. It can be calculated by equation.

Table 4: Parameters and their values while implementation.

Parameters	Value
Operating system	Ubuntu 18.04
Frame work	Paddle paddle
Language	Python 3.7
CPU	Core-i7 (7th gen.)
RAM	16 GB (DDR3)
GPU	1080 Ti (11 GB memory, 3584 cores)
Batch size	256
Epochs	200
Drop out	0.4
Learning rate	$l = 1 \times e^{-3}$
Loss function	Proposed Section 4.1.1
Optimizer	SGD

Table 5: Percentage of different English accents in common voice dataset.

Share (%)	Accent
23	United States English
9	England English
4	India and south Asia (India, Pakistan, and Sri Lanka)
3	Canadian English
3	Australian English
1	New Zealand English
1	Southern African (South Africa, Zimbabwe, and Namibia)
1	Scottish English

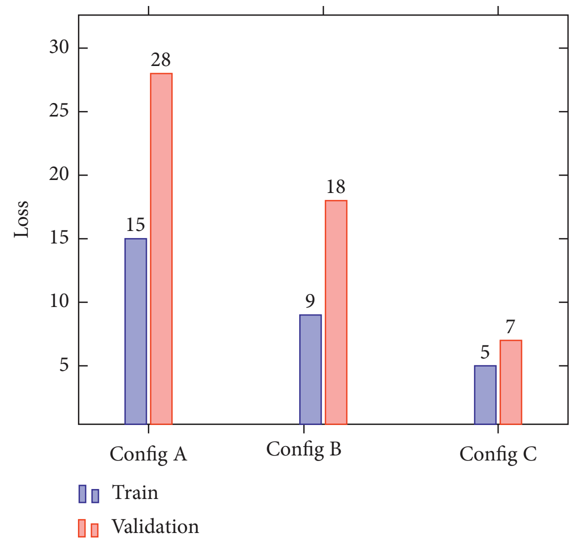

Figure 4: The image shows a calculated loss after training and validation at config A, config B, and config C.

$$\text{W.I.L} = \frac{H^2}{(H+S+I)(H+S+D)}. \tag{11}$$

All three evaluation metrics represent the errors and loss in the output, hence, the lesser the value is, the better the model predicts. However, WER is not an actual percentage as it has no upper bound limit because of the insertion I parameter. So, WER can only be used to compare different models while MER and WIL can be interpreted as how well the model performs.

4.4. Results. Before any modifications happened in DeepSpeech2, we loaded pretrained model on LibriSpeech dataset. As the majority of speakers of this dataset were from US, the model achieved WER of around 6% on the test set on US English accents. As the model was trained on American people and the test was also containing American people, that is why we obtained 6% WER. However, the same model, when evaluated using common voice dataset, gave a drastically high WER of 43% for South Asian accents. The reason for 43% WER is pretrained model of DeepSpeech2, which is not trained for non-native American or non-native English guys, that is why we use parallel pipeline for processing for the non-native English peoples. This is called a learning network. When it finds the input of non-native speakers for English it learns and updates its weights accordingly, meanwhile, we have frozen the learning rate for the freeze network, hence, we can save the performance of our model for the native English users and weights would not be changed for this pipeline. Whereas if the user is not-native English speaker then the learning network will entertain that user and update the weights. That is why our model is working better than other models due to its learning controls.

The training of DeepSpeech2 is done in three different layer configurations as mentioned in Table 3. The loss comparison graph of configurations A, B, and C is shown in Figure 4. The purpose of experimenting through these configurations is that we want to make DeepSpeech2 perform better for South Asian accents by transfer learning. We experimented with different dropout ratios and the best results were achieved with a dropout ratio 0.7. All the results shown here of different configurations have the same dropout ratio of 0.7.

(1) For configuration A, where all layers were learned using a common voice dataset, the model achieved W.E.R of 35.35% on the validation set. The training and validation cost of this modification is shown in Figure 5(a).

(2) For configuration B, the weights of RNN layer have been learned by freezing the both CNN and FC layers. In this configuration, the model retained its low-level features learned from LibriSpeech dataset and learned only the new high-level features from the common voice dataset. The WER achieved on the validation set is 20.419%. Training and validation cost for these configurations is shown in Figure 5(b).

(3) Finally, for configuration C, we learned the weights of RNN and FC layers by freezing the convolutional layer. W.E.R achieved on the validation set is 18.0859%. The cost of training and validation is shown in Figure 5(c).

(4) We performed fine tuning on both the European accent and South Asian accent datasets. The results deduced after fine-tuning showed that it behaved differently for both datasets, as for European accent the W.E.R increased from 6.8% to 7.0% whereas for South Asian accent W.E.R is reduced from 51% to 18.08%.

The WER, MER, and WIL rate of the model on test set are shown in Table 7.

We contrasted our DeepSpeech2 algorithm to Apple Dictation, Bing Speech, Google Speech API, and wit.ai, which are all for profit speech technologies. Our test is

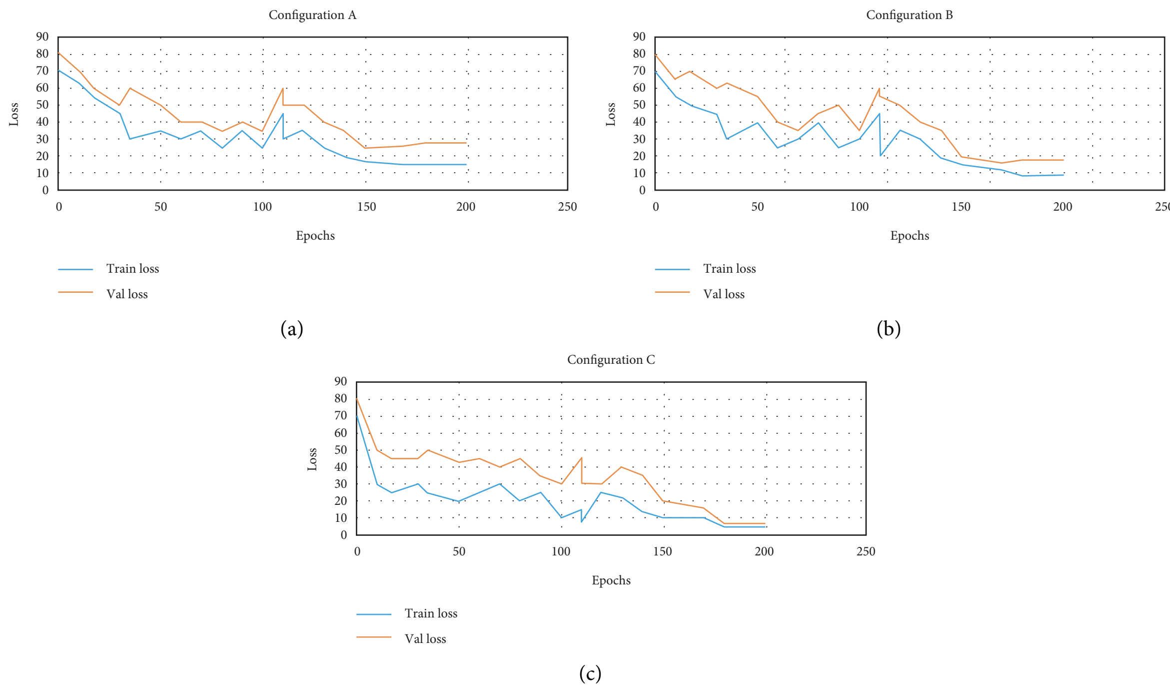

FIGURE 5: Training is done for 200 epochs. The cost or loss of training in different configurations is shown. (a) The trend of loss function for training and validation of the model in configuration A, (b) the trend of loss function for training and validation of model in configuration B, and (c) the minimum loss for training and validation of model in configuration C.

TABLE 6: Total number of audio files in training and test set of non-native English accents with respect to gender.

Utterances	Training set	Test set
Male	4,444	1,112
Female	3,730	933
Total	8,174	2,045

TABLE 7: Results of all three-layer configurations of the proposed model in terms of WER, MER, and WIL.

Config	South Asian accent			Western accent		
	WER (%)	MER (%)	WIL (%)	WER (%)	MER (%)	WIL (%)
A	35.35	29.68	30.98	10.36	12.65	11.22
B	20.419	18.54	19.35	9.68	8.69	9.85
C	18.0859	15.36	15.25	7.0	6.8	7.2

TABLE 8: The comparison between nonoptimized and optimized models with respect to WER and CER.

Model	Nonoptimized		Optimized	
	WER	CER	WER	CER
DeepSpeech2	15.57	4.52	—	—
DeepSpeech2 KENLMc	10.46	3.68	10.45	2.96
DeepSpeech2 KENLMo	10.75	3.79	10.66	2.89
DeepSpeech2 and KENLM (c + O)	9.9	3.61	9.91	2.80

intended to monitor success in noisy situations. This circumstance complicates the evaluation of web audio APIs: whenever the SNR is just too small or, in certain situations, whenever the phrase is too lengthy, such algorithms will provide no results. As an outcome, we limit our analysis to phrases under that all algorithms gave a not-a-void outcome. Table 8 shows the outcome of assessing each system on our test files.

Table 9: Comparison of DeepSpeech2 and proposed model's WER on English and non-native English accent.

Model	WER (English accent) (%)	WER (non-native English accent) (%)
DeepSpeech 2	6	43
Proposed	7	18.08

The comparison of the proposed model and DeepSpeech2 model is shown in Table 9.

5. Conclusion

ASR is being used extensively to enable natural human-machine interaction, but not pliable enough for South Asian accent for English language for which almost 200 million people are unable to use its applications. Our contribution towards resolving this obstacle is the proposed system, that is, inspired by DeepSpeech2. The proposed method provides the two pipelined deep learning architectures that achieve minimum character error rate (CER) and word error rate (WER) on common voice (CV) benchmark. By setting up different experimental configurations and modifications, we are successful in achieving minimum WER, that is, reduced from 43% to 18.08% at a lower validation cost. As this work focused on South Asian's English accents so, there is a little bit of increase in WER and CER for English speakers. The system will be further scalable towards targeting other South Asian languages like Bengali, Urdu, Hindi, and others with more robust datasets and higher accuracy and the training of both pipelines parallelly.

Data Availability

There are two datasets that are used in experiments for the proposed research. The first one is LibreSpeech dataset is audio signals in English language. The total length of the dataset is 1000 hours. The annotation is provided along the dataset in form of a transcription of the audio signal. The readers can find the dataset at this (https://www.openslr.org/12) link. The second dataset, that is, used for transfer learning of DeepSpeech2 is a common voice dataset version 7.0. This dataset also includes the audio signal and their transcription in English language. The total length of dataset is 2637 hours and 75879 different voices. The size of the total dataset is 65 GB. The reader can find the dataset at this (https://commonvoice.mozilla.org/en/datasets) link.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Intervention Methods of College Counselors on Students' Psychological Crisis under the Background of Deep Learning

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In order to quantitatively evaluate the effect of college counselors' intervention methods on students' psychological crisis, an evaluation model of college counselors' intervention methods on students' psychological crisis based on the deep learning model is put forward. The learning model function of college counselors' intervention in students' psychological crisis is constructed. By using the joint statistical feature analysis method, the dynamic factor analysis of college counselors' intervention in students' psychological crisis is established, and the machine learning model of college counselors' intervention in students' psychological crisis is constructed. By using the methods of big data fusion and correlation dimension feature analysis, combined with a fuzzy C-means clustering algorithm, the reliability evaluation of college counselors' intervention on students' psychological crisis and the construction of a large database are realized. By using the deep learning model, the parameters of college counselors' intervention model on students' psychological crisis are optimized and analyzed, and the methods of college counselors' intervention on students' psychological crisis are optimized and designed. The test shows that it is reliable and expandable to use this method for college counselors' intervention in students' psychological crisis, and it can establish the applicable technology of knowledge network to realize the correct intervention of college counselors in students' psychological crisis.

1. Introduction

Our country's new era of education puts forward the fundamental task of "cultivating morality and cultivating people," which has higher requirements for the development of Ideological and political education in Colleges and universities [1–3]. The most important thing to carry out ideological and political education is the psychological health education of college students. Therefore, in order to improve the quality of Ideological and political education, the quality of College Students' mental health education can not become a short board, and it is imperative to explore the related content of improving the quality of mental health education [4–6].

The evaluation of College Students' mental health education plays an irreplaceable role in improving the quality of education. Through the evaluation of College Students' mental health education [7], we can more intuitively show the progress and problems of a certain education stage. Under the background of the new era, the proposal of the educational concept of "cultivating morality and cultivating people" points out the direction for the mental health education in Colleges and universities, and further defines the value judgment and development direction of its quality. The evaluation of College Students' mental health education is a relatively weak part of the work system of College Students' mental health education, but it is also a key way and effective way to improve the quality of College Students' mental health education [8–10]. Therefore, according to the needs of the times, it is of practical significance to update and improve the evaluation system of College Students' mental health education. In a word, if we want to realize the mission of the times to improve the quality of College Students' mental health education, and then improve the quality of College Ideological and political education, we must adhere to the fundamental task of Building Morality and cultivating people, conform to the development of the times, stimulate the vitality of the times, and vigorously carry out the evaluation and research work of College Students' mental health education.

In order to improve the reliability of College Counselors' intervention on students' psychological crisis, this paper proposes an evaluation model of College Counselors' intervention on students' Psychological Crisis Based on the deep learning model. Construct the learning model function of College Counselors' psychological crisis intervention on students, adopt the joint statistical feature analysis method, establish the dynamic factor analysis of the process of College Counselors' psychological crisis intervention on students with the evaluation method, evaluation process, and evaluation index system as the hierarchical analysis structure model, Combined with the fuzzy c-means clustering algorithm, the reliability evaluation and large database construction of College Counselors' intervention on students' psychological crisis are realized. The deep learning model is adopted to optimize the analysis of College Counselors' intervention model parameters on students' psychological crisis, and the optimal design of College Counselors' intervention methods on students' psychological crisis is realized. Finally, the experimental test shows that this method is superior in improving the reliability of College Counselors' intervention to students' psychological crisis.

2. Evaluation Index System of College Counselors' Intervention Effect on Students' Psychological Crisis

2.1. Questionnaire Method and the Parameter Model of Evaluation Index for the Quality of College Counselors' Intervention on Students' Psychological Crisis. The psychological crisis of contemporary college students is mainly manifested in the following aspects:

(1) Unable to adapt to the school environment. The students in the University come from all over the country. Some people will have psychological pressure because they can not adapt to the environment such as the regional temperature, and they also can not adapt to the learning style, which leads to the normal graduation of college students, resulting in psychological crisis.

(2) Withdrawn personality and inferiority complex. There are often some lonely students in the university campus, and they are often the students from poor families. Because of their family circumstances, they often separate themselves from other students, and their interpersonal relations are indifferent; There are also some students who think that they have defects, poor talent, and appearance, and they will have an inferiority complex. This kind of psychology can not be pacified. Over time, students will close themselves up, leading to depression and even suicidal thoughts.

(3) Excessive anxiety and psychological depression. It is mainly reflected in poor academic performance, difficulty in eating and sleeping, and frustration in love life. This kind of students usually have pessimistic thoughts, have poor psychological endurance when encountering setbacks, are unwilling to communicate with others, and lose hope for life. Serious anxiety and psychological depression will lead to students' suicidal thoughts.

Therefore, it is very important to pay attention to the mental health education of college students. The evaluation goals of college students' mental health education can be classified in different ways according to different definition standards, such as short-term goals and long-term goals according to the time dimension, and macro goals and microgoals according to the space dimension. Generally speaking, the evaluation goals of college students' mental health education are mainly supervision, appraisal, and guidance for improvement. Influenced by Screvane's Evaluation Methodology, some scholars study the evaluation objectives according to different educational purposes [11]. For example, Zhang Dajun and Li Chen put forward the basic framework of the evaluation system of psychological quality education according to the enlightenment of the educational evaluation model. They think that there are generally three kinds of goals, namely, diagnostic goals, formative goals, and final goals. This goal setting is also the most widely recognized research mode at present. This paper analyzes the conceptual connotation and theoretical support of college counselors' evaluation on the quality of students' psychological crisis intervention. The route of empirical research is: to understand the current situation of ideological and political work under the network extension resource integration mode. Through questionnaire survey and case investigation, this paper sorts out the development vein of college counselors' intervention quality evaluation on students' psychological crisis in China and understands the actual needs of teachers, students, and administrators, thus laying a solid empirical foundation for the research. Finally, according to the results of theoretical research and empirical research, through logical analysis [12–14], taking the ideological and political work course under the network extension resource integration mode of Chinese universities as the object, this paper systematically analyzes the evaluation index system of college counselors' intervention quality of students' psychological crisis and discusses its operability in depth. The research roadmap is shown in Figure 1.

First of all, according to the research background and research status, the author makes an investigation and then puts forward the content to be studied. According to the research content, the intervention system of college counselors on students' psychological crisis is established, and the index parameters are further set. According to the parameters, the final research conclusions and suggestions are drawn.

2.2. Evaluation Parameter Fusion of College Counselors' Intervention Effect on Students' Psychological Crisis. This paper constructs the basic theoretical framework of the evaluation system of college counselors' intervention on students' psychological crisis, establishes the basic evaluation indexes, and uses the joint statistical feature analysis method to sort the sample level distribution sequence of the evaluation

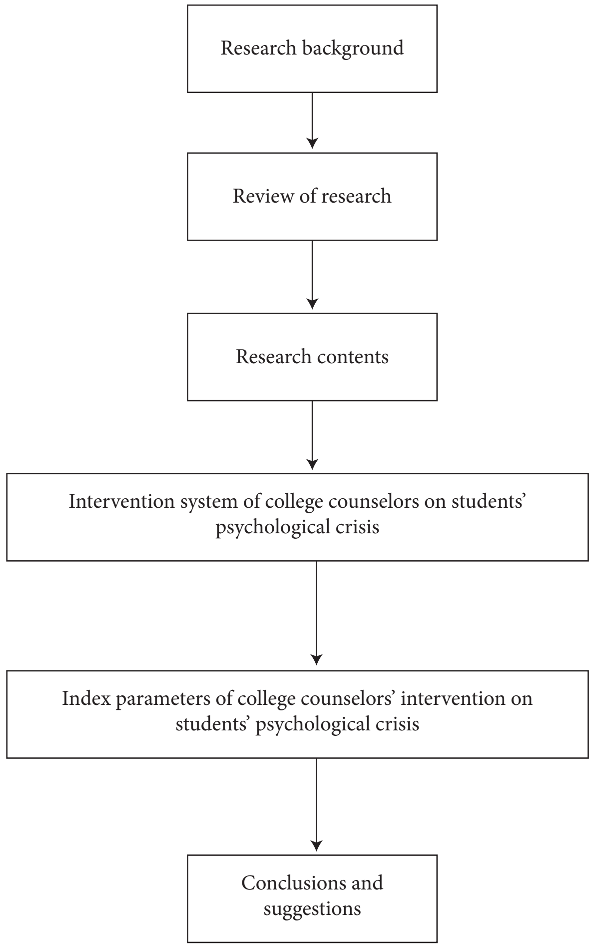

Figure 1: Technology roadmap.

indexes of college counselors' intervention on students' psychological crisis [15, 16]. Through the quantitative regression analysis method [17, 18], the mathematical description of the constraint optimization target of college counselors' intervention on students' psychological crisis is as follows:

$$\begin{aligned}&\min F(x) = [f_1(x), f_2(x), \ldots, f_n(x)],\\&subject.to.g_i(x) \leq 0\,(\text{or} \geq 0) \quad i = 1, 2, \ldots, n,\\&h_j(x) = \quad 0 j = 1, 2, \ldots, m,\end{aligned} \tag{1}$$

wherein, $f_i(x)\,(i = 1, 2, ..., n)$ is the objective letter of college counselors' intervention effect evaluation on students' psychological crisis, $g_i(x)$ is the inequality constraint condition of college counselors' intervention effect evaluation on students' psychological crisis, and $h_j(x)$ is the correlation statistical constraint condition. This paper introduces the ambiguity detection technology of college counselors' intervention characteristics in students' psychological crisis [19, 20], and estimates the effect of college counselors' intervention in students' psychological crisis. In the process of this research, the deep integration of theory and practice has been realized. The theoretical route is as follows: on the basis of analyzing the theory and practice of college counselors' intervention in students' psychological crisis, by examining the relationship between personality traits and mental health, and making clear the regulating effect of psychological capital on the relationship between them, the content information of personality traits and mental health can be fully excavated, and the theoretical basis can be provided for the future research of college students' personality traits and mental health.

The dominating set of college counselors' intervention effect estimation on students' psychological crisis: the dominating satisfaction of decision variables of college counselors' intervention effect estimation on students' psychological crisis: all x^*'s, and there is at least one $f_i(x^*) \leq f_i(x)$, where = 1, 2, ..., n, at this time, the dominating set of autocorrelation fuzzy state of college counselors' intervention effect estimation on students' psychological crisis satisfies local convergence.

For the discriminant statistic $X^* \in S$ of college counselors' intervention effect estimation on students' psychological crisis, if and only if there is a boundary constraint solution $X \in S$, all inequalities will be established. Among them, there is one $f_i(X^*) \leq f_i(X)$ in the distribution range of college counselors' intervention effect on students' psychological crisis, which makes the characteristic distribution of college counselors' intervention estimation on students' psychological crisis satisfy the strict inequality X^*, At this time, the statistics of college counselors' intervention effect estimation on students' psychological crisis is a multi-objective optimization problem. By obtaining the Pareto optimal solution of the objective function of college counselors' intervention effect estimation on students' psychological crisis, the convergence of the estimation model can be satisfied.

3. Optimization of the Evaluation Model of College Counselors' Intervention in Students' Psychological Crisis

3.1. Quantitative Analysis of the Effect of College Counselors' Intervention on Students' Psychological Crisis. Systematically investigate the relationship between personality traits and college students' mental health: at present, there is no measurement study of personality traits on the full dimension of college students' mental health, and there is a lack of relevant model construction. In the future, it will facilitate a more comprehensive and systematic understanding of the relationship between personality traits and college students' mental health.

The new version of the questionnaire is used to study the relationship between personality and college students' mental health: the traditional mental health measurement tools SCL-90 and UPI are abandoned, and the latest Chinese college students' mental health screening scale compiled by the Ministry of Education is adopted, which is more suitable for Chinese college students and can comprehensively measure their mental health. This paper determines the resource information of college counselors' intervention on students' psychological crisis, and gives the constraint function of college counselors' intervention on students' psychological crisis based on the big data fusion scheduling algorithm model [21–23]. Initialize the characteristic parameters of college counselors' intervention effect estimation on students' psychological crisis, and revise the redundant vector set in the conclusion. The optimal constraint index parameters of college counselors' intervention effect estimation on students' psychological crisis are as follows: the ambiguity function of college counselors' intervention effect estimation on students' psychological crisis is determined:

$$\begin{aligned} V_{ij}(g+1) &= V_{ij}(g) + c_1 r_{1ij}(g)\left[\mathrm{Pbest}_{ij}(g) - x_{ij}(g)\right] \\ &\quad + c_2 r_{2ij}(g)\left[\mathrm{Gbest}_j(g) - x_{ij}(g)\right], \end{aligned} \tag{2}$$

wherein, $V_{ij}(g)$ is the joint estimation parameter of evaluation index and evaluation function of college counselors' intervention on students' psychological crisis, c_1 is the adaptability factor of college counselors' intervention on students' psychological crisis, $r_{1ij}(g)$ is the ambiguity coefficient of college counselors' intervention on students' psychological crisis, $\mathrm{Pbest}_{ij}(g)$ is the explanatory parameter of college counselors' adaptability on students' psychological crisis, and $x_{ij}(g)$ is the statistical probability density function of college counselors' intervention on students' psychological crisis. For the distribution set of autocorrelation characteristics of $\mathrm{Gbest}_j(g)D$ college counselors' intervention on students' psychological crisis, a learning model of college counselors' intervention effect estimation on students' psychological crisis is set. Based on the fuzzy mathematical model, the number of nodes and vector elements of college counselors' intervention effect distribution on students' psychological crisis and the autocorrelation characteristic distribution vector of college counselors' intervention effect estimation on students' psychological crisis are obtained:

$$x(t) = \left(x_0(t), x_1(t), \ldots, x_{k-1}(t)\right)^T, \tag{3}$$

wherein, $x_0(t), x_1(t), \ldots, x_{k-1}(t)$ is a subsequence of the evaluation of college counselors' intervention effect on students' psychological crisis. Combining with the association rule mining method, the formal distribution feature set of association rule mining problem of college counselors' intervention effect evaluation on students' psychological crisis is given, and the weighting vector of college counselors' intervention effect evaluation on students' psychological crisis is obtained:

$$\mathrm{Gbest}_i(g+1) = \arg^{\min}_{\mathrm{Pbest}_{ij}} f\left(\mathrm{Pbest}_{ij}(g+1)\right), \tag{4}$$

wherein, $f(\mathrm{Pbest}_{ij}(g+1))$ represents the equilibrium scheduling parameter of college counselors' intervention on students' psychological crisis, and g is the association rule item of effect evaluation. The constraint parameter model of college counselors' intervention on students' psychological crisis is established.

According to the established constraint parameter model, we can know the information of College Students' psychological crisis intervention, analyze its feature similarity and feature distribution, and provide a basis for subsequent feature mining and data fusion analysis.

3.2. Mining the Characteristics of College Counselors' Intervention in Students' Psychological Crisis. By using the developmental characteristic analysis method of effect estimation [24, 25], the hierarchical structural characteristic analysis and data standardization fusion of college counselors' intervention effect on students' psychological crisis are carried out [26]. The correlation factor between X_i and X_j of college counselors' intervention effect on students' psychological crisis is described as the similarity between two characteristic quantities of college counselors' intervention effect on students' psychological crisis, which is expressed as follows:

$$l\left(X_i, X_j\right) = \left\|X_i - X_j\right\|, \tag{5}$$

wherein, X_i and X_j, respectively, represent the statistical time distribution sequence, and the above-mentioned distance similarity level represents the difference degree of college counselors' intervention effect estimation on students' psychological crisis. Through local convergence learning, the optimized weight subset $\{W_O\}_{i=1}^{N-m-a}$ of college counselors' intervention effect estimation on students' psychological crisis and the fuzzy parameter distribution subset of college counselors' intervention effect estimation on students' psychological crisis are obtained. Optimizing the distribution structure of college counselors' intervention quality of students' psychological crisis is expressed as follows:

$$\{W_O\}_{i=1}^{N-m-a} = \left\{\{x_O^i\}_{i=1}^{N-m-a}\right\}, \tag{6}$$

wherein, x_O^i is the characteristic quantity of college counselors' intervention in students' psychological crisis, and $\{x_O^i\}_{i=1}^{N-m-a}$ defines the evaluation range for the price system. If $(N_f/N) < \delta$, the sample attribute set of the evaluation index of college counselors' intervention quality in students' psychological crisis is recorded as $w'\Phi(x_i)$, and through the collaborative optimization method, The random simulation and association rule decision-making method are used to evaluate the effect of college counselors' intervention on students' psychological crisis. Random simulation refers to constructing a model similar to the intervention model and experimenting on the model to study the original model. Association rules are the process of discovering and analyzing the association between feature quantity similarity, time distribution sequence, and intervention quality distribution structure. Combined with random simulation dynamic detection and maximum matching analysis method, the evaluation model of college counselors' intervention on students' psychological crisis is as follows:

$$GD = \frac{\sqrt{\sum_{i=1}^{n} d_i^2}}{n}, \tag{7}$$

wherein, d_i is the evaluation standard adopted by the evaluators of college counselors' intervention effects on students' psychological crisis, and n is the dynamic distribution set of development effects. When $GD = 0$, the convergence formula of college counselors' intervention estimates on students' psychological crisis is expressed as follows:

$$DM = \frac{d_e + d_b + \sum_{i=1}^{n-1}\left|d_i - \left(\sum_{i-1}^{n-1} d_i/n - 1\right)\right|}{d_e + d_b + (n-1)\left(\sum_{i=1}^{n-1} d_i/n - 1\right)}, \tag{8}$$

wherein, d_e is the extreme point in the distribution set S_s of college counselors' intervention effect on students' psychological crisis, and d_b is the dynamic optimization function of college counselors on students' psychological crisis. To sum up, combined with random simulation dynamic detection and maximum matching analysis method, this paper evaluates the effect of college counselors' intervention on students' psychological crisis.

4. Empirical Analysis

SPSS statistical analysis software is used to conduct an experimental test on the evaluation of college counselors' intervention effect on students' psychological crisis. The reliability and validity test is to verify the reliability and consistency of the questionnaire. This study adopts the simplified Big Five Personality Scale (NEO-FFI) compiled by American psychologists Costa and McCrea (Mccrae, 1989) and translated by Chinese scholar Zhang Jianxin according to his own cultural background. There are 60 questions in this scale, which are divided into five subscales: neuroticism, openness, extroversion, conformity, and rigor. Each scale has l2 questions, which are scored by 5 points, of which 1 means "completely out of line with me" and 5 means "completely in line with me." Among them, 25 questions are scored in reverse. The reliability index of each sub-scale is good, among which the internal consistency reliability is 0.66–0.84 and the retest reliability is 0.86–0.90 (Mccrae, 1989). In addition, Yao Ruosong et al. (Yao Ruosong, Liang Leyao, 2010) further verified the applicability of the Big Five Personality Simplified Scale by taking college students as subjects, among which the internal consistency reliability of each subscale was between 0.63 and 0.78, and the model fitting index was good, which fully confirmed that NEO-FFI could be used to test Chinese college students. In this study, the internal consistency reliability is 0.80, among which the reliability indexes of neuroticism, extraversion, openness, conformity, and rigor are 0.86, 0.81, 0.67, 0.60, and 0.8 l, respectively, which have good reliability. Select the unified guidance language to distribute the questionnaire in the classroom, and collect it on the site after completion. The subjects of the test were 100 college students. The content of the questionnaire was the simplified Big Five personality scale, which was mainly related to the psychological problems of college students. The questionnaire star was used to distribute the network questionnaire, and then the received questionnaire was coded and entered, and the invalid questionnaire was deleted. Then, the statistical software such as SPSS and Amos was used to analyze the data. The analysis method based on the deep learning model is compared with principal component analysis (PCA) and analytic hierarchy process (AHP). See Table 1 for the first-level indicators, as shown in Table 2 for the distribution of second-level indicators.

Table 1: First-level indicators for the evaluation of the intervention effect of college counselors on students' psychological crisis.

Primary index	Serial number
Personal traits	INDEX1
Psychological capital	INDEX2
Addiction	INDEX3
Delusion	INDEX4

According to the above index parameters, the questionnaire method is used to evaluate the effect of ideological and political work, and the scores of each dimension of college students' mental health screening scale are analyzed from each dimension in Table 3.

Combined with relevant research, it can be found that, at present, the mental health problems of college students mainly involve emotions, interpersonal communication, psychological stress, environmental adaptation, inner conflict, networking, and so on. The content of college students' mental health mainly includes two aspects: the correction of mental problems and the development of mental health.

Table 2: Secondary indicators of college counselors' intervention on students' psychological crisis.

Index	Serial number	Contribution level	Confidence level	Support level
Professional teaching ability	ID11	0.913	0.616	0.233
College counselors' ability to intervene in students' psychological crisis	ID12	0.296	0.415	0.488
Professional background	ID13	0.227	0.864	0.492
College counselors' intervention attitude to students' psychological crisis	ID14	0.121	0.962	0.328
Perseverance of college counselors' intervention on students' psychological crisis	ID15	0.453	0.344	0.833
The research level of college counselors' intervention on students' psychological crisis	ID16	0.141	0.006	0.862
The content of college counselors' intervention on students' psychological crisis	ID17	0.408	0.002	0.842
The intervention methods of college counselors to students' psychological crisis	ID18	0.255	0.539	0.839
The intervention mode of college counselors to students' psychological crisis	ID19	0.953	0.712	0.534
College counselors' intervention and management of students' psychological crisis	ID20	0.854	0.266	0.510
College counselors' intervention on students' psychological crisis feeds back to the school.	ID21	0.611	0.669	0.460
College counselors' intervention on students' psychological crisis.	ID22	0.466	0.846	0.624
College counselors' intervention in students' psychological crisis suddenly originated from the construction.	ID23	0.168	0.322	0.202
Online resource student satisfaction	ID24	0.954	0.940	0.105
Cultivate lifelong learning awareness and ability	ID25	0.302	0.476	0.635
Achievement award	ID26	0.492	0.504	0.222
Examination	ID27	0.345	0.071	0.822

Table 3: Scores of each dimension of college students' mental health screening scale.

Parameter	Score
Illusion	0.776
Suicide intention	0.083
Anxiety and depression	0.195
Stubbornly biased	0.150
Self-abased	0.369
Sensitive	0.970
Social phobia	0.502
Somatization	0.776
Attack	0.554
Be on an impulse	0.214
Force	0.333
Internet addiction	0.364
Self-injury behavior	0.221
Eating behavior	0.445
Sleep disturbance	0.499
Difficulties with school adaptation	0.235
Interpersonal relationship trouble	0.501
Academic pressure	0.306
Employment pressure	0.973
Trouble in love	0.934

According to the statistical analysis of the parameter results in the table, the scatter diagram of college counselors' evaluation of students' psychological crisis intervention is shown in Figure 2.

According to Figure 2, in terms of hallucination, there are significant differences among students from different places of origin and educational background. The specific performance is as follows: (1) the scores of students in small towns are significantly higher than those in other places. There is no significant difference among other places of origin; (2) undergraduate students are significantly higher than master students.

In terms of suicide intention, there are significant differences among students of different genders and educational background, as follows: (1) the scores of girls are significantly higher than those of boys; (2) undergraduate students are higher than master students.

In terms of anxiety, there are significant differences among students of different genders, nationalities, and educational background, mainly as follows: (1) girls are higher than boys; (2) the minority nationality is higher than the Han nationality; (3) undergraduate students are higher than master students.

In terms of depression, there are significant differences among different genders, places of origin, and educational background, mainly as follows: (1) girls are significantly higher than boys; (2) the number of students in small towns is significantly higher than that in big cities, and there is no significant difference among other students' places of origin; (3) the number of undergraduates is higher than that of master students.

In terms of bigotry, there are significant differences between different genders and educational background, mainly as follows: (1) girls are significantly higher than boys; (2) undergraduate students are higher than master students.

In terms of inferiority, there are significant differences among different genders, nationalities, and educational background, mainly as follows: (1) girls are significantly higher than boys; (2) minority nationality is significantly higher than Han nationality; (3) undergraduate students are higher than master students.

Sensitive aspects. There are significant differences among different genders, nationalities, educational background, and majors. The main manifestations are: (l) girls are significantly higher than boys; (2) minority nationality is

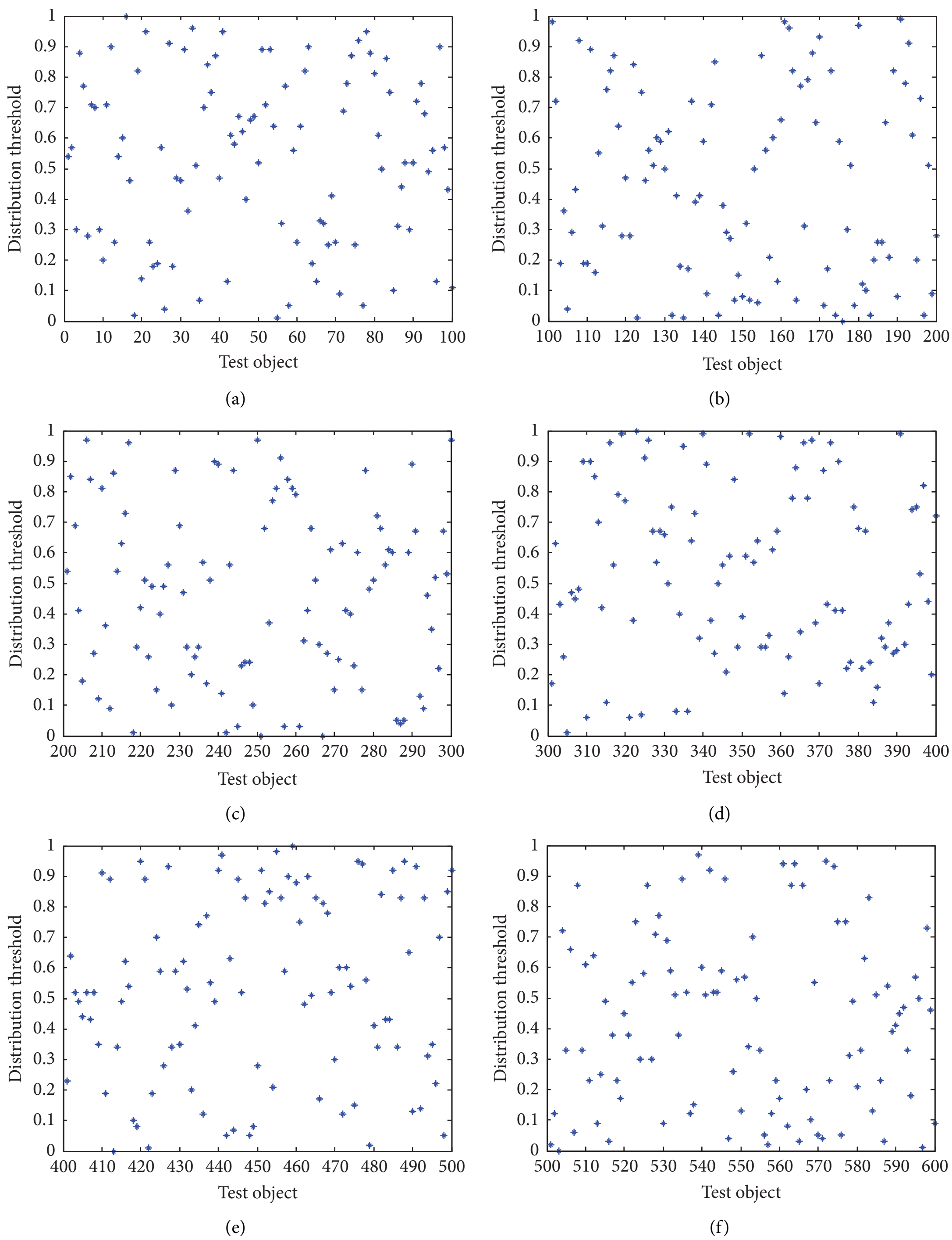

FIGURE 2: Scatter diagram of college counselors' evaluation of students' psychological crisis intervention. (a) Anxiety aspect. (b) Delusion. (c) Suicide intention. (d) Depression aspect. (e) Paranoia. (f) Inferiority.

significantly higher than Han nationality; (3) undergraduate students are higher than master students; (4) the scores of liberal arts students are significantly higher than those of science students and engineering students, and there is no significant difference between science students and engineering students.

The reliability analysis results of college counselors' intervention effect evaluation on students' psychological crisis are shown in Figure 3.

To sum up, neuroticism, conformity, and rigor in personality traits can significantly predict college students' mental health and are the key personality factors to

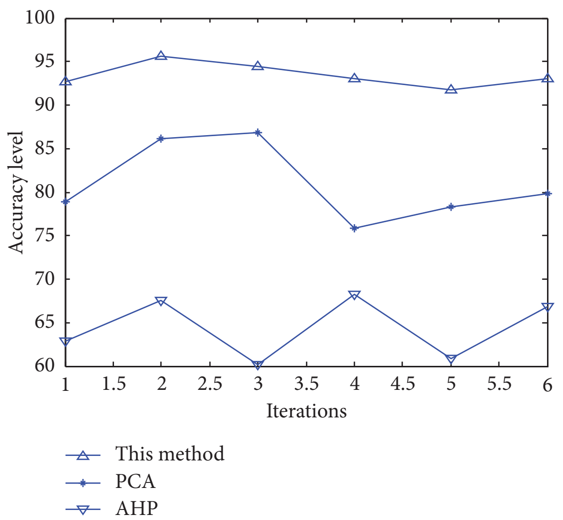

Figure 3: Reliability of evaluation of college counselors' intervention effect on students' psychological crisis.

investigate college students' mental health problems. Compared with the stage and variability of mental health, personality is a relatively stable trait of an individual's long-term development. And, the external performance is more obvious, which is easier for us to observe and evaluate. Therefore. We can further predict the mental health problems that may occur in the future through the individual's personality traits and effectively prevent them. Find problems and solve them in time. This is more conducive to the development of school mental health work and promotes the comprehensive and mature development of students' personality and mental health.

5. Conclusions

The direction of mental health work in colleges and universities can be adjusted appropriately, instead of focusing on problem orientation, the emphasis should be on prevention and maintenance. According to the psychological evaluation results, establish system files; according to the effective prediction model, pay attention to key people; at the same time, when encountering psychological crisis and counseling problems, we often need some stable information to help solve them. For this reason, we can borrow the characteristics of a stable personality and easy investigation. To predict and discover students' potential mental health problems. Construct a personality prediction model. Find problems in time and solve them effectively. For example, paying attention to individual personality traits such as neuroticism, conformity, and rigor, especially students with prominent neuroticism, need to pay more attention. It can predict all aspects of mental health problems, especially depression.

(1) Based on simple description and statistics, it is found that there are significant differences in demographic variables such as nationality, place of origin, gender, only child, educational background and major among college students' personality traits, mental health, the total level of psychological capital, and all dimensions. At the same time, from the analysis of the mental health status quo, college students have higher scores in employment pressure, academic pressure, and Internet addiction.

(2) According to the prediction model of personality on all dimensions of college students' mental health, neuroticism has a significant positive prediction effect on all dimensions of mental health problems, while conformity and rigor have a significant negative prediction effect on all dimensions of mental health problems. On this basis, the prediction model of this huge student group is further compared. It is found that there are differences between them, which mainly show that nervousness, compliance, and rigor among undergraduates have significant predictive effects on all dimensions of mental health problems, in which nervousness is a positive predictor, while rigor and compliance are negative predictors; However, the neuroticism of master students has a significant positive predictive effect on all dimensions of mental health.

(3) According to the multigroup simultaneous comparison model, it is concluded that psychological capital has a moderating effect in the all-dimensional model of personality prediction of mental health. In addition, there are significant differences between high and low psychological capital groups in the paths of some dimensions of mental health, as follows: suicidal intention, sensitivity, impulsiveness, compulsion, Internet addiction, and sleep disturbance. The low psychological capital group is significantly higher than the high psychological capital group, while the high psychological capital group is significantly higher in the paths of paranoia, hostile aggression, school adjustment difficulties, interpersonal troubles, academic pressure, employment pressure, and love disturbance.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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Research Article

The Establishment of College Student Employment Guidance System Integrating Artificial Intelligence and Civic Education

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A logical and appropriate job advising system for college students is the only way to address the current dire work scenario for recent graduates in a society that is becoming more and more competitive. The process of building new career advice systems for college students is still fraught with many major issues. Existing problems are manifested in the lack of a perfect employment guidance system for college students and a lack of effective ideological and political education, which leads to the inability of college students to establish a correct employment concept. At the same time, the recommendation method used in the current college student employment guidance system is not reasonable enough and only considers students' one-way preference for employment units. Then, the history of one user's employment is likely to lead to unreliable negative samples, which affects the recommendation performance. In addition, the current employment recommendation system cannot fully integrate the service function, management function, education function, and research function of the employment guidance system. In this paper, we address the aforementioned issues and propose an unique career counseling system for college students by combining algorithmic recommendation with ideological and political education. The system adaptively aggregates the preferences and needs of students and employers and fully integrates several functions of the student career competence and career guidance system. The experimental results show that the establishment of a college students' employment guidance system integrating artificial intelligence (AI) and civic education not only has better interpretability compared with the traditional employment guidance system but also has a higher area under curve (AUC). Furthermore, we also discuss the importance of ideological and political education and referral systems in the work of the career guidance system through ablation experiments. The results show that the AUC values of integrating ideological and political education and recommender systems were higher than those of integrating only ideological and political education or recommender systems. Therefore, establishing an employment guidance system for college students that integrates AI and civic education can effectively guide students' employment. At the same time, the college student employment guidance system proposed in this paper can offer employment guidance courses in colleges and universities, help graduates to solve their doubts, and make graduates adjust their psychological state in the process of job hunting.

1. Introduction

In recent years, the number of college graduates has been increasing year by year. The employment of graduates has been an unprecedented challenge. Whether college students can successfully find employment after graduation has become a universal concern of the whole society. With the reform of the market-oriented employment system and the expansion of college enrollment, the employment situation faced by college students is becoming more and more severe. Many graduates face the problem of unemployment after graduation. The development and improvement of a college students' employment guidance system, as well as the guidance and service of college students' employment, are receiving increasing attention from society [1]. In response to the problem of the difficult employment of graduated college students, all colleges and universities around the world have established various kinds of college students' employment guidance systems. The establishment of a scientific college students' employment guidance system can not only improve the employability of college students but also improve the value of human resources and create conditions for society to establish a fair and stable employment environment [2, 3].

The United Kingdom (UK) is the first country to pay attention to the establishment of a career guidance system for college students. Nowadays, the career guidance system of college students in the UK is well developed and can make the coordination between society, school, and the state more coordinated. Reviewing the history of the development of college students' career guidance systems, in the 1960s, the British career guidance service entered a rapid development stage. The college student employment guidance system has helped many graduates find suitable jobs. The results of a report point out that career guidance for graduates needs to evolve with the times while suggesting that major universities should set up their own career guidance agencies to be responsible for career guidance services for college graduates [4, 5]. This report also describes how the basic framework of a career guidance system in UK universities should include key elements such as counseling services, advice information, contacting employers, and arranging job interviews. In 2011, European countries, represented by the UK, discussed that the direction of the career guidance system is to upgrade career guidance to lifelong career guidance, in which three strategies were also proposed. First, we should improve the ability of employment guidance personnel and ensure the quality of employment guidance. Second, the government should integrate the labor market and labor resources and analyze the influencing factors of the job market and resources [6, 7]. Third, society needs to give full play to the role of public employment service in employment guidance. On the other hand, Elaine Collinson emphasizes that small and medium-sized enterprises have greater potential to accommodate college students' employment and proposes that the employment guidance system includes employment guidance institutions, employment guidance tools, and employment guidance content. Elaine Collinson also specifies that the government should promote the ideological and political education of college students in career guidance institutions as well as add entrepreneurship education courses to the career guidance curriculum [8, 9].

In 2010, there were 5.754 million graduates from regular institutions of higher learning nationwide, and the number of graduates in 2021 is expected to reach 9.09 million. Over the past decade, the total number of college graduates has increased significantly, and their employment has also changed a lot with the development of the social economy. After long-term development and summary, the function of a college student's employment guidance system can be described in the following four aspects. First of all, the most important thing is the service function. The essence of the college student employment guidance system is to complete the employment service function in the university field. Therefore, in the career guidance system of college students, career guidance is a service that is student-centered and enthusiastic about serving students. The employment guidance system for college students tracks the state of the labor market, investigates, examines, and anticipates its trends and changes, and serves as a foundation for developing and carrying out the school's primary setting, curriculum, and training plan. Additionally, it records and looks into college students' career status as well as how society perceives graduates [10, 11]. On this basis, the school offers students rigorous course instruction to assist college students in choosing the best path to a smooth transition into the workforce. In the coming period, the function of the college career guidance service system will be further changed to strengthen the service, dilute the management, and enhance the overall consciousness, service consciousness, and quality consciousness [12, 13]. At the same time, the college employment guidance service system will vigorously promote the employment and market-oriented higher education reform and promote the sustainable development of higher education. To better serve the students, the career advice staff will gradually become more competent and knowledgeable. Second, the college students' career guidance service system has a management function. The management responsibilities include being responsible for the connection between the school and enterprises, government, talents, and the market, creating a communication platform for students and enterprises, and building and managing the career guidance team. Employment guidance in colleges and universities has moved from education management to service guidance, forming a graduate employment guidance system with service function as the main focus [14, 15]. However, the above phenomenon does not mean that the employment guidance system of college graduates does not need education management, and the two are not mutually exclusive, but promote each other. In addition, the employment guidance system for college graduates also assumes the function of education for students' employment and infiltrates the employment guidance concept of colleges and universities into the teaching mode to stimulate students to consolidate their professional theoretical foundation and strengthen their practice. Finally, research is another component of the college student employment advice system. The school keeps track of the employment status of graduates and the evaluation and requirements of the society on graduation, so as to keep abreast of the development trends of career and workplace. The employment guidance system for college graduates can analyze and predict the trends in the job market and career development through the collected information and provide a reference basis for the formulation and implementation of the school's major setting, curriculum setting, and cultivation plan [16].

In order to give full play to the function of the employment guidance system for college graduates, colleges and universities should also make it clear that employment guidance and service work is an important part of school quality education. At the same time, employment guidance and service is also an effective way of moral education in colleges and universities. Employment guidance, service, and ideological and political education are inseparable. Employment guidance and service should be combined with ideological and political education to help college students find employment successfully [17, 18]. Employment guidance and service are the most important components of the employment guidance system for college graduates, which take career planning and ideal belief education as its core to help graduates establish a correct concept of career selection. The career guidance teachers of college students in colleges and universities first provide guidance to graduates in employment and further provide ideological and political education to graduates, which will strongly promote the innovation and expansion of the ideological and political education of schools in terms of form and content. The objectives and requirements of ideological and political education are permeated throughout employment guidance and services, and the effects of ideological and political education are also reflected through employment guidance and services. At present, graduates' thoughts are complicated by factors such as social environment and employment situation. Attention should be paid to strengthening the ideological and political education of graduates in employment guidance and services. Teachers should help students establish a correct view of employment through ideological and political education.

However, with the rapid development of society and the economy, the previously established college career guidance system has gradually revealed some fatal problems. On the one hand, the employment guidance system for college students is not perfect and lacks effective ideological and political education, which leads to the inability of college students to establish a correct employment concept. On the other hand, the recommendation method used in the current college students' employment system is not reasonable enough, only considering students' one-way preferences for employment units, and the historical records of one user's one employment easily lead to unreliable negative samples, which affect the recommendation performance [19]. At the same time, the current employment recommendation system cannot fully integrate the service function, management function, education function, and research function of the employment guidance system. Therefore, in view of the above-mentioned problems, this paper first elaborates the importance and key points of ideological and political education in the establishment of college students' employment guidance system, so as to draw the attention of educators [20]. We adopt the method of integrating recommendation algorithms and ideological and political education to establish a set of novel employment guidance systems for college students. Second, this paper uses recommendation algorithms in AI to adaptively aggregate the preferences and needs of students and employers in both directions. The experiment is conducted on the employment data for undergraduates (EMDAU), a real dataset of five graduates from a university. The results show that the employment guidance system of college students integrating AI and civic education has better interpretability than the traditional employment guidance system and can fully integrate the service, management, education, and research functions of the employment guidance system. The employment guidance system established in this paper has a higher value of AUC compared to the traditional system, which directly demonstrates the rationality of the method in this paper.

2. Related Works

McLaren [19] examined the effectiveness of computer-assisted career guidance systems. Results compared with the conventional control group show that the computer-aided vocational guidance system is more structured. He also investigated moderators of the effects of occupational interventions. Based on big data, Qi and Zhang [21] designed a personalized employment guidance system for college students based on big data. The system presented by Qi and Zhang designs a B/S structure-based system framework by collecting information about students' employment environments and using the Tptmf algorithm to recommend employment resources for users. Watts [22] not only explored the relationship between career guidance and career orientation and technical vocational education and training but also examines the concepts of career guidance and career orientation and defines the three main elements of career information, career counseling, and career education. He also analyzes the main conceptual elements of providing career guidance, including the increasingly important role played by technology. Fang [23] conducted extensive statistics on the employment decision factors of college graduates in recent years in order to further explore and guide the employment of higher education students. Based on the classification of information data, he analyzed the impact of information data classification on the application of career guidance for college students. Harris [24] examined the history of the development of computer-assisted career planning systems and the promising potential of career guidance systems as part of the implementation of career guidance services in developing countries. Korna and Katane [25] examined specific measures for implementing career guidance in schooling settings that promote students' professional autonomy. Also in home education, they advocate the establishment and recognition of a number of career development guidance systems, including counseling and student career support methods and forms, with a focus on career planning courses.

3. Modeling Methods

3.1. Establishment of Recommendation System. For the problem of negative sample disbelief in employment recommendation data, this paper designs a similarity-based random negative sampling module, including 2 steps of similarity calculation between students and similarity calculation between employment units, and similarity-based random sampling [26, 27]. This paper designs the calculation of interstudent similarity and interunit similarity:

$$\begin{aligned}\operatorname{sim}\left(stu_i, stu_j\right) &= \sum_{k=1}^{N_d} \operatorname{bool}\left(f_{ik} = f_{jk}\right) \\ &\quad + \sum_{k=1}^{N_c}\left(1 - \left|f_{ik} - f_{jk}\right|\right), \quad i \neq j, \qquad (1)\\ \operatorname{sim}\left(\operatorname{unit}_i, \operatorname{unit}_j\right) &= \sum_{k=1}^{M_d} \operatorname{bool}\left(f_{ik} = f_{jk}\right), \quad i \neq j,\end{aligned}$$

where $\mathrm{sim}(stu_i, stu_j)$ denotes the similarity between students a stu_i and $bstu_j$, N_{d} and N_c denote the number of discrete and continuous features of students, respectively, and f_k denotes the value of the kth feature. $\mathrm{sim}(\mathrm{unit}_i, \mathrm{unit}_j)$ denotes the similarity between employment units unit_i and unit_j, and M_{d} denotes the number of discrete features of employment units.

This work employs the strategy of maintaining random sampling while taking into consideration similarity in order to produce negative samples with high confidence and avoid significantly altering the sample distribution of the training set. First, the similarity between student u and other students and the similarity between student u's employment units and other employment units are calculated, and the employment units of the most dissimilar top N students and the most dissimilar top N units are selected as the high confidence negative sample set. Then, the negative samples are randomly sampled from the negative sample set to generate negative samples for training [28, 29].

The interpretable module of employment intention and the recommendation module of employment unit are designed simultaneously using the idea of multitask learning. The characteristics are as follows: the two tasks share feature embedding layer parameters; that is, after obtaining the embedding of student and unit features, the two tasks are modeled, respectively [30, 31]. Aiming at the evolution problem of employment intention, the students' academic performance is used to assist the employment intention modeling, and the gated recurrent unit (GRU) [32] learning method is adopted, which is calculated as

$$G_t = \mathrm{GRU}(G_{t-1}, x_t), \quad t = 1, 2, \ldots, 6. \tag{2}$$

where G_t is the hidden state of students' scores in the t semester, and $x_t \in R^{\mathrm{d}}$ is the embedding vector of students' scores in the t semester. The hidden state G_6 of students' grades in the last semester is taken as the evolution result of students' employment intention, which is spliced with the embedding vector of students and unit features to obtain the embedding vector used to represent students' employment intention. The calculation formula is as follows:

$$E = \mathrm{concat}([P_1, P_2, \ldots, P_M, G_6]), \tag{3}$$

where $P_m \in R^{M\times \mathrm{d}}$ is the embedding vector of student features. Finally, multilayer perceptron [33] is used to model employment intention, which is calculated as follows:

$$O_p = \mathrm{Softmax}(\mathrm{MLP}(E)). \tag{4}$$

The explanation module based on employment characteristics can be divided into the attention mechanism of extracting students' employment preferences and the attention mechanism of extracting unit ability requirements. The attention mechanism of students' career preferences may be extracted in three phases. Given a pair of students and employment units under the condition of information, students' characteristics of the embedded vector are obtained by embedded layer $P_m \in R^{M\times \mathrm{d}}$, lateral characteristics of embedded vector $Q_n \in R^{N\times \mathrm{d}}$ and employment units, the M and N, respectively, students side characteristic number and employment units, M features for students of the first M, N for the employment unit characteristics of the first N, d for embedded vector dimensions. Through the sum-pooling operation, the student feature embedding vector P_m is aggregated, and the student representation vector P^s is obtained as follows:

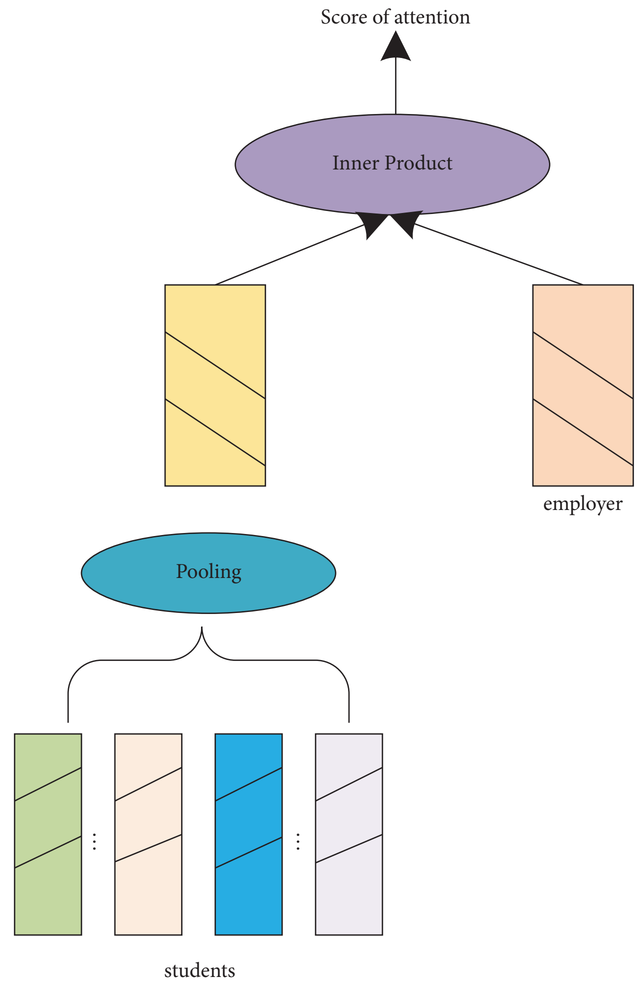

Figure 1: Extraction of students' employment preferences.

$$P^s = \sum_{m=1}^{M} P_m. \tag{5}$$

The student representation vector P^s is used as the query vector to calculate the weight of attention, which is used to calculate the preference degree of students for different characteristics of employment units [34, 35]. The structure is shown in Figure 1, and the calculation method is as follows:

$$\omega_n = \frac{Q_n^T P^s}{\sum_{k=1}^{N} Q_k^T P^s}. \tag{6}$$

The calculated attention weight ω_n indicates the preference degree of students for the n-th feature of the employment unit.

The weighted sum of unit feature embedding vectors is carried out by using the weight of attention, and the embedding vector P of students' employment preference is obtained as follows:

$$P = \sum_{n=1}^{N} \omega_n Q_n. \tag{7}$$

There are three steps to extracting the attention mechanism required by unit ability. The embedding vector $P_m \in R^{M\times d}$ of student features and the embedding vector $Q_n \in R^{N\times d}$ of employment unit features are obtained. Through the sum-pooling operation, the embedding vector Q_n of employment unit features is aggregated, and the representation vector Q^u of employment unit is obtained as follows:

$$Q^u = \sum_{n=1}^{N} Q_n. \tag{8}$$

The employment unit representation vector Q^u is used as the query vector to calculate the attention weight, which is used to calculate the preference degree of employment units for different characteristics of students. The structure is shown in Figure 2, and the calculation method is as follows:

$$\omega_m = \frac{P_m^T Q^u}{\sum_{k=1}^{M} P_k^T Q^u}. \tag{9}$$

The calculated attention weight ω_m represents the preference degree of the employment unit for the m-th characteristic of the student.

The weight of attention is used to weighted sum the embedding vectors of students' features, and the embedding vector Q required by unit ability is obtained by the specific calculation method as follows:

$$Q = \sum_{m=1}^{M} \omega_m P_m. \tag{10}$$

This mechanism not only uses the ranked importance of the characteristics of the employment unit to explain the students' employment preferences but also uses the ranked importance of the characteristics of the students to explain the ability requirements of the employment unit. Specifically, according to (6) and (9), the attention scores (ordinal importance scores) output by the attention mechanism requiring students' employment preferences and unit ability in reciprocity constraints are taken as the explanation of feature level. The normalized attention weight $\omega_n \in (0,1)$ calculated from (6) represents the students' attention score to the NTH feature of the employment unit, which is the explanation of students' employment preference. The normalized attention weight $\omega_n \in (0,1)$ calculated from (9) represents the attention score of the employment unit on the m-th feature of students, namely, the unit's ability requirement explanation.

The core of the employment recommendation module is based on GRU aggregation [36] of employment preference and ability requirement features; i.e., the aggregation weights are computed adaptively and dynamically using neural networks, which are calculated as follows:

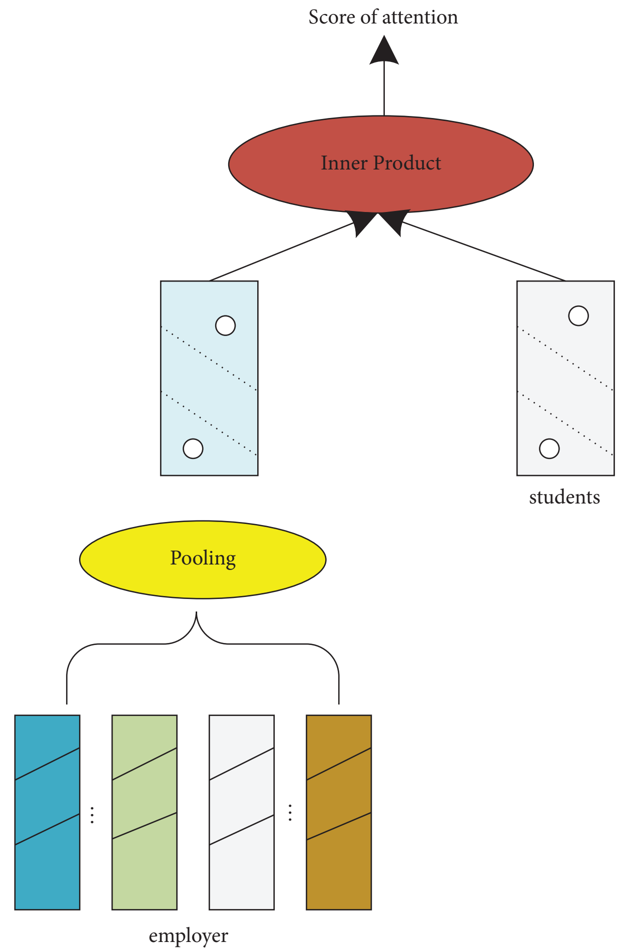

Figure 2: The attention mechanism required to extract unit ability.

$$R = \omega P + (1-\omega) Q, \tag{11}$$

where the adaptive weight ω is implemented by a binary neural network [37], calculated as

$$\omega = \sigma\left(W_p P + W_q Q\right), \tag{12}$$

where W_p and W_q are the parameter matrices of the neural network, respectively.

3.2. Employment Guidance System for College Students Integrating Recommendation System and Ideological Education. A recommendation algorithm is a kind of algorithm in computer specialization. Recommendation algorithms can use some mathematical algorithms to guess what users are likely to like. The employment guidance system of college students, integrating AI and ideological and political education, is a system of human-machine synergy. As for the establishment of an employment guidance system, we fully integrate the service function, management function, education function, and research function of the employment guidance system. Meanwhile, using AI technology based on semantic parsing, precise recognition, and data mining, we analyze students' career ability models and career interest points, carve students' career orientation and career ability

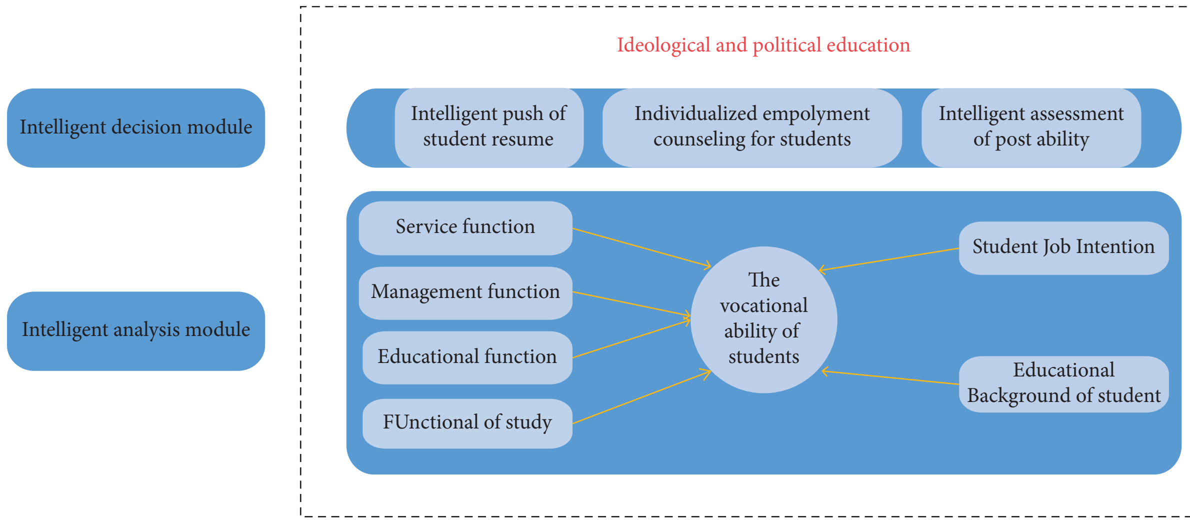

Figure 3: The structure of the employment guidance system for college students integrating AI and ideological and political education.

portraits, and match them by relying on relationship chain through the mixed ranking algorithm of recruitment information flow.

On the one hand, the employment guidance system for college students is not perfect and lacks effective ideological and political education, which leads to the inability of college students to establish a correct employment concept. On the other hand, the recommendation method used in the current college students' employment system is not reasonable enough, only considering students' one-way preferences for employment units, and the historical records of one user's one employment easily lead to unreliable negative samples, which affect the recommendation performance. At the same time, the current employment recommendation system cannot fully integrate the service function, management function, education function, and research function of the employment guidance system. These problems will lead to employment not in line with students' interests.

In terms of ideological and political education, we are deeply aware of the fact that graduates are often in a contradictory position between the needs of the country, the responsibilities of society, and the interests of individuals when choosing employment. How to view the relationship between these three determines the value orientation of their career choice and affects the formation of a correct career choice. When establishing the employment guidance system, we need to provide students with appropriate ideological and political education, so that graduates understand that their personal ambitions cannot be realized in isolation and that only by closely combining them with the requirements of their contemporaries and people can their values be fully reflected. In this way, students should be guided to establish a correct employment outlook so that students and enterprises can find effective ways to solve problems.

In summary, we will establish intelligent pushing of students' resumes, personalized counseling of students' employment, and intelligent assessment of job ability in the intelligent decision-making module, strengthen the ideological and political education of college students, and infiltrate the content of college students' employment education into the teaching of ideological and moral and professional courses. Meanwhile, in the intelligent analysis module, taking students' job-seeking intention and students' educational background as reference factors, we will consider the service function, management function, education function, and research function of the career guidance system with students' vocational ability integrated. Figure 3 shows the structure of the college students' career guidance system, integrating AI and ideological and political education.

4. Discussion and Analysis of Results

The statistical information of EMDAU in the data set used in this experiment is shown in Table 1, where the number of users is the sum of the graduates of the five years, the employment unit is the sum of the employment units of the five years of students, and the interaction record is the information pair of students and employment units (expressing the employment relationship between students and employment units). 10 discrete features and 6 continuous characteristics made up the student features in this data collection. The characteristics of employment units include six discrete features. The employment intentions in the data set are summarized by experts into three types: studying abroad, studying in China, and contracting for employment, as shown in Figure 4.

In this paper, according to the graduation year of students, the data of the two graduates with a small number are, respectively, used as the validation set of 769 items and the test set of 2031 items, and the data of the other three graduates are used as the training set of 5469 items.

AUC is a widely used evaluation index. AUC is an index to measure the performance of binary classification model, which measures the probability that positive samples are ranked before negative samples in the test set, reflecting the ranking ability of the model [38, 39]. This paper uses AUC as an evaluation index to measure the performance of

Table 1: Statistical information of EMDAU.

The number of users	Unit of employment	Number of interaction records	Sparsity/%
8450	1423	8756	0.065

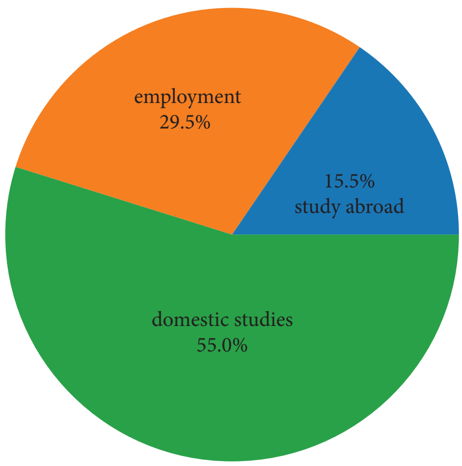

Figure 4: The distribution of employment intention in dataset.

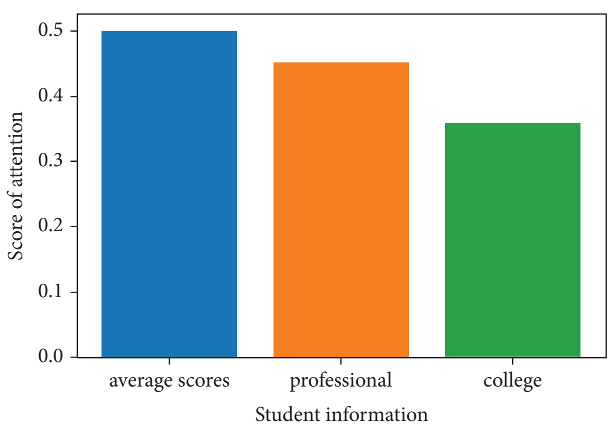

Figure 5: Interpretation based on student characteristics.

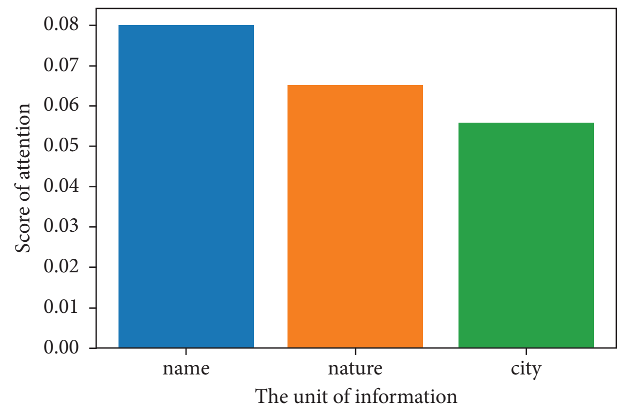

Figure 6: Interpretation based on unit characteristics.

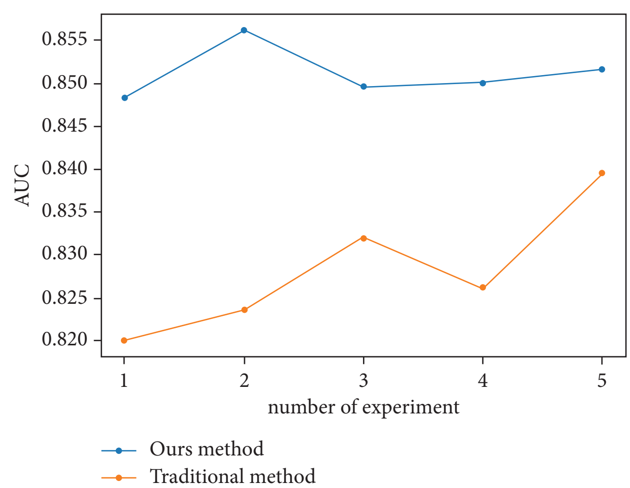

Figure 7: Comparison of AUC between the proposed method and the traditional method.

employment recommendation, and its calculation method is as follows:

$$\mathrm{AUC} = \frac{\sum y_{\mathrm{pos}} > y_{\mathrm{neg}}}{N_{\mathrm{pos}} \times N_{\mathrm{neg}}}, \tag{13}$$

where y_{pos} and y_{neg} are the predicted values of the model for positive and negative samples, respectively, and N_{pos} and N_{neg} represent the number of positive and negative samples in the test set, respectively.

Instead of determining the correctness of the suggested approach, the experiment's goal is to assess how interpretable it is. Therefore, this paper assumes that the actual employment units of students are the units recommended by the method; that is, the samples of the actual employment units of students within the TOP10 of the recommended list are retained. According to this rule, 50 students from the test set are randomly selected as experimental subjects. For each student, the proposed method is used to generate recommendation explanations and randomly generate recommendation explanations. The recommended explanation information contains two modules: the explanation module based on employment characteristics outputs the characteristics of the top three students in importance score and the characteristics of the top three employment units in importance score as explanations, which are presented in the form of bar graphs, as shown in Figures 5 and 6.

A comparative experiment was carried out on the real data set EMDAU, and the experimental results verified the superiority of the career guidance system integrated with artificial intelligence and ideological and political education. In order to ensure the accuracy of the experimental results, we conducted the same experiment on the dataset for five

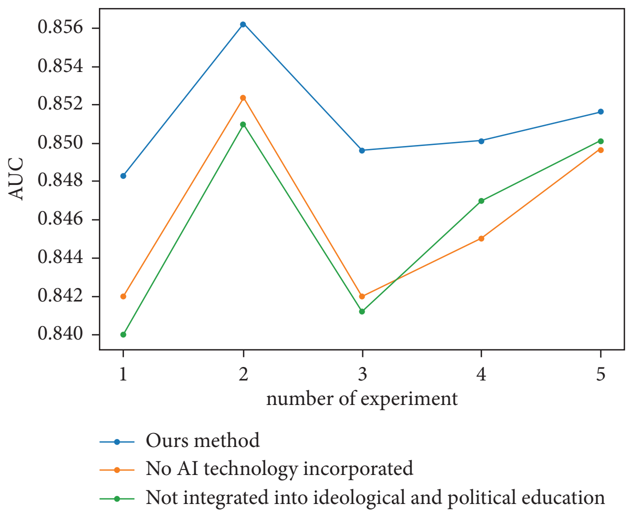

Figure 8: Ablation experiments.

times. Figure 7 shows that the AUC value of the proposed method is higher than that of the traditional employment guidance system, indicating that the proposed method has better performance than the traditional employment guidance system.

The experiment in this study consists of two components: ideological and political education and AI technology. In order to further verify the AI technology and the effect of ideological and political education of university students' employment play, we have done 5 times on data sets of the same ablation experiments. Figure 8 shows the effect of the fusion of artificial intelligence and ideological education in college students' employment guidance systems. According to the result, the AUC value of the guiding systems of artificial intelligence and merged ideological education of college students' employment guidance systems is high. It shows the effectiveness of the fusion method.

5. Conclusions

In this paper, a strategy that combines algorithmic recommendation with ideological and political education is used to suggest an unique career advice system for college students. In this system, we fully integrate the service function, management function, education function, and research function of students' vocational ability and employment guidance systems and add the link of ideological and political education in each process, which promotes students to form a correct employment concept. At the same time, we use recommendation algorithms in AI to make appropriate recommendations based on the capabilities and strengths that students and companies have, increasing the school's employment rate as well as student and company satisfaction. The experiments use the dataset EMDAU to verify the effectiveness of the job guidance system after integrating recommendation algorithm and ideological and political education, and they do ablation experiments to further discuss the importance of ideological and political education and the recommendation system in the work of the job guidance system. The results show that the employment guidance system integrating ideological and political education and the recommendation system has a high AUC value. The value of AUC reflects that our proposed college student employment guidance system has a strong ranking ability, which indicates that our system can assist college students and enterprises to find suitable matches. Therefore, establishing an employment guidance system for college students that integrate AI and ideological education can effectively guide students' employment.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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Research Article

Research on Evaluation of Art Education Effect in Colleges and Universities Based on Big Data Technology

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In order to improve the automatic evaluation ability of fine arts education effect in colleges and universities, this paper proposes the evaluation research of fine arts education effect based on big data technology. We build university fine arts education effect data analysis model, considering the characteristics of the college art education effect; can reflect the effect of art education in colleges and universities' selected index system, with the effect of art education in colleges and universities of the decision about the elements of the decomposed into goals, standards, and plan level, such as university fine arts education effect evaluation of qualitative and quantitative analysis; find out the hidden representative university fine arts education effect evaluation factors; build fine arts education in colleges and universities' effect-associated distribution rules of the data, through unsupervised learning method, the effect of art education in colleges and universities' data feature extraction in the process of adaptive learning, by fuzzy comprehensive evaluation of big data; and realize the effect of art education in colleges and universities. The test results show that the fitness level of using this method to evaluate the effect of art education in colleges and universities is high, the score of the evaluation effect of art education in colleges and universities is significant, and it is in a good state in the evaluation index score table, indicating that the evaluation effect is accurate and reliable.

1. Introduction

The effect of fine arts education in colleges and universities is the key factor to measure the quality of fine arts education in colleges and universities, and the comprehensive quality of observing, analyzing, and solving problems. In the process of teaching evaluation and evaluation of art education in colleges and universities, it is necessary to combine the characteristics and index distribution of art education in colleges and universities, and adopt the method of index parameter analysis to realize quantitative evaluation of the effect of art education in colleges and universities [1]. In this paper, the optimization analysis model of college art education effect is studied, the quantitative optimization model of college art education evaluation is established [2], the big data analysis method is adopted, the big data information analysis model of college art education effect evaluation is carried out, and the big data mining and information fusion methods are adopted to make the evaluation decision of college art education effect. In the process of dynamic management of college art education effect evaluation, the dynamic evaluation and decision-making of college art education effect are realized by combining big data analysis and automatic mode evaluation and decision-making, and the research on related evaluation methods of college art education effect has attracted great attention [3].

The evaluation index system of the effect of art education in colleges and universities is helpful for the state to give macro guidance and management to colleges and universities, and provides the basis for decision-making for the management departments of art education and scientific research in colleges and universities. Scientific evaluation of art education in colleges and universities will clearly show the shortcomings of universities in some aspects and universities in some aspects and point out the direction of construction and management. At present, the evaluation methods of art education effect in colleges and universities mainly adopt the manual evaluation method and the scoring evaluation method. Combined with the development of big data information management technology, the evaluation and optimization of art education effect in colleges and universities can be realized with the aid of multimedia, the information management level of libraries and the ability of optimizing and dispatching art education resources in colleges and universities can be improved, and an automatic evaluation model of art education effect in colleges and universities can be established, combined with the innovative evaluation model of the effect of art education in colleges and universities, can realize the information management of the effect of art education in colleges and universities, and can realize the optimal scheduling of college art education resources under the fuzzy comprehensive evaluation decision of artificial intelligence big data. Based on the comprehensive consideration of the advantages and disadvantages of various methods, in reference [4], the gambling method and the fuzzy comprehensive evaluation method are combined to construct a comprehensive evaluation model of college art education decision-making. The final result of the study not only obtains the fuzzy comprehensive evaluation of each college art education evaluation scheme, but also ranks the advantages and disadvantages of each scheme. However, this method requires a lot of prior knowledge. In reference [5], four first-level indexes and 16 second-level index systems are constructed, and based on this index system, a fuzzy comprehensive evaluation model of the effect of college art education is established to comprehensively evaluate the effect level of college art education for a college student in Hunan Province, but the index evaluation system of this method is not perfect enough [6–8].

Aiming at the above problems, this paper puts forward an automatic evaluation method of college art education effect based on big data fuzzy comprehensive evaluation. A characteristic analysis model of college art education effect data, considering the characteristics of college art education effect, is constructed, an index system that can reflect the effect of college art education is selected, the elements that are always related to the decision-making of college art education effect into objectives, criteria, schemes, and other levels make a qualitative and quantitative analysis of college art education effect evaluation, and a semantic joint degree detection model of college art education effect evaluation index system data is constructed. The statistical analysis method of common factors is used to find out the hidden representative evaluation factors of college art education effect, and the fuzzy regression analysis method is used to construct the association distribution rule set of college art education effect data. The unsupervised learning method is used to carry out adaptive learning in the process of feature extraction of college art education effect data. Finally, the simulation test analysis shows the superior performance of this method in improving the ability of automatic evaluation of college art education effect.

2. Index Model and Characteristic Analysis of the Effect Evaluation of Art Education in Colleges and Universities

2.1. Index Parameter Model of the Effect Evaluation of Art Education in Colleges and Universities. The standard of the evaluation index of the effect of art education in colleges and universities is an organic whole with an internal structure, which is composed of multiple indexes representing the characteristics of the evaluation object in all aspects and their interrelation. It needs to follow the systematic principle, the typical principle, the dynamic principle, and the comprehensive principle to evaluate. In order to realize the comprehensive evaluation of the effect of art education in colleges and universities, it is necessary to construct the parameter distribution model of the evaluation index of the effect of art education in colleges and universities [9, 10]. Each index in the index system is independent and interrelated. Indicators reflect different aspects of scientific research and innovation, and each indicator should not be repeated and crossed [11–13]; at the same time, each index element describes the same ability behavior together, so it is interrelated. Each index has its own unique connotation [14]. Combined with the graph model parameter analysis, the semantic ontology graph model fusion method is adopted to construct the big data decision-making structure model of college art education effect evaluation, as shown in Figure 1.

According to the decision index block big data detection model of college art education effect evaluation shown in Figure 1, under the homomorphic mapping mechanism, the adaptive scheduling and information fusion of college art education effect are realized [15–17], and the edge structure feature quantity of college art education effect is obtained. The distributed node structure model of college art education effect evaluation is constructed by using the directed graph model. According to the established evaluation index of college art education effect, a scale for evaluating the effect of art education in colleges and universities is designed. The scale items are graded according to the 25 indicators of the evaluation system [18]. Likert's 5-point scoring method is adopted, and 1~5 points are used to indicate very unimportant, not very important, average, relatively important, and very important. There are 5 grades in total. The correlation of the distribution nodes of the effect of art education in colleges and universities is expressed as follows:

$$O = \dot{X}\frac{1}{2}\|w\|^2 + \dot{Y}C\sum_{i=1}^{n}\left(\xi_i + \xi_i^*\right) + \sum_{i=0}^{k-1}\left(x_i(t) - \omega_{ij}(t)\right)^2, j = 0, 1, \ldots, N-1. \quad (1)$$

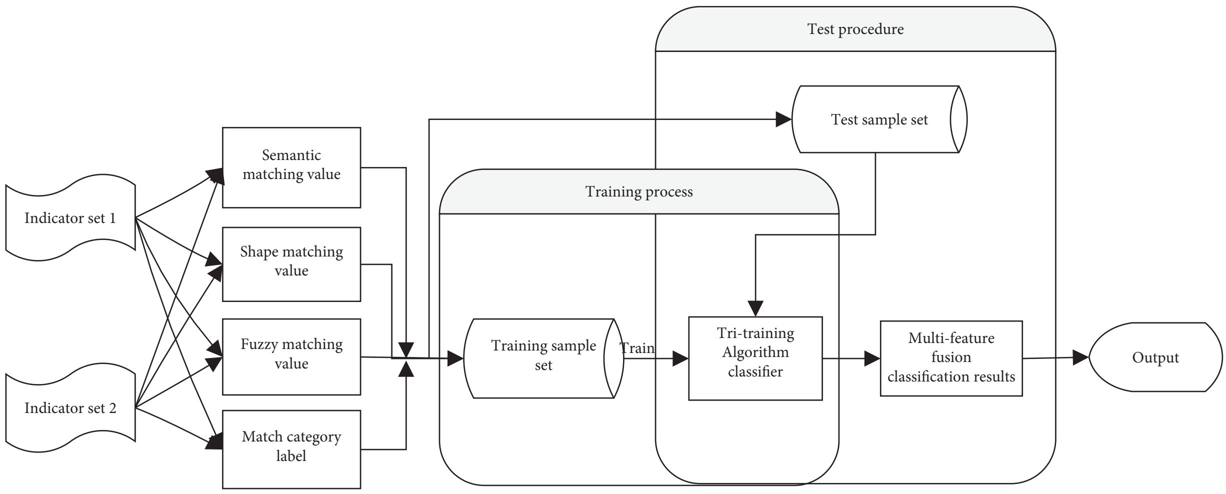

Figure 1: Distribution structure model of decision-making indicators for the evaluation of the effect of art education in colleges and universities.

In formula (1), $\dot{X}$ is the effect of art learning, w is the dimension of art learning, $\dot{Y}$ is the relative importance of influencing factors, C is the comprehensive score of art, n is the number of students, ξ_i is the original space mapping, ξ_i^* is the high-dimensional feature space mapping, k is the distance, $x_i(t)$ is the classification interval of art teaching, and $\omega_{ij}(t)$ is the weighted sum of art education courses. Assuming that the sample set ω has j category labels, the ambiguity function of the effect of college art education is established according to the distribution nodes of college art education effects, which are expressed as follows:

$$\omega_j = \sum_{k=0}^{2N-1} h_k e^{-jk\omega} + \left(\omega_{0j}, \omega_{1j}, \ldots, \omega_{k-1,j}\right). \tag{2}$$

In formula (2), N is the information gain value, h_k is the art course weight, and $e^{-jk\omega}$ is the information entropy. By completing the directional fusion clustering analysis of the useful text feature distribution in the effect of art education in colleges and universities, the edge feature component $H(x, y)$ of the effect of art education in colleges and universities is obtained. Through the design of the semantic graph model, the semantic matching judgment formula of the edge feature component $H(x, y)$ of the effect of art education in colleges and universities is as follows:

$$H(x, y) = \begin{cases} \text{text}, & \text{if}\left(GD_X(x, y) > T_X\right), \\ \text{text}, & \text{otherwise}. \end{cases} \tag{3}$$

In formula (3), the characteristic distribution dimension of the effect of art education in colleges and universities is m, and the edge distribution feature set of the evaluation of the effect of art education in colleges and universities is N_{j*}. Based on the fuzzy decision of the effect of art education in colleges and universities, if Δx is used to represent the weight of the effect of art course education, the minimum distance of node distribution of the effect model of fine arts education in colleges and universities is as follows:

$$Y = \sin\left[2\Delta x\left(t - \frac{m}{2 \times N_{j*}}\right)\right] = \min_{0 \le j \le N-1}\left\{d_j\right\}. \tag{4}$$

In formula (4), t is the test time. Since the effect of art education in colleges and universities is divided into 3×3 topology, through the statistical feature extraction method in which each principal component is the original variable, the big data fusion of the effect of art education in colleges and universities is carried out; the index system that can reflect the effect of art education in colleges and universities is selected; the elements related to the decision-making of the effect of art education in colleges and universities are decomposed into objectives, criteria, schemes, and other levels; and the qualitative and quantitative analysis of the effect evaluation of art education in colleges and universities is carried out [19–21]. This paper constructs the semantic union degree detection model of the evaluation index system data of college art education effect, finds out the hidden representative evaluation factors of college art education effect by using the statistical analysis method of common factors, and adopts the fuzzy regression analysis method to construct the fuzzy parameters of college art education effect evaluation as follows:

$$\begin{aligned} X = P &= \min\left\{\sum_{i}^{5} P_i, 1\right\} \\ &= \frac{2^{-\lambda\left(t_c - t_a + T_d\right) - 1}}{2^{-\lambda T_d} - 1} \subset R^s. \end{aligned} \tag{5}$$

In formula (5), P_i is the feature weight, λ is the feature weight, t_c is the interval mean, t_a is the interval variance, T_d is the number of features, and R^s is the membership value. According to the analysis results of association rules, the quantitative feature components of college art education effect are obtained, wherein the feature components of college art education effect attributes of samples with matched autocorrelation features are as follows:

$$x_i = GXN_0 + \frac{\tilde{x}(t)}{\tilde{x}(u)}. \quad (6)$$

In formula (6), $\tilde{x}(t)$ is the fuzzy correlation degree of college art education effect data, $\tilde{x}(u)$ is the statistical characteristic quantity of college art education effect data, N_0 is the composite parameter of college art education effect evaluation, G is the actual output value of the college art education test sample, and X is the total number of college art education test samples [22, 23].

2.2. Analysis of Characteristics of Art Education Effect Evaluation in Colleges and Universities. Teachers should make different evaluation schemes according to different types of art courses. Instead of making it simple and simple, teachers should make different evaluations according to different characteristics of art courses. In addition to teacher's direct evaluation, various forms can also be adopted. Mutual evaluation of artworks with different characteristics can not only deepen students' understanding of the diversity of works, but also deepen their knowledge and understanding of the diversity of beauty. The application of various forms, rhythms, symmetry, and balance of works strengthens students' aesthetic consciousness, deepens their knowledge and understanding of artistic expressiveness, improves their ability of appreciation and judgment, and at the same time cultivates and exercises their language description ability, as well as their ability to comment on art. In this way, students can learn the strengths of others, recognize their own shortcomings, learn from each other, and at the same time, they can see their own strengths and enhance their confidence in learning. Teachers' affirmation of works of different styles in this process can make students realize that artworks themselves are the result of people with different personalities looking at the world and life from different angles and using different methods to express them. Works embody people's ideal, desire, emotion, personality, love and beauty, and other characteristics, so "there is no uniform standard in art, and personal standards do not apply to all art phenomena." Therefore, one cannot deny the value of works that one does not like. In this process, some questions can also be designed to encourage students to participate in the evaluation, self-evaluation, and mutual evaluation, and encourage students to actively participate and actively speak, rather than a mere formality. To design the evaluation content based on the learning content and homework requirements of each lesson is conducive to consolidating the classroom teaching effect.

According to the design of a large dataset distribution model of college art education effect, combined with the distributed design of fusion characteristics of college art education effect evaluation, the realization process of college art education effect evaluation is shown in Figure 2.

The method of semantic ontology model analysis is used, the feature space distribution model of college art education effect evaluation is constructed, and the process control of college art education effect evaluation is realized by the method of block information fusion and feature matching [24]. On the basis of statistical analysis and fuzzy detection, the fuzzy evaluation set of college art education effect is obtained as follows:

$$Y(U) = \frac{1}{1 + \alpha (\partial S/\partial t)^2} + \frac{p_{i,j}(t) - sp_{i,j}(t)}{p_{i,j}(t)}. \quad (7)$$

In formula (7), α is the feature division point, ∂ is the standardization coefficient, S is the ambiguity set, $p_{i,j}(t)$ is the continuous feature distribution set, $sp_{i,j}(t)$ is the function learning set, and $p_{i,j}(t)$ is a training set for evaluating the effect of art education in colleges and universities. Under the guidance of the fuzzy evaluation set of the effect of art education in colleges and universities, the joint-related parameters of the evaluation nodes of the effect of art education in colleges and universities can be obtained as follows:

$$S_C = \frac{2n(D_1 \cap D_2)}{n(D_1) + n(D_2)}. \quad (8)$$

In formula (8), $n(D_1)$ and $n(D_2)$, respectively, represent the number of semantically directed evaluation nodes of the effect distribution of art education in colleges and universities, and $n(D_1 \cap D_2)$ represents the number of common nodes in the semantic graph of the effect evaluation of college art education. According to the above calculation results, a semantic correlation distribution feature set of the evaluation of the effect of art education in colleges and universities is formed as follows:

$$\begin{aligned} S &= S_C * (a + b * Sr) + \min\left\{\sum_i^5 P_i, 1\right\} \\ &= \frac{2^{-\lambda(t_c - t_a + T_d) - 1}}{2^{-\lambda T_d} - 1}. \end{aligned} \quad (9)$$

In formula (9), $S_C *$ is the art education effect of the target colleges and universities to be evaluated, a is the regression coefficient, $b *$ is the equilibrium coefficient, and S_r is the steady-state model, while $S_r = 0$, and the similarity S of characteristic quantities of art education effect in colleges and universities depends on $S_C * a$. According to the results of feature extraction and similarity analysis of college art education effect, an optimization and innovation model of college art education effect evaluation is constructed. Through random forest optimization of big data mining results of college art education effect, the iterative equation of data disclosure audit of college art education effect evaluation is obtained as follows:

$$\begin{aligned} v_{i,d}^{k+1} &= \omega \cdot v_{i,d}^k + c_1 \cdot \text{rand}() \cdot \\ &\quad \cdot \left(c_3 \cdot \text{rand}() \cdot p\text{best}_{i,d}^k - x_{i,d}^k\right) \\ &\quad + c_2 \cdot \text{rand}() \cdot \left(c_4 \cdot \text{rand}() \cdot g\text{best}_d^k - x_{i,d}^k\right). \end{aligned} \quad (10)$$

In formula (10), ω is the mean value of course grades, $v_{i,d}^k$ is the mean value of course grade items, $c_1 \cdot \text{rand}$ and $c_2 \cdot$

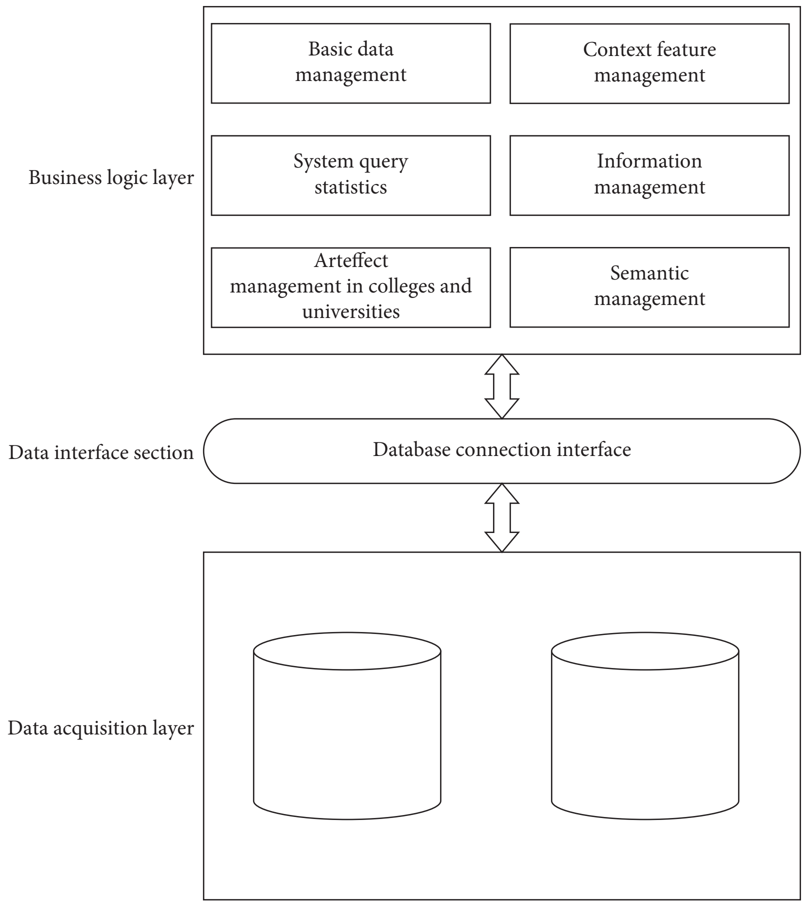

Figure 2: The implementation process of the effect evaluation of art education in colleges and universities.

rand are cryptographic hash functions, $c_3 \cdot$ rand and $c_4 \cdot$ rand are blockchain ownership operators, and their expressions are as follows:

$$\begin{aligned} c_3 \cdot \text{rand}() &= \begin{cases} 1, & e_p > e_{0p}, \\ c_3 \times \text{rand}() & e_p \leq e_{0p}, \end{cases} \\ c_4 \cdot \text{rand}() &= \begin{cases} 1, & e_g > e_{0g}, \\ c_4 \cdot \text{rand}() & e_g \leq e_{0g}. \end{cases} \end{aligned} \tag{11}$$

In formulas (11) and (12), $\tilde{x}_{ij} = x_{\max} + x_{\min} - x_{ij}$ represents registered uplink parameters, c_4 represents global optimization coefficient, e_p stands for the deviation of the evaluation effect of art education in colleges and universities, e_g represents the deviation between the current value and the current global optimal value, and thus, a statistical analysis model is constructed for the evaluation of the effect of fine arts education in colleges and universities.

3. Automatic Evaluation and Optimization of Art Education Effect in Colleges and Universities

3.1. Integration of Parameters and Indicators for the Evaluation of the Effect of Art Education in Colleges and Universities. According to the semantic text abstract feature components of college art education effect [25], the fuzzy regression analysis method is adopted to construct the association distribution rule set of college art education effect data, and the auxiliary decision distribution weight coefficient of college art education effect evaluation is l. Under the condition of generating dynamic evaluation text features of college art education effect, the fuzzy partition block scheduling of college art education effect is combined with the statistical information mining method, and the descriptive clustering function of college art education effect feature distribution is obtained as follows:

$$\begin{aligned} M_v &= GXN_0 + \frac{\tilde{x}(t)}{\tilde{x}(u)} \\ &= \sum_{i=1}^{n} l\left(\alpha_i - \alpha_i^*\right) K\left(x_i, x_j\right). \end{aligned} \tag{12}$$

In formula (12), α_i is the original feature value, α_i^* is the feature value after information mining, and $K(x_i, x_j)$ is the edge number of the effect of art education in colleges and universities. The method of block matching and self-adaptive supervised learning is used to obtain the evaluation decision-making matrix of the effect of art education in colleges and universities. Combined with the method of information fusion, the binary semantic decision-making model of the effect of art education in colleges and universities is obtained. According to the fusion results of the effect of art education in colleges and universities, combined with the method of fuzzy cluster analysis, an automatic evaluation model of the effect of art education in colleges and universities is established [26].

3.2. Evaluation and Output of Art Education Effect in Colleges and Universities. By using big data fusion and feature classification technology, a correlation fusion scheduling model of college art education effect evaluation is established. Through big data fuzzy comprehensive evaluation, the evaluation method refers to a multifactor comprehensive evaluation method when a thing is affected by multiple factors. The scope of some elements does not have clear boundaries, and the fuzzy comprehensive evaluation method can convert qualitative indicators into quantitative indicators according to the principle of maximum membership degree, so as to make a comprehensive evaluation of things affected by multiple factors. The differentiated feature parameter set of college art education effect is analyzed. Under the decision of artificial intelligence big data fuzzy comprehensive evaluation, combined with subspace fuzzy information clustering method, the fuzzy degree matching of college art education effect evaluation process is realized. If P courses are represented as $x_1, x_2, \ldots\ldots, x_p$, $c_1, c_2, \ldots\ldots, c_p$ represents the weight of each course, so the sum of the weights is $s = c_1x_1 + c_2x_2 + \ldots\ldots c_px_p$. We hope that the appropriate weight can better distinguish the students' grades. Each student corresponds to one such comprehensive grade, and N is the number of students. Assuming that the spatial distribution dimensions of current college art education effect characteristics' preference are $s_1, s_2, \ldots\ldots, s_n$, and $N_1, \ldots, N_n$, the priority control cost function of automatic evaluation of college art education effect is as follows:

$$T_i = \frac{G}{D_i^+ + D_i^-} + \sum_{i-m+1}^{n} E\left[(a_i - b_i)^2\right]. \tag{13}$$

In formula (13), D_i^+ is the sample whose feature value is greater than α_i^* in the set D, D_i^- is the sample whose feature value is less than α_i^* in the set D, and $E[(a_i - b_i)^2]$ is the state distribution set submodel of the effect evaluation of fine arts education in colleges and universities. The measurement data of the evaluation of the effect of art education in colleges and universities meet the main characteristic of correlation degree, and the correlation characteristic quantity is obtained as follows:

$$\mathrm{OF}(p) = \frac{|\mathrm{IS}(p)| \cdot c\_\mathrm{distance}(p)}{\sum_{o\in IS(p)} c\_\mathrm{distance}(o)}. \tag{14}$$

In formula (15), in the neighborhood of the k-th distance, the reliability of the evaluation process is searched by combining inertial parameter analysis and feature fitting, the fitness function of the evaluation of the effect of college art education is established, the weight coefficient is k, the subspace planning model of the evaluation of the effect of college art education is constructed, and the parameter optimization model is as follows:

%
$$\begin{cases} f_i(t) = \dfrac{K}{t_0 - t} = \dfrac{K/t_0}{1 - t/t_0} = \dfrac{f_{\max} f_{\min}}{f_0}\left(1 + \dfrac{t}{t_0} + \dfrac{t^2}{t_0^2} + \cdots\right), \\ |t| \le \dfrac{T}{2}. \end{cases} \tag{15}$$

In formula (16), the subspace scheduling and random forest learning model of college art education effect evaluation is established, and the autocorrelation feature matching method is taken. The spatial block distribution function of college art education effect features is r_{ij}, and the attribute set of college art education effect evaluation is obtained as follows:

$$Y(x) = \Delta\left(\frac{\Delta^{-1}(r_{ij}, a_{ij})}{\sum_{i=1}^{n} \Delta^{-1}(r_{ij}, a_{ij})}\right). \tag{16}$$

In formula (16), a_{ij} is the set of common scoring items. The evaluation priority order of the text set Y of college art education effect is calculated, and the feature clustering model of the feature information of college art education effect by the adaptive optimization method is constructed. The quantitative parameters of the feature of college art education effect are as follows:

%
$$h(t) = \sum_i a_i(t)\left[x_1(k), x_1(k+1), \ldots\ldots, x_1(k+N-1)\right]. \tag{18}$$

In formula (18), $a_i(t)$ is the dimension of the feature vector. A fusion model of characteristics' preference of college art education effect is built, the statistical characteristics of college art education effect are established, and a prior decision model of college art education effect through prior data evaluation is obtained as follows:

$$\min F = R^2 + A\sum_i \xi_i, s.t{:}\ \left\|\phi(x_i) - o\right\|^2 \le R^2 + \xi_i \text{ and } \xi_i \ge 0, i = 1, 2, \ldots \tag{19}$$

$$\max \sum_i \alpha_i K(x_i, x_i) - \sum_i\sum_j \alpha_i\alpha_j K(x_i, x_j) s.t{:}\ \sum_i \alpha_i = 1 \text{ and } 0 \le \alpha_i \le A, i = 1, 2, \ldots \tag{20}$$

In formulas (19) and (20), R^2 is the autocorrelation feature matching set of art education effect in colleges and universities, and A is the average distribution set of quantitative statistics of the effect of art education in colleges and universities. According to the above analysis, a correlation fusion scheduling model for the effect evaluation of art education in colleges and universities is established, and the effect evaluation of art education in colleges and universities can be realized through big data fuzzy comprehensive evaluation and statistical analysis methods.

4. Empirical Analysis and Testing

In order to verify the application performance of this method in realizing the automatic evaluation of fine arts education effect in colleges and universities, SPSS13.0 is used to conduct statistical analysis on the results of the questionnaire, and factor analysis is used to synthesize many original variables into few comprehensive indicators. Delphi method, entropy method, fuzzy cluster analysis, analytic hierarchy process are adopted. Then, a comparative experiment is carried out, assuming that the dimension of the sample set of the information distribution of automatic evaluation of the effect of art education in colleges and universities is 45, the data scale is 1200, the performance analysis object is the selected art major student in a college, and the experimental data is selected from iResearch datahttp://www.iresearch.cn). The distribution of evaluation grades of art education effect in colleges and universities is shown in Table 1.

According to the above evaluation grade distribution, the use of AHP first needs to select the relatively important factors from many factors and divide them into several levels according to the relationship between the factors. The relationship between the factors at each level should be marked, and the scale information definition of the evaluation grade is shown in Table 2.

According to the above parameter settings, the effect evaluation of art education in colleges and universities is carried out, and the distribution histogram of the effect of art education in colleges and universities is obtained as shown in Figure 3.

Taking the dataset of Figure 3 as the test object, the effect evaluation and optimization decision of college art education are made, and the graded evaluation results are shown in Figure 4.

According to the analysis of Figure 4, this method can effectively achieve the graded evaluation of college art education effect, and the evaluation results of each test group are better. The reason is that this method adopts big data fusion and feature classification technology to establish a correlation fusion scheduling model of college art education effect evaluation. Under the decision-making of artificial intelligence big data fuzzy comprehensive evaluation, combining the subspace fuzzy information clustering method, the fuzzy degree matching of the evaluation process of college art education effect can be realized, which is beneficial to increase the grading evaluation effect of college art education effect to a certain extent. According to the test and evaluation, the automatic evaluation results of fine arts education effect in colleges and universities are shown in Table 3.

According to the results in Table 4, the integrity score of college art education effect evaluation by this method is high. The reason is that this method adopts fuzzy regression analysis method according to the semantic text abstract feature components of college art education effect, constructs the association distribution rule set, and obtains the descriptive clustering function of feature distribution under the condition of generating dynamic evaluation text features, which is conducive to improving the automatic evaluation results of college art education effect. The accuracy of the score is tested. Different methods are used for evaluation, and the Delphi method, entropy method, fuzzy cluster analysis method, and analytic hierarchy process (AHP) method are used for comparison. The comparison results of evaluation reliability are shown in Table 4.

Analysis of Table 4 shows that the method in this paper has a significant effect on the evaluation effect of art education in colleges and universities, and the evaluation index score table is in an excellent state, indicating that the evaluation effect is accurate and reliable. On the basis of the accuracy of the evaluation effect, the time of automatic evaluation of the effect of art education in colleges and universities is tested and analyzed. The data of 600 different types of college art education courses were randomly selected as test data. By comparing and testing the time for automatic evaluation of the effect of art education in colleges and universities with the Delphi method, the fuzzy cluster analysis method, and the entropy method, the results are shown in Figure 5.

According to Figure 5, the method in this paper adopts the fuzzy regression analysis method to construct the association distribution rule set of the effect data of college art education and generate the correlation fusion scheduling model of the effect evaluation of college art education, so as to improve the effect of college art education, so the automatic evaluation time is shorter, only 5s can effectively predict the effect of 600 different types of high-efficiency art education courses, the efficiency is significantly higher than the other three methods, and it has strong applicability.

To sum up, this method can effectively achieve the graded evaluation of the effect of art education in colleges and universities. The evaluation effect of each test group is good. Using this method to evaluate the effect of art education in colleges and universities, the integrity score is high; the evaluation effect score of art education in colleges and universities is significant; and it is in a good state in the evaluation index score table, indicating that the evaluation effect is accurate and reliable. Only 5s can effectively predict the effect of 600 different types of efficient art education courses, which has strong applicability.

Table 1: Grade distribution of evaluation on the effect of art education in colleges and universities.

Evaluation grade	Semantic constraint coefficient	Text constraint	Similarity index
Grade 01	0.410	0.521	9.9646
Grade 02	0.459	0.607	5.4624
Grade 03	0.456	0.762	2.9528
Grade 04	0.426	0.754	0.3609
Grade 05	0.412	0.496	0.8896
Grade 06	0.430	0.797	9.0462
Grade 07	0.450	0.851	1.1769
Grade 08	0.439	0.506	7.3216
Grade 09	0.415	0.677	7.6317
Grade 10	0.410	0.855	4.0680
Grade 11	0.467	0.742	0.6409
Grade 12	0.464	0.448	7.5907
Grade 13	0.477	0.567	0.8189
Grade 14	0.412	0.519	5.9693
Grade 15	0.459	0.660	2.3849
Grade 16	0.430	0.647	3.2810
Grade 17	0.425	0.746	6.3253
Grade 18	0.470	0.837	5.6985
Grade 19	0.428	0.768	6.6322
Grade 20	0.445	0.984	2.0046

Table 2: Scale information of evaluation grade.

A	A_1	A_2	A_j	...	A_n	Reference value
A_1	a_{11}	a_{12}	a_{1j}	...	a_{1n}	1
A_2	a_{21}	a_{22}	a_{2j}	...	a_{2n}	1
...	...	...	...	...	...	1
A_i	a_{i1}	a_{i2}	a_{ij}	...	a_{in}	1

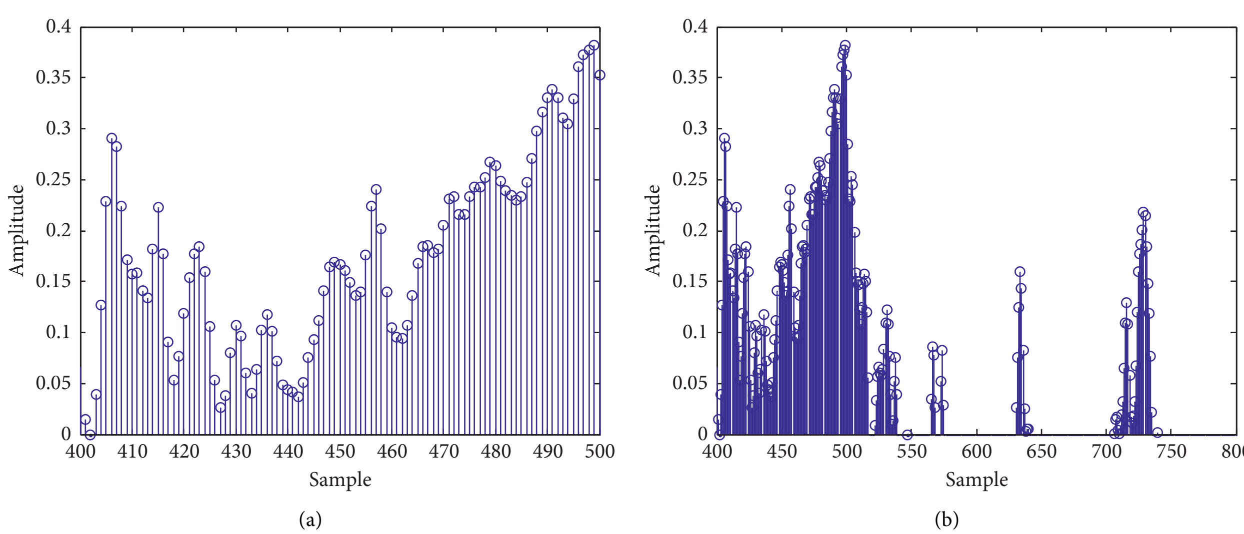

Figure 3: Histogram of the effect distribution of art education in colleges and universities. (a) Test set. (b) Training set.

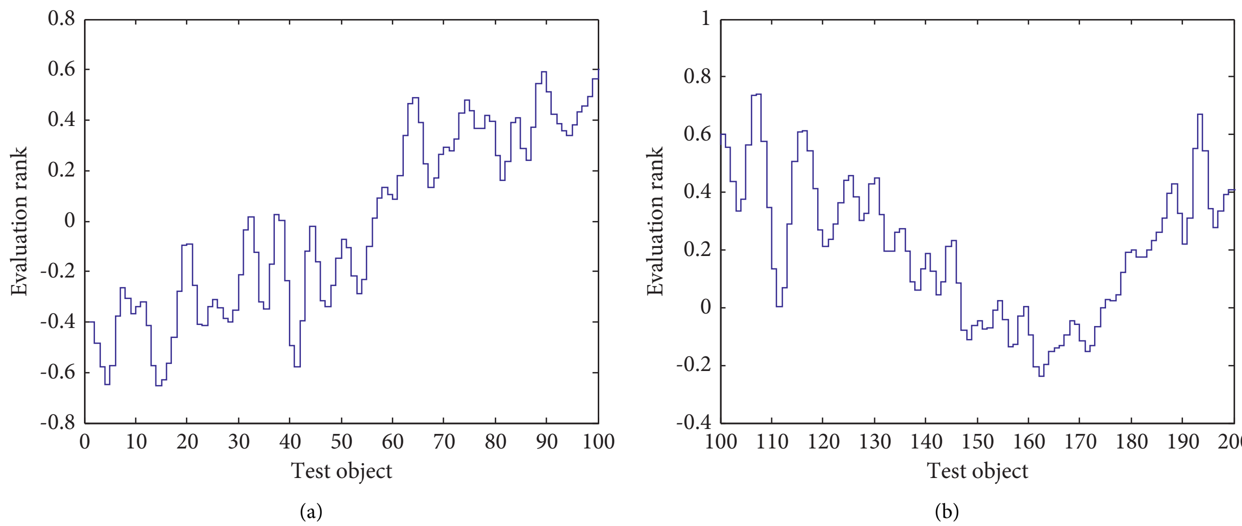

Figure 4: Graded evaluation results of the effect of art education in colleges and universities. (a) Test sample 1. (b) Test sample 2. (c) Test sample 3. (d) Test sample 4.

Table 3: Results of automatic evaluation of the effect of art education in colleges and universities.

Evaluating indicators	Integrity score	Statistical characteristic quantity	Equivocation	Distribution difference
Sample 1	12.747	0.410	0.416	3.0412
Sample 2	12.638	0.424	0.522	0.0669
Sample 3	13.242	0.437	0.476	6.3569
Sample 4	12.048	0.414	0.868	1.1505
Sample 5	12.525	0.407	0.485	5.2021
Sample 6	11.955	0.459	0.535	0.0170
Sample 7	14.479	0.477	0.588	5.4217
Sample 8	12.234	0.480	0.814	2.7214
Sample 9	12.301	0.423	0.857	3.0256
Sample 10	11.830	0.453	0.475	3.9617
Sample 11	14.475	0.427	0.651	7.2505
Sample 12	14.266	0.469	0.675	7.4756
Sample 13	13.868	0.416	0.698	2.7666
Sample 14	11.785	0.431	0.811	2.7352
Sample 15	13.631	0.450	0.835	0.7911
Sample 16	0.327	0.475	0.778	5.3509
Sample 17	0.332	0.418	0.463	5.5651
Sample 18	0.358	0.431	0.828	6.5161

Table 4: Evaluation reliability comparison.

Test time	Methods of this paper	Delphi method	Fuzzy cluster analysis method	Entropy method
10	99.79	73.35	85.02	42.55
20	94.58	71.22	82.79	41.88
30	92.16	71.21	81.76	41.97
40	96.16	71.94	83.47	42.12
50	103.60	72.86	86.65	42.22
60	101.65	71.73	85.82	41.83
70	104.63	73.41	87.09	42.40
80	97.28	72.25	83.95	42.20
90	99.42	70.48	84.86	41.42

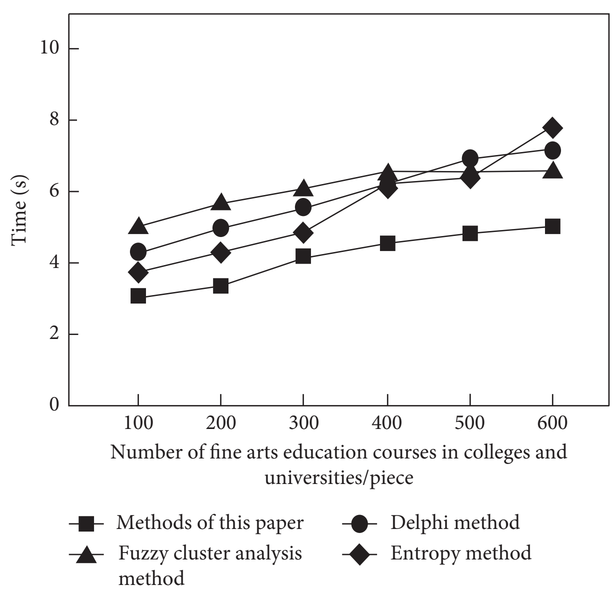

Figure 5: Time results of automatic evaluation of the effect of art education in colleges and universities.

5. Conclusions

In this paper, an automatic evaluation method of college art education effect based on big data fuzzy comprehensive evaluation is proposed. A data characteristic analysis model of college art education effect is constructed; considering the characteristics of college art education effect, an index system is selected that can reflect the effect of college art education. By using big data fusion and feature classification technology, a correlation fusion scheduling model of college art education effect evaluation is established. Through big data fuzzy comprehensive evaluation, combined with the statistical analysis methods, college art education effect evaluation is realized. The test results show that the fitness level of this method is high, and the score of the evaluation effect of college art education is significant. The evaluation index score table is in excellent condition, which indicates that the evaluation effect is accurate and reliable. The test shows that this method has high accuracy and little difference in realizing the automatic evaluation of college art education effect.

Data Availability

The raw data supporting the conclusions of this article will be made available by the author, without undue reservation.

Conflicts of Interest

The author declares no conflicts of interest regarding this work.

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Research Article

Application and Analysis of Bolt Support in Mine Driving Roadway

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Mineral resources are one of the main energy sources used in industrial production. While the economy is going up, the mining of coal mines and other mineral resources has also intensified. With the deepening of coal mining, the difficulty of mining has also increased. In order to ensure the safe production of relevant enterprises, it is necessary to vigorously apply the supporting technology of mineral resources excavation to reduce the occurrence of accidents in the mining area. Based on this, this paper, on the basis of collecting the geological conditions of a mine, combined with the stability theory of roadway surrounding rock, the existing bolt (anchor cable) support theory, and the factors affecting the reliability of bolt support, analyzed the bolt (anchor cable) support principle and deduced and calculated the support capacity of a single bolt and a group of bolts in the process of mining excavation through the energy conservation theorem. Through Mohr-Coulomb strength theory and limit line analysis theory, a reasonable mechanical model is established, and it is concluded that the ultimate bearing capacity of the bolt will increase with the increase of the length of the anchorage section no matter what support method is used for roadway surrounding rock support, and the anchorage length and ultimate bearing capacity have a nonlinear positive correlation. However, the ultimate supporting capacity of the suspension bolt cannot meet the actual work demand, while the composite beam and composite arch bolt support meet the conclusion. In addition, according to the conclusion and the suggestion that the design of bolt support mode should start with the study of the mechanism of bolt support on the roadway, the application of bolt support mode in the resource mine heading roadway is comprehensively analyzed.

1. Introduction

Mineral resources can provide various guarantees for national basic industries and industries, and mineral resources occupy an important position in all kinds of resources. According to statistics, more than 90% of the coal resources in China need to be excavated. Incomplete statistics show that the length of the roadway excavated due to coal mining is up to 8000 km every year. Therefore, it is an urgent problem to maintain the roadway unblocked and control the surrounding rock deformation in the coal mine construction and safety production [1]. The accumulation of engineering experience and the improvement of theoretical research have promoted the improvement of support concepts and technical development. With the extensive use of bolts, shed support is gradually replaced by bolt support, and the concept of active support is gradually adopted by many researchers.

It has been more than 100 years since the bolt was first used to reinforce the slope in the open-pit shale mine in North Wales, England in 1872, and the bolt support technology was first used in the underground roadway in the schelnez mine in Germany in 1912. It is the most widely used support method in coal mines and other underground projects [2]. Australia mainly promotes the full-length resin anchored bolt and has formed a systematic design approach for the bolt support system. The application of bolt support technology in China began in the late 1950s. Bolt support entered the mining area in the 1960s and was still in the exploration stage in the early 1970s. Although China has developed bolt technology for more than 50 years, it has only developed rapidly in recent decades [3, 4].

As an indispensable supporting material in the process of underground engineering structure construction, bolt support is also the main development direction of mine construction. Bolt support can better control the stability and safety of the surrounding rock. The support theory provides a theoretical basis for the design of bolt support parameters. The suspension, composite beam (arch) theory, and surrounding rock loose zone theory are the three roadway support theories mainly used at home and abroad. For a long time, the three support theories have guided the design of bolt support parameters in a large number of practical engineering construction, but there are also some application defects. In recent years, many researchers at home and abroad have further improved the roadway bolt support theory and put forward some new support theories [5–8]. For example, Terzaghi and Peck [9] first put forward the "collapse arch" support theory. They believe that an arched fracture zone without bearing capacity will be generated after roadway excavation, and the role of the bolt is to provide the support capacity of supporting the dead weight of the fracture zone. However, a large number of experimental studies show that the rock mass in the arched collapse zone still has a certain bearing capacity. Hematian et al. [10, 11] established a 2-dof model to analyze the influence of stress distribution of roadway surrounding rock and deformation and failure behavior of rock mass and obtained the corresponding roadway support design scheme. Song et al. [12] put forward the "energy support" support theory. They believe that a new support body will be formed when the support structure acts in coordination with the anchored surrounding rock, in which the energy is conserved. However, the theory has too many assumptions and is too theoretical to be verified and popularized. Akyol et al. [13, 14] analyzed how the structural conditions affect the support effect of soft rock roadway, and obtained the corresponding bolt support parameters and layout parameters when the roadway deformation is stable by using the finite element simulation software, so as to make the support effect more effective and improve the roadway support effect. Moosavi [15, 16] studied the interaction mechanism between the surrounding rock and anchor (cable) based on the interaction mechanism of a full-length bonded anchor and the advantages of the DDA algorithm. On the basis of the above research, Malmgren et al. [17] learned from previous experience and believed that the strength and fracture degree of surrounding rock are the main factors affecting the coordinated deformation of shotcrete and supporting rock mass. They analyze the supporting structure formed by the bolt and surrounding rock sprayed with concrete, which lays a foundation for the design of roadway surrounding rock support. Witthaus et al. [18] studied and analyzed the telescopic rod. Its principle is to completely release the plastic deformation energy of the roadway surrounding rock and reduce the bolt support force and the force on the bolt when the surrounding rock is unstable. The theory is put forward after the optimization of roadway support, with remarkable economic effect and high practical value. Li et al. [19–23] analyzed the axial force and shear force of the bolt body from the point of view of mechanical coupling, considering the interaction between the bolt and surrounding rock, and analyzed the mechanical behavior of bolt support, supplementing the theoretical gap in relevant aspects of bolt support theory. On this basis, Osgoui [24] used the bolt density factor to analyze the influence of bolt support on the reinforcement degree of roadway surrounding rock, and derived the analytical solution of stress and displacement of circular roadway surrounding rock under bolt support; Bobet and Einstein [19, 20, 25, 26] established the mechanical coupling model of bolt and roadway surrounding rock, deduced the displacement and stress expressions of roadway surrounding rock under different types of bolt support, and further improved the bolt support theory based on the displacement and stress of roadway surrounding rock.

However, up to now, most scholars' research on the bolt support theory has remained in the archives of the mechanical behavior of bolt support, and there is little research on the mechanical behavior of group bolt support, and the relevant theories, support methods, and applications have not been better developed. Through long-term practice and a large number of experiments, it is shown that with the bolt technology being widely used in underground engineering, the role of the bolt in roadway anchoring is becoming more and more significant. The original deformation state and stress state of surrounding rock can be effectively improved by using group anchor support. For jointed rock mass with poor integrity, group anchors can effectively improve the overall strength of surrounding rock and also increase the stability and integrity of surrounding rock. These existing theories have been confirmed in engineering practice, but there is no complete theoretical basis and explanation. Therefore, based on the above problems, this paper analyzes the mechanical behavior of roadway surrounding rock under the conditions of the single bolt and group bolt, so as to improve the design and construction level of roadway support.

2. Theory and Method of Roadway Bolt Support

2.1. Bolt Supporting Theory of Roadway

2.1.1. Suspension Theory. According to the suspension theory, after the excavation of the roadway, the original in-situ stress in the surrounding rock redistributes, changing from the original three-dimensional stress to two-dimensional corresponding stress, and creating a stress concentration area. In this area, the original joints, fissures, bedding, faults, and other discontinuities in the rock mass may further develop. Affected by this development, some rock loosening, sliding and fracture phenomena will occur. And new discontinuities may be generated, and caving may occur under the action of self-weight. The suspension function of the anchor bolt is to give sufficient restraint to the subregion at this time and anchor these loose and broken rocks in the hard and stable rock stratum inside the surrounding rock (Figure 1).

2.1.2. Composite Beam Theory. According to the composite beam theory, after the roadway is excavated, if the roof has no firm and stable rock stratum in a certain area, the suspension effect of the bolt is very small. Assuming that the roof rock is divided into many layers, there is certain friction

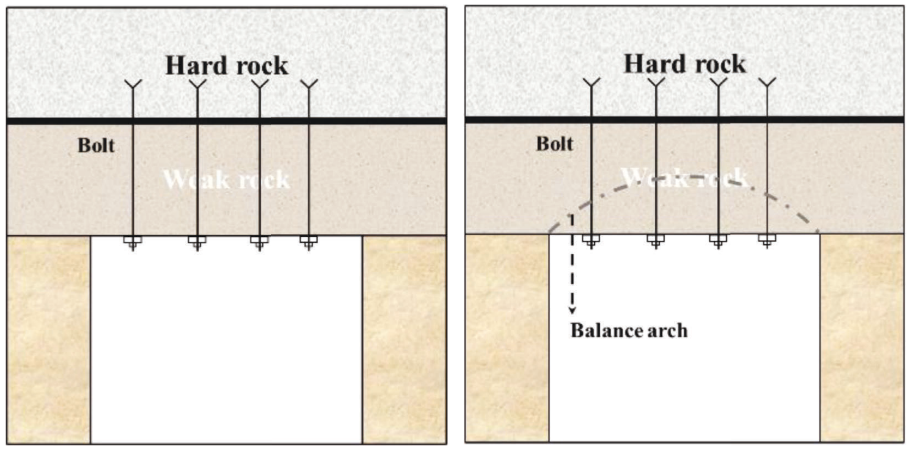


Figure 1: Schematic diagram of suspension theory.

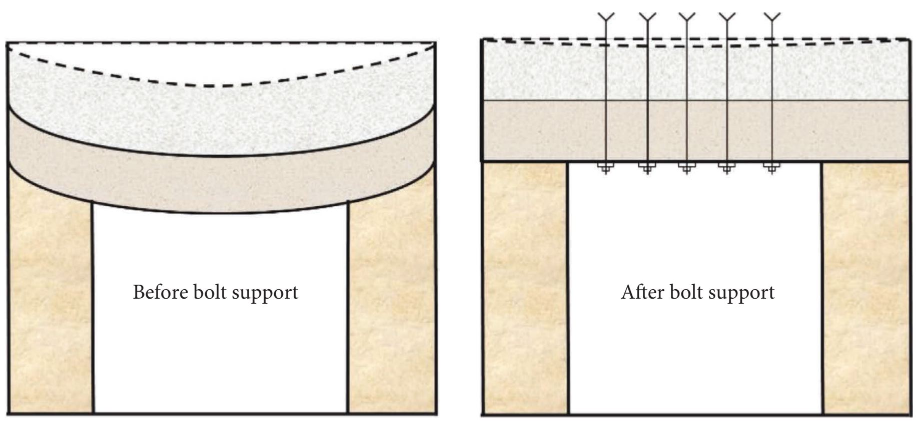


Figure 2: Schematic diagram of composite beam theory.

between layers, and the relative movement between layers is subject to the friction between layers. Bolt in roadway support can reduce the phenomenon of layer separation by increasing the friction between layers. The composite beam theory applies to the roadway whose roof is composed of multi-layer and small-thickness continuous strata. Its principle is to clamp each layer of the roof through the axial force of the bolt to enhance the friction between the layers, and improve the shear strength and bonding degree between the layers of the roof with the help of the bolt's transverse bearing capacity, so that each layer will have overall bending deformation under the action of bending moment, showing the bending deformation characteristics of the composite beam, so as to improve the bending rigidity and strength of the roof. The anchor rod can provide shear force and increase the interlayer friction. It is a combination of several thin layers to form a rock layer composite beam to restrict the rock layer sinking and separation (Figure 2).

2.1.3. Composite Arch Theory. According to the combined arch theory, when the pre-stressed anchor is installed in the fracture zone of the surrounding rock of the arch roadway, conical compressive stress will be formed at both ends of the rod body. If the anchor groups are arranged along the perimeter of the roadway, as long as the anchor spacing is small enough, the compressive stress cones formed by each anchor will be staggered, and a uniform compression zone can be formed in the rock mass, that is, the pressure arch (also known as the combined arch or compression arch). The bearing arch can bear the radial load imposed by the broken rock on its upper part. The rock in the pressure arch is under radial and tangential compression and is in a three-dimensional stress state. A uniformly compressed continuous pressure-bearing zone is formed in the surrounding rock. The strength of the surrounding rock is improved and the support capacity is correspondingly increased. Therefore, the key to bolt support is to obtain a larger bearing arch thickness and higher strength. The greater its thickness, the more conducive to the stability of the surrounding rock and the improvement of support capacity (Figure 3).

2.1.4. Loose Ring Theory. Sahoo and Palei [20, 21] put forward the loose circle support theory (Figure 4). The theory is obtained by carefully studying the deformation state of the roadway surrounding rock. The driving zone of the surrounding rock is the subordinate character of the roadway surrounding the rock. At present, the main method to monitor this range is a multi-point displacement meter or

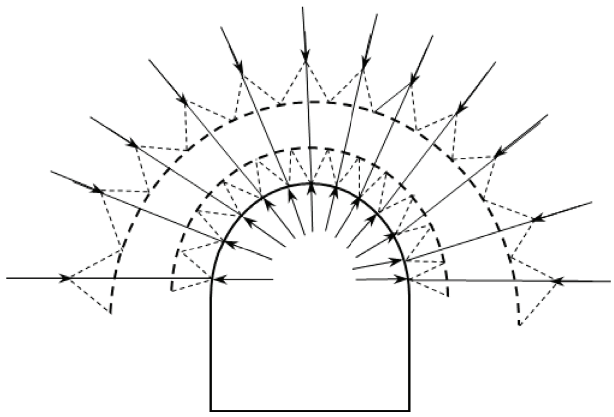


Figure 3: Schematic diagram of composite arch theory.

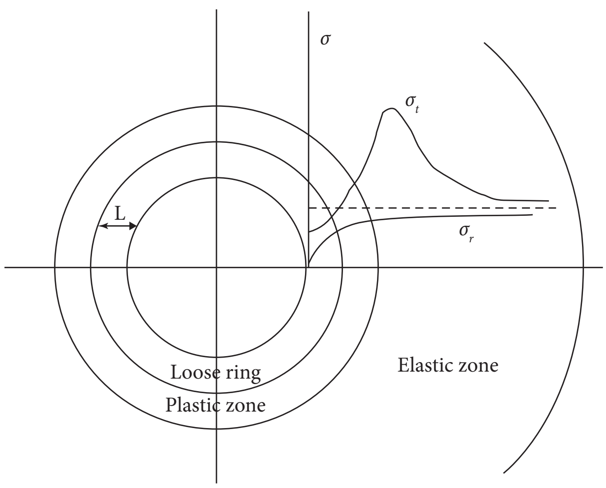


Figure 4: Schematic diagram of loose ring theory.

acoustic monitor. According to the loose circle theory, the main purpose of roadway support is to produce loose and rock fracture and expansion deformation force in the process of excavation. The anchoring force mainly comes from the generation process of the loose ring. The thickness of the loose ring is divided into three categories: small, medium, and large.

2.2. Roadway Bolt Support Mode. With the increasing number of mining projects of mineral resources, the technical processes and construction mean used by them are becoming more and more diversified. On the basis of ensuring and improving the safety of tunneling roadway support, the introduction and application of convenient construction technology should be accelerated, and the cost should be reduced to the greatest extent. Applying different forms of bolt support to the field operation links, on the one hand, can improve the efficiency of support construction in the tunneling operation stage; on the other hand, it also depends on fitting the field construction environment and ensuring the quality of coal mine roadway tunneling operation. At present, there are various bolt support methods used in the process of roadway excavation. From the perspective of support theory, the bolt support methods for the above theory include the following.

2.2.1. Suspended Bolt Support. As one of the earliest support methods used in roadway excavation suspended bolt support has been widely used in most coal mining operations. However, by observing and analyzing its practical application in field support, it can be found that its application time is generally short, and its utilization rate is not high, so it is difficult to achieve a more ideal support effect. In addition, to organize and carry out the construction of a coal mine driving roadway, it usually needs to face more complex surrounding rock lithology, which also brings more difficulties and obstacles to the on-site bolt support. If the stability of the surrounding rock is low during the construction of a coal mine driving roadway, the application of suspended bolt support is likely to cause a collapse of surrounding rock and serious damage to the whole surrounding rock structure, which not only increases many risks for on-site operation but also fails to ensure the personal safety of on-site construction personnel.

2.2.2. Composite Beam Bolt Support. It can be found from the actual situation of most coal mine tunneling roadway construction that, during roadway construction, not only the rock strata in the whole link are complex and changeable, but also their lithological characteristics are quite different, and most of them are multi-layered rock strata. In the face of this construction condition, the composite beam bolt support method can be selected, which mainly depends on the different functions reflected by the different lithology of the rock stratum, and further strengthens the anchoring of multi-layer surrounding rock to improve the bearing capacity of surrounding rock.

2.2.3. Combined Arch Bolt Support. In the process of organizing and carrying out the construction of a coal mine driving roadway, if most of the rock strata are broken, it is appropriate to adopt the combined arch bolt support. Compared with the support form of a combined beam bolt, it can play a better role in stabilizing the whole rock stratum structure and give full play to its advantages. In recent years, the application of this form of support is also common in coal mine tunneling. In the anchor support construction stage of large section roadways and arch roadways, the application of combined arch bolt support can achieve a more significant stability effect, which provides a reliable guarantee for the safety of roadway tunneling construction and greatly improves the reliability of surrounding rock support.

3. Analysis of the Upper Limit of Bearing Capacity of Bolt Support in Mine Driving Roadway

In the process of tunneling in different mines, the choice of roadway bolt support depends on the ultimate bearing capacity of the roadway surrounding rock and the upper bearing limit of bolt support. How to judge the potential failure form and failure range of surrounding rock when the surrounding rock reaches the critical state of failure becomes the basis for judging the stability of surrounding rock in the process of tunneling. Nowadays, most of the roadways surrounding rock stability problems are simulated by some finite element software. Although finite element software has been widely used in engineering practice, the displacement vector diagram, plastic zone range, and stress nephogram simulated by the software is not accurate enough. Therefore, this paper deduces the external force power and internal energy dissipation power of the allowable velocity field when the surrounding rock is damaged by using the limit upper bound analysis method, so as to achieve the accurate support of the roadway in the process of mine excavation.

3.1. Determination of Ultimate Bearing Capacity of Single Anchor. Based on the plastic limit equilibrium theory and assuming that the damaged rock mass is cone-shaped, the calculation formula of the ultimate bearing capacity of a single anchor can be derived. According to this calculation method, the calculation formula of the ultimate bearing capacity of group bolts is further derived. The calculation method has a clear idea, and the assumption is more in line with the actual project, which is conducive to the application of geotechnical engineering design. The following assumptions are made for this method:

(1) The rock mass is an ideal rigid medium and meets the conditions of the Mohr-Coulomb failure criterion.
(2) The broken rock mass takes the anchor rod as the axis and the rock mass shear plane as the bus, and the included angle between the two is a $45^\circ - \varphi/2$ angle cone.
(3) Within the shear failure range, the failure block is a three-dimensional axisymmetric block.

3.1.1. Calculation of Ultimate Bearing Capacity of Single Roof Bolt. According to the plastic limit theory of rock, when a small slip occurs in the rock mass, assume that the strain rate of the sliding rock block is V, the strength of the sliding surface follows the Mohr-Coulomb strength theory, the gravity of the rock mass is γ, the bonding force is C, the internal friction angle is φ, the included angle between the bolt and the vertical plane is α, and F is the bearing capacity of a single bolt, then the work done by the external force (bolt tension and gravity) is

$$W_{\text{External Force}} = (F + W\cos\alpha)V\cos\left(45^\circ - \frac{3}{2\varphi}\right), \tag{1}$$

where $W = 1/3\pi\gamma L_p^3 \tan(45^\circ - \varphi/2)$, L_p is the length of the free section of the anchor rod, m, and L_m is the length of the anchor bolt anchoring section, m.

$$W_{\text{Internal Force}} = c\pi L_m^2 \frac{\tan(45^\circ - \varphi/2)}{\cos(45^\circ - \varphi/2)} V\cos\phi. \tag{2}$$

According to the comprehensive formulas (1) and (2), the ultimate bearing capacity of a single bolt is

$$F = c\pi L_m^2 \frac{\cos\alpha\tan(45^\circ - \varphi/2)}{\cos(45^\circ - \varphi/2)\cos(45^\circ - 3\varphi/2)} - \frac{1}{3\pi\gamma} L_p^3 \tan^2\left(45^\circ - \frac{\varphi}{2}\right)\cos\alpha. \tag{3}$$

3.1.2. Calculation of Ultimate Bearing Capacity of Single Anchor at the Side. It can be seen from the stress on the top bolt that the external force of the side bolt is only the bolt tension:

$$W_{\text{External Force}} = F\cdot V\cos\left(45^\circ - \frac{3}{2\varphi}\right). \tag{4}$$

Internal power dissipation work is

$$W_{\text{Internal Force}} = c\pi L_m^2 \frac{\tan(45^\circ - \varphi/2)}{\cos(45^\circ - \varphi/2)} V\cos\varphi. \tag{5}$$

From: $W_{\text{External Force}} = W_{\text{Internal Force}}$:

$$F\cdot V\cos\left(45^\circ - \frac{3\varphi}{2}\right) = c\pi L_m^2 \frac{\tan(45^\circ - \varphi/2)}{\cos(45^\circ - \varphi/2)} V\cos\varphi. \tag{6}$$

Then: the bearing capacity of the single anchor of the upper is

$$F = c\pi L_m^2 \frac{\tan(45^\circ - \varphi/2)}{\cos(45^\circ - \varphi/2)\cos(45^\circ - 3\varphi/2)}\cos\varphi. \tag{7}$$

3.2. Determination of Ultimate Bearing Capacity of Group Anchors. According to the failure form of a single bolt, the maximum influence range of a single bolt is the diameter $R = 2L\tan(45^\circ - \varphi/2)$ of the cone. When the axial spacing of anchor rods in a group of anchor rods is greater than the maximum influence range of a single anchor, the stress zones of the anchor rods do not affect each other, and the ultimate total bearing capacity of the group anchor is not affected, which is equal to the sum of the ultimate bearing capacity of each single anchor rod, that is, F Group anchor $= nF$ (n is the number of group anchor rods).

3.2.1. Calculation of Ultimate Bearing Capacity of Roof Group Anchors. The formula for calculating the ultimate bearing capacity of group anchors can be derived by using the single anchor ultimate bearing capacity calculation theory. Set the size of the group anchor along the vertical and roadway direction as SX, and the size parallels to the roadway direction as SY. Then the external work done by the pulling force and the gravity of the damaged block is

$$W'_{\text{External Force}} = \left(F_{\text{Group anchor}} + W' \cos\alpha\right) V \cos\left(45^\circ - \frac{3}{2\varphi}\right),$$

$$W' = \frac{1}{3\gamma} L_p S_X S_Y + \left(S_X + 2L_p \tan\left(45^\circ - \frac{\varphi}{2}\right)\right)\left(S_Y + 2L_p \tan\left(45^\circ - \frac{\varphi}{2}\right)\right) + \sqrt{S_X S_Y \cdot \left(S_X + 2L_p \tan\left(45^\circ - \frac{\varphi}{2}\right)\right)\left(S_Y + 2L_p \tan\left(45^\circ - \frac{\varphi}{2}\right)\right)}. \tag{8}$$

Due to the large spacing of anchor bolts, the internal loss work of the anchor section during a shear failure is

$$W'_{\text{InternalForce}} = c \cos\alpha \left(\frac{2L_m \left(S_X + S_Y + 2L_m \tan\left(45^\circ - \varphi/2\right)\right)}{\cos\left(45^\circ - \varphi/2\right)} + S_X + S_Y\right). \tag{9}$$

From: $W'_{\text{External Force}} = W'_{\text{Internal Force}}$

$$\left(F_{\text{Group anchor}} + W' \cos\alpha\right) V \cos\left(45^\circ - \frac{3}{2\varphi}\right) = c \cos\alpha \left(\frac{2L_m \left(S_X + S_Y + 2L_m \tan\left(45^\circ - \varphi/2\right)\right)}{\cos\left(45^\circ - \varphi/2\right)} + S_X + S_Y\right). \tag{10}$$

The group bolts at the top of the roadway are arranged in a square grid. When the distance between the horizontal and vertical anchor bolts is less than $2L \tan(45^\circ - \varphi/2)$, the ultimate bearing capacity of group anchors is

$$F_{\text{Group sanchor}} = \frac{c \cos\alpha \left(2L_m \left(S_X + S_Y + 2L_m \tan\left(45^\circ - \varphi/2\right)\right)/\cos\left(45^\circ - \varphi/2\right) + S_X + S_Y\right)}{\cos\left(45^\circ - 3\varphi/2\right)} - W' \cos\alpha. \tag{11}$$

3.2.2. Calculation of Ultimate Bearing Capacity of Group Anchors at the Upper Part. According to the stress of the top group anchor, the external force of the side group anchor is only the anchor tension:

$$W_{\text{External Force}} = F_{\text{Group anchor}} \cdot V \cos\left(45^\circ - \frac{3}{2\varphi}\right). \tag{12}$$

The internal loss work on the shear plane is

$$W'_{\text{Internal Force}} = c \cos\alpha \left(\frac{2L_m \left(S_X + S_Y + 2L_m \tan\left(45^\circ - \varphi/2\right)\right)}{\cos\left(45^\circ - \varphi/2\right)} + S_X S_Y\right). \tag{13}$$

From: $W_{\text{External Force}} = W_{\text{Internal Force}}$:

$$F_{\text{Group anchor}} V \cos\left(45^\circ - \frac{3}{2\varphi}\right) = c \cdot V \cos\alpha \left(\frac{2L_m \left(S_X + S_Y + 2L_m \tan\left(45^\circ - \varphi/2\right)\right)}{\cos\left(45^\circ - \varphi/2\right)} + S_X S_Y\right). \tag{14}$$

The bolts of the roadway side group are arranged in a square lattice. When the distance between the horizontal and vertical anchor bolts is less than $2L \tan(45^\circ - \varphi/2)$, the bearing capacity of the side group anchor is

$$F_{\text{Group anchor}} = \frac{c \cos\alpha \left(2L_m \left(S_X + S_Y + 2L_m \tan\left(45^\circ - \varphi/2\right)\right)/\cos\left(45^\circ - \varphi/2\right) + S_X S_Y\right)}{\cos\left(45^\circ - 3\varphi/2\right)}. \tag{15}$$

4. Application Analysis of Bolt Support in Mine Driving Roadway

4.1. Project Overview. The mining area is located in Western China. The coal seams in the heading roadway are controlled by a northeastward dipping syncline. The axial direction is SW-NE, the northwest wing inclines to east-ne, with an inclination of 0° 11′–0° 52′, and the southeast wing inclines to the northwest, with an inclination of 0° 77′–1° 26′, with an amplitude of 5.4 m–10.9 m. The elevation difference between the South and North coal seams in this area is expanded from 1.5 m at the west end to 11.7 m at the east end. The coal

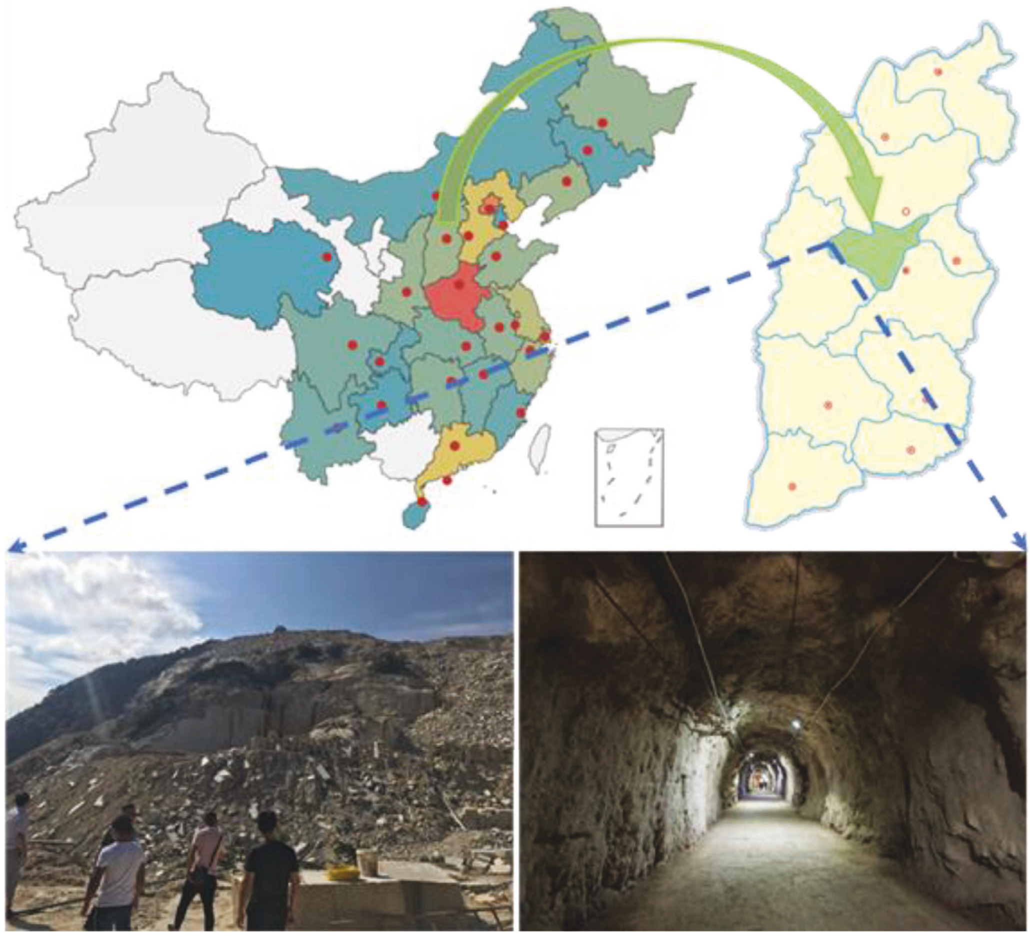


Figure 5: Schematic diagram of loose ring theory.

seam structure is simple, and there may be a roof sandstone scour body locally, with a simple geological structure. The upper part of the coal seam contains a layer of gangue with a thickness of 0.1–0.7 m, which gradually thickens from west to East. The thickness of the coal seam is 3.6–4.9 m, the average thickness is 4.5 m, and the burial depth is about 87.2–185.0 m, of which the bedrock is 46.4–80.0 m thick and the soil layer is 22.3–80.0 m thick. The coal seam has a simple structure and stable occurrence Figure 5.

4.2. Coal Seam Condition

4.2.1. Coal Quality Index. The coal quality indexes can be obtained through indoor experiments on coal seams, as shown in Table 1.

Table 1: Coal quality index.

Serial number	Entry name	Index	Company
1	Ad(Ash content)	6.98	%
2	Mad(Water content)	6.54	%
3	Std(Sulfur content)	0.24	%
4	Qnet, d(Low calorific value on dry basis)	28.00	MJ/kg
5	Qnet, dof(Analytical basis high calorific value)	27.54	MJ/kg

4.2.2. Properties of Coal Seam Roof and Floor. According to the control of the upper part of the area, the strike of the coal strata is nearly north-south, dipping to the East, with an average dip angle of 40°, and the area is monoclinal. The coal seam structure is very complex. The coal seam contains 2–8 layers of lenticular stones, which occur irregularly and frequently. Its lithology is mainly grayish-black sandy shale or grayish-white medium-grained sandstone, with a small amount of carbon shale, argillaceous shale, and aluminous shale. See Table 2 for roadway roof and floor information.

4.3. Field Monitoring and Data Analysis. Before the bolt support design and support mode selection, we need to evaluate the existing support mode, so as to provide a theoretical basis for the subsequent support design calculation and support mode selection. The field-measured surrounding rock deformation and bolt stress are the most

Table 2: Coal quality index.

Name	Rock stratum	Thickness (m)	Features
Old roof	Medium-grained quartzitic sandstone	20.0–40.0	Light gray, poor sorting, and weak water content
Direct roof	Sandy shale	2.0–3.0	Gray, with a large number of layered joints
False bottom	Argillaceous shale	0.5–1.0	Grayish black, mainly siltstone
Old background	Coarse-grained sandstone	10.0–50.0	Gray, with massive bedding, easy to break

direct and reliable evaluation basis. Therefore, it is necessary to monitor the surrounding rock convergence, roof separation, and bolt axial force, analyze the data, analyze and evaluate the support effect, and judge whether the roadway is safe and stable under the corresponding support parameters. In order to analyze and evaluate the support effect of bolts on the roadway surrounding rock, two monitoring faces (section 2 is common to support, and section 1 is enhanced bolt support) are arranged at the front and back of 1000 m of auxiliary transportation roadway of S1 working face. During the excavation process, the surrounding rock separation, convergence, and bolt stress are monitored on site, and then the monitoring data are analyzed to determine the impact of excavation on roadway stability and judge whether the roadway support scheme is reasonable and the effect of the bolt in roadway surrounding rock support.

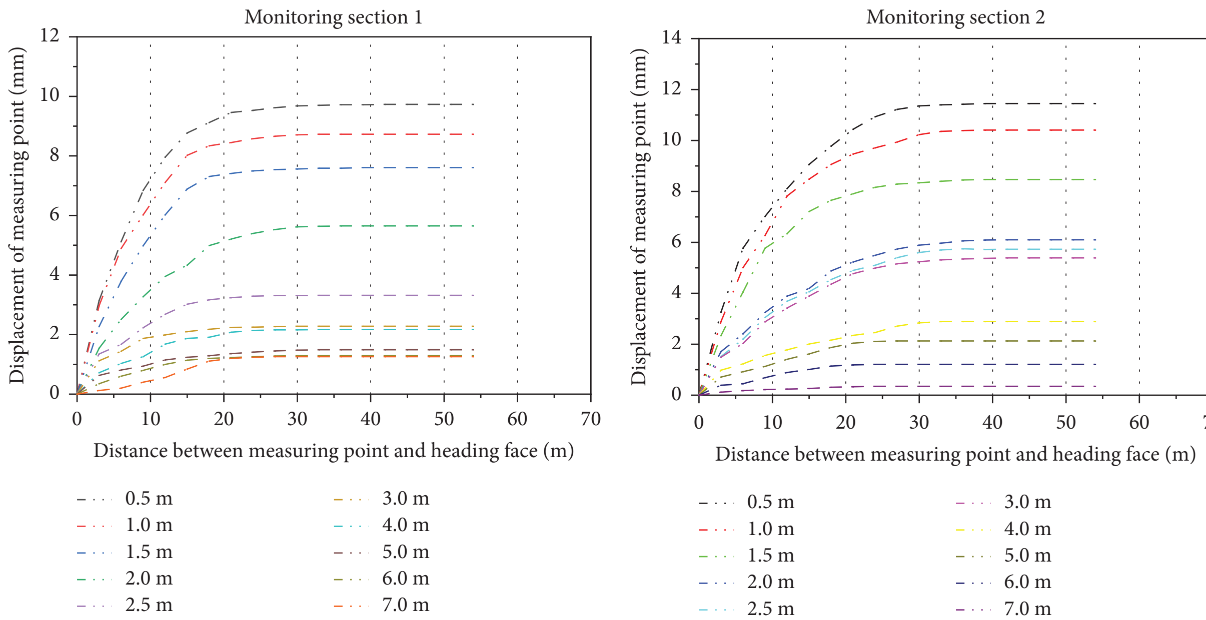
4.3.1. Separation Layer Monitoring. The monitoring points of roadway roof separation are generally arranged at the central axis of the roof. The deepest measuring points of the roof separation layer are arranged at 10 points according to the length of the anchor cable. The buried depths of the roof base points are 0.5 m, 1.0 m, 1.5 m, 2.0 m, 2.5 m, 3.0 m, 4.0 m, 5.0 m, 6.0 m, and 7.0 m respectively. The monitoring points for the separation layer of the upper part are arranged at the middle horizontal position of the two upper sides. The monitoring points for the separation layer of the two upper parts are usually arranged at 5 points depending on the length of the anchor rod. The depth of the top measuring points is 0.5 m, 1.0 m, 1.5 m, 2.0 m, and 2.5 m respectively.

Figures 6(a) and 6(b) are on-site monitoring charts of roof delamination at two different monitoring sections on working face S1. It can be seen from the figures that when the heading face is more than 30.0 m away from the monitoring section, the roof delamination remains unchanged with the advance of the heading face. Rock layer separation occurs at 1.5 m~2.0 m and 2.5 m~3.0 m of section 1, with separation values of 1.96 mm and 1.04 mm respectively, and the maximum separation is 3.32 mm; section 2 has delamination at 1.5 m~2.0 m and 3.0 m~4.0 m, with delamination values of 2.37 mm and 2.5 m respectively. It can be inferred that the thickness of the top anchor structure is about 1.5 m~4.0 m, and the anchor structure in this range has a bearing effect. Therefore, when designing the anchor rod, the length of the anchor rod can be designed as 4.0 m according to the data of this study. In addition, it can be seen from the section separation results that the separation displacement of section 1 supported by reinforced bolts is significantly smaller than that of section 2, which shows that the bolt has a significant control effect on the separation of roadway surrounding rock.

4.3.2. Tunnel Convergence Deformation Monitoring. The convergence deformation of the roadway is monitored by the triangular point distribution method as shown in Figure 7. Two sections are arranged in total, and 9 monitoring points are arranged for each section. Figures 8(a) and 8(b) are on-site monitoring diagrams of roadway convergence deformation in the roof layer of two different monitoring sections on working face S1. It can be seen from the figures that the closer the heading face is to the monitoring section, the greater the deformation rate. As the working face goes on, the roof also begins to sink, and the two sides of the roadway also begin to converge. As the working face goes on, the roadway deformation rate also gradually decreases. When the heading face is about 30.0 m away from the monitored section, the deformation of the roadway remains unchanged and the roadway is stable. The final convergence of the three measuring points on the two sides of Section 1 is 10.34 mm, 4.72 mm, and 4.92 mm, respectively. The final convergence of the three measuring points on the two sides of Section 2 is 14.55 mm, 6.44 mm, and 5.98 mm, respectively. It can be seen from the surrounding rock convergence deformation that the convergence deformation between the two sections is significantly different. The convergence deformation of the surrounding rock of the roadway in ordinary section 2 is significantly larger than that in section 1 and is as large as 4.21 mm, 1.72 mm, and 1.06 mm, respectively. This shows that the anchor rod has a significant control effect on the convergence deformation of the surrounding rock of the roadway.

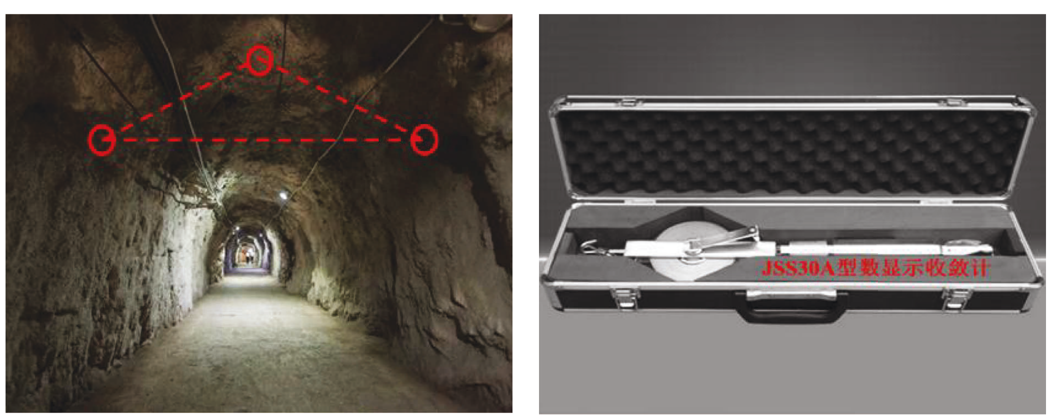
4.3.3. Bolt Axial Force Monitoring. The anchoring force of the bolt needs to be monitored by a bolt dynamometer, and the deformation of the surrounding rock will cause the bolt to play a greater role. The prestress of the anchor rod and the deformation of the surrounding rock make the axial tension and shear of the anchor rod. This force will change the resistance or frequency of the anchor rod dynamometer in a proportional relationship, and then the axial force of the anchor rod can be converted through the formula. There are many monitoring instruments for anchor rod axial force, and the monitoring instruments we use are shown in Figure 9. During on-site monitoring, monitoring tables are set in two sections, respectively at M2 in the middle of the auxiliary wall and M1 in the middle axis of the roof.

As shown in Figure 10, the axial force of the anchor rod at the monitoring section S1 changes more slowly with the



(a) (b)

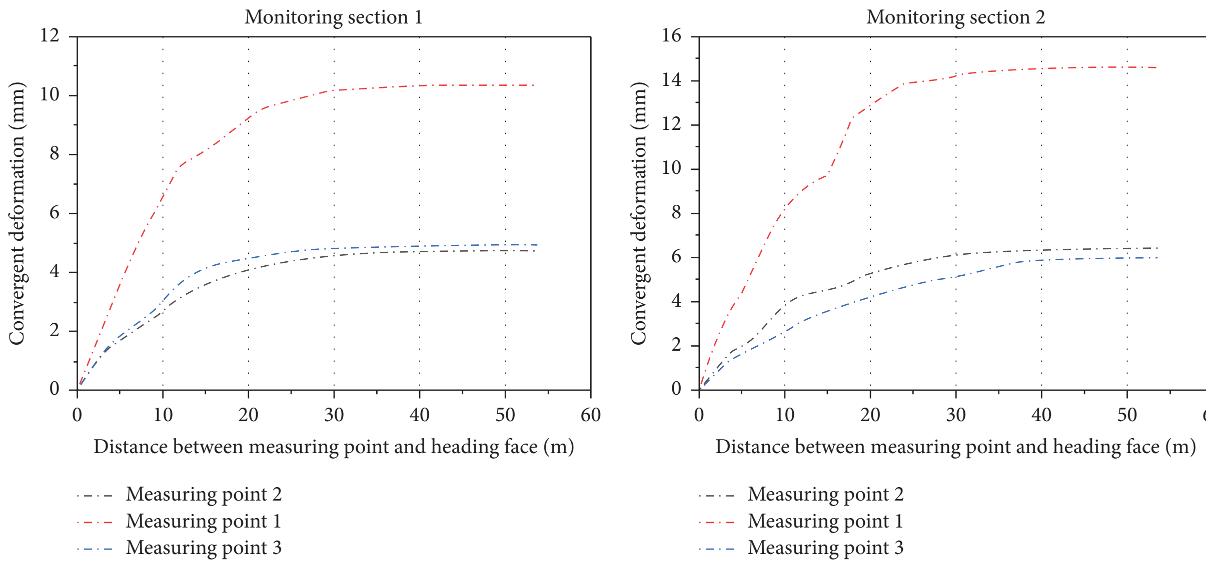
Figure 6: Field monitoring data of roof separation at different monitoring sections of the S1 working face. (a) Monitoring section 1. (b) Monitoring section 2.



(a) (b)

Figure 7: Field monitoring of S1 roadway convergence deformation. (a) Site monitoring points. (b) Field monitoring instrument.

advance of the heading face, and the stress on the surface of the anchor rod gradually stabilizes. The maximum axial force of the bolt is less than the initial design value, and the bolt body is not yielding, which indicates that the surrounding rock is in a stable state. The bolt dynamometer shows that the axial force of the side bolt is less than that of the roof bolt. The monitoring results of the two sections are very similar, and the shear force is less than the yield value of the bolt. Therefore, the normal operation of the bolt can be guaranteed. However, when the force of the anchor rod is small, it means that its support effect is not fully exerted, the support design is not reasonable and the economy is poor, and there is room for further optimization. The stress of the top anchor and side anchor of section 1 is 37.41 kN and 17.59 kN respectively. The stress of the top anchor and side anchor of section 2 is 42.62 kN and 26.42 kN respectively. It can be found from the axial force of the anchor rod of sections 1 and 2 that the axial force of the anchor rod of section 2 is significantly higher than that of section 1, and is 5.21 kN and 8.83 kN higher, 13.93% and 50.20% higher, respectively. It can be seen that the axial force of the local anchor rod is too large, and more than half of that of the anchor rod 1. The reason is that the bearing capacity of the surrounding rock of the roadway is fully developed under the effect of strengthening the anchor rod support of section 1, which shows that with a certain number of anchors, With the increase in the number of bolts, the better the self-stabilization effect of surrounding rock.



(a) (b)

Figure 8: Field monitoring data of roof convergence at different monitoring sections of the S1 working face. (a) Monitoring section 1. (b) Monitoring section 2.

Figure 9: Anchor rod dynamometer.

4.4. Calculation of Ultimate Bearing Capacity of Bolt under Different Support Modes. When the suspended bolt support is used for roadway surrounding rock support, due to the suspension bolt support mode and its characteristics, the support effect can be approximately equivalent to that of single bolt support. Therefore, when calculating the ultimate bearing capacity of the bolt, the bearing capacity of a single bolt can be directly used for calculation. Composite beam bolt support and composite arch bolt support can be similar to group anchor support. However, a composite beam cannot be fully utilized by bolt and surrounding rock when anchoring, so it is only regarded as a side group anchor in the calculation, while a composite arch can be regarded as a top group anchor. After calculation, the relationship between the support result of a single bolt and the length of the bolt under each support condition is shown in Figure 11, and the change in the ultimate bearing capacity of the group of bolts is shown in Figure 12 (where a represents the tensile force borne by the suspension bolt group, B represents the tensile force borne by the composite beam bolt group, and a represents the tensile force borne by the composite arch bolt group). From its change curve, it can be seen that under any support form, with the continuous increase of the length of the anchorage section, the ultimate bearing capacity of a single bolt also increases, and the anchorage length has a nonlinear positive correlation with the ultimate bearing capacity. However, in the suspended bolt support, when the anchorage length of a single bolt is increased from 20 cm to 40 cm, the ultimate bearing capacity F of a single bolt is increased from 27.71 kN to 39.87 kN, which is less than the measured bearing capacity of the actual roadway bolt support. In the composite beam bolt support, when the anchorage length of a single bolt of bolt increases from 20 cm to 40 cm, the ultimate bearing capacity F of a single bolt increases from 32.97 kN to 46.51 kN, which is greater than the measured bearing capacity of the actual roadway bolt support. In the combined arch bolt support, when the anchorage length of a single bolt of bolt is increased from 20 cm to 40 cm, the ultimate bearing capacity F of a single bolt is increased from 30.12 kN to 51.08 kN, which is much greater than the measured bearing capacity of the actual roadway bolt support and has certain safety reserves.

To sum up, in the roadway surrounding the rock support of this project, no matter what support method is used for roadway surrounding rock support, the ultimate bearing capacity of the bolt will increase with the continuous increase of the length of the anchoring section, and the anchoring length has a nonlinear positive correlation with the ultimate bearing capacity. However, the ultimate bearing capacity of suspended bolt support

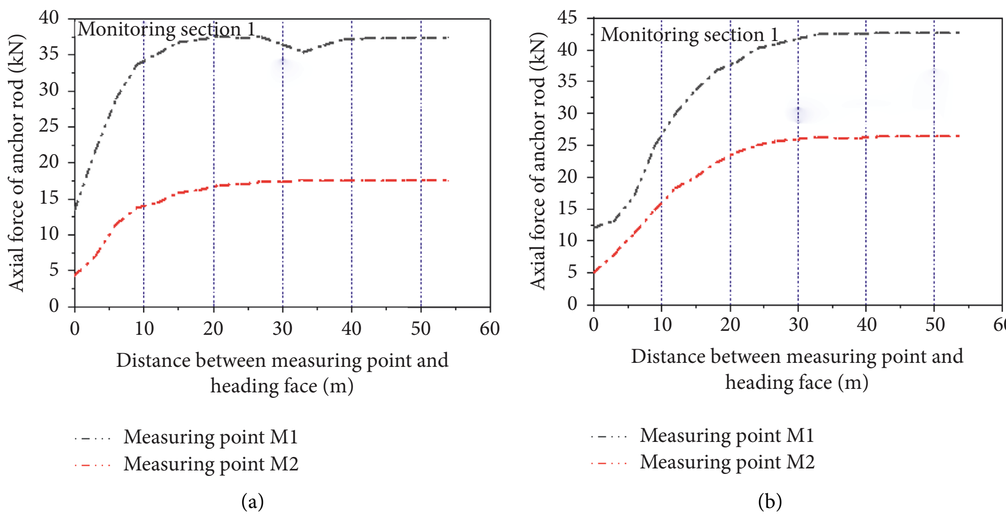


FIGURE 10: Monitoring data of axial force of bolts at different monitoring sections of the S1 working face. (a) Monitoring section 1. (b) Monitoring section 2.

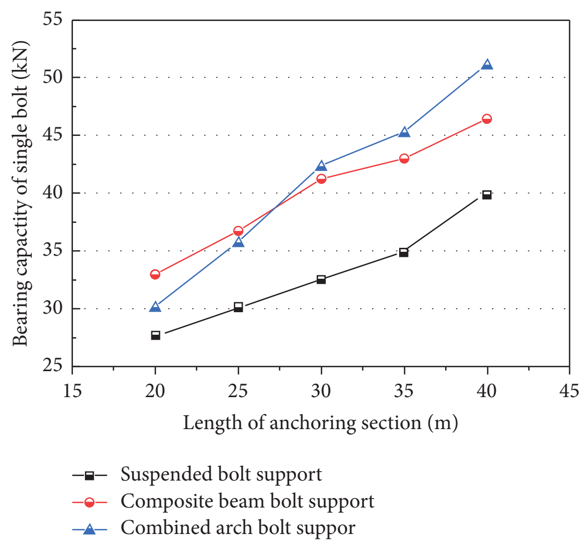


FIGURE 11: Variation curve of ultimate bearing capacity of single anchor rod with the length of anchorage section.

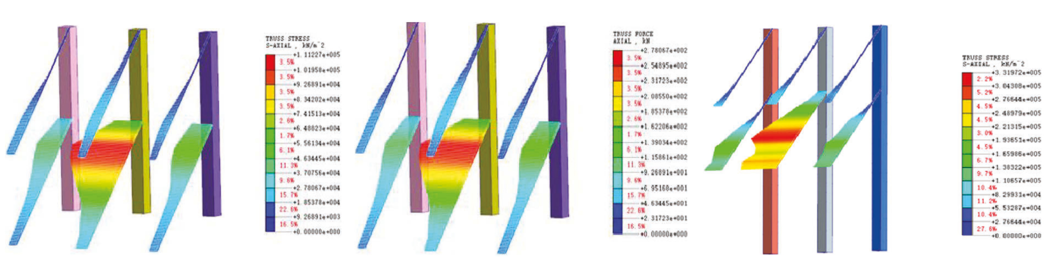


FIGURE 12: Variation curve of ultimate bearing capacity of group anchors with the length of anchorage section.

cannot meet the actual work needs, while the composite beam and composite arch bolt support can meet the requirements. Therefore, in the design, in order to reduce the support cost of the roadway, the design of the bolt support mode should start with the research on the support mechanism of the bolt on the roadway, analyze the joint action of the support body and surrounding rock, determine the geological conditions of the surrounding rock, calculate the stress of the bolt support, and select the support mode and length of the bolt, so as to seek the best support period and method and reduce the support cost of the roadway surrounding rock.

5. Conclusion

Based on a coal mine roadway support project, combined with the roadway surrounding rock stability theory, the existing bolt (an anchor cable) support theory, and the factors affecting the reliability of bolt support, this paper analyzes the bolt (an anchor cable) support principle and deduces and calculates the support bearing capacity of the single bolt and group bolt in the process of mine excavation through the energy conservation theorem. The conclusions are as follows:

(1) Based on Mohr-Coulomb strength theory and limit line analysis theory, a reasonable mechanical model is established to analyze the deformation law and failure mechanism of roadway surrounding rock, and the ultimate bearing capacity of group bolts can be calculated; The influence of surrounding rock mass parameters on the ultimate bearing capacity of roadway roof bolts is analyzed, which provides a basis for the long-term stability evaluation of roadway surrounding rock.

(2) Based on the field monitoring and theoretical analysis, the convergence deformation of roadway surrounding rock, roof separation, and the change of bolt axial force on different sections of the S1 working face are studied. It is concluded that the bolt has a significant reinforcement effect on the roadway surrounding rock. When the anchoring length of a single bolt of bolt increases from 20 cm to 40 cm, the ultimate bearing capacity F of a single bolt increases from 30.12 kN to 51.08 kN, which is far greater than the measured bearing capacity of the actual roadway bolt support, and has certain safety reserves.

(3) According to the field monitoring data, combined with theoretical analysis and formula calculation, the support conditions of different bolt support modes are analyzed, and the support ultimate bearing capacity values of three different bolt support modes of suspension, composite beam, and composite arch are calculated. The results show that the effect of the composite arch in the roadway surrounding rock support is better than the other two

Data Availability

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

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Research Article

Research on the Optimization Strategy of the Low-Carbon Economic Development Model based on the BP Neural Network Model

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Low-carbon economy has become a topic of great concern to the international community. Sea level rise caused by climate change, flood disasters, biodiversity reduction, global famine, and other issues have begun to threaten the normal survival of human beings, and the climate problem needs to be solved urgently. While ensuring rapid economic development, in order to better control the total amount of greenhouse gas emissions, this paper, based on the theory of low-carbon economy, takes control of total carbon emissions for low-carbon economic development, as a perspective, and selects the optimization for the development of low-carbon economy. From the aspects of structural emission reduction technology and emission reduction, a carbon emission control optimization index system for low-carbon economic development based on total carbon emission control is constructed. Under the framework of the index system, construct an optimization model for the total amount of carbon emissions in a low-carbon economy and use the BP neural network model to seek the balance point between economic development, energy consumption, and carbon emissions so as to promote the rational and scientific development of the low-carbon economy. *Planning and development.* First of all, on the premise of maintaining the same economic growth rate, the optimization plan will reduce carbon emissions. Secondly, on the premise of keeping the cost of energy consumption unchanged, it is more reasonable to adjust the energy consumption structure. Taking the optimization plan as the suggestion for the development direction of the low-carbon economy, it provides scientific and feasible technical support for achieving the emission reduction target of reducing the unit greenhouse gas emission to 40%.

1. Introduction

The proposal of a low-carbon economy can basically be considered as the first proposal by the United Kingdom when the institutional framework of the United Nations Climate Change Conference suffered setbacks, especially the Kyoto Protocol, which was subject to unprecedented doubts. On February 24, 2003, the then Prime Minister of the United Kingdom, Tony Blair, published a white paper entitled, The Future of Our Energy: Creating a Low-Carbon Society. Its overall goal is to cut carbon dioxide emissions by 60% from 1990 levels by 2050, fundamentally transforming the UK into a low-carbon economy. The publication of the white paper marks the birth of a new economic development model, which means that economic development cannot be at the expense of resources and the environment, and the government can guide business incentives to encourage the market to use new low-carbon technologies to promote the entire economy. *Structural transformation.* The more positive significance of the white paper is to break the deadlock in international climate negotiations, focus on the mutual promotion and integration of national economic development and global climate change, promote the construction of the foundation of the international climate system, and build a bridge for mutual understanding between developed and developing countries.

Although the United Kingdom took the lead in proposing the concept of low-carbon economy and clarified its own goals and schedule for realizing low-carbon economy, it did not define the concept of low-carbon economy in detail nor did it provide an indicator system for measuring and evaluating low-carbon economy. The widely cited definition of low-carbon economy is that of the elaboration of British environmental expert Rubinster who stated that low-carbon economy is an emerging economic model, the core of which is based on market mechanisms, through the formulation and development of institutional frameworks and policy measures. Innovation promotes the development and application of energy efficiency technology, energy-saving technology, renewable energy technology, and greenhouse gas emission reduction technology and also promotes the transformation of the entire social economy to a model of high energy efficiency, low energy consumption, and low carbon emissions [1]. In 2009, the China Council for International Cooperation on Environment and Development released a study on China's development of low-carbon economy, arguing that a low-carbon economy is a new economic technology and social system, which can save energy in production and consumption compared with the traditional economic system, reduce energy consumption, and reduce energy consumption and greenhouse gas emissions, while maintaining the momentum of economic and social development [2]. Other scholars [3–7] have also defined the connotation of low-carbon economy, no matter what the definition of low-carbon economy is, its essence is to improve energy efficiency, and the core of the issue of clean energy structure is to achieve clean and sustainable economic and social development through energy technology innovation and policy innovation, taking into account economic development and global climate issues. Based on the above viewpoints, this paper believes that low-carbon economy is an increasingly serious problem faced by human society. It is a brand-new development concept put forward by the global climate issue. While attaching importance to reducing greenhouse gases, it fully respects the needs of economic development of various countries and uses technological revolution and policy innovation as the main means to guide the economy to low energy consumption, low pollution, and low emissions. The direction of development is in line with the needs of sustainable development and ecological balance.

In general, the understanding of the connotation of low-carbon economy can be considered that the focus of low-carbon economy is low-carbon, and the purpose is development, which mainly includes three situations: the first situation is that the growth rate of greenhouse gas emissions is less than the growth of GDP; the second scenario is zero emissions, that is, carbon emissions and carbon sink construction are offset each other; the third scenario is absolute carbon emissions reduction. Of course, the preconditions for the above three scenarios are economic development; that is, the GDP is greater than zero. For developed countries, the goal should be an absolute low-carbon economy, reducing carbon emissions. For developing China, the goal should be relatively low-carbon development. Low-carbon economy is to seek a long-term global level sustainable development [8–12]. Countries should achieve low-carbon economic development in multiple ways according to their own national conditions and achieve the ultimate goal of the Convention: to stabilize the concentration of greenhouse gases in the atmosphere at a level that prevents the climate system from being threatened and disturbed. In view of the great significance of the low-carbon economy, the transition to a low-carbon economy has become a major trend in the development of the world economy. Countries such as France, Japan and Canada have taken corresponding policy measures and actively develop a low-carbon economy. Although the United States does not explicitly accept or oppose the concept of a low-carbon economy, it has always advocated solving the problem of climate change through technological means, which is consistent with the connotation of a low-carbon economy. At the annual meeting of the World Economy in Davos, Switzerland, 2008, the issue of climate change and the handling of the global financial crisis have become the top issues of the annual meeting. The international community has gradually realized that the fundamental way to solve the problem of climate change lies in cutting off economic growth and greenhouse gas emissions and to establish a low-carbon economic development model.

The core of the low-carbon economy is the technological innovation of energy emission reduction. The innovation of the industrial structure system and the transformation of the concept of human survival and development are essentially the problems of improving energy efficiency and clean energy structure. Although the UK has proposed the concept of low-carbon economy, it has not defined low-carbon economy. The concept of economy [13] gives an indicator system that can be compared, and the general understanding of low carbon can be divided into three situations: (1) the growth rate of greenhouse gas emissions is less than the growth rate of DGP; (2) zero emissions; and (3) reduction of absolute emissions. Positive economic growth (GDP growth rate greater than zero) is a prerequisite for realizing low-carbon development. For developed countries, an absolute low-carbon economy should be the goal. For developing countries, relative low-carbon development should be the development goal. How to develop a low-carbon economy and explore the development path of low-carbon economy are the key links in the study of low-carbon economy at this stage, and it is also the most controversial field.

Based on the theory of low-carbon economy and from the perspective of total carbon emission control in the development of low-carbon economy, this paper selects the optimal indicators for the development of low-carbon economy based on the types of energy consumption in economic structure from structural emission reduction, technical emission reduction, etc. In terms of carbon emission control, a low-carbon economy development carbon emission control optimization index system based on total carbon emission control is constructed. The balance point is sought between consumption and carbon emissions so as to promote the rational and scientific planning and development of low-carbon economy.

2. Background

2.1. BP Neural Network. In 1943, McCulloch et al. reinduced and expanded the basic characteristics of neurons, forming the prototype of neural network. The most basic component of the human brain is neuron organization. The interconnection model of brain-like machines is mainly based on the characteristics of biological neurons. This conceptual model can be applied to logical operating systems and has been used since then. Computer expert McCarthy extended the concept of artificial intelligence in the 1950s [14]. However, the research of traditional artificial intelligence methods fell into a low point after a series of changes. In the early 1980s, Hopfield published two articles based on artificial neural networks, which attracted the attention of experts and scholars in the field. This broke the previous low tide period and continued further research on artificial intelligence methods. In late 1986, experts and scholars found that the original system was not applicable in some fields, and disciplines such as machine learning artificial neural networks can effectively make up for traditional artificial intelligence. Due to the shortcomings of intelligent methods, artificial intelligence has entered a new era. As one of artificial intelligence methods, artificial neural network can best reflect its far-reaching impact. Liu et al. used the BP neural network model to better predict the precipitation in Hexi in summer [15]. Zhang studied the GDP data of Guangxi from 1996 to 2010, added a momentum term to the BP neural network for improvement, and changed the learning rate to analyze the performance [16]. Yuan Shuai et al. studied Hunan from the perspective of multidimensional factors. Based on the provincial poverty measurement standard, the spatial distribution results are simulated by the BP network and compared with the remote sensing data to provide a reference for regional poverty alleviation [17]. The related risks also include nonfinancial factors, and a new model is constructed by adding BP neural network to promote sustainable innovation of enterprises [18].

The BP neural network is an algorithm that calculates the error and propagates the error in the opposite direction of the network calculation. The simplest BP neural network has three layers. There is no connection between neurons in a single layer, and there is no direct connection between the input layer and the output layer. The BP neural network algorithm is one of the most widely used neural network models. It is a multilayer feedforward network whose main feature is error backpropagation. It is used to learn and memorize a large number of mapping relationships between input and output models without prior disclosure description. Its learning rule is the steepest descent method, in which backpropagation is used to adjust the BP neural network model. Figure 1 shows the model structure of the BP neural network.

The BP learning process is divided into two steps: (1) Forward propagation of the working signal: the input signal is propagated from the input layer to the output layer through the hidden layer. During the forward propagation of the working signal, the weight and offset values of the network are constant. The state of neurons in each layer will only affect the neurons in the next layer. In the case that the output layer cannot achieve the expected output, it can be switched to the backpropagation of the error signal. (2) The inverse of the error signal backpropagation: The difference between the actual output and the expected output of the network is defined as the error signal. In backpropagation, the error signal propagates from the output to the input layer in a hierarchical manner. During the backpropagation of the error signal, the weights of the network are adjusted by the error feedback. Through the continuous modification of the weights and offsets, the obtained network output is getting closer and closer to the expected output.

In a BP neural network, the activation function of a neuron is a simulation of the mathematical process between the layers of the neuron. The mathematical function reflects the relationship between the layers. In the traditional three-layer BP neural network, the most commonly used activation function is the standard sigmoid function. The mathematical expression of the standard sigmoid function is as follows:

$$g(x) = \frac{1}{1 + e^{-x}}. \tag{1}$$

2.2. Analysis of Economic Development Rights and Emission Reduction Responsibilities. In order to achieve the goal of reducing greenhouse gas emissions, a binding climate agreement should include more participants and clearer sharing of responsibilities. China should adhere to the fair distribution of initial emission rights and its own economic development needs when participating in international emission reduction cooperation. Calculate the responsibility of each country according to the historical cumulative consumption emissions and determine the emission reduction capacity of each country according to the per capita income of each country and the size of the people who can afford it. It is recommended to use the value of the country with the lowest annual per capita cumulative consumption emission stipulated by the Kyoto Protocol as the standard value. Countries that are higher than the standard value implement the limit target, and countries that have not yet reached the standard value implement voluntary emission reduction. The more voluntary emission reductions are made, the further it can be delayed to join the cap. In addition to clarifying their own emission reduction responsibilities, they should also strengthen technical cooperation with developed countries, seek more financial support, advocate the removal of any barriers to technology transfer required for emission reduction, do a good job in collecting and providing emission reduction information and inventory, and develop and implement measures to mitigate and adapt to climate change.

When there is no international agreement on emission reduction, China insists on taking carbon emission intensity as its emission reduction target, which not only reflects the determination of emission reduction, as a responsible major country, but also safeguards the needs of its own economic development. China's economic construction is still in the

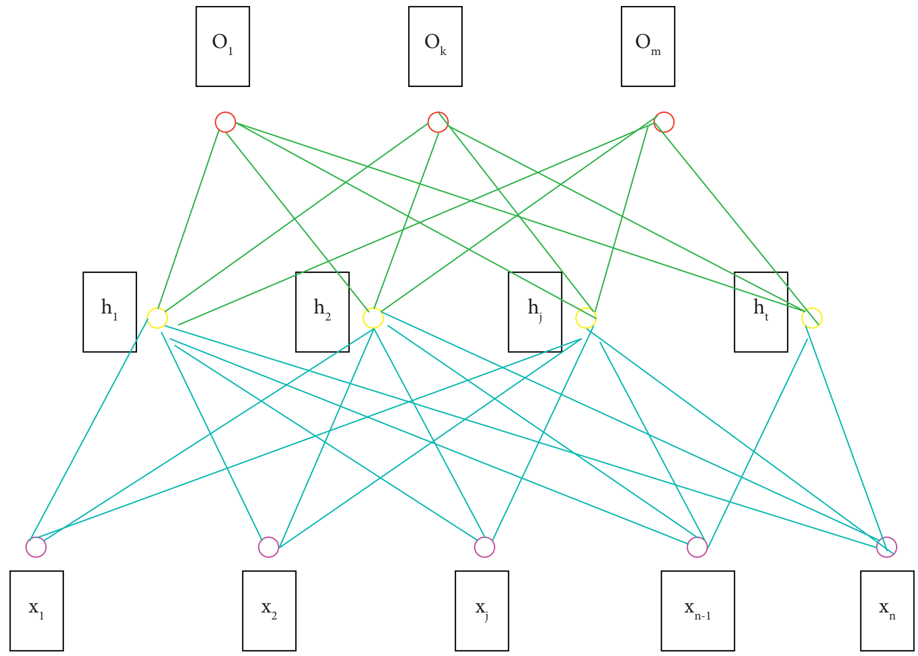

Figure 1: BP neural network structure.

process of industrialization, the transformation of the economic structure is facing many difficulties, and carbon emissions are bound to increase rapidly in the short term. Figure 2 shows the carbon emission intensity of various countries. Among them, China and India have the largest carbon emission intensity, which is much higher than the world average level, but the difference is that India's carbon emission intensity changes gradually, while China's carbon emission intensity curve changes rapidly after a rapid decline. In 2005, China's carbon emission intensity was 27,490 tons per 100 million yuan. In 2020, the carbon emission intensity l dropped by 40–45%, and the approximate range is 1.51–1.65. This data show that China's emission reduction pressure is still very high. Therefore, the development of a low-carbon economy and reducing carbon emissions is the key path for China to fulfill its emission reduction commitments.

2.3. Influencing Factors of Low-Carbon Economic Development in the ISM Model. The low-carbon economy is an economic model based on low energy consumption, low pollution, and low emissions. The essence is the efficient use of energy, the development of clean energy, and the establishment of a low-carbon life model. For China in the stage of industrialization, the development of a low-carbon economy means the transformation of the industrial structure, technological innovation and application in many industries, changes in land use patterns, and the enhancement of residents' low-carbon awareness. Involving the government, enterprises, institutions, and individuals, its complexity and system urgently require an efficient framework to clarify the structural relationships and constraints among the influencing factors of a low-carbon economy. This paper uses a combination of literature search and expert consultation to list and analyze the following eight factors hindering the development of China's low-carbon economy: (1) extensive economic development; (2) lack of a perfect low-carbon policy framework; (3) the population base is large, and the residents' low carbon awareness is weak; (4) insufficient low-carbon technology and management experience; (5) the energy structure needs to be improved urgently; (6) there is an extreme shortage of professionals in the low-carbon field; (7) there is a lack of a sound carbon emission trading mechanism; and (8) the investment is large and financing is difficult.

System Explanation Structural Model (ISM) is a system analysis method developed by Professor Warfield of the United States in 1973 to analyze complex social and economic systems. The method is mainly based on directed graph models and Boolean matrices. The system is decomposed into several subsystem elements, using people's practical experience and knowledge and the help of computers, and finally constitutes a multilevel hierarchical structural model. The idea is transformed into an intuitive model with good structural relationships. It is especially suitable for system analysis with many variables and complex relationships and unclear structure and can also be used for the sorting of programs. The explanatory structural model method is a widely used method in modern systems engineering. This analysis method is a kind of structural modeling technology, and its application is very wide from international issues such as energy issues to regional economic development, enterprises and institutions, and even personal issues. Figure 3 is a hierarchical structure diagram of influencing factors of low-carbon economy. As can be seen from Figure 3, the four main factors affecting the

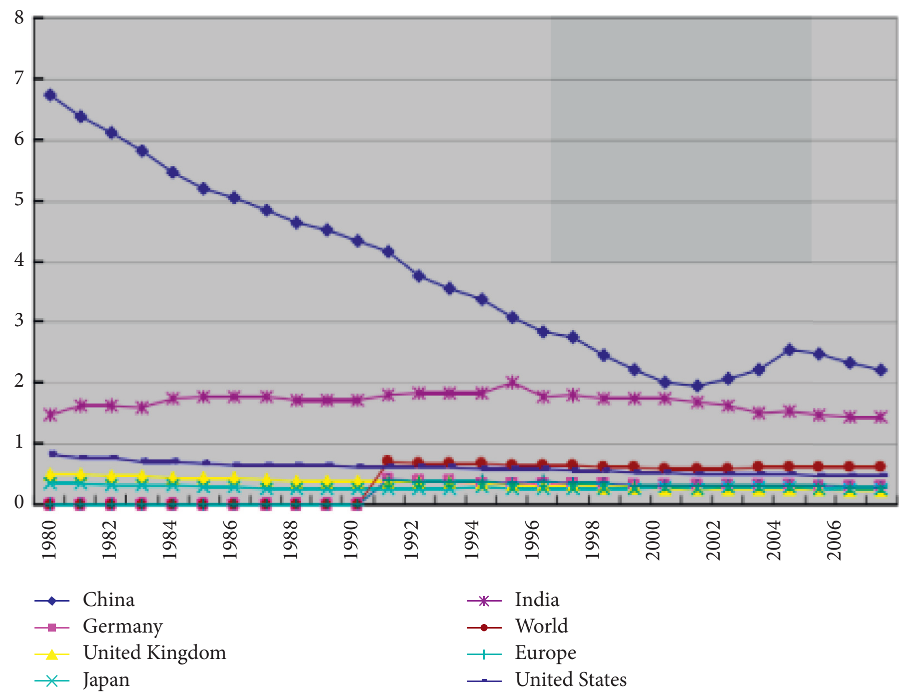

FIGURE 2: Comparison of carbon emission intensity across countries.

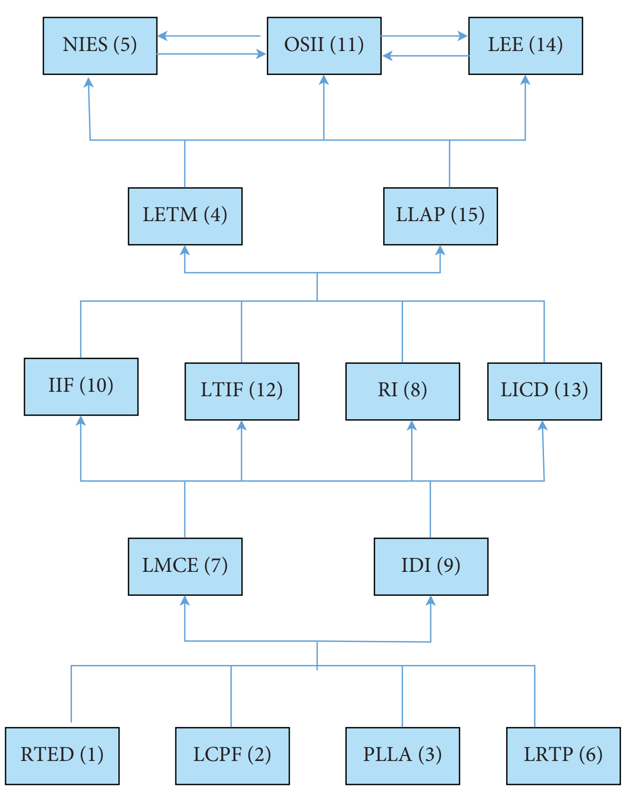

FIGURE 3: Hierarchical structure of influencing factors of low-carbon economy.

development of China's low-carbon economy are the fourth level in the ISM analysis, namely, extensive economic development (RTED), lack of a perfect low-carbon policy framework (LCPF), a large population base, and the low carbon awareness of residents (PLLA) and the lack of professionals in the low carbon field (LRTP).

3. Research on the Optimization Strategy of the Low-Carbon Economic Development Model based on the BP Neural Network Model

The carbon sinks of China's terrestrial ecosystems are mainly related to the increase of plantation forests in China, regional climate change, fertilization effects of increased carbon dioxide concentration, enhanced natural vegetation activity, and vegetation restoration. This conclusion not only shows the huge carbon sink function of China's terrestrial ecosystems in absorbing or offsetting greenhouse gas emissions, which in turn becomes the scientific basis for China to formulate greenhouse gas emission reduction policies but also explains to a large extent China's current and future prospects. For decades, through various measures to increase sinks, the carbon sequestration potential of terrestrial ecosystems and the huge potential of mitigating and responding to climate change have been utilized. Combining existing research and the characteristics of China's carbon sink, this study uses the following formula to calculate China's carbon sink:

$$C_{\text{sink}} = \sum_{i=1}^{n} C_i = \sum_{i=1}^{n} \lambda_i S_i. \tag{2}$$

In the formula, C_{sink} is China's carbon sink; n is the number of carbon sink types; C_{i} is the carbon sink of the i-th type of carbon sink in tons of carbon equivalent; λ_i is the carbon sink coefficient of the i-th type of carbon sink; and S_i is the effective area of the i-type carbon sink. The actual carbon emissions and carbon sink estimation parameters are shown in Table 1.

Over the past 30 years of reform and opening up, China has been in the process of rapid industrialization, and carbon dioxide emissions have maintained a rapid growth trend. The situation of controlling and reducing carbon dioxide emissions is very serious. The consumption of fossil energy is one of the important reasons for the increase of carbon dioxide. The factorization methods commonly used in environmental and energy economics can be roughly divided into two categories. One is the structural factor decomposition method (SDA) based on the input-output table, and the other is the exponential factor decomposition method (IDA). Compared with the SDA method, which requires input-output table data as support, the IDA method is more suitable for decomposing models containing time series data and less variable factors because it only needs the data of the research department and is widely used in environmental energy economic research. In summary, the basic form of IDA is as follows:

$$F = \sum_{i=1}^{n} X_{1i} X_{2i} \ldots X_{\mathrm{ni}}. \tag{3}$$

Among them, F represents the object to be decomposed, such as indicators including carbon emissions, energy intensity, or energy consumption; X represents n factors that have an impact on F, and i represents the indicators of different industrial categories, different energy types, or different regions. Exponential decomposition generally takes time series data as the object and examines the influencing factors behind the changes of variables in different periods. The BP neural network model and IDA are used to forecast , and the obtained results show the different calculation results of China's energy demand and carbon emissions in each period from 2020 to 2050. The predicted results are shown in Table 2.

As can be seen from the above table, the total terminal energy demand in 2050 will be 40.01 billion tons of standard coal . Due to the 5th-level influencing factors in the ISM analysis, namely, RTED, LCPF, PLLA, and LRTP, the end sector implements effective energy-saving measures, and the low-carbon scenario reduces the total energy demand by 850 million tons of standard coal compared to the base scenario. Under the setback scenario, the progress of energy-saving measures is unfavorable, the implementation of low-carbon technologies is hindered, and the energy intensity remains high. Compared with the base scenario, the final energy demand increases by 140 million tons of standard coal. CO_2 emission in 2050 is equivalent to 3.546 billion tons of carbon . Compared with the CO_2 emissions of the low-carbon scenario and the base scenario, it will decrease significantly after 2030, peak between 2030 and 2040, stabilize and have a downward trend from 2040 to 2050, and the total emissions by 2050. Volume decreased by 20%. Due to the hindered adjustment of the energy structure ratio in the frustrated scenario, carbon emissions increase by 420 million tons of carbon equivalent compared with the base scenario. There is no CO_2 peak before 2050, which will undoubtedly greatly increase the cost of energy conservation and emission reduction in China and the difficulty of economic transformation.

Table 1: Estimated parameters of carbon emissions and carbon sinks.

Carbon emission factor	Average carbon sink coefficient			
	Wetlands	Arable land and crops	Forest	Grassland
0.7194	30	110	189	110

Table 2: The predicted results of the model.

	2020	2030	2040	2050
GDP per capita ($)	7560	15833	26307	35464
Carbon dioxide emissions (10^6t)	2604	3060	3702	4001
Total energy consumption (Mtcc)	4539	5082	5516	5913

4. Model Prediction Results Analysis

Based on the results predicted by the BP neural network model, it can be known that the change in energy demand has increased rapidly from 1.157 billion tons of standard coal in 2005, and after reaching the peak between 2020 and 2030, the decline rate is slow, and it stays at a relatively long time. In order to meet economic development, under the condition of slow development of new energy, oil demand has also increased significantly. Between 2020 and 2050, oil demand will triple and peak between 2040 and 2050. Although the quantity of hydropower, nuclear power, natural gas, and other new energy sources is also increasing, their speed is slow and far behind that of coal and oil increase. By 2050, coal will account for 42% of primary energy demand, oil will account for 32%, natural gas will account for 9%, nuclear power will account for 6%, hydropower will account for 7%, and other new energy sources will account for 4%.

At present, China is in a critical stage of transition from a resource-dependent economy to a low-carbon economy, and many difficulties and challenges lie ahead for policymakers. As an important part of low-carbon economy research, scenario analysis provides prediction and verification basis for the development path of low-carbon economy. The model in this paper constructs the characterization of China's low-carbon economy development level, which refers to the framework and parameter setting of scenario analysis to quantitatively simulate the development trend of China's low-carbon economy in 2050. From the model results, the following conclusions can be drawn:

(1) The establishment of indicators to characterize the development level of China's low-carbon economy is based on carbon sources. This model can not only accurately and systematically reflect the carbon cycle characteristics of low-carbon development but also reflect the development goals of low-carbon economy, which is convenient for prediction and evaluation. It also analyzes the emission reduction potential from four aspects: increasing the speed of carbon sink

construction, reducing carbon consumption, which mainly refers to reducing the rapid development of fossil energy, strengthening the proportion of carbon utilization and transformation, and developing carbon capture and storage technologies.

(2) Different economic development paths and policy orientations have a great impact on energy demand and carbon emissions. Future energy demand and carbon emissions are likely to fluctuate within a large range. Based on the analysis of factors affecting the development of low-carbon economy, different policies and implementation efforts are to be formulated. According to the results of scenario analysis, by 2050, China's terminal energy demand under the low-carbon scenario will be around 5.2 billion tons of standard coal. This is a difference of about 1 billion tons of standard coal compared with about 6.2 billion tons of standard coal, which shows that the formulation and implementation of the strategy have a huge impact on energy demand.

(3) It can be seen from the scenario analysis plan that the optimization of energy structure, such as the development and utilization of hydropower, the development of new energy, and the vigorous development of nuclear energy and wind energy, has been optimistically conceived. However, due to the constraints of natural resource supply conditions and energy conversion technologies, it is very difficult to ensure an adequate supply of these clean energy sources. Therefore, combining the characteristics of China's energy structure, developing clean coal and coal utilization technologies, and improving energy utilization efficiency is a more effective guarantee for achieving the goal of a low-carbon economy.

(4) Seeking a breakthrough point for a win-win situation in energy conservation, emission reduction, and economic growth is one of the key issues in developing a low-carbon economy. From the energy consumption of various industries in the scenario forecast, it can be seen that the low energy-consuming service industry is not only a new bright spot for economic growth but also solves the employment of a large number of people and is an important area of China's development in the next few decades. On the contrary, the importance of industries, especially high energy-consuming industries, is gradually decreasing, and the focus is on improving energy-saving technologies; with the improvement of residents' living standards, the energy consumption in life continues to increase, and the increase in residents' low-carbon awareness will reduce this part of energy consumption. It plays a vital role.

5. Conclusion and Outlook

The development of low-carbon economy involves many fields such as policy, economy, environment, technology, and management. It is a complex systematic process. Due to the limitation of my own ability and research time, there are still many deficiencies, and many problems need to be further studied. The factors affecting China's low-carbon economy, especially the main influencing factors and the quantitative research on the development level of low-carbon economy deserves further research, which will help to predict energy consumption and carbon emissions more scientifically and accurately and provide more information for low-carbon economic development strategies for a reasonable decision-making basis. For example, the lack of low-carbon talents in the influencing factors, the poor low-carbon awareness of residents, and the relationship between the energy structure and energy efficiency in the scenario parameters. This paper also mainly adopts methods such as expert scoring and trend prediction and lacks the quantitative description of relationships. In order to facilitate analysis and calculation, this model ignores or incorporates some sources of carbon sources, such as carbon loss and some treatments lack rigor. The research angle mainly focuses on energy consumption, and there is insufficient research on other forms of carbon emissions, such as land use changes, which is the focus of the next stage of research. In this paper, the research on the development path of low-carbon economy mainly considers the relationship between energy consumption and total carbon emissions. It does not consider the cost of emission reduction nor does it consider other greenhouse gas emission reduction issues. This can be more helpful to scientifically and accurately predict economic development, the combination strategy between energy consumption and greenhouse gas emissions, and provide reasonable cost prediction and analysis for low-carbon economic development strategies.

Data Availability

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

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Retraction

Retracted: Dynamic Modeling and Analysis of Innovative Development Model and Ideological and Political Education Based on Big Data

Mathematical Problems in Engineering

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

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

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

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

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[1] X. Xie, "Dynamic Modeling and Analysis of Innovative Development Model and Ideological and Political Education Based on Big Data," *Mathematical Problems in Engineering*, vol. 2022, Article ID 8804756, 9 pages, 2022.

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Research Article

Dynamic Modeling and Analysis of Innovative Development Model and Ideological and Political Education Based on Big Data

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With the increasing number of college students, the difficulty and workload of ideological and political education are also increasing. For the calculation and analysis of big data, it is most suitable to use data mining algorithm for calculation and research. In order to help college students' ideological and political education to develop and innovate, this paper establishes a new model of college students' ideological and political education combined with particle swarm optimization algorithm to help carry out college students' ideological and political education. The particle swarm optimization algorithm is tested. Therefore, this paper uses data mining algorithm to calculate and analyze the research in this paper. The algorithm is tested and analyzed. Through the test of data mining algorithm, the calculation accuracy of the algorithm is proved, and the feasibility of this paper is proved. This paper studies the ideological and political education by using data mining algorithm. The computational efficiency of the optimized data mining algorithm is twice that of the traditional algorithm, and the optimized algorithm has also been significantly improved. In general, the data mining algorithm optimized in this paper is reasonable, which can improve the calculation accuracy and efficiency of the algorithm.

1. Introduction

Nowadays, the development of society has brought us into a new environment. In the current big data and self-media environment, this paper must also keep pace with the times in ideological and political education research [1]. In the context of a new era, this paper needs to conduct innovative research on ideological and political education and use new ways of education to educate young people today [2]. But now all kinds of information are more complicated, and the difficulty of education reform is also very large [3]. Through the research of data mining algorithms and the ability of data mining algorithms to analyze and calculate big data, this paper helps us to optimize and reform ideological and political education deeply [4]. Also, through some optimization of traditional data mining algorithms, this paper can better calculate the content of calculation [5].

It continues to carry out the program of university enrollment expansion. But with the quality of citizens constantly improving, the difficulty of ideological and political education is ensuing [6]. Ideological and political education has always been the center of education in the country. When cultivating students' cultural level, the ideological and political education of students also needs to be paid more attention. For the rising number of college students, the ideological and political education is carried out through computer [7]. Based on the detailed analysis and research of need theory, a timeliness model of college students' ideological and political education combined with particle swarm optimization is established in this paper to help us carry out the ideological and political education of college students. But the combination of the need theory and particle swarm optimization is the place where it is needed to pay more attention, and it is also the difficulty of calculation. The two theories are combined with the calculation of this article [8].

Particle swarm optimization algorithm, also known as particle swarm optimization algorithm or bird swarm foraging algorithm, is abbreviated as PSO [9]. It is a new evolutionary algorithm. PSO algorithm is a kind of evolutionary algorithm, which is similar to simulated annealing algorithm [10]. It also starts from the random solution, searches for the optimal solution through iteration, and evaluates the quality of the solution through fitness [11]. However, it is simpler than the rules of genetic algorithm, and there is no "crossover" and "mutation" operations of genetic algorithm. It searches for the overall optimal solution by following the best quality currently searched. This algorithm has attracted attention for its advantages of easy implementation, high precision, and fast convergence and has shown its advantages in solving practical problems [12].

This paper mainly studies the data mining algorithm for the calculation of ideological and political education reform. The first is a comprehensive analysis and calculation of data mining calculation steps. The steps of data mining can help us to understand the difficulties and the key points of its calculation. After studying the calculation steps of data mining calculation, this paper also needs to study the calculation formulas and mathematical models of data mining algorithms. Then, according to the requirements of the research contents in this article, this paper carries out some optimization.

2. State of the Art

In terms of scientific definition, data mining is a process of extracting information and knowledge that are hidden, unknown, and potentially useful from a large number of noisy, incomplete, fuzzy, and random data. From a technical point of view, data mining is a process that uses a series of related algorithms and technologies to extract the knowledge that the industry or company needs and has practical application value from big data. Data mining is not only a specific step in the whole process of knowledge discovery but also the most important core step in the process of knowledge discovery. The qualitative prediction method is used to predict the past and present experience and judgment and intuition of the system. It is mainly based on people's logical judgment and requires to provide qualitative results such as the direction, state, and form of system development. This method is applicable to systems lacking historical statistical data. Time series prediction, based on the historical data of the system object changing with time and considering the change law of system variables with time, quantitatively predicts the future performance time of the system, mainly including moving average method, exponential smoothing method, trend smoothing method, and so on, which are suitable for predicting the trend of the research object changing with time using statistical data. Causality prediction: there is a certain cause and effect relationship between system variables. Find out the factors that affect a certain result, establish a mathematical model between cause and effect, and predict the change of result variables according to the change of factor variables, so as to predict the development direction of the system and determine the specific value change law.

The study of data mining algorithm is mainly because of the complexity of big data processing. This paper must find a computer algorithm that is suitable for data processing to help us calculate research. Therefore, in this context, the American scholars first studied the data mining algorithm [13]. This is also due to the high level of technology and computer technology in the United States. Faced with the increasing amount of data, this paper calculates the study of a new type of computer algorithm which is imperative. At the beginning, the research on data mining is only based on the calculation and study of data [14]. Then, as calculation expands, the calculation of data mining algorithms is gradually increasing. The scope of data mining has also gradually expanded [15]. It has become one of the most widely used computer algorithms in the country [16].

China's domestic research on data mining algorithms started in the nineties of last century. Data mining has been introduced into the United States from within. The study of data mining in China, with the aid of advanced technologies in the United States, has a very high starting point and is developing rapidly [17]. However, the computational studies on data mining in China are mainly theoretical studies, but the application of data mining is rarely applied [18]. This enables us to reduce the application of data mining algorithm examples, for data mining computational research has increased a certain degree of difficulty [19]. This paper studies the calculation of ideological and political education based on the theoretical basis. According to application requirements, it conducts a detailed analysis of its final calculation to achieve the goal [20].

3. Methodology

3.1. The Algorithm Principle of Particle Swarm Optimization. In PSO, the solution of each optimization problem is a "particle" in the search space. All particles have a fitness value determined by the optimized function, and each particle has a speed that determines the direction and distance they fly. Then, the particles follow the current optimal particle to search in the solution space. PSO is initialized as a group of random particles (random solutions). Then, the optimal solution is found by iteration. Particle swarm optimization (PSO) is actually a computer algorithm based on the simplification of the behavior of a bird colony. The foraging of populations in nature, especially in birds and ants, is very efficient and accurate. There are close cooperation and information transmission patterns between them. Auxiliary calculations could be done based on this behavior. Through study of the bird population, the particle swarm optimization algorithm used in this paper has been popularized. Research process is simulated according to the following scenarios: first, a known area is set up and birds' food spots are randomly put into this area. Then, a certain number of birds in this area are released, but this quantity is neither too small nor too many. The number of annual classes is set according to the size of area. This paper assumes that all the birds are not aware of the location of the food point. The process by observing birds looking for food and notifying the entire population is simulating. However, the entire avian community did not know the food delivery point in advance, but they could find food points at a quickest speed and notify other individuals quickly. What is

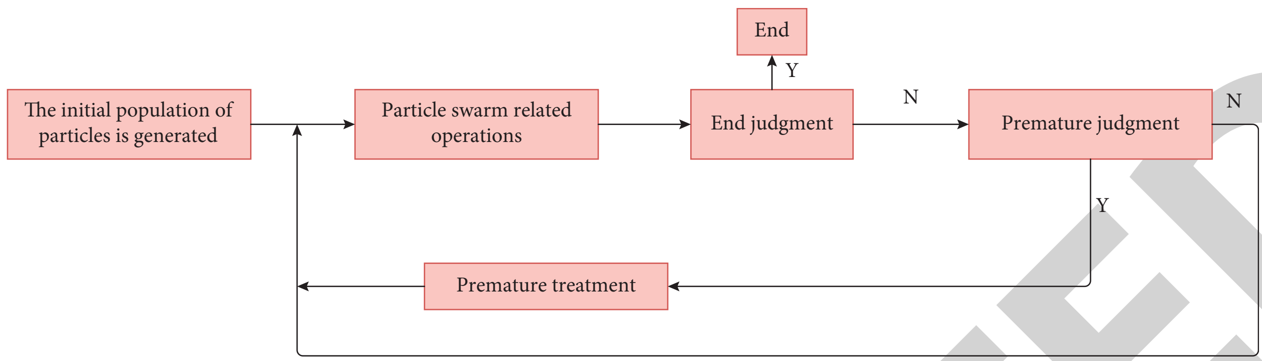

Figure 1: Particle swarm optimization algorithm flowchart.

the specific behavior of the bird community? Through the long-term study, groups of birds are spontaneously looking for the area within a certain range, many birds will completely fill the entire test area, the total search range of one or more birds will cover the food delivery point, and then the bird will inform the population to eat. Calculation is to simulate the process. Individuals in birds are regarded as particles or particles. Each particle is probably the best solution for calculation. In this way, the whole process of the particle swarm optimization is described. The flow of the particle swarm algorithm is shown in the form of Figure 1.

In addition, in the calculation of particle swarm optimization, a very important concept is the value of adaptation. The fitness is shown in the form of a function. PSO is initialized to a group of random particles (random solutions), and then the optimal solution is found by iteration. The process of finding food by this bird is not exactly the process of calculation. It has been optimized in the actual calculation. An optimal value for each active area of each particle is calculated and then the best of all the optimal values is chosen. In this way, the whole calculation is finished. This processing will help us analyze the calculation results, and the calculation situation can be checked effectively to help us understand the calculation process and help us improve the accuracy of calculation.

In practical application, the process of the particle in finding the optimal solution is not completely random, and it is subjected to a certain human interference. The degree of interference is set by us. In addition, what has been noticed is that the fitness of each particle cannot be set exactly the same. Furthermore, the difference in the fitness of each particle should be made as much as possible. Because every individual in the bird community is different, the real situation needs to be restored as much as possible. In addition, the calculated particles have multiple kinds of information, which cover a series of information, such as the fitness values that have been set and the scope of the search. All the particles being set up will be found through this information.

When calculating, the movement process of each particle online has been processed, that is to say, when a particle moves to a certain location, another particle will never run to this location again. In this way, a lot of calculation time is saved so that calculation process can have a correct result. Otherwise, it is likely that the optimal solution cannot be found in the infinite calculation. In addition, this online way can also make particles learn the advanced experience of other particles continuously so that computing efficiency will also increase steadily with the increase of computing time. This is the effect that the traditional particle swarm optimization cannot achieve, and it is also the focus of optimization.

3.2. Mathematical Description of Particle Swarm Optimization. After studying the principle of particle swarm optimization, the mathematical model of the particle swarm optimization and the computing model of the computer are needed to be set up. Also, in this period, the algorithm is needed to be optimized moderately so that it is more adaptable to the application of this article. Next, the modeling process is started.

In this paper, the algorithm principle of particle swarm optimization is introduced in detail. The particle swarm optimization algorithm is a method of obtaining optimal solution by multiple iterations. So next, the mathematical description of the particle swarm algorithm is introduced. First, a population size is needed to be set up. This scale is set as N, particles are set as X, and the location of particles in D dimensional space can be expressed as $X_i = \{x_{i1}, x_{i2}, \ldots x_{i\,D}\}$; among them, i represents the code of particles and the location of particles is represented by V. Then, P is set as the best position in the position of the particle. The value of the objective function has an effect on the fitness value, which is inversely proportional. The greater the value of the function is, the worse the adaptive value is. In addition, the target function is represented by $f(x)$. This is the minimized objective function; then, the best position of the particle can be calculated and analyzed with the following formula.

$$P_i(t) = \begin{cases} P_i(t), & f\left(x_i(t+1) \geq f\left(P_i(t)\right)\right), \\ x_i(t+1), & f\left(x_i(t+1) \leq f\left(P_i(t)\right)\right). \end{cases} \quad (1)$$

The speed of flight is represented by v, and then the calculation is adjusted according to the following formula:

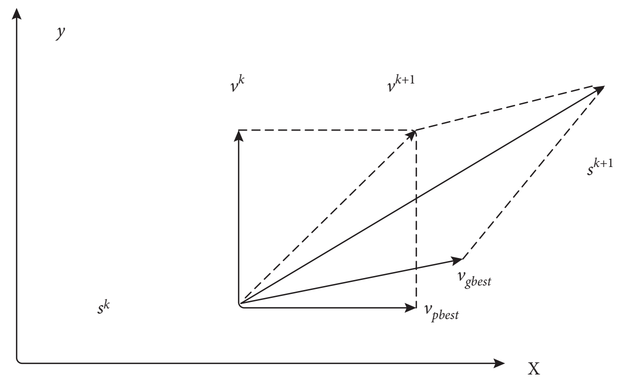

Figure 2: Principle of particles moving.

$$
\begin{gathered}
v_{id}(t+1) = wv_{id}(t) + c_1\text{rand}_1\left(P_{id}(t) - x_{id}(t)\right) \\
+ c_2\text{rand}_2\left(P_{gd}(t) - x_{id}(t)\right), \\
\begin{cases} v_{id} = v_{\max}, & \text{if}, v_{id} \geq v_{\max}, \\ v_{id} = -v_{\max}, & \text{if}, v_{id} \leq -v_{\max}. \end{cases}
\end{gathered} \tag{2}
$$

w in last formula is inertia weight. C is acceleration constant. Through the adjustment of the above formula, the calculation has been optimized. Turn it into simpler calculations.

In addition, the position of particles is adjusted to ensure the accuracy and flexibility of calculation. For the adjustment of particle position, the following formula is used to calculate.

$$x_{id}(t+1) = x_{id}(t) + v_{id}(t). \tag{3}$$

The specific movement of particles is actually done by a variety of factors. Not only it is related to the experience of sports, but this experience refers to group experience, not individual experience. It is also related to the maximum speed. Velocity limits the trajectories of particles and the velocity of motion. The principle of motion of particles is shown in Figure 2.

With the analysis of formulas and pictures above, the movement of particles is the result of the interaction of three accelerations. The first is the influence of the inertia weight. This is determined by the state of its own motion because inertia is the main mode of motion of an object. The inertia weight is actually the effect of the inertia motion on the movement of the object. Finally, continuous analysis is needed, and r_1, r_2 are set as two uniformly distributed random numbers. $\phi = rc$ is defined, and the formula is sorted into the following form:

$$
\begin{gathered}
v_{id}(t+1) = wv_{id}(t) + c_1 r_1\left[P_{id}(t) - x_{id}(t)\right] \\
+ c_2 r_2\left[P_{gd}(t) - x_{id}(t)\right], \\
v_{id}(t+1) = (1-\phi)x_i(t) + \phi_1 p_i(t) + \phi_2 p_g(t).
\end{gathered} \tag{4}
$$

By optimizing the calculation formula and calculation steps of PSO, the main process of calculation formula has been optimized. But calculations are calculated by computer. So, the computer computing model is needed to be set up,

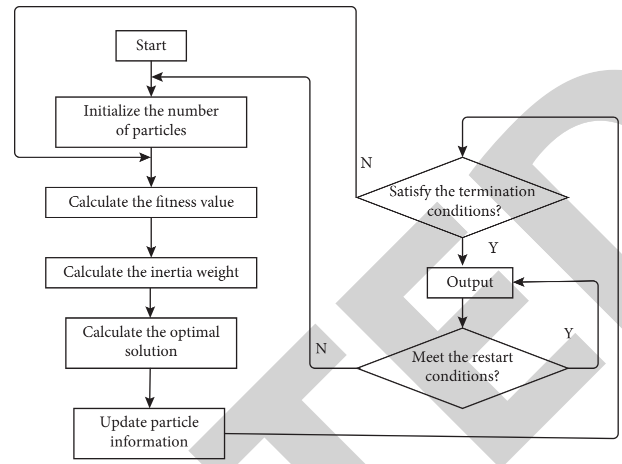

Figure 3: Computer calculation model of the calculation process.

and the calculation of this paper through the form of calculation model is carried out and analyzed. The calculation process diagram of the computer computing model that has been established is shown in Figure 3.

3.3. Establishing the Calculation Model Based on Data Mining Algorithm. Data mining algorithms have long been the focus of research. However, in the last century, the research on computational theory was mainly conducted, and the actual application of data mining began to be studied in this century. Data mining algorithm has strong data analysis ability and strong data organization ability. This paper calculates the data mining which is usually associated with the association rule algorithm for computing research. Data mining algorithm extracts and associates data by studying data mining and association rules. It helps us to better analyze the relationship between the data. The two are closely combined. Usually, the data calculated for data mining in this paper is very large and complex, so we need to use some specific data mining calculations to carry out data mining calculations. Generally, this paper is divided into the following steps for data mining calculation. First of all, this paper needs to determine the goal of data mining. Determining the goal of data mining will help us have a direction of data mining. Do not be too blind. The other is data preprocessing. Data mining algorithms face a large amount of data computation. If the data cannot be preprocessed in this paper, data mining will take a lot of time and the calculation accuracy will not be very high. Because there is no data mining data preprocessing. Various complex data will interfere with the calculation target, so this paper cannot accurately calculate the results required in this paper. Data mining preprocessing not only includes the scope of the data delineation but also includes the data this paper need to conduct preassociation rule analysis. Finally, this paper did the data mining calculation process. After this paper calculated the data mining, this paper also needs to analyze the results of calculation. Data mining algorithms are precise because this rigorous calculation of the data in the big data is only useful for analysis of data which are very thorough.

Table 1: The usage statistics of data mining algorithms in each model.

	Data mining algorithm structure	Data mining algorithm formula	Data mining algorithm data
1	56%	59%	66%
2	58%	52%	76%
3	59%	36%	46%

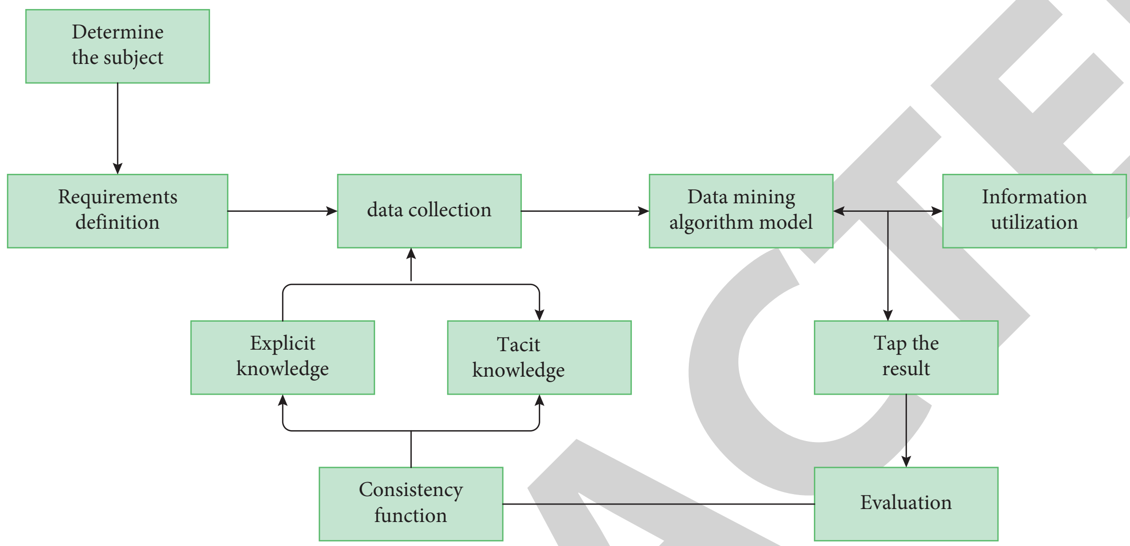

Figure 4: Data mining algorithm computer computing model diagram.

In this paper, the computing research of data mining algorithm is based on the limited psychology of young people in the new era. For the calculation and study of this article, this paper conducted some analysis and evaluation according to the usage situation. The test results are shown in Table 1.

For data mining calculations, this paper calculates the data and the results will generally be incorrect. This paper needs to further calculate the association rule calculation data. Through the study of association rules, it is found that the calculation data is not closely related to other data, and these data need to be excluded in the future. Through the calculation of association rules, the calculation results calculated by data mining are finally sorted out, and the correctness of calculation data is reduced. Through data mining algorithms and association rules, finally, the accuracy of data mining results is higher, which is also a great innovation in this paper, which is one of the biggest differences with the traditional data mining algorithm calculation process.

Data mining is analyzed and researched from some incomplete and uncertain data. Through the comprehensive data management of the data needed in this paper, it is the intrinsic significance of the study to study the relationship between the data contents. This is where the purpose of data mining lies. Data mining is the need for us to establish a computer computing model. This paper also established a computer computing model, and the calculation model is shown in Figure 4.

The classification model is a supervised learning model, that is, the classification needs to use some sample sets of known categories to learn a pattern and use the learned model to label the instances of those unknown categories. When constructing the classification model, we need to use the training set and the test set. The training set is used to train the parameters of the model. The test set is used to verify the effect of the trained model, that is, to evaluate the degree of the model. The commonly used evaluation indicators are accuracy and recall. There are different classification algorithms for different classification tasks, different data, and different adaptation scenarios. Common classification methods include decision tree, Bayesian, K-nearest neighbor, support vector machine, association rule-based, ensemble learning, and artificial neural network.

3.4. Data Mining Algorithm Mathematical Formulas and Optimization. Based on calculation requirements, this paper needs to create a new input sample as follows:

$$S = \{(x_1, y_1, s_1), (x_2, y_2, s_2), \ldots (x_n, y_n, s_n)\}. \tag{5}$$

In addition, in order to ensure the fairness of calculations, this paper needs to calculate both positive and negative samples. This definition can ensure that the data in calculation can be calculated separately in two categories. This reduces the computational pressure, so the algorithm can compute twice the data in a small number of resources. For the calculation center, this paper set up the following formula for calculation and analysis. The relationship between tennis speed and center is calculated as follows:

$$m = \frac{1}{n}\sum_{i=1}^{1} x_i. \tag{6}$$

The movement of the tennis ball can be modeled as a point moving in x, y controlled axes. In this case, this paper can simulate the Euclidean distance in a Cartesian coordinate system, calculated as follows:

$$d(x, y) = \sqrt{K(x, y) - 2K(x, y) + K(x, y)}. \tag{7}$$

K in the formula is a kind of kernel function. In this case, this paper can get a new center-vector function by combining (2) with (3), which is expressed as

$$m_\phi = \frac{1}{n}\sum_{i=1}^{n} \phi(x_i). \tag{8}$$

Since there are two positive and negative areas in calculation, then this paper naturally has two center points, and the two center points can be represented as m^+ and m^-. The former is the center and the latter is the negative center. This paper can naturally get the distance between the two center points in the calculation and the distance is calculated as follows:

$$D = |x_i - m|. \tag{9}$$

This will eliminate the calculations. This paper only keeps $D' \leq D$ data for other data. In this paper, it is set as irrelevant in optimized data mining calculation for deletion. This can greatly reduce the calculation difficulty and calculation time. This paper takes the ball as the center, which will be located near the coordinates of the point of calculation and analysis on the line. The sample style is shown in Figure 5.

In this paper, a new membership function is defined, which makes the membership degree of a sample increase with the distance from the centroid, that is, the effect of the farther samples from the centroid is increased. Far support vector will get a greater degree of membership, thereby enhancing the support vector for building fuzzy support vector machine classification hyperplane effect. According to the need, the membership function is designed as follows:

$$u_i = \begin{cases} \dfrac{d_i^+ + \delta}{\max d_i^+}, & y = +1, \\[2ex] \dfrac{d_i^- + \delta}{\max d_i^-}, & y = -1. \end{cases} \tag{10}$$

This paper has completed the mathematical model of data mining calculation and the algorithm has been reasonably optimized according to the calculation needs of this article. Also, a new membership function is established. Through the above optimization, this paper has closely integrated the data mining algorithm with the ideological and political teaching to help us carry out theoretical calculations in the present big data and ideological and political education reform from the media background. For the optimized algorithm, this paper reestablishes the

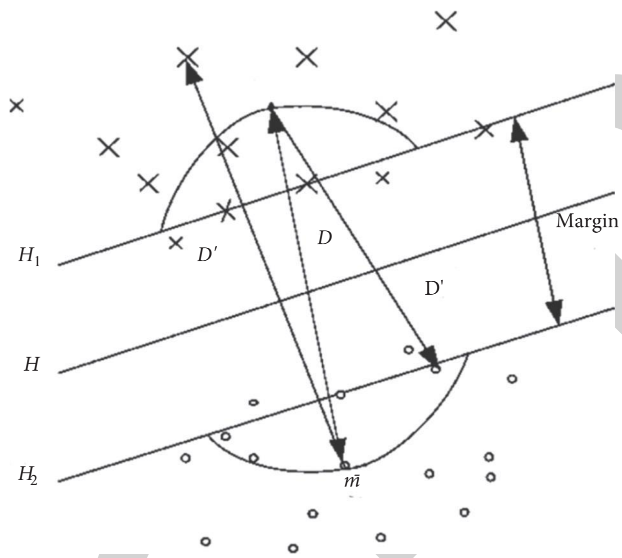

Figure 5: The style of the sample.

computational model of the computer. The information transfer model is shown in Figure 6.

4. Result Analysis and Discussion

This paper has completed the calculation of data mining algorithms and calculation steps and mathematical models. In addition, this paper also makes reasonable optimization on the data mining algorithm and studies the calculation points needed. In order to prove that the optimized data mining algorithm is more suitable for the calculation in this paper, this paper tests the traditional data mining algorithm and the optimized data mining algorithm in this paper. By comparing the two algorithms, the superiority of optimized data mining algorithm is proved.

First of all, this paper sets up the test environment, the experimental environment of CPUInteli52.60 GHz, RAM4.00 GB and MATLABAB7.13. In this paper, we use Gaussian function to test the comparison content of data mining algorithm of kernel function. Because the Gaussian function can be calculated and studied for a variety of parameters and the calculation range is wide, in line with the calculation requirements, this paper conducts a separate experiment on optimized data mining algorithm. Expressed as a straight line in the coordinate axis, the closer the data from this straight line, the more correct the data. Within the two dashed lines is calculation of allowable error line, and the data within the two dashed lines are correct and those outside the two dashed lines are wrong. This paper will calculate the results of the composition of the image shown in Figure 7.

The observation and analysis of the figure above show that there are only two points in the whole calculation result that do not exist within the two dotted lines and the rest are within two dotted lines and are basically concentrated near the straight line. This shows that after optimization, the accuracy of the data mining algorithm is very high, which is in line with calculation requirement. The error of two points

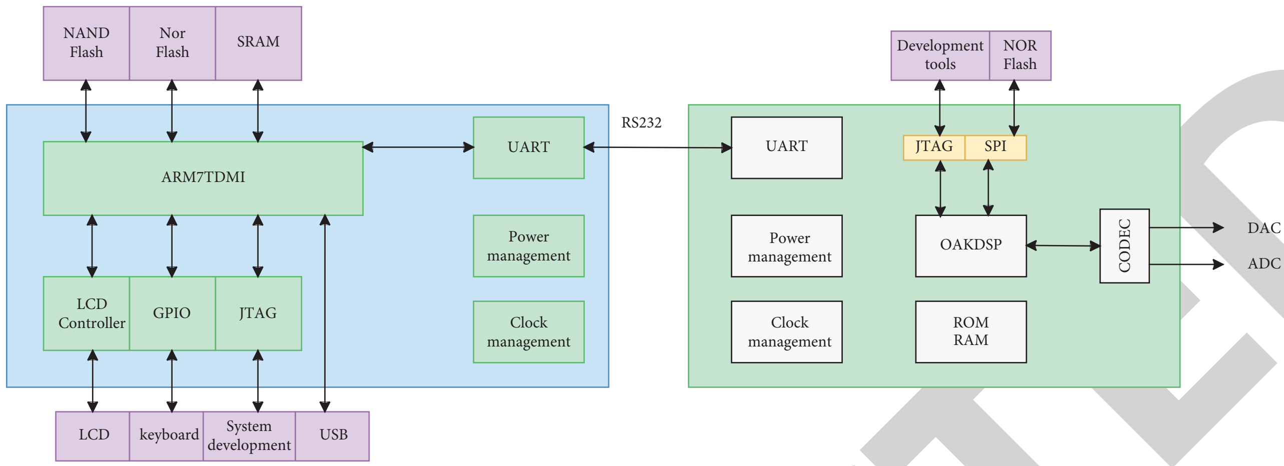

Figure 6: Computer model information transfer mode diagram.

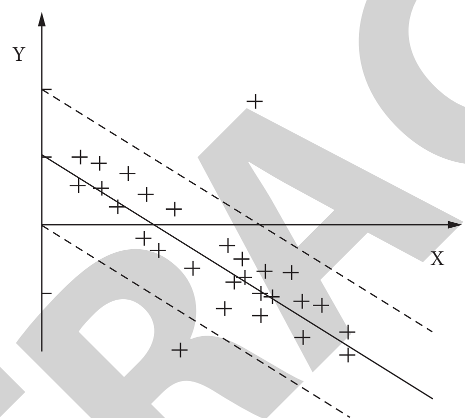

Figure 7: Calculation results.

does not affect the correctness of entire calculation result. Of course, no calculation of one algorithm is completely correct. There will be some mistakes. However, the calculation error rate of the optimized algorithm in this paper is obviously lower than that of other algorithms commonly used, which shows that optimization process is effective and achieves optimization goal, and the calculation effect is very good.

In addition, this paper also tests the calculation time of the algorithm. The calculation of the time is carried out by comparing the calculation time of the traditional algorithm with the optimized calculation time. This paper mainly studies the training time and classification time; the experimental group is optimized algorithm calculation group, and the contrast group is the traditional algorithm calculation group. The test results are shown in Table 2.

Table 2 shows the results of five sets of experiments. For the training time, the training time of the traditional algorithm increases rapidly with the increase of the calculation items. It is from the beginning of 4.1 seconds to 8.7 seconds, but for optimized algorithm training time, it increased from only 2.1 seconds to 2.6 seconds. For the classification time, the classification time of the traditional algorithm increased from 11.4 seconds to 18.5 seconds, a total increase of 7.1 seconds, but optimized algorithm classification time increased from 5.2 seconds to 9.7 seconds. A total increase of 4.5 seconds calculates the rate of increase of time. The traditional data mining algorithm is twice as fast as optimized data mining algorithm. For the calculation of time, this paper has a clear contrast as shown by Figure 8.

From these two points, the computational efficiency of optimized data mining algorithm has doubled compared with the traditional algorithm, and the algorithm this paper optimized has also significantly improved. Overall, optimized data mining algorithm in this article is reasonable and can improve the computational accuracy and computational efficiency of algorithm.

5. Conclusion

With the development of the present society, young people gradually lose interest and learn patience for traditional ideological and political education. But the importance of ideological and political education goes without saying. How to sort out a new model of ideological and political education according to the development of society now is the focus of research. This paper studied the ideological and political education through the use of data mining algorithms and through testing of optimized data mining algorithm. The

Table 2: Test results.

Training samples	Test sample	Training time		Category time	
		Control group	Test group	Control group	Test group
200	100	4.1	2.1	11.4	5.2
400	200	5.2	2.5	12.6	6.4
600	300	6.5	2.6	15.4	7.1
800	400	7.4	2.8	16.7	8.7
1000	500	8.7	3.1	18.5	9.7

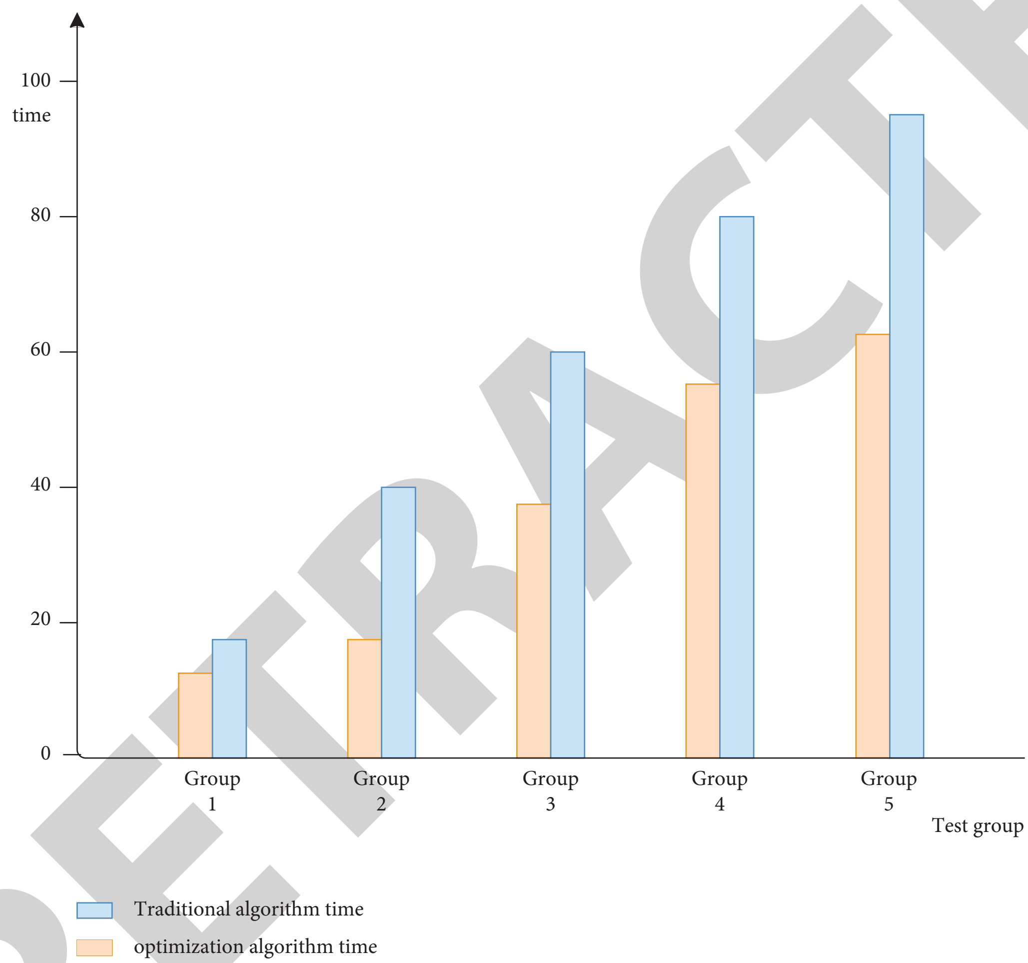

Figure 8: Time test results.

calculation accuracy of the optimized algorithm was very high, the calculation results were in the vicinity of the correct value, and only two points were beyond calculation range, but the error was within the allowable range. In addition, this paper also compared the calculation of time and optimized the data mining algorithm. The calculation time and calculation time growth rate are reduced to half of the original traditional data mining algorithm. This showed that optimized algorithm not only had a perfect improvement on the calculation time but also improved the calculation accuracy to a very high level, reaching more than 95% of the calculation accuracy.

However, the research of this paper is insufficient in the face of multiple abstract levels of interactive knowledge mining. Because it is difficult to know exactly what can be found in the database, the data mining process should be interactive. Further analysis should be made to use appropriate sampling techniques for interactive data exploration.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Exploring the Mechanism Analysis of Men's Retirement and Physical Activity Participation Based on the IV-Probit Model

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The issue of population aging is of great concern to all countries in the world, and China is one of the countries with more serious population aging. Under the situation of increasingly serious population aging, we should pay more attention to the life of the elderly after retirement. Paying attention to the health behavior and living conditions of the elderly population will contribute to the process of successful aging. Retirement is a critical point, and the transition period will have different effects on the health of the retired population, with some literature suggesting negative effects on the health of individuals after retirement, and others suggesting positive effects on health. Retirement has caused a lifestyle change in older adults, and few studies have addressed the impact of retirement on individuals' choices of specific healthy lifestyles, particularly the impact of retirement on physical activity participation. In this study, we used data from the 2015, 2017, and 2018 China Social Tracking Survey (CGSS) to explore the effect of retirement on individual male physical activity participation using the sample size of retired male individuals from the three data periods and using the IV-Probit model. The results showed that retirement had a significant positive effect on individual men's physical activity participation. In terms of the influence mechanism, physical health, psychological health, active learning during leisure time, and Internet use of retired individuals may be the main reasons for increasing physical activity participation. It provides a channel for China to encourage and support older adults to expand their physical exercise participation after retirement and improve their physical and mental health and to promote the shift of older adults' postretirement lifestyle toward an active and healthy lifestyle.

1. Introduction

Population aging is of great concern worldwide, and China is one of the countries with more serious population aging. By the end of 2021, China is a large agricultural country with more than 40% of its population in agriculture, and it is mainly located in rural areas of towns and villages, so it can be said that there is no real national fitness without the strong health of farmers [1]. With the rapid development of China's economy and society, the phenomenon of aging is emerging, and young people in poor rural areas have to leave their hometowns and start their own business for a better life, which has caused the phenomenon of empty nest elderly in many poor rural areas, which is a problem worthy of social attention. Although economic conditions have improved, they are facing new problems such as empty nest syndrome, reduced care from children, and loneliness. The more frequently they participate in sports activities, the higher the happiness index and the lower the loneliness of the empty nesters. In view of this, we should pay more attention to the postretirement life of the elderly in the face of an increasingly serious population aging [2]. The exercise situation of the elderly in China is shown in Figure 1.

Paying attention to the health behaviors and living conditions of the elderly population will promote the process of successful aging. Retirement is a critical point, and the transition period will have different effects on the health level of the retired population, with some literature suggesting a negative effect on the health level of individuals after retirement, and others suggesting a positive effect on health after retirement [3]. It is evident that the findings of domestic and foreign scholars on this research topic are

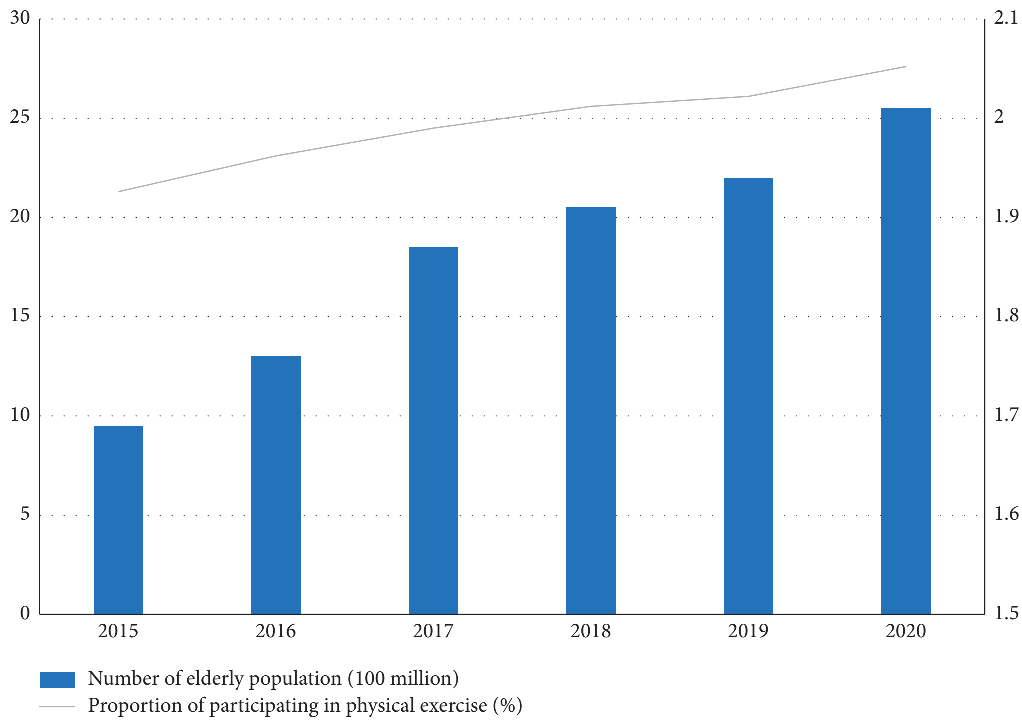

Figure 1: The physical exercise situation of retirees from 2015 to 2020.

controversial. The most important feature of the retirement transition is the reduction or loss of occupational routines, income, social connections, and status, and this change in personal status may stimulate changes in behavior, which will influence healthy lifestyle choices [4]. Some scholars have found that retirement makes lifestyle changes such as socializing, sleeping, smoking, and drinking, which affect one's health level. Our scholar Jinzhen Ye, on the other hand, argued that retirement will change habits that were developed in the short term, and for habits that have persisted over time cannot be changed by the event of retirement alone [5]. The behavioral changes caused by individuals experiencing retirement will also affect the changes in their own health levels, and among these healthy lifestyles, participation in physical activity is one of the most important health behaviors among retired older adults, and exercise is conducive to improving the physical and mental health of individuals, while exercise plays a crucial role in the process of active anti-aging [6]. However, there are few studies investigating the causal relationship between retirement and physical activity participation, in which there is a complex causal relationship between retirement policies and retirement age restrictions on individual participation in physical activity in different countries, which makes it very difficult to identify the effects between the two [7]. An overview of the existing literature mostly explores the effects of retirement on health from empirical quantitative analyses, with less research on causal inferences about health behaviors, such as the lack of literature examining the effects of retirement on physical activity participation. This may be due to the fact that the most difficult issue to identify the effect of retirement on participation in physical activity is model endogeneity [8]. Therefore, the causal effects of physical activity participation can be identified using the mandatory retirement age as an instrumental variable. The methodology for exercise among older adults is shown in Figure 2.

This study uses data from CGSS 2015, 2017, and 2018 to conduct the analysis. The contribution of this study is reflected in, first, the use of the instrumental variables approach to address the endogeneity of the model, which makes the findings robust and error-free. Second, the analysis of the impact of retirement behavior on individual male physical activity participation is helpful to understand the changes in individual male physical activity participation after retirement [9]. Third, to analyze the mechanism causes that affect individual male physical activity participation. Fourth, it provides a channel for China to encourage and support older adults to expand their physical activity participation after retirement and improve their physical and mental health and to promote the change of elderly people's postretirement lifestyle toward active and healthy.

2. Research Background

To promote physical activity participation as a healthy lifestyle, there is little literature that deals with causal inference exploration studies of retirement and physical activity participation alone [10].

The literature review is centered on the following sections: first, studies on the impact of retirement on participation in physical activity, which are mostly used in the foreign literature to study the impact relationship between the two using leisure physical activity as a proxy variable for participation in physical activity. The findings are divided into two parts, with some scholars arguing that retirement increases participation in leisure physical activity and others

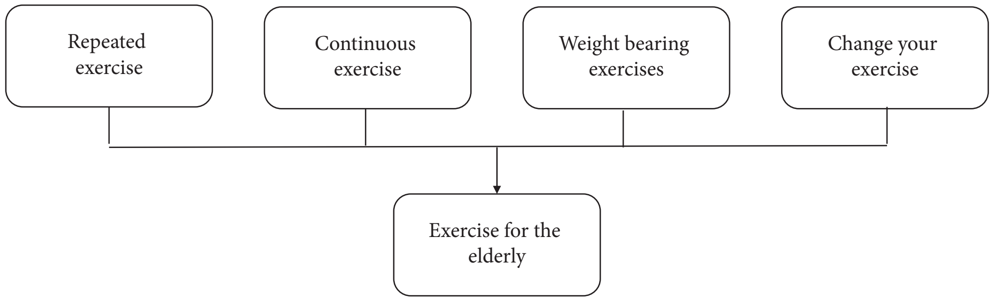

Figure 2: Approaches to exercise among older adults.

arguing that retirement decreases physical activity participation or that there is little change in exercise participation before and after retirement, and existing studies have not formed consistent conclusions [11]. The reason for the inconsistent findings is partly attributed to the fact that the definition of the concept of physical activity participation has gradually become broader among people of different age groups: participation in physical activity initially included participation in sports or organized exercise; in middle and old age, the scope of physical activity participation was expanded to include activities such as housework, caring for family members and children, or gardening. Another part of the reason is attributed to the slightly different perspectives from which research scholars cut their studies, distinguishing the intensity of exercise participation or the impact on physical activity participation in the long and short term after retirement will cause differences in the results [12]. This is shown in Figure 3.

Second, the influence of other factors such as family on post-retirement participation in physical activity was studied. According to foreign scholars, spouse's retirement was found to reduce their personal physical activity. There are also studies where there is no significant correlation between the two, probably due to individual habits, and there are few cases where both spouses participate together or influence each other's participation in physical activity. Considering the household level, the effect of retirement on physical activity participation has gender differences, which may be due to the fact that physical activity participation after retirement includes household physical activity, which is reflected in higher physical activity participation of men than women after retirement.

Third, scholars' different choices in the selection and use of research methods and research theories for both can cause some bias in the research results. In the descriptive analysis scholars mostly use research methods such as the chi-square test and t-test; in the inferential analysis, they mostly use basic models such as the general linear regression model and logistic regression model for inference. However, descriptive analysis is simple and limited by a single perspective, and it may not be possible to present the correct results in complex cause–effect relationships. One of the most important problems facing the selection of models for inferential analysis is that the models themselves have endogeneity problems, and if they are not solved, then the inferred results will also be biased [13]. Some other scholars have inferred the relationship between the two through qualitative studies, and this approach has some limitations. The theoretical aspect is mainly studied in the theory of health needs. The health analysis theory assumes that the retired group faces two different constraints of time and income when making health investment decisions. Time and income may be important reasons for individuals to reduce/increase their physical activity participation because physical activity participation takes place outside of work hours and the occurrence of retirement behavior lifts the time constraints, meaning that more time can be spent in physical activity [14]. By comparing retired individuals experiencing different retirement life states after retirement, foreign scholars found that individuals who retired to part-time jobs or were in a completely nonworking position had higher rates of physical activity compared to those who remained in full-time jobs after retirement. Since China is a mandatory retirement policy and foreign countries are flexible retirement policies, individuals may have different effects on their attitudes toward physical activity participation when faced with different situations of retirement policies. Foreign scholars have found that mandatory retirement does increase the physical activity of individuals, and it is further noted that the two are mediated through leisure time [15].

In summary, the method of causal inference between the postretirement male population and physical activity participation in China has not been fully applied to this field; therefore, the present study on the analysis of the influence and mechanism of postretirement male individuals on physical activity participation will make up for the shortcomings of previous studies and help to explore how the postretirement male population can further maintain their health level and actively promote the successful aging process and improve the healthy living behavior of retired individuals.

3. Materials and Methods

3.1. Basic Theory

3.1.1. Retirees' Physical Exercise. With the improvement of people's living conditions and the improvement of the social medical security system, the life expectancy of the population continues to increase and the number of elderly people continues to grow, which also intensifies the development of aging in the world. Therefore, the physical and mental health, social well-being, and quality of life of older

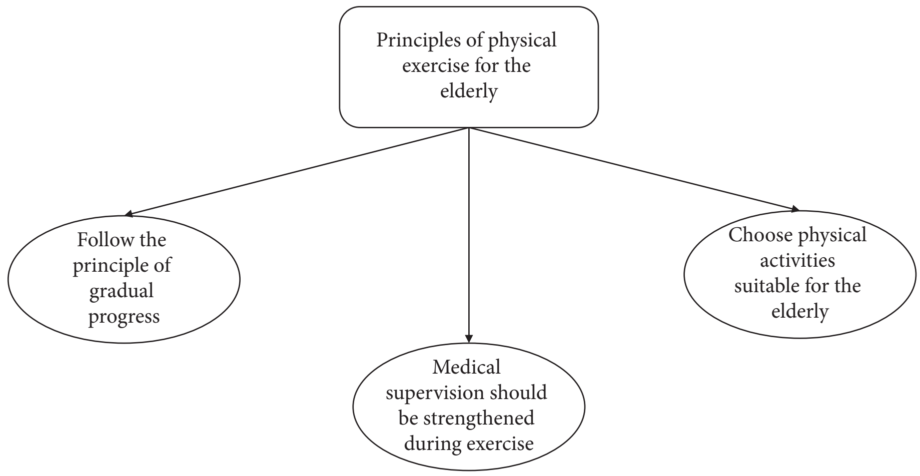

FIGURE 3: Principles of physical activity among the elderly.

adults are of great concern to society, yet older adults often suffer from physical illness as well as social isolation and family loneliness, and subjective well-being can reflect an individual's mental health, which is a holistic assessment of the evaluator's own quality of life based on certain self-defined criteria. In this study, by reviewing the literature, we found that physical activity can improve subjective well-being [16]. For example, Eyler et al. [17] found that after 10 weeks of physical activity, it was able to significantly improve the quality of life and reduce depressive symptoms in older adults. Antunes et al. conducted an experimental study of 46 sedentary older adults aged 60–75 years and found that those who participated in a 6-month experiment with a fitness program had significant decreases in depression and anxiety scores and significant improvements in quality of life, while the control group showed no significant changes. Bandura [18] included data from studies of older adults with only nonclinical conditions, but included data from clinical patients with spinal injuries and related research studies. Based on the existing studies, this meta-analysis study provides the results of empirical studies by foreign scholars in recent years and summarizes the available evidence for the best intervention effect [19]. Suitable sports for older adults are shown in Figure 4.

3.1.2. Main Evaluation Method. This study uses algorithms of neural networks in addition to the IV-Probit model for computational probing. All other kinds of algorithms require relevant mathematical mapping relationships. The artificial neural network algorithm involved in this study does not require a large number of mathematical mapping relations, so it does not need to input a large number of mathematical equations in the first place, because it needs to be able to learn some additional basic mathematical rules systematically through the training of data in advance, so that it can output the required mathematical calculation results and simulate the mathematical model better given certain function values and mathematical function values. One of the main core functions of artificial neural networks, as a relatively complex discipline in computer science and mathematics and statistics, when performing mathematical calculations and information statistics, is the training algorithm [20].

The process of the BP algorithm mainly consists of output signal, error forward, and backward linear propagation process. That is, the signal error can be adjusted according to the two input directions from the actual input signal direction to the actual expected signal output, respectively, to calculate the signal output, from the direction of the real expected signal output and then to the real expected input direction of the two directions, respectively, to calculate the signal error to adjust the signal error weight range and error threshold. In the study of the propagation method after the forward superposition of the signal, the input node signal is mainly the node on the actual output of the signal after the inverse superposition through the role of the hidden layer, and the actual output node signal can be generated through the non-linear transformation process [21]. If we find that the actual signal output node position does not coincide with the actual output node direction position of the actual input node expectation signal, the process of backward feedback propagation method for signal error compensation will be easily generated. The principle of error input signal back propagation processing system is that the system will automatically back propagate its various output signals or error information values to each error input layer of the system through the hidden layer nodes layer by layer, and will sequentially transfer its output error signal value distribution to the nodes on each layer corresponding to all other layers of the system error input signal elements, with the system in each layer of the system nodes obtained. The output error input signal values obtained by the system at each layer node are used as the basis for its calculation to automatically adjust the weights among the system's error output signal elements [22].

Neural network is essentially a nonlinear predictive model and, as its name suggests, an algorithm that imitates the human and animal nervous systems for computation. It is based on imitating the human and animal-like brain neural network system to perform the computation and then

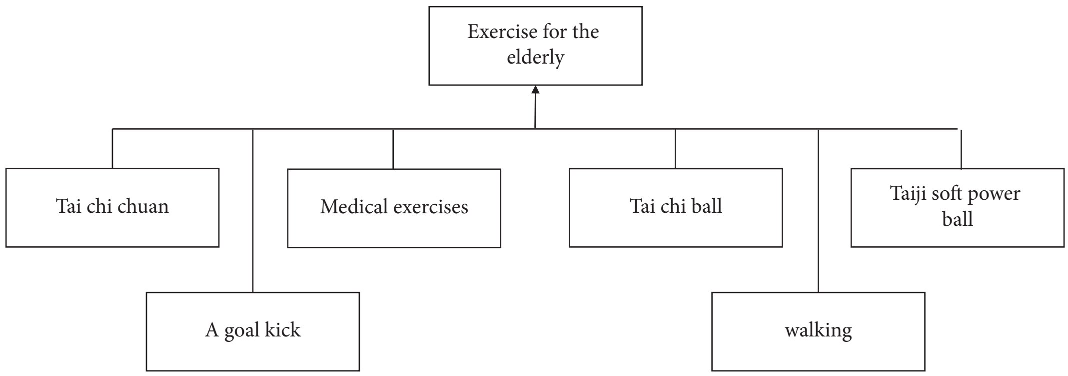

FIGURE 4: Sports suitable for the elderly.

to process the content of each module. Neural network algorithm is a derivative of data mining technology, which is one of the types of data mining technology that can be used for big data mining, such as analysis, classification, aggregation, and other data mining functions. Its advantages and disadvantages are very clear, the first advantage is that it is extremely resistant to interference, and the second is that it is capable of deep learning and better memory in a nonlinear situation, and can handle more complex situations. At the same time, it has two disadvantages. First, its computation and processing results are low-dimensional and cannot be adapted to a high-dimensional environment, so it has a hard-to-interpret nature. The second is that whether it is supervised or unsupervised learning, it requires a long learning time and the data are collected using a more traditional neural network approach.

In this study, we use fuzzy neural networks. This type of neural network (FNN for short) is first, a deep combination of fuzzy theory and neural network algorithms. In the process of data mining and information processing by neural network algorithms, fuzzy theory is incorporated to improve the mapping and the relevance of mathematical relationships. The efficiency of supervised learning and unsupervised learning is better improved. The algorithmic formulas of such neural networks and the related structural diagrams are more commonly used and common and can be found in general textbooks. This type of neural network is shown in the figure, and it goes through five layers in supervised and unsupervised learning. In the beginning two layers, the required computational range doubles as the number of layers increases, but gradually decreases as it enters the third, fourth, and fifth layers. Of course this type of graph is first tested for dimensionality at this node in the input layer when the input is made. The specific value assumes that the dimension value is n and the node that needs to be input is n. Depending on the number of nodes needed, it is passed all the way to the layer of the dimensionality function and the related layer of further computed functions, as well as finally to the output layer. This type of fuzzy theory combined neural network has the same nature as the wavelet neural network and the neural network combined with the generalized theory, which both use the traditional gradient form of computation downward to calculate the centroid of the affiliation and the associated required width value and the final output value and the weights that we need. This is shown in Figure 5.

3.2. Model Setting and Variable Selection. In order to solve the endogeneity problem with unbiased estimation in the above study, instrumental variables are selected in this study to solve the endogeneity problem. Because of the unique advantages of the instrumental variables approach used in this study compared to the limitations of other research methods, the data in this study have exceptionally excellent statistical significance.

3.2.1. Model Setting. A Probit model of whether retired male individuals participate in physical activity was first established with the following standard normal distribution equation:

$$P(y_i = 1) = \Phi(\beta_0 + \beta_1 S_i + \beta_2 X_i), \quad (1)$$

where $y_i = 1$ indicates that retired men i have participated in physical activity. S_i denotes whether retired X_i or not is a series of personal and other variables such as age, education, income, and health self-satisfaction. Equation (1) can actually be written in the following form:

$$y_i^* = \beta_0 + \beta_1 S_i + \beta_2 X_i + \varepsilon_i, \quad y_i = 1(y_i^* > 0), \quad (2)$$

where ε_i is the y_i^* error term, then $y_i^* > 0$ is a latent variable, $y_i = 1$, i.e., if, then, the unbiased estimator $\mathrm{Cov}(S_i, \varepsilon_i) = 0$ is obtained. And the instrumental variable probability ratio model (IV-Probit model) can be represented by the following set of equations:

$$y_i^* = \beta_0 + \beta_1 S_i + \beta_2 X_i + \varepsilon_i, \quad y_i = 1(y_i^* > 0), \quad (3)$$

$$S_i = \gamma_0 + \gamma_1 Z_i + \gamma_2 X_i + \varepsilon. \quad (4)$$

In this system of equations, must $\mathrm{Cov}(Z_i, \varepsilon_i) = 0$ satisfy, $\mathrm{Cov}(\varepsilon, \varepsilon_i) = 0$ and. $\mathrm{Cov}(Z_i, S_i) \neq 0$. Using the two-stage method, equation (4) is regressed in the first stage and then the S_i predicted values $S_i^\wedge = y_0^\wedge + y_1^\wedge Z_i + y_2^\wedge X_i$ are obtained. In the second stage, the used inside S_i equation $S_i^\wedge$ (3) is regressed after replacing it to obtain the unbiased estimator.

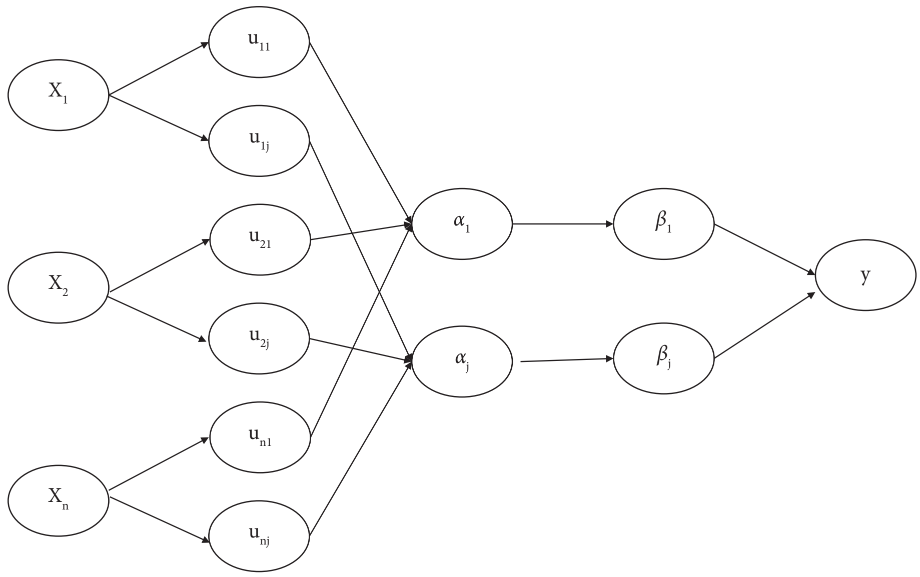

Figure 5: Fuzzy neural network.

3.2.2. Data Sources. The data used in this study are all reference data and processed data. The source of the data in this study is mainly from a demographic research institute of a university in Beijing. The relevant statistics conducted include those of a project with a three-year period. The project covered more than 400 villages and related village committees, and each village committee also surveyed more than 20 households. A total sample size of 40,762 was obtained. The data covered basic personal information, family situation, health, work, retirement, and community information for people aged 17–117 years. After eliminating the samples with missing data, this study finally determined and collated 29,419 valid sample data.

3.2.3. Variable Definition and Descriptive Statistics. Dependent variable: physical activity participation. This study focuses on the impact of retirement on physical activity participation. This study uses the combined data from CGSS 2015, 2017, and 2018 to measure this indicator of physical activity participation. The answers to the questions in the original questionnaire were divided into five categories, and this study re-established a dichotomous variable as the dependent variable through the above questions and answers, where residents who had participated in exercise, regardless of frequency, were recorded as 1; those who did not participate once or never participated in exercise were recorded as 0.

Independent variable: retirement variable. In this study, the retirement variable was reassigned as a dichotomous variable, and the selection item retired was defined as the retirement status and reassigned as 0. The rest of the variables were set as the active status and assigned as 1.

(1) Control Variables: demographics, socioeconomic status, and self-health level. There are many factors affecting retirement and physical activity participation that must be controlled for in the model as much as possible, and the control variables in this study include three categories.

This study examines the effect of retirement on physical activity participation in the male population, so the gender all retains the male sample size. The average age among retired men was around 67 years old, and individual men with partners were higher than working men, with education levels basically close to the secondary school level. The education levels were classified as elementary school and below education, secondary school, and university and above, where secondary school included middle school and high school.

Socioeconomic status characteristics variables including household registration and so on are not normally distributed. The province of residence, according to economic development, is divided into eastern, central, and western regions.

Health and behavioral characteristics variables: respondents' self-evaluation of health and social activities (Internet use) in their free time were included. Activities engaged in during free time included Internet use and study, both of which were assigned as dichotomous variables.

4. Results and Discussion

4.1. Analysis of Descriptive Statistical Results. Instrumental variable: statutory retirement age. According to the experience of instrumental variables often used in previous literature, this study chooses the statutory retirement age as the instrumental variable.

This time, the retirees, specific physical exercise participation, household registration, marriage, education, health, depression, learning status, and Internet use were statistically analyzed, as shown in Figure 6.

The specific physical exercise participation, household registration, marriage, education, health, depression, learning status, and Internet use of on-the-job personnel were statistically analyzed, as shown in Figure 7.

In this study, the specific physical exercise participation, household registration, marriage, educational background, health, depression, learning status, and Internet use were statistically analyzed, as shown in Figure 8.

In the description of model variables in this study, the first is the explained variable, physical exercise participation variable is a classification variable, representing in the past year, do you often engage in the following activities in your spare time, namely physical exercise 0 = do not participate in physical exercise; 1. Get physical. The second is the explanatory variable (endogenous); retirement is a categorical variable, representing the reason why you did not work last week 0 = in-service; 1 = retirement. Third, the explanatory variable (exogenous): (1) age is a continuous variable, unit: years. (2) Educational background is a categorical variable, 1 = primary school or below; 2 = middle school; University degree or above. (3) Marriage is a categorical variable, 0 = no partner; 1. (4) Household is a classification variable, 0 = agricultural household; 1 = nonagricultural household. (5) Region is a categorical variable, 1 = eastern region; 2. 3 = Western Region. (6) Health was a categorical variable, 0 = NO; 1 = yes. (7) Depression was a categorical variable, 0 = depression; 1 = no depression. (8) Learning status is a categorical variable, 0 = no learning; 1 = learning. (9) Internet use is a categorical variable, 0 = does not apply to the Internet. (10) Income is a continuous variable, unit: ten thousand yuan/year. Finally, the age of 60 for men as the legal retirement age is a categorical variable.

4.2. Estimated Results of the IV-Probit Model. The statistical results in this study have good statistical significance, where $^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$. This study presents the one-stage regression results of the IV-Probit model. The results of the first stage regression can also understand which factors are associated with the decision to participate in physical exercise. The level of annual income, the level of development in the region, and the level of health will have a significant positive impact on individuals' participation in physical exercise after retirement. The parameter of age is significantly negative, indicating that the opportunity to participate in physical exercise decreases with the increase of individual age, which is consistent with the trend of people reducing physical activity with the increase of age. The coefficients of the first-stage regression instrumental variables were significant at a 1% level.

This study presents the two-stage regression results of the IV-Probit model. Except for age square and marital status, the coefficients of other variables are significant at a 1% level, age is negative, and other variables are positive. In other words, the individual's income, health level, years of education, and the area where they live after retirement all have a positive impact on physical exercise participation.

In the analysis of the effect of retirement on physical exercise, variable names mainly include household registration (refer to: agricultural household registration): nonagricultural household registration, whose Probit model value is $0.411(13.70)^{***}$, IV-Probit model value is $0.254(0.045)^{***}$; Age, its Probit model value is $-0.019(-4.08)^{***}$, IV-Probit model value is $-0.007(0.005)^{***}$; Education background (refer to primary school and below): High school, its Probit model value is $0.236(0.029)^{***}$, IV-Probit model value is $0.167(0.034)^{***}$, university and above, its Probit model value is $0.851(0.047)^{***}$, IV-Probit model value was $0.851(0.047)^{***}$; Marriage (reference: no partner): there is a partner, whose Probit model value is −0.038(0.034), IV-Probit model value is −0.037(0.034); Region (see Western Region): in the eastern region, the Probit model value is $0.119(0.029)^{***}$, IV-Probit model value is $0.105(0.029)^{***}$, in the central region, the Probit model value is $0.118(0.032)^{***}$, IV-Probit model value is $0.126(0.033)^{***}$; Income, its Probit model value is $0.130(0.043)^{***}$, IV-Probit model value is $0.088(0.017)^{***}$; Retirement status (refer to: in-service): retirement, its Probit model value is $0.418(0.043)^{***}$, IV-Probit model value is $1.167(0.178)^{***}$; Health (reference: unhealthy): health, its Probit model value is $0.277(0.034)^{***}$, IV-Probit model value is $0.259(0.034)^{***}$.

4.3. Test of Tool Variables. Among many methods to identify causality, the IV instrumental variable has obvious advantages. Therefore, this study selects tool variables to solve the endogeneity problem of the model, and the function of tool variables after use will carry out an unbiased estimation of the estimation results. According to the experience of selecting instrumental variables in the previous relevant literature, this study chooses the statutory retirement age as the instrumental variable because legal retirement age is an exogenous variable under China's compulsory retirement policy. Statutory retirement age is correlated with retirement but does not have a direct impact on the dependent variable physical exercise participation.

One, the Hausman test of Endo-CAVALIer shows that the value of different is IV-Probit minus Probit. Nonagricultural household different value is −0.155; age difference value is 0.009; the different value of educational background is −0.008; the difference of having a partner is −0.006; the difference value of eastern region is −0.016; difference value of western region is −0.023; income difference value is −0.047; health difference is −0.047, and overall P value is 0.0046.

The results show that $P = 0.0046 < 0.05$, rejecting null hypothesis H0: there is no systematic difference between a single equation and an instrumental variable equation. The results do differ, so instrumental-variable estimates should be adopted. The F statistic was significantly larger than the empirical value of 10 and significant at 1% ($P < 0.001$). That is to say, the instrumental variables selected in this study are strongly correlated with the dependent variables and will not lead to bias in the result estimators.

4.4. Mechanism Analysis of Influence of Retirement on Male Participation in Physical Exercise. Based on the above analysis results, it is found that the retirement variable has a significant positive impact on participation in physical exercise. Meanwhile, this study solves the endogeneity problem through an instrumental variable method, proving the causal relationship between the two. It is because of the unbiased estimation and the proof of the causal relationship between the two that the limitations of previous literature research can lay a foundation for the following mechanism

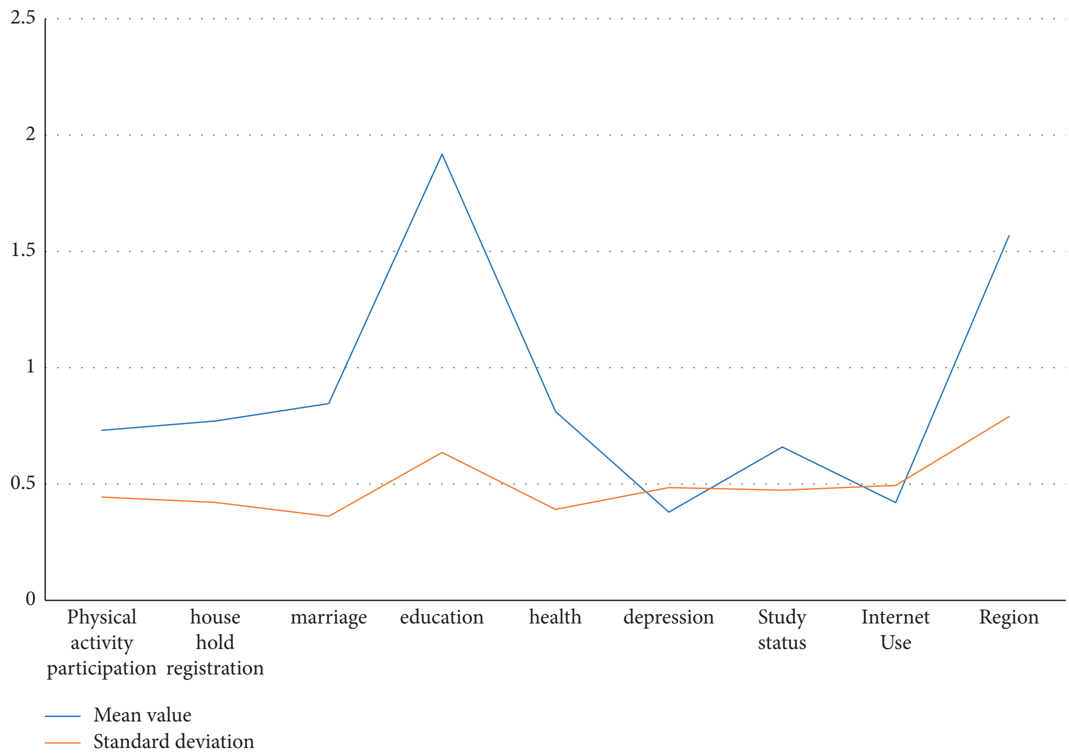

Figure 6: Descriptive statistical analysis of retiree variables.

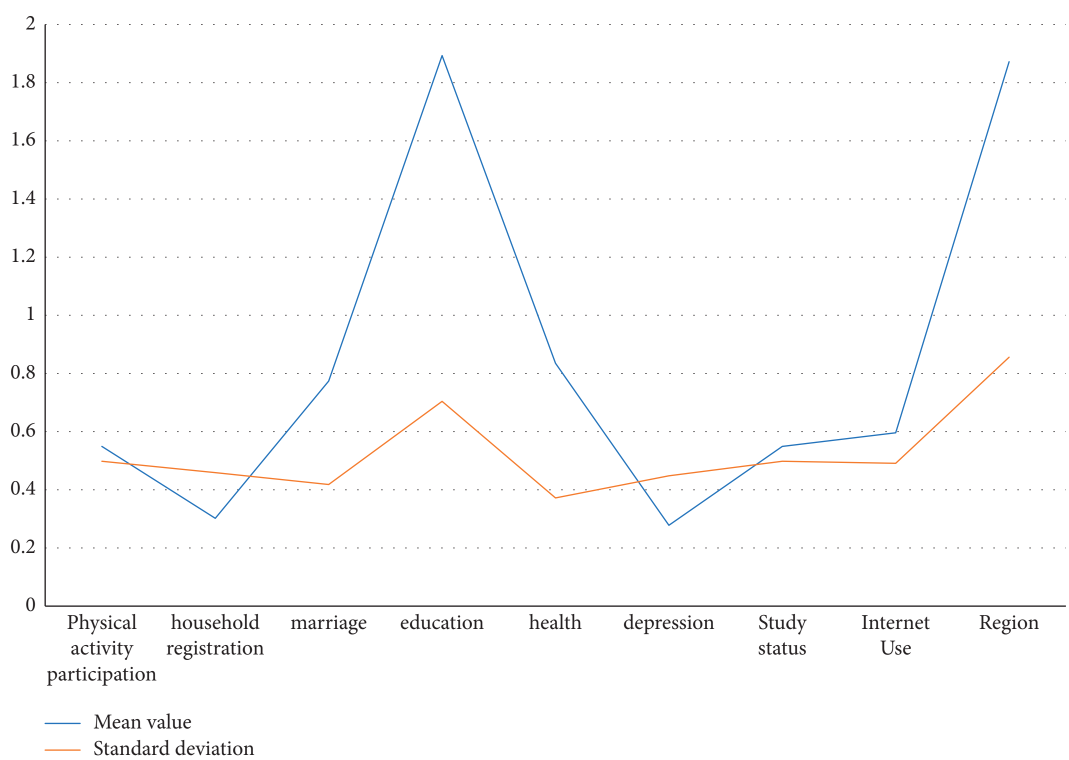

Figure 7: Descriptive statistical analysis of on-job variables.

research and analysis of this study. What is the influence mechanism of retirement on physical exercise participation? This study summarizes the following aspects from numerous studies. The first aspect of this study considers the physical and mental health of retired individuals. After retirement, the change in individual identity and status may stimulate

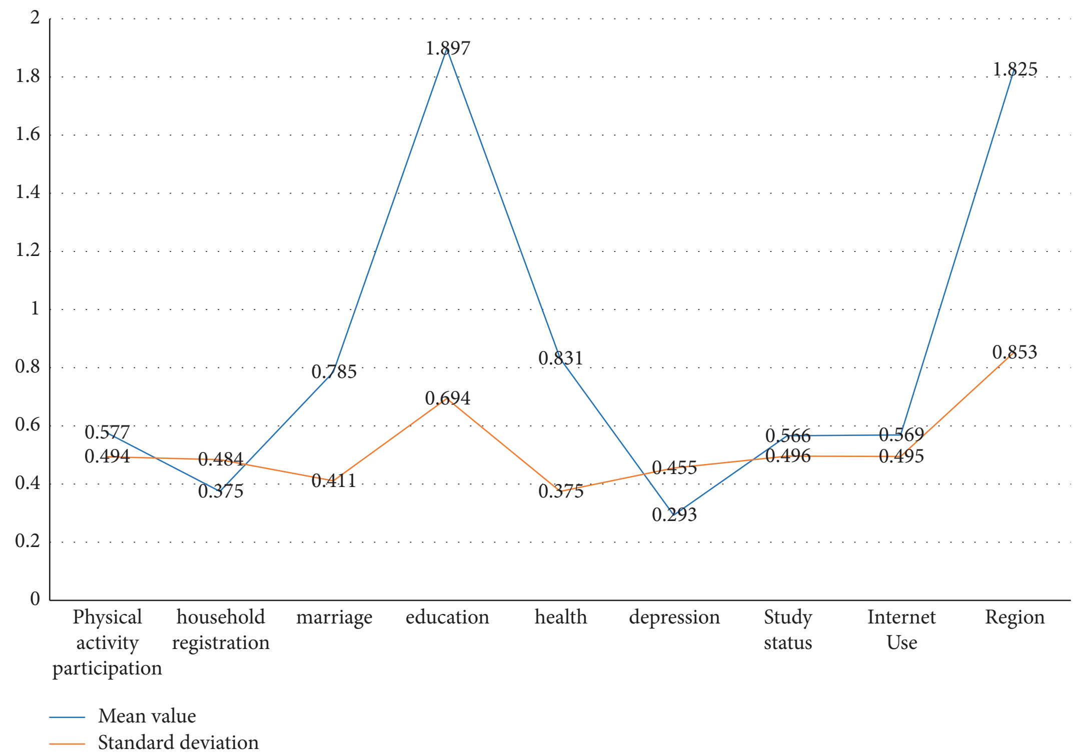

Figure 8: Descriptive statistical analysis of common variables of retirees and active personnel.

the change of behavior, including physical exercise. The interaction between physical health variables and mental health variables (depression degree) and retirement variables was taken as the core independent variables affecting retired male individuals' participation in physical exercise, and Probit regression analysis was conducted. If retirement affects residents' participation in physical exercise through the above variables, then regression will show that the positive influence of variables interacting with retirement should be larger or further significant.

In the first two models, the health variable and the depression variable interact with the retirement variable, respectively, and the retirement variable and their interaction variables show significant differences after controlling for demographic variables ($P < 0.001$). Compared with reference variables, dissatisfaction with one's own health status after retirement will significantly positively affect physical exercise participation behavior. According to the health needs theory, the investment in health after retirement depends on the marginal value of time and the importance that individuals attach to maintaining health. There is plenty of time after retirement, and individuals will increase their awareness of the importance of health as they get older and more experienced. So individuals will increase their participation in postretirement physical activity with the combined effect of more time and increased health awareness. After retirement, individuals who are satisfied with their own health will also increase their participation in physical exercise, which will increase their exercise behavior by 0.54 compared with those who are not satisfied with their own health. The difference between the two is because the choice of physical exercise behavior has been widely considered as an important nonmedical factor of health, physical exercise has become both a way for healthy people to further improve their health level and a way for unhealthy people to improve their health level. Foreign literature points out that individuals actively pursue their own hobbies and participate in sports activities after retirement, which have beneficial effects on physical and mental health. There is no significant difference in the influence coefficient of physical exercise between individuals without depression and those with depression after retirement, but both of them are significant at 1% level. In general, nondepressed individuals tend to engage in more physical activity than depressed individuals. Because physical activity may have an antidepressant effect, retired individuals should actively play the anti-depressant effect of physical exercise and increase their participation in physical exercise in order to prevent depression. Some domestic and foreign scholars believe that retirement shock has a negative impact on men's mental health. After retirement, men can regularly participate in physical exercise and reduce depression due to the disappearance of work pressure and the increase of time flexibility.

In the latter two models, based on the subversive change of individual roles after retirement, the retired elderly are encouraged to continue to learn new skills and update their knowledge and concepts in order to better adapt to the aging life. This study chooses learning and Internet use as two variables for mechanism analysis. Learning variables and Internet use variables interoperated with retirement variables. Controlling for demographic variables, retired individuals' Internet use had a significant positive effect on physical exercise participation ($P < 0.001$). This is in line with the findings of scholars WANG Shiqiang and KEARNS that the Internet promotes physical activity participation among older adults and increases the frequency of exercise. The impact of Internet use by retired individuals on physical activity participation increased by 0.47 compared to no Internet use, which is due to the fact that the Internet changes the values of retired older adults; accesses more information about physical activity; improves cognitive abilities; and also increases social activities of older adults, so it also promotes their physical and mental health more. Under the influence of learning factors, retirement and learning interacted, and controlling for demographic variables, active learning among retired individuals would have a significant positive effect on physical activity participation ($P < 0.001$). This is consistent with the findings of foreign scholars that active learning can improve health literacy, increase physical activity, and promote healthy lifestyles among older adults. This is because high health literacy is associated with good health behaviors. Learning is not only the ability to understand health information, but also includes the ability to assess and apply health information. This explains the 0.51 difference between learning and not learning respectively and retirement interaction on physical activity participation. Active and positive learning is very effective in increasing physical activity.

5. Conclusion

This study focuses on the study and analysis of retired men's physical activity participation and solves the model endogeneity problem through an instrumental variables approach to achieve unbiased estimation. The estimated results show that, first, retirement leads to a significant increase in men's physical activity participation. Second, further study of the effect mechanism suggests that the positive effect of retirement on men's physical activity participation may be due to men's own health status, mental health status, and active study or Internet use in their free time.

In the first two models, the health and depression variables were interacted with the retirement variable, respectively, and the retirement variable showed significant differences with both interaction variables, controlling for demographic variables ($P < 0.001$). Comparing the reference variables, postretirement individuals' dissatisfaction with their health status would significantly and positively influence physical activity participation behavior. According to health needs theory, investment in health after retirement depends on the marginal value of time and the importance that individuals place on maintaining health, and individuals will increase their level of awareness of the importance of health after retirement when they have plenty of time and as their age and experience increases. Therefore, individuals will increase their participation in physical activity after retirement due to the dual effect of having more time and increased health awareness. Individuals who are satisfied with their self-health after retirement will also increase their participation in physical activity and will increase their exercise behavior by 0.54 compared to those who are not satisfied with their self-health. The difference between the two is due to the fact that the choice of physical activity behavior has been widely recognized as a healthy and important nonmedical factor, and physical activity has become both a way for healthy people to further improve their health and a way for unhealthy groups to improve their self-health. Foreign literature indicates that postretirement individuals who actively pursue their hobbies and participate in physical activity have beneficial effects on physical and mental health. The coefficients of the effects of physical activity for postretirement individuals who do not suffer from depressive states and those who suffer from depressive states do not differ significantly, but both are significant at the 1% level. Overall, physical activity participation tended to be higher in nondepressed individuals than in depressed individuals. Precisely because physical activity may have anti-depressant effects, retired individuals should be more active in the anti-depressant effects of physical activity and increase physical activity participation in order to prevent themselves from suffering from depression.

In the latter two models, based on the disruptive shift in the role of individuals after retirement, retired older adults are encouraged to continue learning new skills as well as updating their knowledge perceptions in order to better adapt to aging life. In this study, two variables, learning and Internet use, were selected as the variables for mechanism analysis. The learning variable and the Internet use variable were interacted with the retirement variable, and a significant positive effect of Internet use on physical activity participation was found among retired individuals, controlling for demographic variables ($P < 0.001$). This is in line with the findings of scholars WANG Shiqiang and KEARNS that the Internet promotes physical activity participation and increases exercise frequency among older adults. The effect of using the Internet on physical exercise participation increased by 0.47 for retired individuals than not using the Internet. This is due to the fact that the Internet changes the values of retired older adults; gets more information about physical exercise, improves cognitive ability, and also increases social activities of older adults, so it also promotes their physical and mental health development more. Under the influence of learning factors, retirement and learning interacted, and controlling for demographic variables, active learning among retired individuals would have a significant positive effect on physical activity participation ($P < 0.001$). This is consistent with the findings of foreign scholars that active learning can improve health literacy, increase physical activity, and promote healthy lifestyles among older adults. This is because high health literacy is associated with good health behaviors. Learning is not only the ability to understand health information, but also includes the ability to assess and apply health information. This explains why there is a difference of 0.51 between learning and nonlearning respectively and retirement interaction on physical activity participation.

Data Availability

The dataset is available upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Retraction

Retracted: Discrete Dynamic Modeling Analysis of College Students' Ideological and Political Education Based on Particle Swarm Optimization Algorithm

Mathematical Problems in Engineering

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

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

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

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

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[1] H. Wang, "Discrete Dynamic Modeling Analysis of College Students' Ideological and Political Education Based on Particle Swarm Optimization Algorithm," *Mathematical Problems in Engineering*, vol. 2022, Article ID 4118265, 8 pages, 2022.

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Research Article

Discrete Dynamic Modeling Analysis of College Students' Ideological and Political Education Based on Particle Swarm Optimization Algorithm

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Today, with the rapid development of the Internet, the new carrier and platform of college students' ideological and political education innovation need to be improved. In order to improve the timeliness of college students' ideological and political research, in view of this characteristic, particle algorithm is studied. Combined with the principle of particle algorithm, the core idea of particle algorithm is applied. College students think about their past behaviors and conduct self-evaluation and reflection. On the other hand, it is the competition and cooperation between multiple academic groups. Combined with particle swarm optimization algorithm, through model optimization, deal with the fitness value between the two attributes to optimize the work. Positive and negative excitation measures are introduced in the experimental research, and the particle swarm optimization evaluation function and behavior weighting factor are analyzed to hypothetically describe the working method. At the same time, it is pointed out that the educational working methods should be adjusted in time according to the changes of student groups and individual behaviors, so as to achieve good work results. Research shows that positive incentives are better than no incentives, and the introduction of negative incentives can only prevent college students from becoming negative role models because they cannot give them the best state of consciousness.

1. Introduction

Ideological education in colleges and universities can improve students political consciousness, so ideological education in colleges and universities is very important to students. Nowadays, ideological and political education in colleges and universities has diversified characteristics. Compared with traditional teaching methods, today's ideological and political education in colleges and universities not only needs to enhance students' ideological and political consciousness in teaching but also needs to guide students' ideological development in life, so it has a more difficult teaching task [1]. The ways of ideological education in colleges and universities include student unions, ideological and cultural courses, the election of activists, or the election of reserve teams. How to improve students teaching level in colleges and universities has become an important task [2].

At present, China's education is in a critical turning period, and there are some inefficient problems in many teaching links. Low efficiency is not only a common problem in college students' ideological education but also a normal phenomenon in the process of ideological construction [3]. Due to the neglect of some teaching frequencies, there are some fuzzy management phenomena in the process of college students' ideological education, which has even affected the normal progress of ideological and political work in colleges and universities. Therefore, the teaching pressure in colleges and universities is gradually increasing [4]. After investigation, some colleges and universities are unwilling to invest too much energy in ideological education, which makes the phenomenon of fuzzy management more prominent. Only a few colleges and universities believe that it is very necessary to strengthen ideological and political education. Therefore, some colleges and universities need to strengthen management negligence [5]. The most relevant research in teaching management analysis is generally analyzed from the perspective of development direction, so we can analyze the shortcomings of current teaching. In many studies, the evaluation results of ideological and political education are not accurate enough. This makes the teaching management to be optimized. This paper uses particle swarm optimization algorithm to optimize it.

PSO is a behavior of prey by simulating birds, which can be also called a bird foraging algorithm and represents the best recent strategy for birds to find food in the closest range [6]. Apply the particle swarm algorithm to people, which is the process of human interaction, as well as the process of mutual influence, mutual imitation, and mutual learning. Finally, people will become more and more similar and later become a norm and civilization. There are many different behavioral habits on the Earth, such as the behavioral habits of humans and birds or fish. Although the behavioral habits between humans and other species are vastly different, when we are together in a multidimensional cognitive space, human trajectories are very similar to them [7]. Some researchers simulated the foraging behavior of birds and studied the particle swarm optimization algorithm. Solve the problem by using fitness. Start the search from a random solution and gradually track and search the optimal value of the current algorithm [8]. After verification, particle swarm optimization algorithm has the advantages of high precision, easy implementation, and fast convergence speed. However, particle swarm optimization algorithm has the disadvantage of premature aging in practical operation, resulting in low calculation accuracy [9].

2. State of the Art

Positive motivation is an initiative incentive that affirms or supports a certain behavior so that it can continue. Ultimately, human needs are met and the goals of the organization are achieved [10]. For college students, positive motivation is first of all by affirming a certain positive behavior of students and giving certain material rewards, thereby mobilizing students to become positive and take typical subjective initiative. Through correct education and creating useful paradoxes, set the benchmark for college students, point the direction, and establish positive energy to resist negative energy [11]. Through correct education and useful public opinion, the benchmark for college students is established, the direction is specified, and positive energy is used to resist negative energy. For example, it is necessary to praise students who perform well in a timely manner and affirm their words and deeds. The students' mistakes and words are promptly criticized and corrected to plan the daily behavior of the college student group, thus promoting good ideology and morality and becoming collective wealth [12]. However, negative incentives are considered a passive incentive. By stopping, it denies people's behavioral habits and finally weakens them until they disappear and develops in a good direction. Both positive and negative incentives are essential. First of all, these two incentives directly affect individuals and then ferment and indirectly guide the surrounding individuals and groups [13]. Jongbin once did a study and proved from a psychological perspective that a certain amount of negative feelings is greater than the satisfaction of the same amount of positive feelings [14]. For example, if a person loses a hundred yuan, the negative feeling he produces will be stronger than the positive feeling brought about by the one hundred yuan. Therefore, when educating college students, negative incentives must be used with caution because punishment will leave students with trauma in their hearts [15]. In college students, there are several types of negative incentives adopted by the school for students, including criticism, punishment, detention, and expulsion. In these negative stimulations, measure must be grasped, and any deviation cannot be produced. The effective use of positive and negative incentives for students can effectively improve their ability to distinguish between right and wrong and enhance group consciousness behavior [16].

3. Methodology

3.1. Network-Based Teaching Theory. Network multimedia technology brings many advantages that traditional teaching cannot match. Network teaching is a student-centered teaching method. The huge virtual reality teaching space in the network provides students with conditions for autonomous learning.

The network makes students face a large number of fragmented resources, and they must find knowledge according to the teaching objectives. With the help of network platform and cyberspace, the interactive teaching mode has become an all-round interaction. In the process of network-based teaching, teachers not only impart knowledge but also play the role of designers, organizers, managers, and assistants in the whole teaching process, so as to promote the formation of their positive learning attitude, improve their autonomous learning ability, and lay a good foundation for lifelong learning. However, the traditional classroom emphasizes the understanding and memory of knowledge, which makes students often passively accept the knowledge and training in the classroom, resulting in dependency psychology and lack of positive learning spirit. Therefore, the role of teachers is changing from the foreground to the background.

The interaction between traditional classroom teaching and online teaching environment is shown in Figure 1.

3.2. Content of Mobile Internet Ideological and Political Education. With the gradual popularization of mobile terminals, mobile networks, and mobile applications, the innovation of ideological and political education model and the construction of new education platform have become important means to improve the effectiveness of education. The ideological and political education content of mobile Internet is shown in Figure 2, including the following. (1) Adjust the content of mainstream terminals, strengthen layout design, and promote the rationalization of ideological and political theory education content. According to the appearance design and operating system of different types of products, in order to ensure that the educational content is

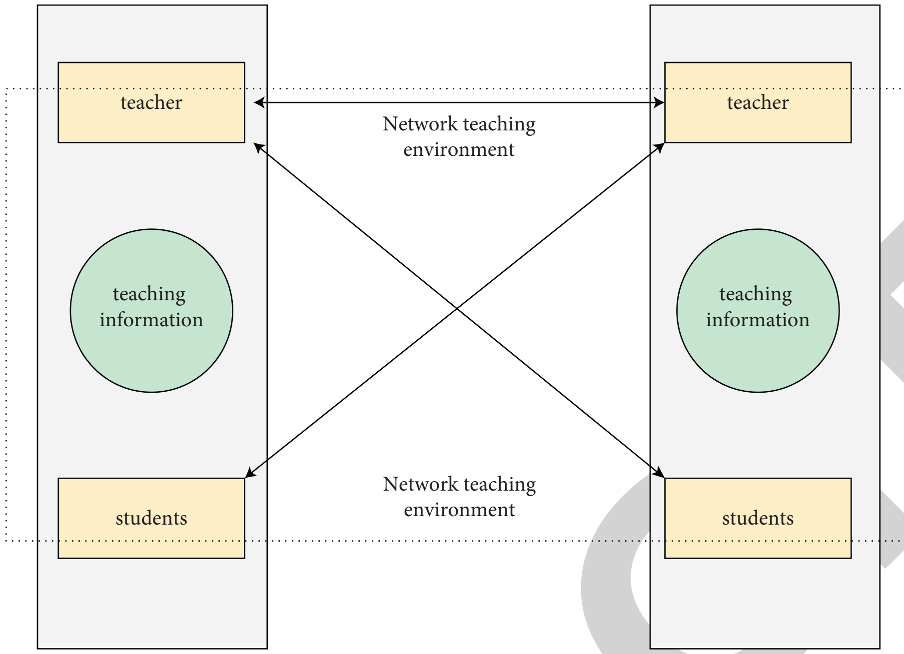

Figure 1: Interaction between teachers and students in network teaching environment and traditional classroom teaching environment.

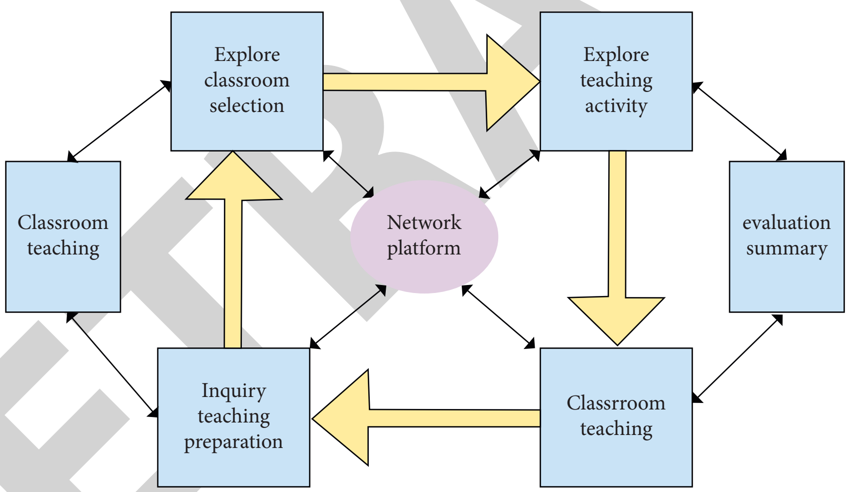

Figure 2: Content of mobile Internet ideological and political theory education.

more clear and coherent, the ideological and political education of college students should strengthen the cooperation between colleges and universities, and the layout design should be carried out according to the ideological and political education content of college students around the current mainstream terminal. (2) Through data analysis, the quality of after-school recommendation is improved and the personalization of ideological and political education content is improved. Perfect after-school knowledge recommendation refers to information browsing based on mobile Internet users and providing information resources required for user data analysis. In order to improve the content of ideological and political education, it is necessary to actively combine mobile Internet technology, conduct data analysis and algorithm research according to college students' web page records, comprehensively analyze college students' reading interests, develop personal learning database, and actively guide college students' ideological and political learning direction. (3) Pay attention to audience experience, deepen the integration of learning and entertainment, and promote the diversification of ideological and political theory education content. The survey found that when using the mobile Internet, college students prefer simple and vivid entertainment information and are more likely to express their interest in pictures, videos, and audio. The pan entertainment in network culture is manifested in the large number of dissemination subjects of Internet entertainment information and the entertainment of Internet information content and form. The Internet pan entertainment has formed a challenge to the ideological and political education of college students, which is embodied in testing the quality of ideological and political educators; dispelling the thinking ability of college students; impacting the authority of ideological and political education content; and reducing the effectiveness of ideological and political teaching methods. Facing these challenges, colleges and universities should improve the political and theoretical literacy of ideological and political educators; strengthen the education of ideals and beliefs and cultivate the healthy personality of college students; strengthen the supervision of campus network and create a clean campus network environment; and combine teaching with pleasure to enhance the effectiveness of ideological and political education methods. Therefore, in the innovation of ideological and political theory education based on mobile Internet technology, we should pay attention to the characteristics of college students' thought and behavior, pay attention to the combination of students' interests and teaching content, meet the practical emotions and needs of college students, establish vivid, happy, and relaxed teaching content, and improve the interest and attraction of ideological and political theory education.

3.3. The Basic Principle of PSO. The search population size consists of N particles $Xi = (X_{i1}, X_{i2}, \ldots, X_{iN})$, where $Vi = (V_{i1}, V_{i2}, \ldots, V_{iN})^T i = 1, 2, \ldots, N$ indicates the flight speed of the ith particle. $xi = (x_{i1}, x_{i2}, \ldots, x_{iD})^T i = 1, 2, \ldots, N$ represents the spatial position of the ith particle. $pi = (p_{i1}, p_{i2}, \ldots, p_{i\,D})^T i = 1, 2, \ldots, N$ indicates the individual extremum of the particle swarm search. g represents the entire population, and the global optimal position searched for the entire particle swarm is represented by $pgi = (p_{g1}, p_{g2}, \ldots, p_{g\,D})^T$. The speed and position update formula of the particle swarm algorithm is expressed as follows:

$$\begin{cases} V_{id}^{k+1} = V_{id}^{k} + c_1 r_1 \left(p_{id}^{k} - x_{id}^{k}\right) + c_2 r_2 \left(p_{g\,d}^{k} - x_{gd}^{k}\right), \\ x_{id}^{k+1} = x_{id}^{k} + V_{id}^{k+1}, \end{cases} \tag{1}$$

where r_1 and r_2 are two different functions that are randomly extracted in the interval [0, 1]. c_1 and c_2 represent learning factor, which is also called an acceleration factor. The speed at which individual particles search in a local range is adjusted by c_1, and the speed at which individual particles are searched globally is adjusted by c_2. The dimension of a particle in D-dimensional space is represented by d. k is the number of iterations of the algorithm. Particle search has certain limitations, and it can only be searched if a certain constraint is met. It is also necessary to set the speed at which the particles change in position and to be limited to the maximum speed.

The first is $V_{i\,d}^{k}$, which indicates the original velocity of the particle. The second is $c_1 r_1 (p_{i\,d}^{k} - x_{i\,d}^{k})$, which represents the "cognitive" part of the particle, expressing the thoughts of the particle itself. It is the direction of a certain direction of action when the particle is now compared to the best position that has ever appeared. The third is $c_2 r_2 (p_{g\,d}^{k} - x_{g\,d}^{k})$, which represents the "social" part. It is a comparison of the current position of the particle with the best position that the entire group has ever seen, showing the process of sharing, cooperating, and learning between the particles. Through this iterative search, particles not only combine their own motion changes and experience but also contrast with other particles, so as to avoid being a local optimal solution.

3.4. Implementation Flow of PSO. PSO gets inspiration from the model and is used to solve optimization problems. In PSO, the potential solution of each optimization problem is a point in the search space called particle. All particles have a fitness value determined by the optimized function, and each particle also has a speed that determines the direction and distance they fly. Then, the particles follow the current optimal particle to search in the solution space. PSO is initialized as a group of random particles (random solutions), and then the optimal solution is found through iteration. At each time, the particle tracks two extreme values to update itself. The first is the optimal solution found by the particle itself, which is called individual extremum. The other extreme value is the optimal solution of the whole population, which is the global extreme value. In addition, the whole population cannot be used as all neighbor values of particles, which are considered local extremum. The process of the algorithm is as follows: the most important thing of iterative search is to set the basic parameters of particle swarm optimization. Firstly, the number of particle groups N in PSO is set to search the dimension D of space, so as to solve the range of space, the maximum flight velocity of particles, the sum of acceleration factors, and the maximum iteration times of PSO. Then, the velocity and position of each particle are initialized in the solution space, and its current position is regarded as a single extreme value. Secondly, each particle is evaluated according to its fitness function value. Thirdly, the fitness function of each particle is compared with its extreme value. If it is better than a single extreme, it is replaced by a new single extreme; otherwise, the single extreme remains unchanged. Then, the updated individual extremum is compared with the global extremum. If it is better than the global extremum, it is replaced by a new global extremum; otherwise, the global extremum will not change. Fourthly, the positions and velocities of all particles are updated according to formula (1). Fifthly, check whether the algorithm satisfies its ending condition. If the number of iterations is already the maximum number of iterations or the result satisfies the convergence requirement of a set, the iterative search is stopped and the final result is output. Otherwise, return to Step 2 and start a new calculation iteration. The flowchart of the algorithm is shown in Figure 3.

The standard PSO algorithm is an improvement to the basic PSO algorithm by adding an inertia weight ω to the velocity iterative update formula. The formula of the standard particle swarm algorithm is as follows:

$$\begin{cases} V_{id}^{k+1} = \omega V_{id}^{k} + c_1 r_1 \left(p_{id}^{k} - x_{id}^{k}\right) + c_2 r_2 \left(p_{gd}^{k} - x_{d}^{k}\right) \\ x_{i\,d}^{k+1} = x_{id}^{k} + V_{id}^{k+1} \end{cases},$$

$$\omega = \omega_{\text{start}} - \frac{\omega_{\text{start}} - \omega_{\text{end}}}{T_{\max}} \times T, \tag{2}$$

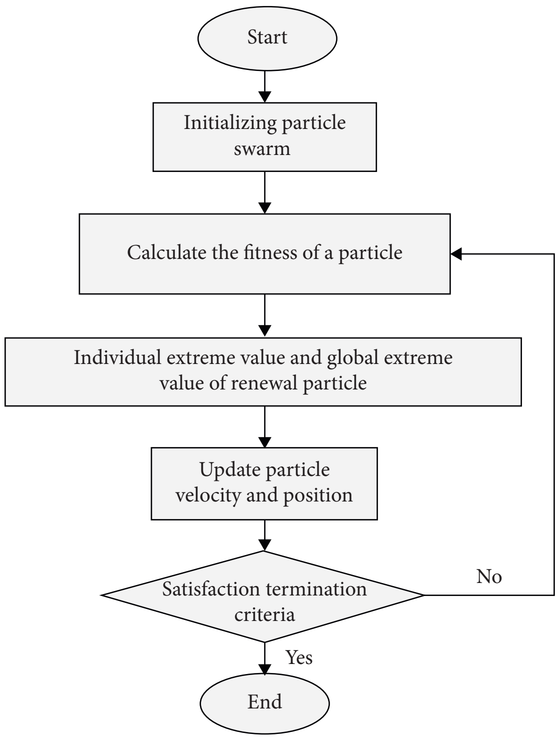

Figure 3: Flow diagram of particle swarm optimization.

where $T_{\max}$ represents the maximum number of iterations of the population, T represents the current number of iterations, and ω_{start} and ω_{end} are the inertia weights at the beginning and end, respectively.

3.5. Experiment on the Effect of Positive and Negative Incentive Strategies under PSO. Guided by the PSO model and connected with the work of ideological and political education, it can be easily found that each college student's consciousness behavior may be influenced by the habits he cultivates, the usual experience, and the experience of the group. Only a part of the students' herd mentality is relatively strong, that is, the $c_2 r_2$ value is large, so the group experience has a greater impact on him. The other part of the college students may have stronger personality, that is, the $c_1 r_1$ value is larger. There are some more rebellious college students, and c_2 may still be negative. Generally speaking, college students' thinking is more active and divergent, and its inertia weight ω is relatively large. At present, the most commonly used ideological and political education strategy includes positive and negative incentives. Negative motivation was originally a concept in management. In order to improve the efficiency of ideological and political education, management knowledge has been widely used in ideological and political education. Negative motivation is to regulate individual behavior by means of punishment and effectively realize the systematic activities of organizing daily targets. It follows the principle of negative reinforcement of human behavior results to realize the role of motivation and weaken the individual to continue to take such behavior. Then, under the PSO algorithm, what is the role of positive and negative incentives specifically in ideological and political education? With this question, positive and negative incentives are introduced into the PSO model. At this time, the position of each particle, that is, the updated state of the individual's individual consciousness behavior, is still expressed by formula (1):

$$\begin{aligned} V_{id}^{k+1} &= \omega u_{id}^{k} + c_1 r_1 \left(p_{id}^{k} - x_{id}^{k}\right) + c_2 r_2 \left(p_{gd}^{k} - x_{gd}^{k}\right) \\ &\quad + c_3 r_3^{k} \left(S_1^{k} - x_{id}^{k}\right) + c_4 r_4^{k} \left(S_2^{k} - x_{id}^{k}\right). \end{aligned} \tag{3}$$

For the sake of research, first of all, assume that each teacher's positive and negative incentives for students are the same and remain the same throughout the observation timeframe. S_1 indicates the positive excitation point. c_3 indicates the normal number, which is also called the trend constant of the positive excitation. S_2 indicates the negative excitation point. c_4 indicates the negative constant, which is also called the negative excitation tendency constant, and c_3 and c_4 are randomly selected values between [0, 1], which can only express the conscious behavior of each stage of college students, and are subject to the uncertainty reaction of positive and negative incentives. Based on the discrete group model, the students' group consciousness behavior is simulated by the positive and negative incentives.

Assume that the dimension of the consciousness state of the student group is $n = 2$, the overall scale is $m = 10$, and the evaluation function is expressed as a quadratic continuous surface. The larger the value of this quadratic function is, the better the state of consciousness it exhibits. Its minimum value is F and the maximum point is R. The positive incentive point S_1 is in the vicinity of the maximum value point R, which indicates that the teacher guides the student consciousness state. The negative incentive point S_2 is in the vicinity of the minimum value point F, indicating that the teacher establishes a typical value of negative direction, thus regulating the student's state of consciousness. The small dot is the initial state of consciousness that each college student randomly generates, as shown in Figure 4.

In this experiment, the parameters of the particle swarm model are set as follows: $\omega = 0.5$, $c_1 = 0.5$, $c_2 = 0.5$, $c_3 = 0.5$, and $c_4 = 0.5$. There are 4 cases, represented by curves a, b, c, and d. Curve a indicates that no excitation is introduced. Curve b indicates that only positive excitation is introduced. Curve c indicates that only negative incentives are introduced. Curve d indicates that both positive and negative stimuli are introduced. These four cases are repeated 20 times, and the curves evolved by the college students' group consciousness optimization model were averaged in the 20 experiments, as shown in Figure 5. From the figure, the following can be found. (1) When positive and negative incentives are introduced at the same time, the student group's sense of optimism is the best. (2) It is better to introduce only positive incentives than to introduce no incentives. (3) The experimental effect of not introducing any incentive is better than the introduction of only negative incentives. Combined with the working experience of ideological and political education, the results of the experimental results (1) and (2) are not surprising. What draws

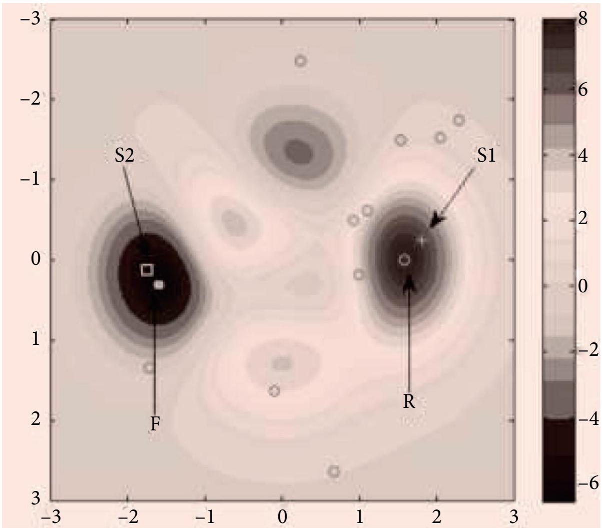

Figure 4: The position of each student's positive incentive point.

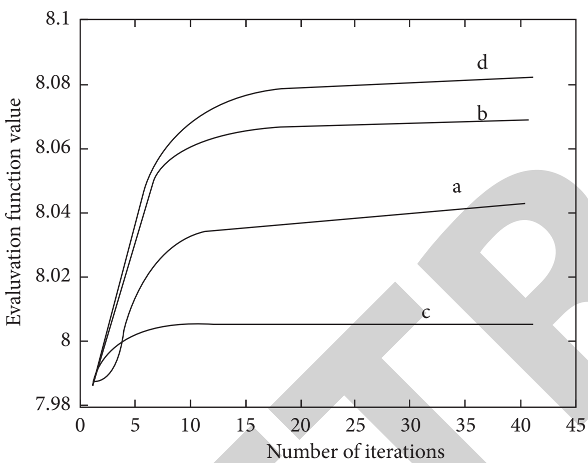

Figure 5: The average curve of student group consciousness optimization and evolution under the four conditions.

our attention is experimental result (3). In the ideological and political education, if only the negative incentives are introduced and the positive incentives are not introduced, the students should not be allowed to converge on the state of optimal consciousness, and at most, the college students can be kept away from the negative typical.

The experiment found that it is necessary for educators to improve their work strategies in response to the effects of positive and negative incentives. Students can become active because they are stimulated by a certain factor, and they become negative because of the stimulation of a certain factor. Negative motivation is a kind of stimulating information that is unpleasant to the ear and uncomfortable to people. Most people will have the psychology of exclusion and resistance to it. Negative incentives should be carried out appropriately and realistically. Therefore, when using negative incentives, we must grasp the scale. If the negative incentive is weak, then the negative incentive is in vain and cannot help students and teachers' introspection. If the negative incentive is too strong and exceeds its limit, such as the use of corporal punishment, it is easy to deepen the misunderstanding between teachers and students. It can be seen from the graphs of the student group consciousness optimization model under the above four different incentive situations that positive and negative incentives should be actively introduced in the ideological and political education work, and cautious treatment should be taken when the negative incentive measures are adopted separately. In this experiment, the evaluation function and the ideological and educational education system that influence the ideology of the student group are simplified. However, the principle and result of the quadratic continuous surface of this paper can also play a very good educational role in the daily ideological and political education of colleges and universities.

4. Enlightenment from the Working Methods of Ideological and Political Education

4.1. Behavioral Inertia. The particle swarm algorithm is actually the evaluation and reflection of the particles on their previous behavior. Among them, the weight factor ω plays the most important role. In the PSO algorithm, the weighting factor ω enables the particles to continue to move the inertia at all times and also directly affects the direction and displacement of the particles. In the ideological and political education of colleges and universities, ω value can be regarded as the inertia of the behavior of the educators. In the entire group, if the behavior of the educated person is too large or too small, the best solution will not be found in it. The key issue in solving this problem is to find out why this behavior is too fast or too slow. The study found that people's behavioral inertia and their own consciousness development have an inseparable inertia. The growth and development of self-consciousness is the process of self-recognition of the relationship between the individual and the environment and the inertia of environment on Friday and the behavior. It is necessary for teachers to adjust the students' behavioral inertia, so as to enhance the self-recognition of college students and make them develop in a healthy way. Among them, psychological counseling and self-education can play a very good role. Counseling can enable students to enhance their understanding of themselves, better adapt to society, and tap their potential. But ideological and political education and general psychological counseling are also different. The focus of ideological and political education is on the social attributes of people, while psychological counseling is the natural attributes of people. The self-education law is also an important way of ideological and political education. It is mainly aimed at the characteristics of the behavioral inertia factor of the educated, adopting a reflective method, comparing the past thoughts and behaviors, finding the inadequacies, and finally self-reforming. In the above mentioned publicity, ωu_i^k and $c_1 r_1^k (S_i^k - x_i^k)$ represent the status quo and cognition of particles, and self-reformation allows the educated to reflect on the status quo and reconstruct the state compared with the past.

4.2. Learning Factors. The weight of the learning factor also plays a crucial role. It can not only represent the size of the particle learning ability but also affect the particle's entire search ability. The game of subjectivity and autonomy of learning factors also determines its optimal position. If its autonomy is stronger, the greater the weight of the learning factor, the stronger its learning ability, but it may also think too much and lose personality. Autonomy is primarily about action-oriented education. It is student-centered, giving students a sense of subjectivity, allowing them to make full use of what they have learned to improve their ability to solve problems and express their opinions. Action-oriented process is a process of constructing a knowledge system through passive and practical activities, which makes students change from passive to active. It is not a simple input and extraction process but a process of collision between old and new experiences. Its main character is cramming and instilling education. It is the process in which teachers send theoretical knowledge to students in a planned way, so that students can establish a correct outlook on life and values, and it is a process of convincing people and implanting specific ideas. Its learning ability and imitation ability are small, so in the particle swarm algorithm, its learning factor weight is relatively small. It can help the lack of self-learning particles to implant a fixed awareness, so that their learning ability is improved.

4.3. Adaptive Adjustment of Parameters. The most important and most sensitive parameters of the positive and negative excitation PSO algorithms are ω and c_1, c_2. The parameter settings for the particle swarm algorithm are usually set based on experience. The problem that the optimal solution of the algorithm will produce oscillation cannot be completely solved, which will slow down the convergence speed and affect the global search. Therefore, it is necessary to adaptively adjust and optimize these parameters to improve the accuracy.

Positive reinforcement refers to the time when the effect of education is relatively good, and measures are taken to strengthen it. It is an education based on student activities that are reinforcing behaviors. The reinforcement theory was proposed by American behavioral psychologist Skinner. He believed that Pavlov was a reactive operation to the "dog bell saliva" secretion test, which was a passive reaction. It is the purpose of the person to propose the target behavior, and the third person's reinforcement or regression will increase or decrease the target behavior. In the daily development of ideological and political education activities, there are usually two problems. On the one hand, some student activities are carried out because there is no application for comprehensive evaluation points, and student participation is very low. On the other hand, some students' activities are empty, the form is boring and unattractive, and even if there is a comprehensive evaluation score, it is impossible to attract students to the scene, and the effect is not good. The main position of college students' ideological and political education activities is activities, which can achieve positive effects through activities. By participating in activities, students can realize their own value, strengthen their recognition of themselves, and achieve the ideal effect of positive reinforcement.

The negative reinforcement behavior is based on the management rules for college students' disciplinary action. Negative reinforcement behavior has always been a means used by educators cautiously. However, when negative models cannot be negatively strengthened, other companions will adjust their status according to the location and status of the surrounding students, which will have a negative impact on the entire group. The rules for the management of college students' disciplinary actions are the negative reinforcement tools for college students' ideological and political education, and they are also negative evaluations and incentives for college students' negative behaviors. Not all negative reinforcements can act as incentives. If the college student disciplinary regulations only punish the negative behavior of college students and the students do not lose the evaluation or participate in the scholarship selection rights, then such negative reinforcement cannot play an incentive role. Therefore, whether negative reinforcement can play an incentive role will depend on the nature of negative reinforcement. The correct use of negative reinforcement tools and methods is conducive to the evaluation and motivation of individual and group behavior.

5. Conclusion

The group of college students is very complex. If it is regarded as a system, the system will make corresponding changes according to the changes of environment and the needs of task objectives. Through the change of knowledge and experience a person has learned, his behavior will also change. In this paper, positive and negative excitation measures are introduced in the experimental research, and the particle swarm optimization evaluation function and behavior weighting factor are analyzed to hypothetically describe the working method. It is pointed out that the educational working methods should be adjusted in time according to the changes of student groups and individual behaviors, so as to achieve good work results. Inspired by the PSO model, the group consciousness behavior of college students is modeled. Positive and negative incentives are introduced into the model. Introducing positive incentives is better than not introducing any incentives. It cannot help them enter the optimal state of consciousness. In view of this incentive effect, positive and negative incentive work strategies are actively introduced. Also, carefully use negative incentives alone, innovate work ideas, and implement the reverse application of positive and negative incentives to improve the work strategy of ideological and political education. Ideological and political education activities for college students are activities that have achieved positive and typical effects through practical activities. By

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Research Article

Joint Injury of Taijiquan Based on Computer Image Analysis

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With people's attention to physical health and health preservation, more and more people practice Taijiquan to achieve the purpose of physical fitness and self-cultivation. However, many people do not fully understand the principles of Taijiquan in the early stage of practicing Taijiquan, rely on imitation to practice, and ignore the action essentials and characteristics of Taijiquan, resulting in joint pain. At the same time, many beginners ignore the causes of these situations, resulting in joint damage. Therefore, this paper proposes the research on the joint injury of Taijiquan based on computer image analysis and carries out the dependent research and analysis through the joint image processing model based on the improved Robert's edge detection algorithm. The experimental results show that the action cycle time of wrong action is longer than the total time of correct action due to the increase of action displacement, and the long displacement distance increases the pressure on the knee joint and improves the probability of knee joint damage. In addition, there are obvious differences between wrong action and correct action in knee adduction and abduction, flexion and extension, internal rotation, and external angle. Wrong action knee joint movement does not conform to the natural movement law of human body, which increases the pressure or tension to the knee joint and surrounding related tissues and improves the probability of knee joint damage.

1. Introduction

With the improvement of people's quality of life, people pay more and more attention to physical health and health preservation. As one of the national intangible cultural heritages, Taijiquan boxing is continuous and continuous and integrates elements such as martial arts, art, and traditional Chinese medicine, which can achieve the role of self-cultivation while strengthening the body. The movement situation of Taijiquan is mainly slow. In the movement process, it pays attention to the mutual cooperation of meaning, Qi and body, which can meet the physiological and psychological requirements of people of different ages and promote the development of human physical and mental health [1]. In addition, long-term Taijiquan practice is obviously helpful for the prevention and treatment of some chronic diseases. Some scholars intervened in the traditional Yang's Taijiquan system training for 26 days for the middle-aged and elderly subjects with hypertension. The experimental results show that Taijiquan can improve the quality of life of patients with hypertension and promote the development of physical and mental health of patients [2]. Other scholars pointed out that the balanced and coordinated round and soft movement with blood shown by Taijiquan is consistent with the physiological law of the human body and can regulate and enhance the order of the Zang Fu organs and the functions of various systems of the human body [3]. Therefore, the value and significance of Taijiquan in fitness has been deeply recognized by people, and more and more people achieve the purpose of fitness by practicing Taijiquan.

However, many people do not have a comprehensive understanding of Taijiquan at the beginning of Taijiquan practice. They think that the movement speed is slow and stable, the action intensity is not large, and there is no excessive burden on the body. They ignore the requirements of Taijiquan practice related to the strength of lower limbs, resulting in knee pain during practice [4]. At the same time, beginners mainly focus on rough imitation practice at the beginning of learning and do not really master the essentials and techniques of Taijiquan. Therefore, they are confused about the phenomenon of joint pain symptoms in practice, and even some learners ignore this situation, which aggravates the physical joint pain and causes joint injury [5]. Therefore, the correlation and influence of total wrong movements in Taijiquan practice on knee injury has become a hot spot of attention and research. Some scholars analyzed the causes of knee joint injury caused by Taijiquan from the perspective of knee joint movement mode, and pointed out that the relevant reasons include too low center of gravity, nonstandard technical movements, and lack of muscle strength [6]. Other scholars have studied the relationship between the knee joint injury caused by Taijiquan through the analysis of the three straight and five Shun boxing theory in the Style Taijiquan and pointed out that understanding and mastering the boxing theory can effectively prevent the knee joint injury caused by Taijiquan [7].

This paper is mainly divided into four parts. The first section expounds the background research of Taijiquan regulating physical and mental health. Section 2 analyzes the characteristics of Taijiquan and the mechanism of knee injury. This paper expounds the characteristics of Taijiquan and the mechanism of knee joint injury. The third section is to establish the image analysis model of joint injury based on computer image analysis algorithm and construction of image analysis model of joint injury based on computer image analysis algorithm. This paper expounds the basis of computer image digitization. The fourth part is the analysis of the experimental results of Taijiquan joint injury based on computer images. The improved result of Robert's edge detection algorithm. This paper presents the research of Taijiquan joint injury based on computer image analysis and processes the corresponding images through computer image algorithm, so as to provide more accurate and intuitive data for the later joint injury analysis.

2. Exercise Characteristics of Taijiquan and Mechanism of Knee Injury

Knee ligament relaxation will lead to instability of the knee because the ligament is the stable structure of the knee. If there is relaxation, the stable structure of the knee joint will be destroyed. This leads to the instability of the knee joint, when the patient later flexes and stretches the knee joint, or runs, jumps, and squats. It will lead to instability with obvious shaking of the knee joint. After learning and practicing Taijiquan, practitioners need to be able to have a calm mind, relaxed posture, move at a slow and uniform speed, and be flexible, natural, coordinated, and complete in the process of movement, with relaxed and soft movements running through the front and back [8]. The practice principle of Taijiquan also includes the concept of Taijiquan. It pays attention to the combination of yin and Yang, deficiency and reality in the process of exercise. The action form includes unique forms of expression such as up, down, left, and right, inside and outside, advance and retreat. The practitioner should be able to sink Qi into the Dantian and follow his mind. In the process of Taijiquan practice, it is also necessary to understand, master, and apply the theory of three straight and five Shun boxing, that is, the practitioner should keep the head, body, and lower legs straight in the practice process, the head should not be tilted, the body should not swing around, the lower leg knees should not be too bent, and the crotch should be kept straight [9, 10]. Wushun refers to a natural law that conforms to the physiological structure and anatomical requirements of the human body, that is, when practicing Taijiquan, no matter what action should conform to the movement law of the human body, and the movement should be carried out within a reasonable range [11, 12]. However, if beyond this range, internal twisting, kneeling, and other movements will cause certain damage to the body of Taijiquan practitioners.

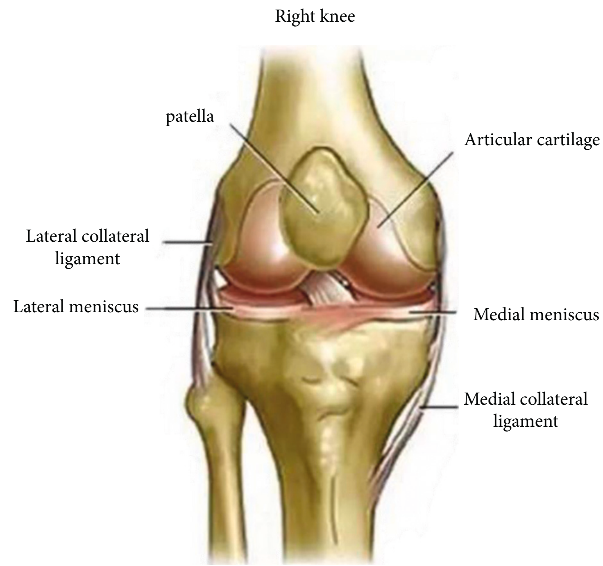


Figure 1: Schematic diagram of right knee joint.

The hinge of human movement is the joint, which can produce activity between two or more bones [13]. In general, this connection can be divided into immovable joints and movable joints with liquid at the joint, but intervertebral joints and knee joints do not belong to these two categories [14]. The knee joint is a double ankle joint, including the lower femur, the upper tibia and the patella. As shown in Figure 1, it is the schematic diagram of the right knee joint. In addition, the knee joint includes a meniscus that can deepen the joint fossa and increase the flexibility and stability of the joint, the tendons of the quadriceps femoris surrounding the front and side of the patella, and the peroneal collateral ligament and tibial collateral ligament on both sides of the joint [15]. The knee joint has two motion axes that can move around the coronal axis and the vertical axis, which can make the knee joint flexion and extension and small internal and external rotation. When practicing Taijiquan, the knee joint relies on these two axes to complete different Taijiquan movements. Due to the characteristics of Taijiquan, the knee joint always maintains a state of flexion during the movement, that is, most of the movement of the knee joint is carried out around the vertical axis [16, 17].

Taijiquan exercise for a long time will lead to the problem of ligament relaxation of the knee joint that has been in the flexion state, so as to reduce its stability. It can only rely on the patella and quadriceps femoris to maintain the required stability, which makes the patella and patellar ligament need to bear a lot of pressing pressure to support the weight of the practitioner's body and complete the corresponding actions, Therefore, patellar strain, patellar ligament injury, and meniscus tear are common injuries in Taijiquan practice [18]. Among them, patellar strain and patellar ligament injury belong to chronic injuries, mainly because the continuous movement of the practitioner under the condition of excessive weight-bearing of the knee joint makes the subtle injuries accumulate repeatedly into injuries [19]. The meniscus tear is caused by the sudden reverse movement of the thigh or the sudden straightening of the knee joint when the knee joint remains in the flexion state and the lower leg is fixed in the abduction and external rotation state [20]. It can be seen that in the process of Taijiquan movement, when the movement is not standardized or does not conform to the law of human movement, it is easy to cause corresponding joint damage. In addition, the weak strength of the lower limbs of the exerciser will cause chronic injury caused by excessive weight-bearing of the knee joint.

3. Construction of Image Analysis Model of Joint Injury Based on Computer Image Analysis Algorithm

3.1. Fundamentals of Computer Image Digitization. With the development of computer technology and the expansion of image application field, computer image analysis technology has developed rapidly and has been widely used in many fields. In biomedicine, the application of computer image analysis technology improves the definition and resolution of images, provides a clearer number of images for doctors and related research, and is conducive to improving the accuracy of corresponding diagnosis and judgment. Before computer image analysis, it is necessary to discretize the continuous image, that is, convert the analog image into digital image through sampling and quantization and set the continuous image as $f(x, y)$. Image digitization is the process of converting analog images with continuous spatial distribution and brightness distribution into digital images that can be processed by computer through sampling and quantization. To process images in the computer, we must first convert the real images (photos, pictorials, books, drawings) into the display and storage format that the computer can accept through digitization and then use the computer for analysis and processing. The process of image digitization is mainly divided into three steps: sampling, quantization, and coding. After digital processing, the matrix $g(i, j)$ can be obtained, which is composed of discrete quantities, as shown in the following formula:

$$g(i,j) = \begin{bmatrix} f(0,0) & f(0,1) & \dots & f(0,n-1) \\ f(1,0) & f(1,1) & \dots & f(1,n-1) \\ \dots & \dots & & \dots \\ f(m-1,0) & f(m-1,1) & \dots & f(m-1,n-1) \end{bmatrix}, \quad (1)$$

where $g(i, j)$ represents the luminance value of each element and $0 \leq g(i, j) < \infty$.

During image sampling, if the number of horizontal pixels is M and the number of vertical pixels is N, the size of the image can be expressed as $M \times N$. The selection of sampling interval has an impact on the image quality after sampling. The smaller the sampling interval, the more details will be reflected. According to the correlation theorem, if the one-dimensional signal is expressed as $g(t)$, its maximum frequency is expressed as ω, and the sampling interval is selected as $T \leq 1/2\omega$, $g(t)$ can be completely recovered through the sampling results, as shown in the following formula:

$$g(t) = \sum_{-\infty}^{+\infty} g(iT)s(t - iT). \quad (2)$$

The sampling result is expressed as $g(iT), i = \dots, -1, 0, 1, \dots$, $s(t)$ as shown in the following formula:

$$s(t) = \frac{\sin(2\pi\omega t)}{2\omega t}. \quad (3)$$

Although the sampled analog image is a discrete pixel in time and space, its pixel value is still a continuous quantity, and the process of transforming the gray value of each pixel into a discrete quantity is the quantization of image gray. Sampling points and quantization stages of each pixel in the quantization process have an impact on the quality of digital image and the amount of data. Image sampling is to divide a spatially continuous analog image into a network of m × n, which is called the spatial resolution of the image. According to Shannon sampling theorem, as long as the sampling frequency is greater than twice the maximum frequency of signal sampling, the original signal can be completely restored by the sampling signal. In addition, in biomedical applications, the image edge in the basic image features has a certain impact on image processing and image digitization. It exists in the boundary between the required targets, between the target and the background, and between the primitives, which can reflect the actual content of the required targets. However, the traditional image edge detection algorithm in practical application will be affected by the uneven illumination and noise of the edge part, and the accuracy of determining the image edge position is poor. In this way, it will cause some analysis errors when analyzing the joint image. Therefore, the improved Robert edge detection algorithm is selected as the computer image analysis algorithm in this paper.

3.2. Edge Detection Algorithm Based on Robert and Its Improvement. In the traditional Robert edge detection algorithm, the gradient is replaced by the difference between two adjacent pixels in the diagonal direction. The gradient is calculated as shown in the following formulas:

$$f_x = f(i, j) - f(i + 1, j + 1), \quad (4)$$

$$f_y = f(i, j + 1) - f(i + 1, j), \quad (5)$$

where the convolution operator of gradient is shown as

$$f_x: \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, f_y: \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}. \quad (6)$$

The gradient amplitude is calculated as shown in the following formula:

$$R(i, j) = \sqrt{f_x^2 + f_y^2}. \quad (7)$$

Or its approximation is shown in the following formula:

$$R(i, j) = |f_x| + |f_y|. \quad (8)$$

From the above formula, it can be obtained that the approximate value of the continuous gradient amplitude displayed by the Robert operator at the difference point $(i + 1/2, j + 1/2)$ is $R(i, j)$. If the selected threshold is expressed as τ and when $R(i, j) > \tau$, the point (i, j) is the edge point.

From the above process, it can be seen that the traditional Robert algorithm mainly relies on diagonal adjacent pixels in gradient detection and ignores horizontal and vertical adjacent pixels, so it is highly sensitive to noise. At the same time although detailed edges can be obtained through the traditional Robert algorithm, when the noise interference cannot be eliminated, it will also lose the detection of the local edges with slow gray value change, resulting in the discontinuous state of the contour edge of the target. The threshold setting of the traditional Robert algorithm needs to be set manually, and the threshold setting cannot be determined by the image feature information, so it has a low degree of automation. In addition, in some special needs scenarios, the traditional Robert algorithm still cannot meet the needs, so the traditional Robert algorithm needs to be improved accordingly.

In view of the problems existing in the gradient amplitude calculation of the traditional Robert algorithm, this paper determines the pixel gradient amplitude through the first-order partial derivative finite difference of the pixel horizontal, vertical, 135 degrees, and 45 degrees and adds the corresponding weights to the 135 degrees and 45 degrees. It can meet the requirements of edge positioning accuracy and noise reduction at the same time. The calculation method is shown in the following formulas:

$$P_0[i, j] = I[i-1, j] - I[i+1, j], \quad (9)$$

$$P_{90}[i, j] = I[i, j-1] - I[i, j+1], \quad (10)$$

$$P_{135}[i, j] = 2 \times (I[i-1, j-1] - I[i+1, j+1]), \quad (11)$$

$$P_{45}[i, j] = 2 \times (I[i+1, j-1] - I[i-1, j+1]). \quad (12)$$

The corresponding convolution operator is shown in the following formula:

$$P_0: \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & -1 \\ 0 & 0 & 0 \end{bmatrix}, P_{90}: \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & -1 & 0 \end{bmatrix}, P_{135}: \begin{bmatrix} 2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -2 \end{bmatrix}, P_{45}: \begin{bmatrix} 0 & 0 & 2 \\ 0 & 0 & 0 \\ -2 & 0 & 0 \end{bmatrix}. \quad (13)$$

The gradient amplitude and direction in rectangular coordinates are transformed into polar coordinates through second-order norm. The calculation method is shown in the following formula:

$$M(i, j) = \sqrt{P_0^2[i, j] + P_{90}^2[i, j] + P_{135}^2[i, j] + P_{45}^2[i, j]}, \quad (14)$$

Put the formula (14) as simplified formula:

$$M(i, j) = |P_0[i, j]| + |P_{90}[i, j]| + |P_{135}[i, j]| + |P_{45}[i, j]|. \quad (15)$$

By applying the idea of neighborhood average gray level, the improved Robert algorithm can automatically generate the threshold and automatically calculate the threshold of the point to be detected, as shown in the following formula:

$$x = \frac{1}{9} \times \sum_{i=0}^{2} \sum_{j=0}^{2} I(i, j). \quad (16)$$

In edge detection, if the threshold setting is fixed, it is easy to produce false edges when the threshold setting is too small; if the threshold is set low, it is easy to make the edge discontinuous. Therefore, this paper automatically calculates the threshold through formula as follows:

$$g(x) = \begin{cases} -0.009549x^2 + 30, & 0 \le x \le 48, \\ -0.000641x^2 + 0.162794x + 1.662554, & 48 < x \le 206, \\ -0.017493x^2 + 8.921283x - 1087.463557, & 206 < x \le 255. \end{cases} \quad (17)$$

4. Analysis of Experimental Results of Joint Injury Caused by Taijiquan Based on Computer Image

4.1. Improved Results of Edge Detection Algorithm Based on Robert. As shown in Figure 2, the complexity of Robert's edge detection algorithm before and after improvement is compared. When performing edge detection and thinning on different images, the distribution of edge points is different. From the results in the figure, it can be seen that before Robert's edge detection algorithm is improved, the number of operations in the best case is six and the number of operations in the worst case is eleven. The operation times of the improved Robert's edge detection algorithm are maintained at three times in both the best and worst conditions. The multiplication times of the improved Robert's edge detection algorithm are four in the best situation and eight in the worst situation, while the multiplication times of the improved Robert's edge detection algorithm are zero. It can be seen that the complexity of the multiplication operation times after the improvement is much lower than that before the improvement, has good stability, and does not affect the operation results of the original algorithm while ensuring the improvement of operation efficiency.

As shown in Figure 3, the effect of Robert's edge detection algorithm on the thinning of knee joint image before and after improvement is compared. It can be seen from the

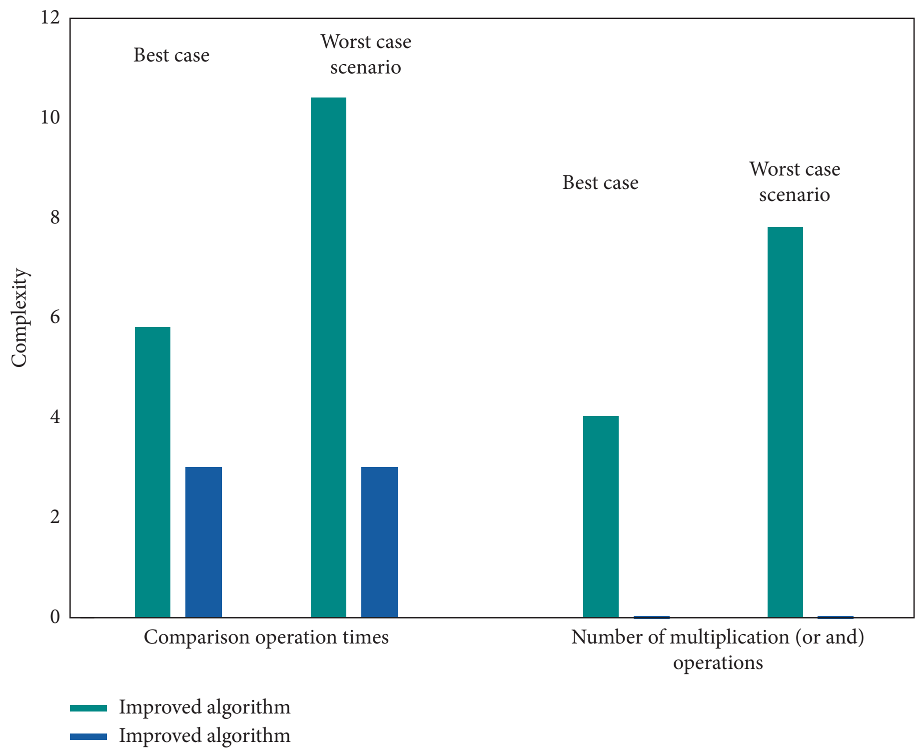
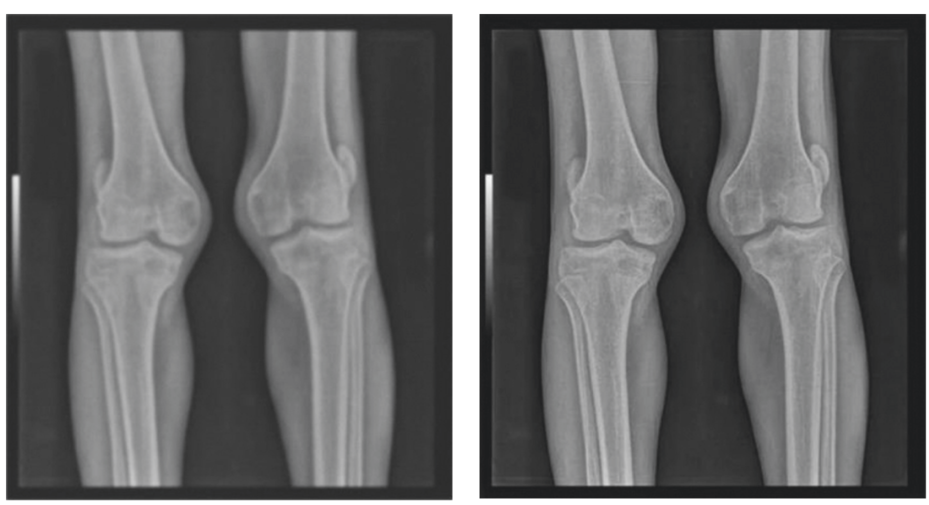


Figure 2: Comparison results of the complexity of Robert's edge detection algorithm before and after improvement.



(a) (b)

Figure 3: Comparison of the effect of Robert's edge detection algorithm on the thinning of knee joint image before and after improvement. (a) Traditional Robert's edge detection algorithm. (b) Improved Robert's edge detection algorithm.

figure that the improved Robert's edge detection algorithm can reduce the impact of noise, refine better, detect weak edges, and show more details. Therefore, the improved Robert's edge detection algorithm has better performance.

4.2. Analysis of Experimental Results of Joint Injury Caused by Taijiquan. The experimental object of this paper is a 48-year-old female. The practice time of Taijiquan is 14 years. According to the action characteristics of Taijiquan, the experimental action is divided into three stages, that is, moving forward is the first stage, sitting back is the second stage, and turning feet is the third stage. As shown in Figure 4, the comparison of the average time test results of the time spent in different stages by the subjects' high and low correct actions and wrong actions is shown. It can be seen from the data in the figure that the time for correct action is significantly shorter, whether it is the time spent in different stages or the total time spent in an action cycle. From the time spent in different stages, compared with the

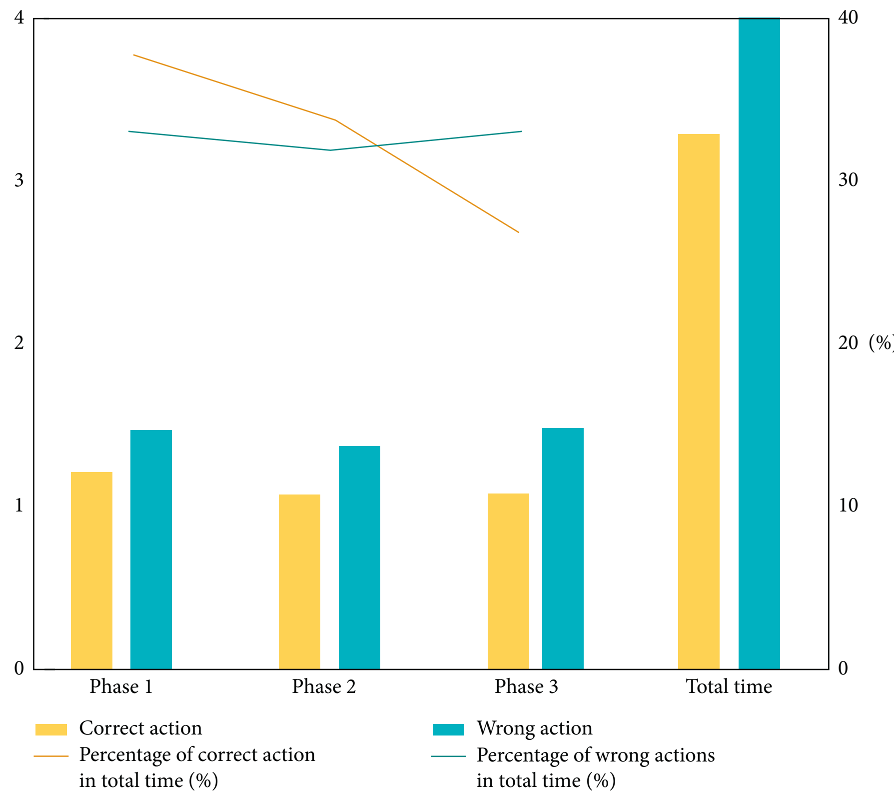


Figure 4: Comparison of the test results of the average time taken by the subjects in different stages of high and low correct action and wrong action.

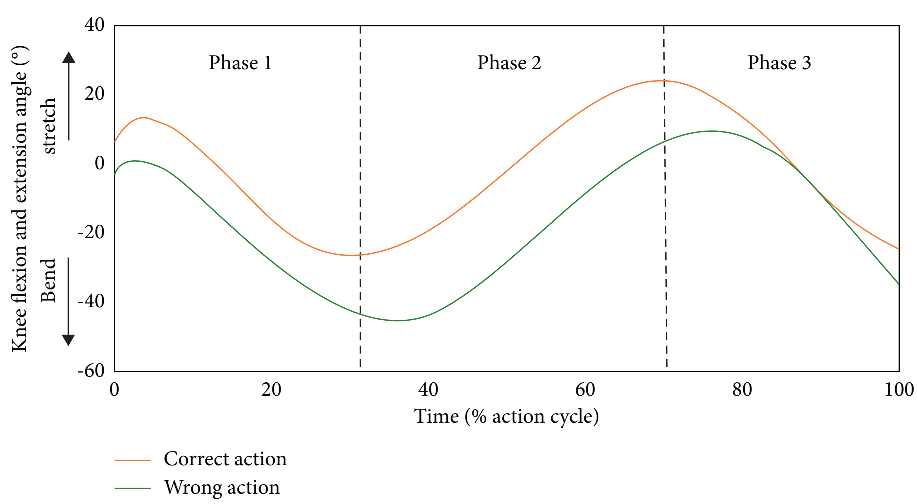


Figure 5: Comparison of flexion and extension angle of right knee joint in high position between correct action and wrong action.

time spent in different stages of wrong actions, the percentage of time spent in the first stage and the second stage in the total time is higher than that in the wrong stage. This shows that the correct action takes more time to move forward and sit back, while the time for turning the foot is shorter, while the wrong action takes less time in the first two stages and takes longer in the turning stage. From the comparative analysis of movements, it is found that the wrong movement moves the right knee farther forward in the first stage, which lengthens the displacement distance of turning the center of gravity from the right to the left in the second stage, so that the time of the first two stages is long. At the same time, the wrong action has excessive torsion of the right foot in the third stage, which prolongs the time of the third stage.

When practicing Taijiquan, the knee joint angle in the high position is maintained in the range of 110 degrees to 130 degrees, as shown in Figure 5. It is the comparison result of the flexion and extension angle of the right knee joint in the correct and wrong movements of the practitioner. As can be

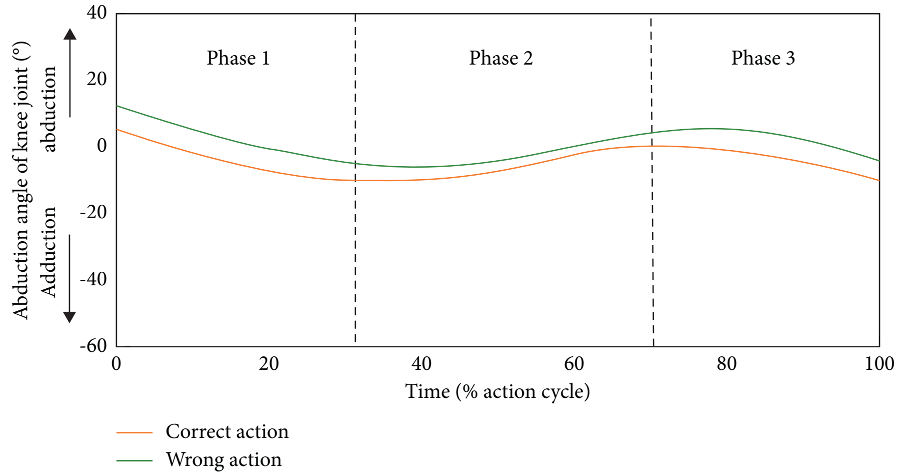


FIGURE 6: Comparison of adduction and abduction angle of right knee joint in high position between correct and wrong movements.

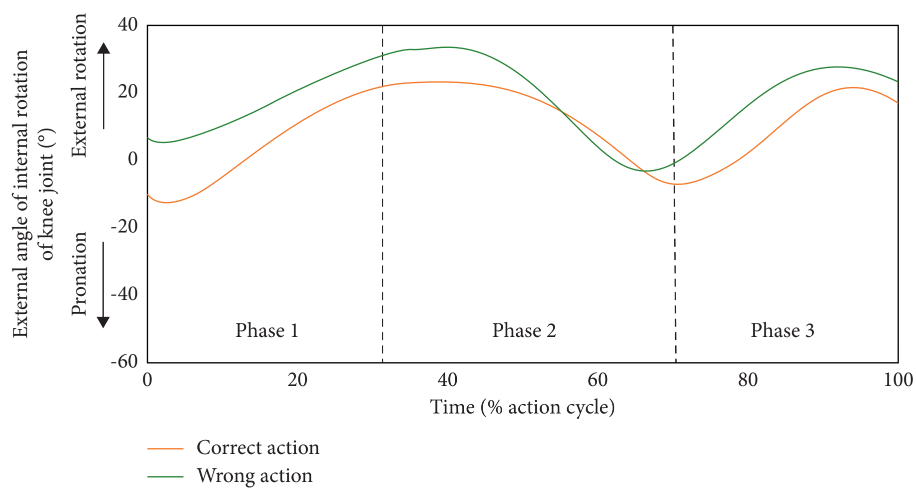


FIGURE 7: Comparison of the external angle of internal rotation of the right knee joint in the high position between the correct movement and the wrong movement of the practitioner.

seen from the figure, the knee joint will produce sagittal flexion in the first stage. When the right foot lands, the knee joint in the correct action is in the state of bending the knee, while the knee joint in the wrong action is in the state of extending the knee. And the difference of knee flexion angle between the two action states will gradually increase with time and action, so that the difference of flexion and extension angle between correct action and wrong action reaches the maximum in the second stage. The normal range of motion of the knee is 135 degrees flexion, 0 degrees extension, and 10 degrees overextension. If the patient's overextension is obvious, knee reflex may occur. Active knee flexion and passive knee flexion can reach 135 degrees and 160 degrees, respectively. At this time, the knee joint in the correct action is in the normal range of motion of the knee joint, and the force borne by the surrounding ligament tissue is small, so it is not easy to cause damage. The knee joint in the wrong action has a large extension angle at this time, and there is a certain degree of overextension. Please exert great pressure on the ligament tissue and posterior muscles on both sides of the knee joint, which is easy to cause injury. In the first two stages, there are obvious differences in action angle and action cycle between correct action and wrong action, but there is no significant difference between them in the stage of turning feet.

As shown in Figure 6, it is the comparison result of the adduction and abduction angle of the right knee joint in the high position in the correct action and wrong action of the practitioner. When human knee joint produces flexion angle, its coronal plane will have a certain angle of adduction and abduction. It can be seen from the figure that in the forward stage, the adduction angle of the wrong action is always less than that of the correct action, and it always maintains a certain abduction angle in the recoil stage, while the adduction and abduction angle of the correct action is about zero. Therefore, the abduction angle maintained by the wrong action not only increases the tension borne by the knee ligament but also improves the probability of knee injury.

As shown in Figure 7, it is the comparison result of the internal rotation external angle of the right knee joint in the high position in the correct action and wrong action of the practitioner. It can be seen from the figure that there is no obvious difference between the correct action and the wrong action in the recoil stage, but in the first stage, the external rotation angle of the wrong action is greater than that of the correct action, which increases the pressure on the medial ligament of the knee joint of Taijiquan practitioners, thus improving the probability of knee joint damage. At the same time, the wrong angle makes the toe abduction angle too large in the process of turning the foot, which has an obvious gap between the correct actions. Excessive external rotation will produce too much pressure on the knee joint, so as to reduce the balance of the practitioner, which is easy to cause knee sprain and so on.

To sum up, whether in the action cycle time or the time used in different stages of the wrong action, the wrong action increases the action time due to the increase of knee displacement, and there is the problem of excessive rotation of the right foot. In the high position movement, the knee joint with correct action is always in the flexion state, which is in line with the law of human movement. However, there are obvious differences between the flexion and extension, adduction and abduction, external rotation angle, and correct action of the knee joint with wrong action, which increases the probability of knee joint damage.

5. Conclusion

This paper presents the research of Taijiquan joint injury based on computer image analysis and processes the knee joint image based on the improved Robert edge detection algorithm, which provides a clearer image basis for future research and analysis. In the action cycle, the time of wrong action is longer than that of correct action, and it is too long in the foot turning stage. This is mainly due to the increase of displacement distance caused by action error. At the same time, the increase of displacement distance will also produce excessive pressure on the knee joint and ligament tissue. In addition, there are obvious differences between the wrong action and the correct action in adduction, abduction and pronation, which makes the high position of the knee joint too inconsistent with the law of human movement, and it is easy to cause damage by bearing greater pressure or tension on the knee joint, medial muscles, and ligaments. To sum up, whether in the action cycle time or the time used in different stages of the wrong action, the wrong action will increase the action time due to the increase of knee displacement, and there is the problem of excessive rotation of the right foot. In high-level movement, the knee joint with correct action is always in a flexion state, which conforms to the law of human motion. However, there are obvious differences between knee flexion and extension, adduction and abduction, external rotation angle and correct and wrong movements, which increases the probability of knee injury.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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Research Article

EM Algorithm-Based Enterprise Digital Transformation: Green Innovation Efficiency of Enterprise Investment

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The digital transformation of manufacturing industry refers to the integration and application of the new generation of information technology in the field of manufacturing in the context of the current digital economy development. Architecture is the foundation of the real economy, which is closely related to digital chemistry and industrial digitalization. On the one hand, high-tech manufacturing of digital information products such as terminal equipment, smart equipment, electronic components, and integrated circuits is the material basis of digital chemical industry. It is a product of traditional manufacturing, blockchain, and artificial intelligence. On the other hand, digital technologies such as simulation technology are the core of the development of manufacturing, the key to achieving precise market positioning, expanding product functions, and improving product quality and added value. Digital technology is an intellectual industry. From the perspective of investment returns, the investment behavior of enterprises is manifested as effective investment and invalid investment. If the capital cost during the investment process is lower than the company's income, the company will not increase the investment amount for any reason, so it will not receive enough investment. Due to the low threshold of investment income, investment growth exceeding a certain threshold will actually reduce investment income and lead to excessive investment. In this context, this article studies the digital transformation of corporate enterprises based on algorithms: green innovation in investment efficiency organizations. This article deeply studies the status quo and the advantages of green innovation investment in digital technology and puts forward corresponding suggestions.

1. Introduction

With the development of the modern organization system, corporate governance is an important factor affecting enterprise investment performance. The level of company governance is an inevitable issue in the background of the company's financial disputes, and it is also one of the core issues of the majority of scholars' research [1]. The foundation of the company's governance is that there are appropriate mechanisms, regulatory, and supervision of the company's system, so that the management level can fully fulfill its decentralized duties and handle matters of relevant institutions and institutions. Therefore, the level of company governance affects investment policies and investment management efficiency [2]. This article summarizes factors such as the company's equity structure, board management, and equity incentives. In the context of my country's industrial transformation and company's financial constraints, the impact of research on the impact of company governance on important industries in strategic industries has certain theoretical value and practical significance.

My country's modern enterprise system is established late, and most enterprises have low investment returns and low resource allocation efficiency [3]. The level of corporate governance is important to the effectiveness of the company's investment. Many thinkers also examined the impact of corporate governance on the company's investment performance from the aspects of decision-making, directors' decision-making ability, fair nature, and decentralization of power [4]. This article analyzes the relationship between corporate governance structure, financial constraints, and company investment performance from the perspective of corporate orientation. Combined with the characteristics of China's emerging strategic company and the capital market, it reveals the connection between corporate governance structure, financial constraints, and company investment performance. In addition, the theory has also derived the role of the theory in solving the strategic issues of emerging industries and restricting the financing channels of SMEs. The efficiency of corporate governance, fiscal constraints, and strategic and emerging departments has improved [5].

Strategic emerging industries are an important support for promoting my country's social and economic development, and it is also an important support for maintaining national technological security. On the basis of empirical analysis, you can understand the insufficient investment in my country's emerging and forward-looking strategic industries [6]. The improvement of the company's governance, the significant improvement of the company's investment efficiency, and the impact of financial constraints on decentralized management can promote the improvement of the company's investment decision-making and management. However, fiscal tightening can directly improve the company's investment efficiency without having to bear risk. This is also very good. Directly restrict the company's over-investment. The conclusion of this article reflects the current situation of the investment benefits of strategic industries and emerging industries. In response to the status quo of my country's capital market, suggestions to improve corporate governance, reduce financial constraints, and improve the investment efficiency of emerging strategic industries have certain practical value.

2. Research Background

With the end of the planned economy and the continuous advancement of reform and opening up, the development of Chinese enterprises is in full swing. Entrepreneurs have found that with the continuous expansion of the scale and number of enterprises, the traditional family management model can no longer meet the needs of enterprise development, and human resources managers have become the best choice for entrepreneurs [7]. However, if the enterprise develops to a certain degree, its owner will not be able to effectively and comprehensively control the decision-making of the senior managers they hired. In particular, the employed managers are directly related to the production and operation of the enterprise. They know more about the business and financial conditions of the enterprise than the business owner, which will lead to information asymmetry. The owner and the manager have their own interests [8]. The conflict of interest has led to serious factors. Therefore, it is an opportunity to introduce corporate governance theory to the organizational management of my country. There are many elements of company governance. Domestic and foreign scholars have different evaluations and definitions of corporate governance. Corporate governance is a means to protect the interests of shareholders. The starting point and goal of the company's governance are the basic elements of the company's governance [9]. In addition, the owner and creditors should be considered the form and method of raising funds for the company to ensure that the actual directors and their interests can be merged. Ensure that commercial decisions take into account the company's maximum interests, and ensure that operators will not invest in low-efficiency resources for the company's interests without pursuing their own interests [10]. Poor limbs believe that the code of behavior of economic organization operators, owners, and directors is an integral part of corporate governance and has different evaluation methods and evaluation standards. Corporate governance is usually called internal management. The basic elements of corporate governance are equity structure, board relationship, and company incentives. Enterprise digital growth trend is shown in Figure 1.

3. Materials and Methods

3.1. Basic Theory

3.1.1. Digital Transformation of Enterprises. The digital economy is based on the data economy. As an important part of the information industry, data will run through the entire process of the information industry and generate information and services from different countries. The digital process is the process of storing and developing data through the new generation of information technology. The digital economy is the new economy form of digital knowledge and information as new production activities, digital technology tools, and information networks [11]. The digital process is shown in Figure 2.

According to data from the National Bureau of Statistics, the digital economy is characterized by the digital economy. The first four elements are digital manufacturing, service industry, technical conditions, and latest trends [12]. The digital industry is the best digital activity. It is the index income from traditional industries. It is the best production and operation and coordinated development of traditional industries.

The transformation of digital products provides opportunities for the transformation and application of the new generation of information technology in the digital economy. The manufacturing industry in the real economy is digital [13]. On the one hand, manufacturing technology is better than digital-related products such as terminal equipment, smart equipment, electronic components, and interconnection, and supports data from the digital industry. On the other hand, traditional equipment uses digital technology, such as chain blocks, design information, simulation technology, production activities, market access, increasing production activities, and improving product quality and cost. Other digital production methods show that the production and design of these two fields have changed in the digital field.

The industrial structure refers to the interconnection and interaction between production factors under certain socioeconomic conditions and resource conditions, the continuous changes of the industrial level, and the continuous evolution of the industry. It changed production activities, and eventually Western scientists developed the theory of industrial structure through research on

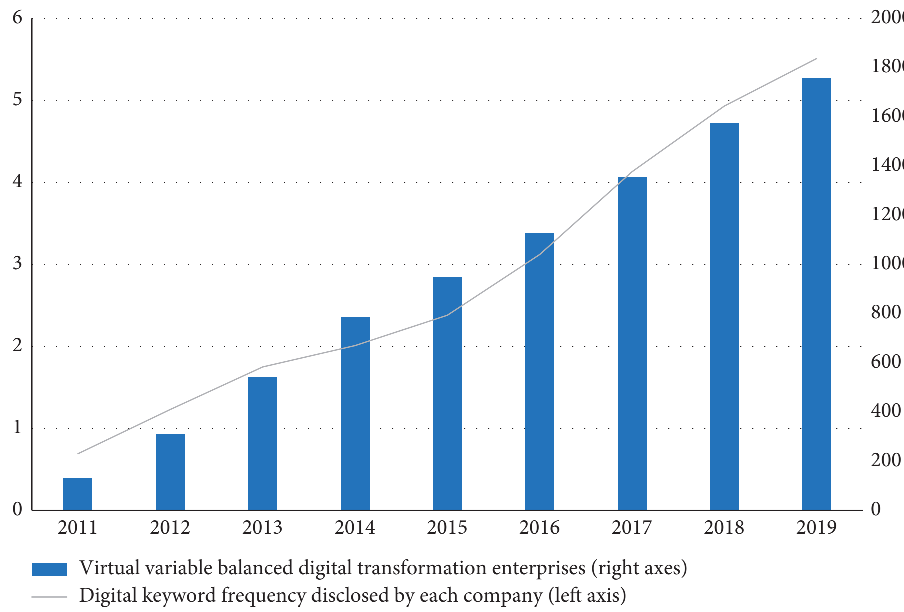

Figure 1: Enterprise digital growth trend.

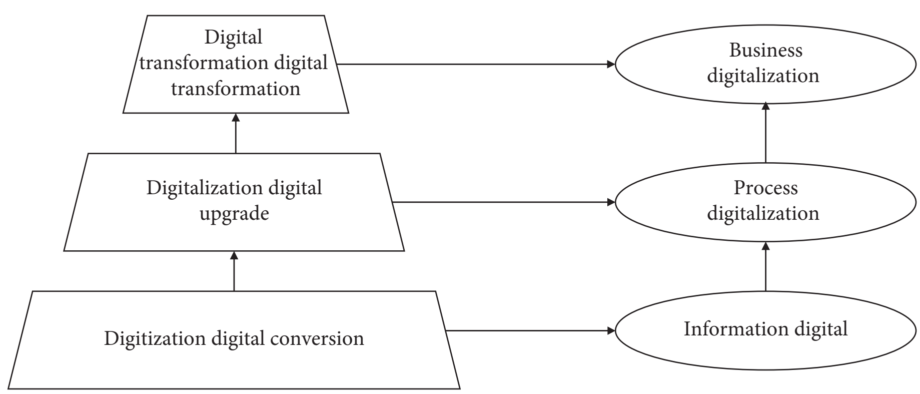

Figure 2: Digitalization process.

developing countries. British scientist Clark pointed out that with the improvement of productivity, income attracts people into the second industry at a price higher than any capital [14]. With the increase of per capita income, the level of departmental population is also changing. On this basis, the emperors of all ages have gradually formed three major industrial development rules. German scientist Hofman designed industrial development and divided it into different stages. In the first stage of the automotive industry, when the car started to change, the company was still the first. The light industry has led to the growth of the middle manufacturing industry on the basis of the gradual development of enterprises. At the end of the industrial stage, the significant return of technological progress and industrial structure is the most important factor. In technological expansion, American scientists have called for a large industry through learning and innovation, scientific data collection, human capital collection and innovation, and developing ideas on the basis of the theory of invalid economic growth [15]. In the future, the technology and service industry will dominate. In the process of industrialization, a higher legal structure has been established from bottom to top. There are many sources of industrial technology. With the rise of the intellectual industry, many industries attach importance to the industry to become higher and higher. Yeah, I know. Compared with Western industrialized countries, my country is an industrialized country, and the concentration of investment and technology is unpleasant. The development of advanced technologies is affected by the technology of foreign monopoly enterprises in the global value chain for a long time. Based on the theory of industrial structure and digital growth, the digital industry transformation, digital industry production services, and digital industry development have been accelerated. Change the success of the industry, revitalize the economy, and expand the market boundary.

3.1.2. Enterprise Investment Efficiency. Investment is an economic activity. In order to increase the added value, people engaged in economic activities invested a certain amount of money or natural income. From the perspective of investment returns, the company's investment behavior has two consequences. One is effective investment, and the other is inefficient investment. If the investment cost is lower than the company's income, the company will not increase investment for any reason, resulting in insufficient investment. As the marginal income of investment will decrease when exceeding a certain limit, investment growth will actually reduce returns, resulting in too much investment [16].

Each company has different characteristics, different business environments, and different investment opportunities in different industries, different market environments, and different companies. Therefore, comprehensive coverage and investment positioning are the test of operators' management level. On the other hand, the investor's investment can also be determined by its own interests. Therefore, investment efficiency also reflects the management level of entrepreneurs [17]. The constraints of investment efficiency are shown in Figure 3.

In the modern organization system, the company has independent rights. In addition, the control of shareholders is consistent with the right to cash flow. The major shareholders can take action for their own interests to harm the interests of other small shareholders. The interests of a small number of shareholders have been ignored by most shareholders and are "improper." A research team at the University of Cambridge confirmed the direct connection between corporate governance and company investment performance. If the company does not run well, the business value will be low [18]. The participation of foreign institutions can improve the corporate governance level of foreign institutions. It can supervise the governance of the company and restrict the self-discipline of major shareholders to a certain extent. If the shareholders' shares increase, the interests of shareholders should be consistent with the interests of the company. An empirical study of a research institution in Ukraine's governance and investment efficiency of the company shows that the expansion of the board of directors can improve the transparency of the company's information and reduce the asymmetric supply and demand in the company's financing process [19]. To a certain extent, reducing the sensitivity of financial constraints and operating cash flow can enable enterprises to make reasonable investment decisions and improve investment efficiency. In the study of the performance of corporate governance and investment organization, a Russian research institution pointed out that the type of stock is an important factor affecting the company's investment performance [20]. The higher the concentration of state-owned enterprises, the lower the investment efficiency. When a company tries to improve investment efficiency, it can effectively use incentive measures to maintain the management of management and business goals. Remuneration incentive combines management advantages with corporate performance, reducing inefficient investment driven by personal interests. This study found that increasing the number of managers can reduce bank risks.

Internal scholars have also studied stock management to strengthen the company's system, prevent shareholders' monopoly, prevent the interests of major shareholders from being affected by the interests of small shareholders, and promote mutual supervision between shareholders. Organize investment decisions to improve the company's investment efficiency. Some scholars emphasize the efficiency of enterprise investment and believe that different corporate property rights relations and the interaction between enterprises and the government have exacerbated the political background of high-level corruption and led to low investment efficiency. Researchers at the University of Science and Technology of China have found that due to their unbalanced ownership, the investment efficiency of state-owned enterprises is lower than nongovernmental organizations. This is because state-owned enterprises have obtained the government's financial approval, and financial institutions have poor supervision. Low financing costs mainly lead to excessive investment. China Electric Power Securities found that the participation of institutional investors can reduce the invalid investment behavior of the enterprise. Investment projects of institutional investors are usually relatively stable income projects, which determines the frequency of institutional investors' excessive investment. In addition, institutional investor groups can provide scientific basis for corporate investment decisions.

If the company's system arrangement can reduce the cost of information symmetry, investment efficiency will be improved. Many scholars believe that the higher the level of the company's governance, the more complete the structure, the higher the resource allocation and investment efficiency.

3.2. EM Algorithm Research Method. The unknown parameter of the life density distribution function was calculated using the parameter estimation method. The decomposition data of some long-term product samples often reach the threshold and often lose, which makes it difficult to estimate the model parameter. The EM algorithm is a correct way to maximize experiments by a group of external researchers. The EM algorithm can calculate the maximum possible potential distribution parameter based on limited lack of observation data. Studies have shown that the management of management on the controlling shareholders has decreased, and the proportion of controlling shareholders has increased. The ability to control major shareholders must be affected by the decision-making power of organizational management. Rights are violated, and decision-making is often influenced by major shareholders. The positive and effective decision-making based on the overall interests of the enterprise makes it difficult to achieve the institutional investment at the investment level.. Many thinkers in this country also come to different conclusions of different industries. Some researchers believe that a certain equity concentration has a positive effect on reducing invalid investment.

Set (Ω, ζ, P) a conceptual space that x involves the collection of all walking variables in the space. Risk

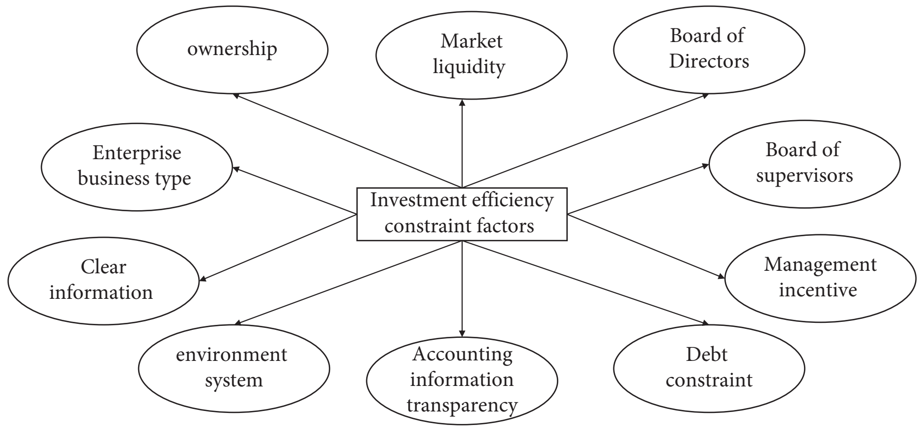

Figure 3: The constraints of investment efficiency.

measurement is ρ a mapping of x a x_ρ subset to R real number, which is recorded as ρ: $X \in x_\rho \leftrightarrow \rho(X) \in R$.

First g defines the g: $[0,1] \longrightarrow [0,1]$ function called the distortionFunction. $g(0) = 0, g(1) = 1$.

Secondly define risk measurement: often ρ_g: $x \longrightarrow R$ referred to as distortion risk measurement, if it $\rho_g(X)$ is satisfied.

$$\rho_g(X) := \int_{-\infty}^{0} \lg(S_X(x)) - 1)dx + \int_{0}^{\infty} g(S_X(x)))dx, X \in x. \quad (1)$$

This g is a distorted $S_X(x) = P(X \succ x)$ function, X which is distributed.

Suppose X is the total risk faced by the f: $[0,\infty) \longrightarrow [0,\infty)$ insurer, and it is $f(X)$ the division function, which represents the insurer to transfer some of the risks they face to the re-insured. The insurer collects insurance costs from the insurer because of the risk of the insurer to supplement the risks they bear. This article assumes that the re-insurance cost standards have the following form:

$$\mu_r(f(X)) = \int_{0}^{\infty} r\left(S_{f(x)}(x)\right)dx. \quad (2)$$

Among $S_{f(x)}$, $f(X)$ is the tail distribution r: $[0,\infty) \longrightarrow [0,\infty)$ is a monotonous nonreduction $r(0) = 0$ function. Without losing generality, we assume r that it is not a function that is almost zero everywhere. The total risk of an insurer is to face the surplus risk we will face and the cost of transfer risk. It can be expressed as

$$T_f(X) = X - f(X) + \mu_r(f(X)). \quad (3)$$

The EM algorithm is composed of E step and M steps. Stepping Em is looking for expectations. Step M will expect to be greatly expected. Two steps are alternated until convergence. The specific steps of the EM algorithm are shown in Figure 4.

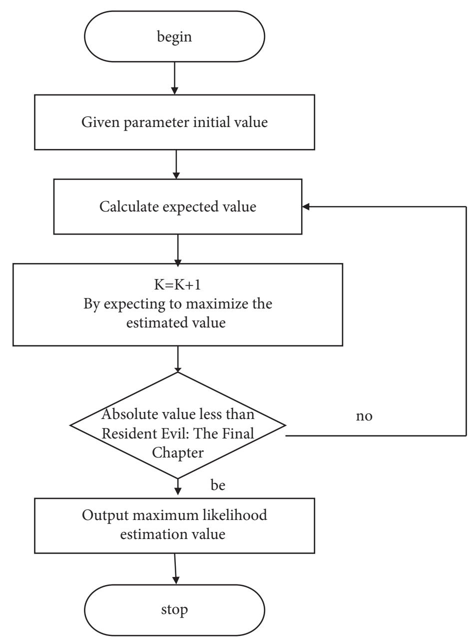

Figure 4: EM algorithm flowchart.

4. Results and Discussions

4.1. Digital Transformation Status Quo. This chapter analyzes the status and challenges of digital transformation of China's manufacturing industry from the perspective of the entire manufacturing and key industries. This article summarizes the main content of modern digital policies in China's manufacturing industry, analyzes related family expenditures, analyzes the problems of family expenditure policies, and tries to analyze the reasons.

4.1.1. Digital Transformation and Difficulties in Chinese Enterprises. In recent years, my country has actively explored and practiced the digital transformation of the manufacturing industry and has gradually made certain progress. From the simple combination of primary production process and the Internet, it is convenient, fast, flexible, mobile, and intelligent, and other technologies achieve new technologies and corporate value chains. From 2013 to 2020, the development level of the national manufacturing and Internet integration is shown in Figure 5.

From the perspective of the entire manufacturing industry, the integration of the construction industry and the Internet is still a good trend. In 2020, the integration rate of the two major industries reached 56, an increase of 20% over 2013, reflecting the continuous attention and promotion of the Chinese government's development of the digital industry. At the same time, production itself has strong digital potential. 2016 is the beginning of the "Thirteenth Five-Year Plan," and the fusion growth of the two major industries has slowed significantly. At the same time, the manufacturing industry will gradually eliminate the decline in energy production, accelerate technological transformation, increase the number of aircraft, and achieve diversified quality. The integration of these two forms has been enhanced to the depth of digital and intelligent. During the production process, the numerical control rate of the core process in 2020 reached 51.1%, an average annual increase of 2.8%; it is expected to reach 71.5%. We will use digital transformation to offset the impact of excess production and return to growth. In the process of digital production, new products, new technologies, and new forms have entered the world, and economic development has entered a new stage. According to the "China Digital Economy Development White Paper" released by the China Information and Communication Research Institute, in 2019, the scale of China's digital industry accounts for 80.9% of the total digital economy and 31.2% of GDP support.

From the perspective of large manufacturing, the focus of digital transformation depends on the location of the production chain, different needs, and different production characteristics. From 2018 to 2020, the digitalization and intelligence of the main indicators of large-scale manufacturing are on the rise. As a traditional high-cost industry, the raw material industries are metallurgy and petrochemical emphasizing the transformation process of digital production. The main process management and digital indicators are significantly higher than the domestic industry, reducing costs and improving efficiency. The raw material industry is at the forefront of the production line. In order to effectively and timely meet the new needs of downstream enterprises, the proportion of enterprises that implement production line coordination are higher than other industries, which has improved the efficiency of intelligent production. Communication equipment, special equipment, etc., mainly meet the needs of other technical equipment industries in the industrial chain. The focus of research and digital applications is related to the status of Chinese manufacturing in the global value chain. Digital research, tool design penetration, and key business links have reached the total number of digitalization, which is much higher than the average level of other industries in the country. The focus is on consumers' demand for food, textiles, and other consumer goods that are closely related to final consumers. The focus is on industrial chain technology, coordinating the value chain, and providing consumers with personalized, diverse products and influential enterprise share. The number of industrial *e*-commerce and value chain is significantly higher than the national average. From 2018 to 2020, the key indicators of digital and intelligent manufacturing industries in manufacturing are shown in Figure 6.

From 2018 to 2020, the key indicators of digitalization and intelligence in the raw material industry are shown in Figure 7.

Therefore there will be a lack of independent innovation technology. In the past, the competitive advantage of China's manufacturing industry came from the rapid development of population growth and traditional labor-intensive manufacturing, but independent innovation and technological investment accumulated insufficient accumulation. Although China's manufacturing industry has made significant progress in digital research and development and application, it has not yet reached a high-level technical management and digital industry. The core components, key technologies, and precision tools of advanced manufacturing technology rely on foreign imports. To accelerate the digital transformation process of China's manufacturing industry, we need to continuously break through traditional key technologies, establish an intelligent manufacturing system, and achieve the localization and innovation of core components as soon as possible.

The coordination between people is becoming more and more complicated, and digital corporate culture needs to be improved. The lack of chips has limited the development of China's industry. Chinese chips are locked because of design, but because of industry. Due to technology and research and development, it is difficult to achieve large-scale production. Compared with chip designers, there are fewer mechanical designers in China's industry. Although the number of college graduates in China has increased year by year, due to the lag in the reform of the educational model to improve the skills and improvement of digital technical talents, talent dividends cannot be fully distributed. Digital transformation and middle managers have also put forward higher requirements for the comprehensive capabilities of processing enterprises. This requires the management process, organizational structure, and culture of the enterprise to convert the soft power of the enterprise into the opportunity of digital transformation. However, many companies have not yet had a concept of digital transformation. Due to the implementation of the law, it failed to transform to digital from top to bottom.

Digital transition costs high, and financing channels must be closed immediately. Manufacturing transition to digitalization is a long-term system engineering. With the implementation of digital transformation and the implementation of corporate modernization, the investment costs of digital assets and the increase in corporate governance investment are huge. However, the efficiency of reducing production costs and increasing organizational efficiency

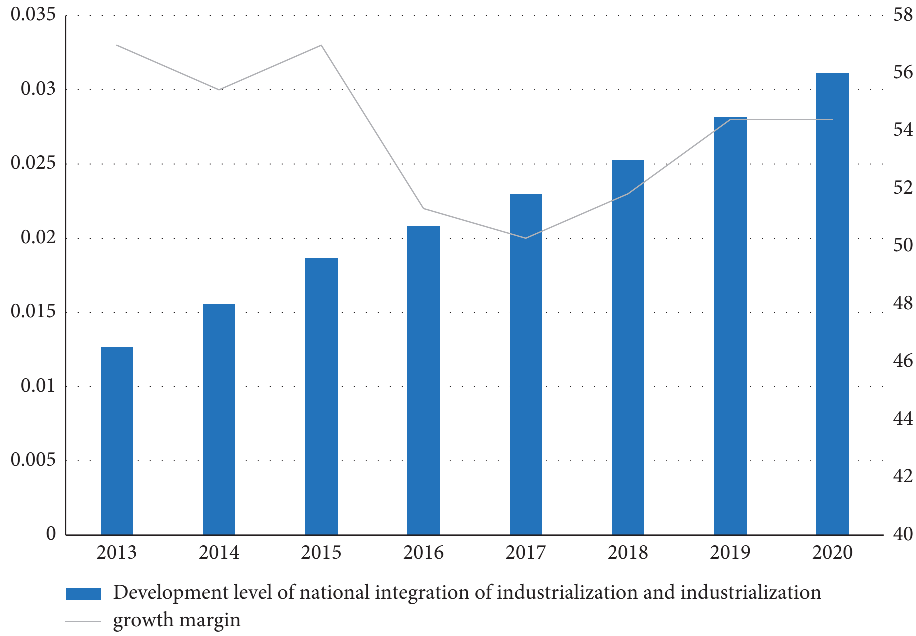

Figure 5: The level of integration and development of the national manufacturing and Internet from 2013 to 2020.

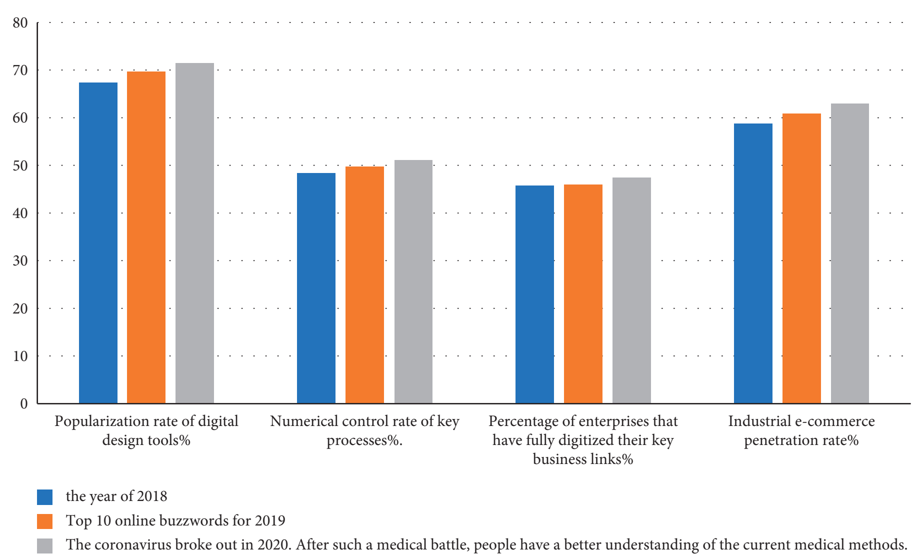

Figure 6: 2018~2020 key-level manufacturing key industry digital and intelligent key indicator level.

cannot be achieved in the short term. In addition, digital transformation companies may follow other digital transformation companies, resulting in imbalances in investment indicators. In the process of digital transformation, traditional manufacturing companies have invested a lot of funds, the transformation effect is slow, and the selection of digital transformation measures is insufficient. Since 2020, my country's manufacturing enterprises have achieved rapid growth in production supply and market structure. Many traditional manufacturing companies are small and personalized business models. The financial chain is determined to be in the short term before digital transformation. Companies would not be able to afford the excessive costs, so digital transformation is not enough. In addition, high external financing thresholds, lack of standards or consistency, and need to better obtain financing, these have brought challenges to manufacturing companies to digital and applications.

4.1.2. Promote the Arrangement of Fiscal Expenditure Policies for Digital Transformation of Manufacturing. From the perspective of government needs, funds to promote the digital transformation of manufacturing in the manufacturing industry are mainly supporting and implementing the national supply system to support innovation. On the one hand, the government encourages the government to acquire third-party digital services, such as cloud

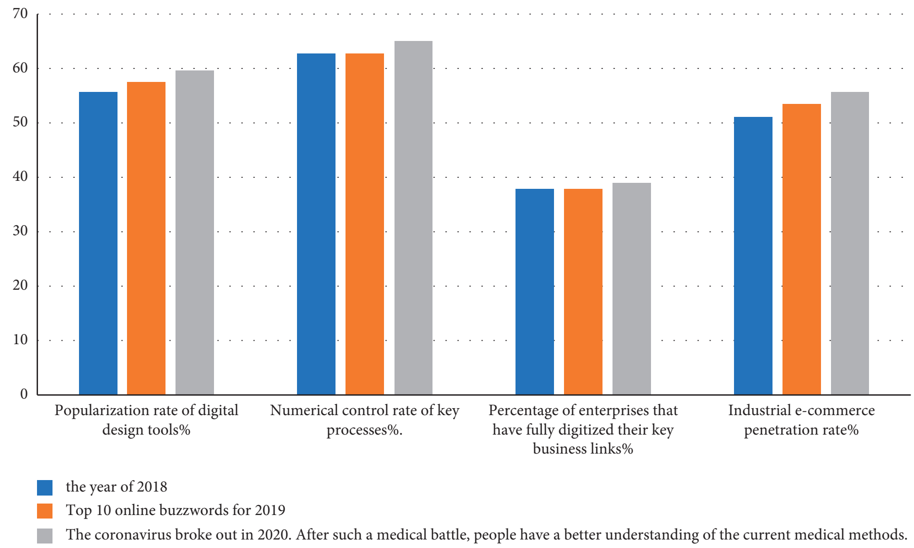

Figure 7: 2018~2020: the raw material industry digital and intelligent key indicator level.

computing and digital associations, and strengthen support for government and enterprises to establish a wider partnership in data collection and innovation alliances, promote the use of industrial software, and enhance the digital technology manufacturers' ability. On the other hand, the purchase of new products for digital production of manufacturing is also a positive signal to the market, which helps the development and is widely used in new products and the digitalization of manufacturing.

From the perspective of organizational needs, financing has promoted the digital transformation of the manufacturing industry, mainly by increasing the company's demand for digital consumer goods. On the one hand, explore sponsorship models such as previous logistics procurement and priority order, establish risk compensation funds, regularly promote the first large-scale process and equipment compensation pilot work, and jointly undertake costs and risks, and digital related to production enterprises. On the other hand, user subsidies, fiscal incentives, and pilot demonstration projects can enhance the digital transformation of manufacturing companies. For example, Yunnan Province has established a special fund to motivate and supplement cloud service providers to enable them to enjoy the advantages of the enterprise and stimulate its "upward cloud."

From the perspective of market demand, China's financial system will use supermarkets and industrial chains to accelerate the production of digital transformation. From the perspective of personal consumption, on the one hand, it is necessary to increase the proportion of residents' life consumption and reduce their motivation for cautious consumption. On the other hand, we must increase the willingness of residents' consumption. On the other hand, we must focus on building new infrastructure, optimize consumer infrastructure, and maintain new consumption. In terms of value chain management, funds are used to stimulate investment, and upstream and downstream companies are established in the 5G + value chain to support digitalization of industrial space, spread new crops, and develop and strengthen the domestic demand system.

From the perspective of talent training, finance supports the development of higher education and vocational education, and helps technical workers to achieve digital production. On the one hand, help universities to establish a practical teaching base, encourage scientific research and production and digital enterprises, promote integration of production, academic, and research, and ensure that digital talent training and service positions. On the other hand, human resource development subsidies are the reasons for the project to attract and implement the project aimed at improving the performance of organizational leaders. For example, Guangdong Province provides high-tech talent training scholarships and digital education funds for elites, entrepreneurs, general managers, and other entrepreneurs. Every year, Jinan City, Shandong Province, will establish a large-scale foundation dedicated to the transformation of new and old engines to create high-level issues for high-end development and invite top entrepreneurs and managers at home and abroad to study, train, and exchange well-known universities and enterprises at home and abroad. Strengthen the collective construction of enterprises.

In the public service department, the Ministry of Finance supports the development of digital transformation of digital infrastructure, digital platforms, and manufacturing. The government is working with professional companies to establish an industrial transformation fund focusing on the Internet, platforms, and security systems to provide external services and promote public exchange between government data and government data sources. Reduce the cost of rebuilding internal and external networks, using industrial assets and construction data centers. For example, Qingdao City, Shandong Province, allocates special funds for Internet industry services each year, builds the Internet industry demonstration platform, summarizes promotion experience and practices, introduces intelligent processing services, forms intelligent production experimental lines, and gives commendation. Heilongjiang Province is building a complete Internet data exchange service platform and a state-owned SME platform, bringing new advantages to digital integration and development.

This chapter analyzes the status and existing problems of the digital industry in my country, analyzes the fiscal policy elements that reflect the supply and demand relationship, analyzes the current situation of taxation, summarizes the problems of fiscal policy, and analyzes the reasons. Financial suggestions are very important for the digital transformation of manufacturing.

4.2. Investment Efficiency Green Innovation Status Quo. In strategic industries and emerging industries, excessive investment and investment coexistence, in most cases, are insufficient. Although financial tightening has a certain impact on excessive investment in management, it may reduce the problems caused by excessive investment transfer and institutional institutions, and it should be clear that most companies in China should encourage the development of the capital market and relax financial restrictions.

China's capital market began in the 1980s, with stable development and huge scale. However, compared with developed countries, the characteristics of my country's capital market are still the role of economic development and capital markets in promoting organizational development and investment. In order to continuously optimize the pyramid structure of the Shanghai Science and Technology Innovation Conference, Shenzhen Board of Directors, and Shenzhen New Board, it is necessary to continuously improve and develop multi-level board mechanisms, strengthen supervision of the registration system, and promote the continuous improvement of the legal system, such as the Chinese capital market.

Information asymmetry is an important reason for restricting corporate financing. Information asymmetric increases financing costs from abroad, making financing more difficult. Some companies violate the information disclosure law and refuse to open this system for their own interests, thereby increasing investors' information costs and investment risks. Information disclosure can reduce information asymmetry. On the one hand, it can help strengthen corporate governance capabilities. On the other hand, the government should also implement an innovative disclosure system.

Strategic industries and emerging industries require preferential policies. The government should continue to provide preferential policies for emerging and promising strategic industries, appropriate government subsidies, tax incentives, and fiscal guarantees for good development prospects. The relationship between the company's governance, institutional environment, financial market, and investment performance is shown in Figure 8.

Companies that lack capital usually show low domestic cash flow. According to the traditional basic element theory, CEOs often control resources, and financial constraints will reduce their attractiveness to celebrities to avoid excessive investment and overwork. The equity transfer caused by equity separation is one of the main reasons for the low investment efficiency. Capital constraints optimize the investment decision-making process and improve investment efficiency. Studies have found that external financial constraint enables enterprises to first consider internal financing, and internal financing is relatively limited. Under capital constraints, the focus of management is to improve capital allocation efficiency and optimize enterprise investment. If a company has a large amount of cash flow, it exacerbates its potential problems, and financial constraints may inhibit its over-investment. Some Chinese scholars have found that capital constraints can inhibit the invalid investment of agents and improve the research investment efficiency of enterprises. Fiscal tightening may dominate over-investment companies, but if there is no investment, it may exacerbate the investment flow of the enterprise. The impact of fiscal tightening on different scale companies is different. Increased cash flow can improve the investment efficiency of small enterprises and enhance the excessive investment tendency of large enterprises. If the company is facing financial constraints, CEO will work hard to reduce the negative impact of financial constraints by improving productivity and management level. Insufficient company funds can help management improve the efficiency of fund use.

Tax restrictions have a negative impact on investment efficiency. Scholars holding the "negative fund constraint theory" believe that external fund constraints will transfer people's attention to organization investment and reduce corporate investment efficiency. The tightening monetary policy leads to fiscal tightening. When innovative investment depends on domestic financing, fiscal tightening is more effective (1,000 dollars) . The higher the financing limit, the higher the company's financing and investment cost. After the investment cost and deducting the present value (NPV), the company will return the investment to the company. The company lacks funds, on the one hand, due to the lack of funds, and on the other hand, it is due to the transfer of factoring agents. Studies have found that under the same capital restrictions, state-owned enterprises are more likely to be capitalized. The scale of organization is also an important factor that affects low efficiency of enterprises. Small companies often invest too little, and large companies often invest too much. Studies have found that the overall investment of cultural and creative industries is insufficient, and the budget constraints have led to insufficient flexibility of corporate financial resources and cannot provide sufficient investment. Promoting innovation requires a lot of funds. If capital constraints cannot make the investment policy achieve the expected effect, companies will not be able to adapt to market conditions in a timely manner.

4.3. Company Governance Level and Investment Efficiency Green Innovation. The level of corporate governance is determined by many factors, and these factors are not necessarily related to investment performance. In fact, the

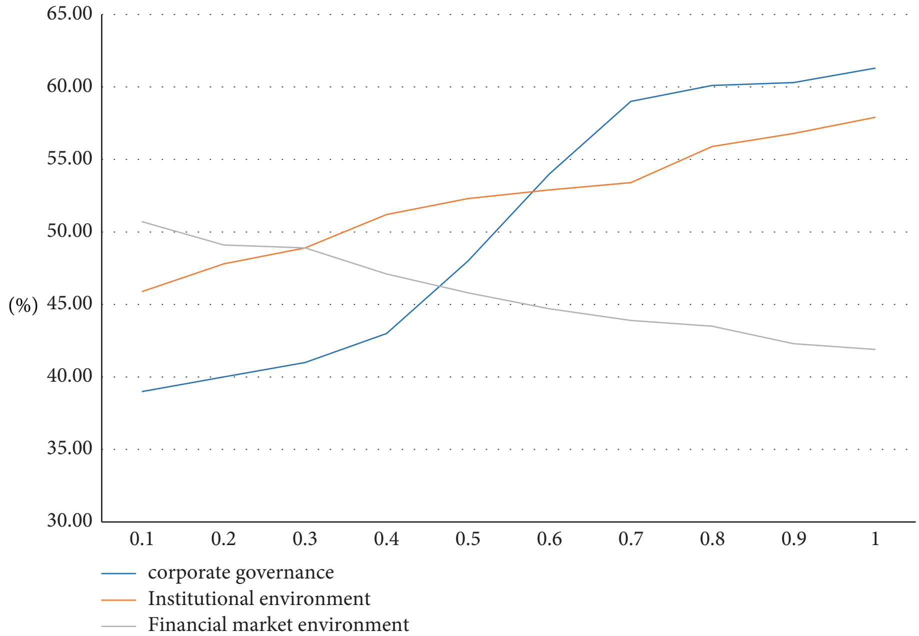

Figure 8: The relationship between company governance, institutional environment, and financial market environment and investment efficiency green innovation.

premise of corporate governance is to maximize the interests of the company through various institutional arrangements to achieve the convergence of owners, managers, and creditors. Investment decision-making is the result of the game between owners, managers, and creditors. A good investment decision can create added value for your company. The main factors of information asymmetry cannot be resolved by regulating the legislation of the system. The negative decisions and moral risks between creditors and companies cannot be resolved through contracts and appropriate supervision. Management is always interested in investment decisions. Many thinkers analyze the different elements and investment performance of the company's governance from different angles, and have achieved considerable results. However, the level of corporate governance depends on the comprehensive impact of various governance factors, and its quality is difficult to measure from a single factor. Therefore, this article discusses the impact of equity structure, board leaders and management incentives, decision-making capabilities, and CEOs on corporate governance, and gives comprehensive indicators reflecting the level of corporate governance. Studies have found that companies with low management level often perform poorly. Improve corporate governance conducive to solving distribution and representative problems, realize the unity of property rights management and goals, avoid management short-sighted behavior, take into account moral risks, rationally allocate corporate resources, improve capital utilization efficiency, and reduce inefficient investment.

The development of China's capital market is not mature. Information asymmetric and imperfect capital markets lead to increased risk of investors and lead to financial tightening. The investment of foreign companies is not only expensive, but also very limited. Financial restrictions usually make the company unable to invest in favorable investment decisions and ensure the greatest return. This restricts the investment capital of the enterprise and highlights the low investment efficiency of my country's high-tech enterprises. Some companies continue to invest too much. In this case, financial constraints can increase the company's investment costs and reduce their investment, but can improve the company's investment efficiency. Financial constraints are important factor in controlling investment. Therefore, it is necessary to study the impact of financial constraints on investment efficiency and distinguish excessive investment and too low investment. Financial constraints and interaction are the main factors affecting the company's investment decisions. Improving the corporate governance structure not only facilitates the transfer of interests between shareholders and investors, but also helps to solve the conflict between shareholders, management, and investors. In the case of low level of corporate governance, investors cannot evaluate the company's real investment goals and can only passively increase returns and capital costs. Fiscal tightening can not only directly affect the company's investment, but also indirectly affect the company's contribution by reducing basic factors. The growth of the company's internal cash flow has led to excessive investment and labor exhaustion in corporate governance, which has exacerbated basic problems and systems. The financial restrictions faced by the company may alleviate the problem of transmission institutions. If some financial restrictions are imposed on regulatory agencies, restrictions on foreign capital markets may force regulatory agencies to improve their operating decisions.

5. Conclusion

Digital transformation of manufacturing refers to the integration and application of new generation of information technology in the field of manufacturing under the background of the current digital economy development. Architecture is the foundation of the real economy, which is closely related to digital chemistry and industrial digitalization. On the one hand, high-tech manufacturing of digital information products such as terminal equipment, smart equipment, electronic components, and integrated circuits is the material basis of digital chemical industry. It is a product of traditional manufacturing, blockchain, and artificial intelligence. On the other hand, digital technologies such as simulation technology are the core of the development of manufacturing, the key to achieving precise market positioning, expanding product functions, and improving product quality and added value. Digital technology is an intellectual industry. From the perspective of investment returns, the investment behavior of enterprises is manifested as effective investment and invalid investment. If the capital cost during the investment process is lower than the company's income, the company will not increase the investment amount for any reason, so it will not receive enough investment. Due to the low threshold of investment income, investment growth exceeding a certain threshold will actually reduce investment income and lead to excessive investment. In this context, this article studies the digital transformation of corporate enterprises based on algorithms: green innovation in investment efficiency organizations. This article deeply studies the status quo and the advantages of green innovation investment in digital technology, and puts forward corresponding suggestions.

Data Availability

The dataset is available upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgments

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Research Article

Planning and Design Method of Multiangle Ecological Building Edge Space under the Background of Rural Revitalization

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Under the background of rural revitalization, in order to realize the planning and design of ecological building edge space, a multi-perspective ecological building edge space planning and design method based on remote sensing image edge segmentation is proposed. The remote sensing visual detection of ecological buildings is realized by fusing multiscale features and multisource scene remote sensing images, and the extracted remote sensing image feature points are calibrated to extract the location information, texture features, super-resolution edge information features, and different levels of change features of the spatial distribution of the edge of ecological buildings. The background difference detection model of an ecological building remote sensing image is established, and the distance of the centroid of the corresponding level is calculated through frame dynamic planning and differential image clustering. Combined with the edge contour detection method of ecological building remote sensing image, the edge space planning and design are realized. The simulation results show that this method has higher accuracy in planning and better accuracy in detecting the contour of ecological building edge space and improves the dynamic planning and positioning ability of multi-perspective ecological building edge space distribution.

1. Introduction

With the development of rural revitalization, people pay more attention to the study of multi-perspective ecological building edge space planning under the background of rural revitalization. In the past, the concept of public space was defined as the design of traffic organization space combining corridors, squares, atriums, etc. Under the background of rural revitalization, the design of multiperspective ecological architecture fringe space planning model focuses on the mutual organization and wearing of point line plane space, large space, and small space. Through multiview tracking and recognition, the multiview ecological building edge space detection under the background of rural revitalization is realized, and the remote sensing image recognition technology is adopted to improve the rural revitalization background [1, 2].

Focusing on the geometric level of multiangle ecological architecture under the background of rural revitalization, this paper studies the spatial combination of multiangle ecological architecture aesthetics under the background of rural revitalization [3, 4]. Under the background of rural revitalization, the complex design of public space under the integration of multiview ecological buildings needs to stand on the demand of people and discuss the role and influence of the complex design of multiview ecological buildings in the integration under the background of rural revitalization. Starting with the development process of multi-perspective ecological architecture design and the related theories of architectural integration under the background of rural revitalization, this paper combines them and analyzes the driving mechanism of multi-perspective ecological architecture design under the background of rural revitalization and studies the spatial planning and design methods of multi-perspective ecological architecture under the background of rural revitalization, which is of great significance in promoting the improvement of the ecological structure and the optimization of architectural design aesthetics [5–7].

In reference [8], a study on a building edge space planning method based on symmetric inverse layout merging is proposed. UAV remote sensing equipment is used to obtain the image of building edge space, and the feature information of building edge space is extracted based on ICA threshold optimization coupling information entropy. The function of building edge space is analyzed. Based on the obtained feature information and function information of building edge space, the feature and function of building edge space are matched based on the symmetric inverse layout merging algorithm, and the initial building edge space planning is obtained. Based on the initial building edge space planning, the particle swarm optimization algorithm is used to optimize the building edge space planning and get the best building edge space planning and realize the building edge space planning based on symmetric inverse layout merging. In reference [9], the research summarizes the characteristics of urban fringe from the perspective of urban renewal and discusses the planning and design strategies of urban fringe from four aspects: industrial function upgrading, spatial structure remodeling, ecological network improvement, and cultural context inheritance, combined with the relevant practice of urban design in Linhuai area of Fengyang County, in order to provide a reference for other planning. In reference [10], a multiview eco-building planning method under the background of rural revitalization based on the joint analysis of six characteristics of contrast, brightness, smoothness, information content, third-order moment, and entropy was proposed, and new feature vectors were generated to compare the features before and after, so as to achieve multiview eco-building edge space positioning. However, the dynamic planning performance of multiview eco-building edge space positioning by this method was poor. In reference [11], a multiview ecological building edge space positioning technology based on an efficient and scalable improved residual structure neural network is proposed, which can realize the multiview ecological building planning under the background of rural revitalization through complex ecological planning and design, but this method has poor feature clustering and convergence.

To solve the above problems, this paper proposes a multiview ecological building edge space planning and design method based on edge segmentation of remote sensing images. Firstly, the multiview ecological building edge space is detected by fusing multi-scale features and multi-source scene remote sensing images. Then, the distance between the corresponding level centroid of multiview ecological building edge space is calculated. According to parameter estimation and pixel gray value detection, combined with edge contour detection of ecological building remote sensing images, the multiview ecological building edge space planning and design under the rural revitalization background is realized. Finally, the experimental test analysis shows the superior performance of this method in improving the planning and design ability of multi-perspective ecological building edge space under the background of rural revitalization.

2. Remote Sensing Image Edge Segmentation Theory and Method

Image segmentation refers to the technology of dividing the image into non-overlapping areas and extracting the interested objects. Remote sensing image has gradually played a great role in all fields of national life with its good timing, abundant information, and gradually improved resolution. Therefore, it is of great significance to use image segmentation technology to conduct in-depth research on it and discover the hidden information. At the same time, remote sensing images are usually characterized by low contrast, great changes in regional features due to different shooting conditions, blurred boundaries between different regions, complex and diverse distribution of shapes, structures, and fine structures, and large information capacity of images, which increase the difficulty of image segmentation. Therefore, remote sensing image segmentation is the technology of remote sensing image segmentation. It is the basis and key step of remote sensing image processing and application. It can transform the original image into a more abstract and compact form, making it possible for high-level analysis and decision-making. Edge refers to the set of pixels in an image whose gray level has a step or roof change. The step edge is located where the gray values of pixels on both sides are obviously different, and the roof edge is located at the turning point where the gray values increase to decrease. The segmentation method based on edge detection tries to solve the problem by detecting the edges of different areas. Usually, the gray values on the edges of different areas often change greatly, which is one of the main assumptions for the realization of edge detection methods. Edge segmentation is mainly divided into following categories.

2.1. Point Detection. Discrete points are detected first, and then the points are connected into closed boundaries. The process is to use a template to detect discrete points in the area to be detected.

2.2. Line Detection. In online detection, there are two ways: one is to use line detection module for line detection, and the other is to use huff transform for direct detection.

2.3. Edge Detection. Edge detection technology can be divided into serial edge detection and parallel edge detection according to the processing order. In the serial edge detection technology, whether the current pixel belongs to the edge to be detected depends on the detection result of the previous pixel. In parallel edge detection technology, whether a pixel belongs to the detected edge is only related to the current pixel and its adjacent pixels. This needs to detect all pixels in the image at the same time, so it is called parallel edge detection technology.

3. Overall Realization of Technology and Visual Preprocessing of Remote Sensing Technology

3.1. Remote Sensing Visual Detection of Spatial Distribution of the Ecological Building Edge. In order to realize the planning and design of multiview ecological building edge space under the background of rural revitalization based on remote sensing image edge segmentation, a multiview ecological building edge space remote sensing image acquisition model was established by combining color space feature analysis and saliency map model, and the dynamic frame sequence of multiview ecological building edge space remote sensing was analyzed by combining the method of ecological building space complex hierarchical segmentation and video frame detection [12, 13]. Using the method of hierarchical segmentation and frame counting of ecological building space complexity, through object feature detection and template matching under the condition of multiview ecological building edge space occlusion, combined with fine-grained feature analysis, a multiview ecological building edge space remote sensing image matching and ambiguity detection model is constructed, and the design flow chart of multiview ecological building edge space remote sensing image collection and multiview ecological building edge space planning is obtained as shown in Figure 1.

Based on edge segmentation and positioning of remote sensing images, this paper analyzes the location information, texture features, super-resolution edge information features, and different level change features of multiview ecological buildings' edge space distribution. According to the driving mechanism of spatial composite design and parameter information detection, it adopts the methods of adjacent frame registration and deformation template detection to analyze the appearance features of the remote sensing edge such as gray, color, texture, contour, and corner, of the whole building public space and adopts deformation template matching. Through the direction and the deformation of the direction gradually adapting to the real buildings in the image, the dynamic planning of the edge spatial distribution of multiview ecological buildings can be realized. The flow chart of the technical realization structure of the method proposed in this paper is shown in Figure 2.

According to the above overall structure design, the multiview remote sensing visual detection of ecological buildings under the background of rural revitalization is realized by fusing multiscale features and multisource scene remote sensing images, and the extracted multiview remote sensing images of ecological buildings under the background of rural revitalization are calibrated by threshold segmentation and corner location [14, 15].

3.2. Multi-Perspective Remote Sensing Image Sampling and Preprocessing of Ecological Buildings under the Background of Rural Revitalization. On the basis of the overall structural analysis of the planning and design of multiview ecological building edge space under the background of rural revitalization, the multiview ecological building remote sensing vision detection under the background of rural revitalization is realized by fusing multiscale features and multisource scene remote sensing image detection, and the extracted multiview ecological building remote sensing image under the background of rural revitalization is segmented by the threshold and corner location, and the multiview ecological building remote sensing image under the background of rural revitalization is obtained as follows:

$$L = J(w, e) - \sum_{i=1}^{N} a_i \varphi(x_i), \tag{1}$$

where $J(w, e)$ represents the dimension of the feature map, a_i is the pixel feature quantity of the remote sensing image of the edge space of multiview ecological building, $\varphi(x_i)$ is the second-order geometric moment of multiview ecological building under the background of rural revitalization, N is the pixel number of multiview ecological building under the background of rural revitalization, and the contour feature distribution of multiview ecological building image under the background of rural revitalization in the neighborhood pixels is defined as

$$J^{\text{dark}}(x) = \min_{c\in\{r,g,b\}} \left(\min_{y\in\Omega(x)} \left(J^c(y)\right) \right), \tag{2}$$

where J^c is the filter transmission coefficient of multiview eco-building images under the background of rural revitalization, and $\Omega(x)$ is the neighborhood size of location information distribution of multiview eco-building edge space. Combining with the feature reorganization of motion parameter information of eco-building edge space, the white balance sensitivity feature decomposition result of multiview eco-building images under the background of rural revitalization is as follows:

$$I(x) = J(x)t(x) + A(1 - t(x)), \tag{3}$$

where A is the scale information of multiview remote sensing images of ecological buildings under the background of rural revitalization, $t(x)$ is the enhancement coefficient of multiview remote sensing images of ecological buildings under the background of rural revitalization, and $J(x)t(x)$ is the parallax component of multiview remote sensing images of ecological buildings under the background of rural revitalization. By smoothing the feature map set and weighted summation pixel-by-pixel, the discriminant function of ecological building edge space detection after the feature fusion in the first stage is obtained as follows:

$$\begin{aligned} &H_1\colon U(t) = V(t) + \alpha(t)W(t), \\ &H_0\colon U(t) = V(t), \end{aligned} \tag{4}$$

where $V(t)$ represents the prior information component of remote sensing vision sensing of spatial distribution of multiview ecological building edge; $W(t)$ represents the statistical value of dynamic planning of multiview remote sensing image frames of ecological buildings under the

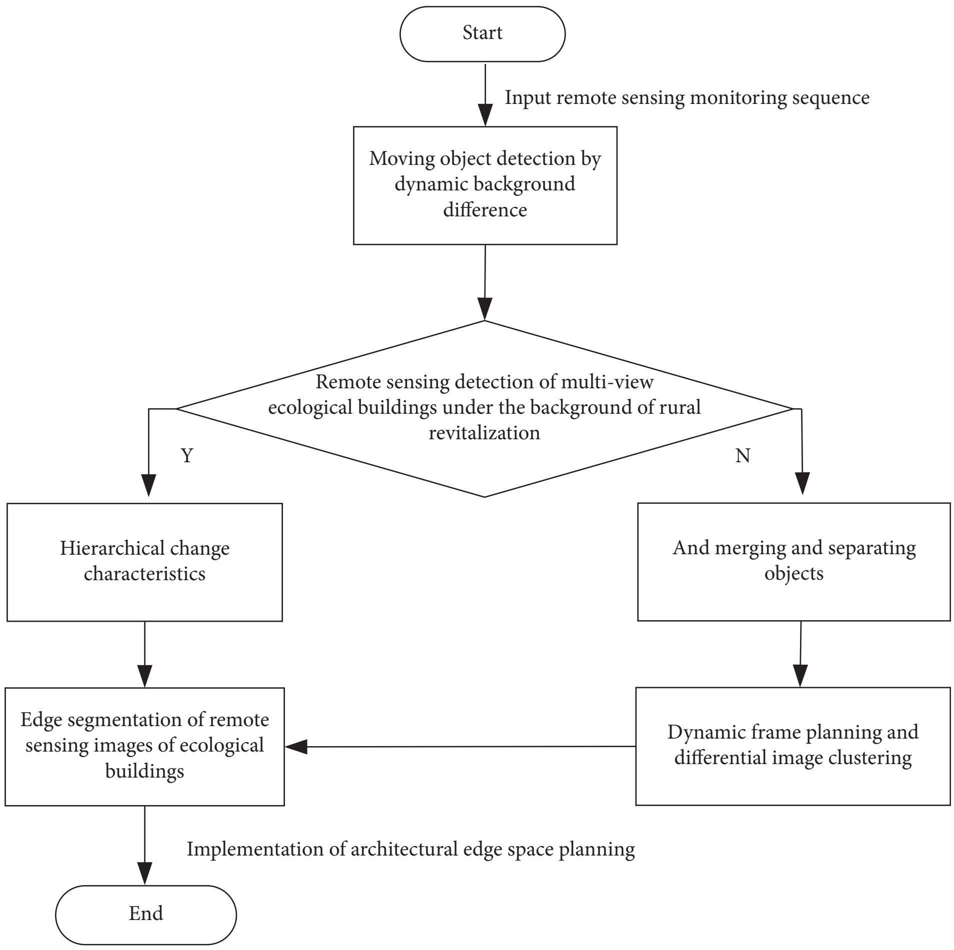


Figure 1: Flow chart of edge space positioning of multiview ecological buildings.

background of rural revitalization; $\alpha(t)$ represents multiple chromatic aberration nuclei; H_1 represents the fine-grained feature distribution area, and H_0 represents the layer feature distribution area of multiview ecological building edge space distribution [16–18].

According to the above analysis, the background differential detection model of multiview ecological building remote sensing images under the background of rural revitalization is established, and the dynamic planning of multiview ecological building edge spatial distribution is carried out through frame dynamic planning and differential image clustering [19–21].

4. Multi-Perspective Ecological Building Edge Space Planning and Design

4.1. Extraction of Spatial Distribution Characteristics of the Multiview Ecological Building Edge Based on Edge Segmentation of the Remote Sensing Image. The edge pixel fusion method is adopted to locate the edge space of multiview ecological buildings by remote sensing vision, and the pheromone intensity at the characteristic points is obtained. Based on the tracking detection method of the deformation template [22–24], the appearance features of multiview ecological buildings such as gray scale, color, texture, outline, and corner are obtained, and the appearance features of multiview ecological buildings under the background of rural revitalization are differentiated and fused, and the detected pixel sequence distribution of multiview ecological buildings under the background of rural revitalization is as follows:

$$J(x) = \frac{I(x)A}{\max\left(t(x), t_0\right)} + A, \tag{5}$$

where $I(x)$ is the optical flow field of multiview remote sensing images of ecological buildings under the background of rural revitalization in horizontal direction, A is the scene appearance component of multiview remote sensing images of ecological buildings under the background of rural revitalization, $t(x)$ is the detection time variation parameter of multiview remote sensing frames of ecological buildings under the background of rural revitalization, and t_0 is the optical flow characteristic value projected in the adjacent area on the image plane [25, 26]. Combining with the Markov chain method, the visual characteristic distribution set of multiview remote sensing images of ecological buildings under the background of rural revitalization with high resolution is obtained, and the multiview ecology under

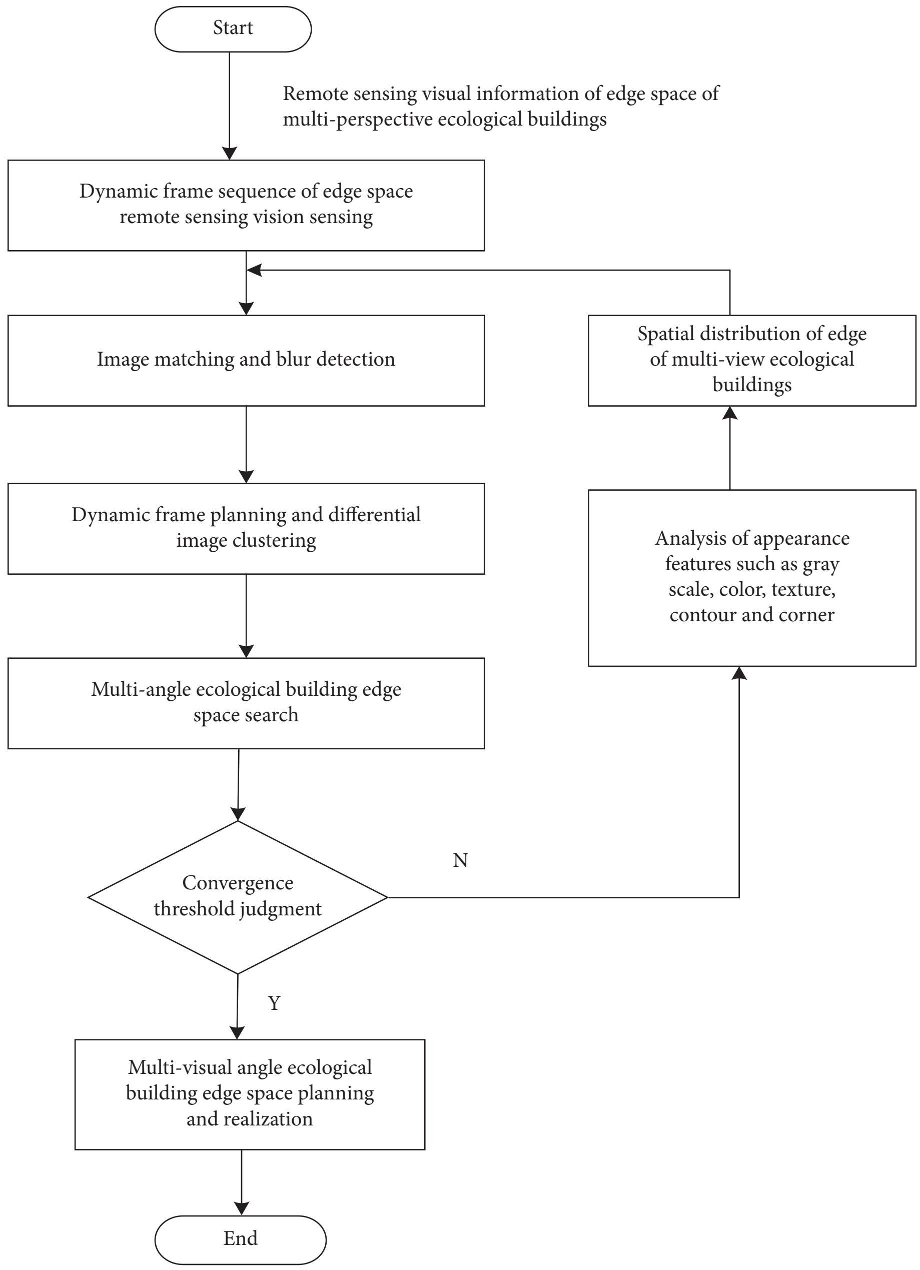


Figure 2: Block diagram of the technical process structure.

the background of rural revitalization is obtained within the adjacent points in a small area.

$$w(d_{ij}) = f\left(\left|x_i - x_j\right|\right) = \frac{1}{\sqrt{2\pi}}\exp\left\{\frac{\left(x_i - x_j\right)^2}{2}\right\}, \tag{6}$$

where x_i represents the background gray value of an $N \times N$ window, and x_j represents the gradient operator of the multiview ecological building edge space remote sensing image. In the image stabilization stage of the multiview ecological building edge space remote sensing image, the output Lab color feature is $\widehat{A}_n$. On this basis, the multiview ecological building edge space remote sensing image is subjected to image stabilization processing, and the detection results of multiview ecological building space planning feature points under the background of rural revitalization are as follows:

$$\begin{cases} y_0 = f\left(c_0, c_1, \ldots, c_{N-1}\right), \\ y_1 = f\left(c_0, c_1, \ldots, c_{N-1}\right), \\ \ldots, \\ y_m = f\left(c_0, c_1, \ldots, c_{N-1}\right), \end{cases} \tag{7}$$

where c_0 represents the corner information of multiview remote sensing images of ecological buildings under the background of rural revitalization after the registration of adjacent frames, c_{N-1} represents the edge space movement information of ecological buildings after tracking the edge space of ecological buildings through remote sensing optical flow field tracking, and according to the feature extraction results, the dynamic planning of edge space of ecological buildings is realized by using the information fusion and clustering processing of the inter-frame movement.

Figure 3: Orientation information of ecological building edge space.

4.2. Planning and Design of Edge Space of Multiangle Ecological Buildings under the Background of Rural Revitalization. By using frame dynamic programming and differential image clustering, the distance of multiview ecological building edge space corresponding to the hierarchical centroid is calculated, and the detection and estimation of statistical characteristics of the multiview ecological building remote sensing image background model under rural revitalization background are established. Let $F_m(x, y)$ be the gray value of multiview ecological building remote sensing image pixels under rural revitalization background at the T frame m, and $B_m(x, y)$ represents the gray value of multiview ecological building remote sensing image background pixels under rural revitalization background calculated from the previous frame. The optical flow equation of each multiview ecological building edge space distribution is

$$B_m(x, y) = \frac{1}{m}\sum_{i=0}^{m-1} F_i(x, y), \tag{8}$$

where m is the serial number of the current frame, and $F_i(x, y)$ is the optical flow gradient of multiview remote sensing images of ecological buildings under the background of rural revitalization. When m gradually becomes larger, the pixels occupied by the edge space of ecological buildings are smooth and close to the real pixels of the background model. According to the remote sensing parameter estimation and pixel gray value detection of multiview ecological buildings under the background of rural revitalization, combined with the edge contour detection of remote sensing images of ecological buildings, the multiview ecological building edge space planning is realized. The realization steps are as follows:

(1) The edge space information of ecological buildings is used for matching or data association, and the image is divided into the foreground area and the background area by the initial threshold. Observe the distribution of these two areas, determine the correlation and matching relationship between the edge spaces of ecological buildings and get that the orientation parameters of the edge spaces of ecological buildings in the current frame and successive frames before the current frame of multiview remote sensing optical flow trajectory of ecological buildings under the background of rural revitalization are

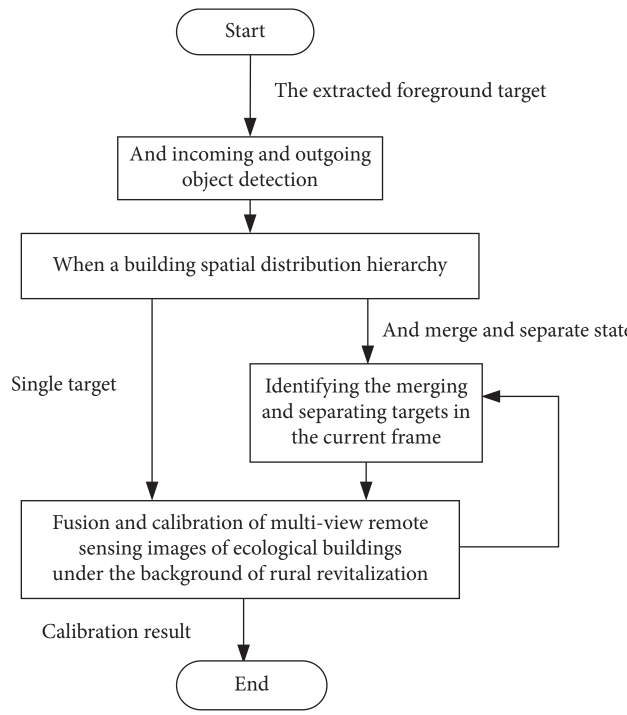


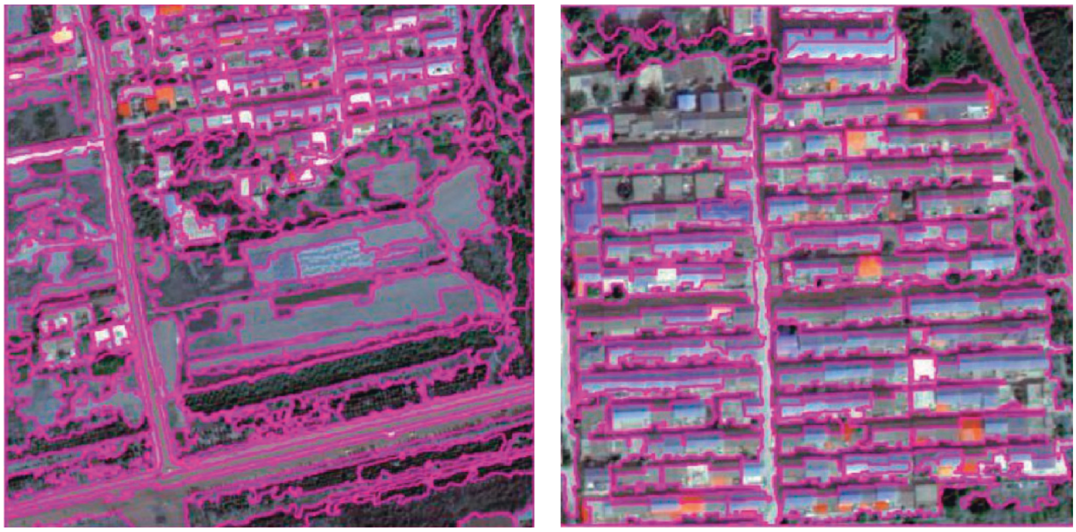
Figure 4: Implementation process of the improved algorithm.

$$\begin{aligned}\mu_B &= \frac{\sum_{(i,j)\in \text{background}} F(i, j)}{\#\,\text{background\_pixels}},\\ \mu_O &= \frac{\sum_{(i,j)\in \text{objects}} F(i, j)}{\#\,\text{object\_pixels}},\end{aligned} \tag{9}$$

where background_pixels is the gray pixel value of the background area, $F(i, j)$ is the spatial location constraint parameter of the multiview ecological building under the background of rural revitalization, and object_pixels is the gray pixel value of the edge space area of the ecological building;

(2) Set the characteristic variable T, $T = (\mu_B + \mu_O)/2$ of remote sensing vision sensing in the edge space of multiview ecological buildings. Among them, the spatial orientation information of the ecological building edge is obtained.

(3) The updated T setting, through tracking the optical flow trajectory characteristics of multiview remote sensing images of ecological buildings under the



(a) (b)

Figure 5: Visual image acquisition of spatial distribution at the edge of multiview ecological buildings. (a) Frame 1024. (b) Frame2000.

background of rural revitalization, obtains the light transmittance in all directions of the images, thus obtaining the specific characteristic points of the edge space of regional ecological buildings, as shown in Figure 3;

(4) Repeat (1) to (3), and end when approaching μ_B. The implementation process of the improved algorithm is shown in Figure 4.

5. Experimental Analysis

The simulation experiment verifies the performance of this method in the planning and design of multiview ecological building edge space under the background of rural revitalization. The hardware configuration of the experiment is a desktop with a main frequency of 2.6 GHz, a memory of 2 GB, and Matlab R2011a simulation software. The remote sensing video VIVID database is used for sampling the information of ecological building edge space, and the visual sensing pixel value of multiview ecological building edge space under the background of rural revitalization is 4,500*2,400. The detection threshold of ecological building edge space is set to 0.38, and the spatial regional fusion feature distribution set of remote sensing visual sensing is 125. The 1024th and 2000th frames are taken as research objects, and the multiview visual sensing image collection of ecological building edge space distribution is shown in Figure 5.

Taking the above two multiview ecological building edge spatial distribution visual sensing images as the research object, the position information, texture features, super-resolution edge information features, and different level change features of multiview ecological building edge spatial distribution are extracted, and through frame dynamic planning and differential image clustering, the fusion results of multiview ecological building edge spatial distribution images are obtained as shown in Figure 6.

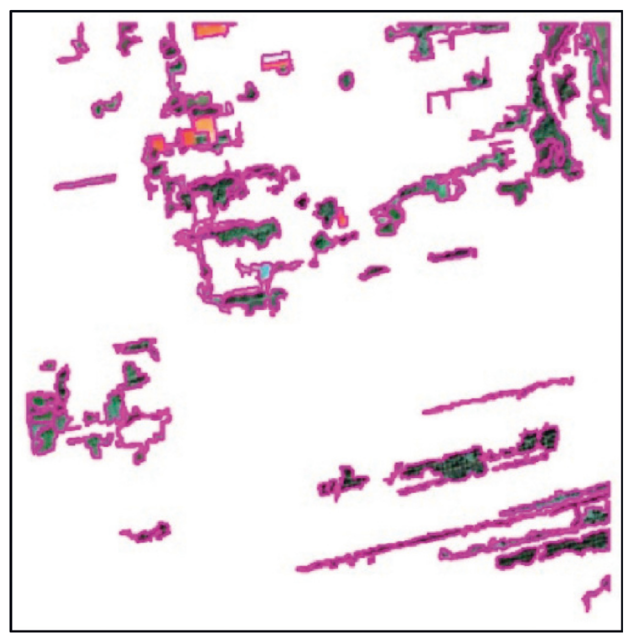
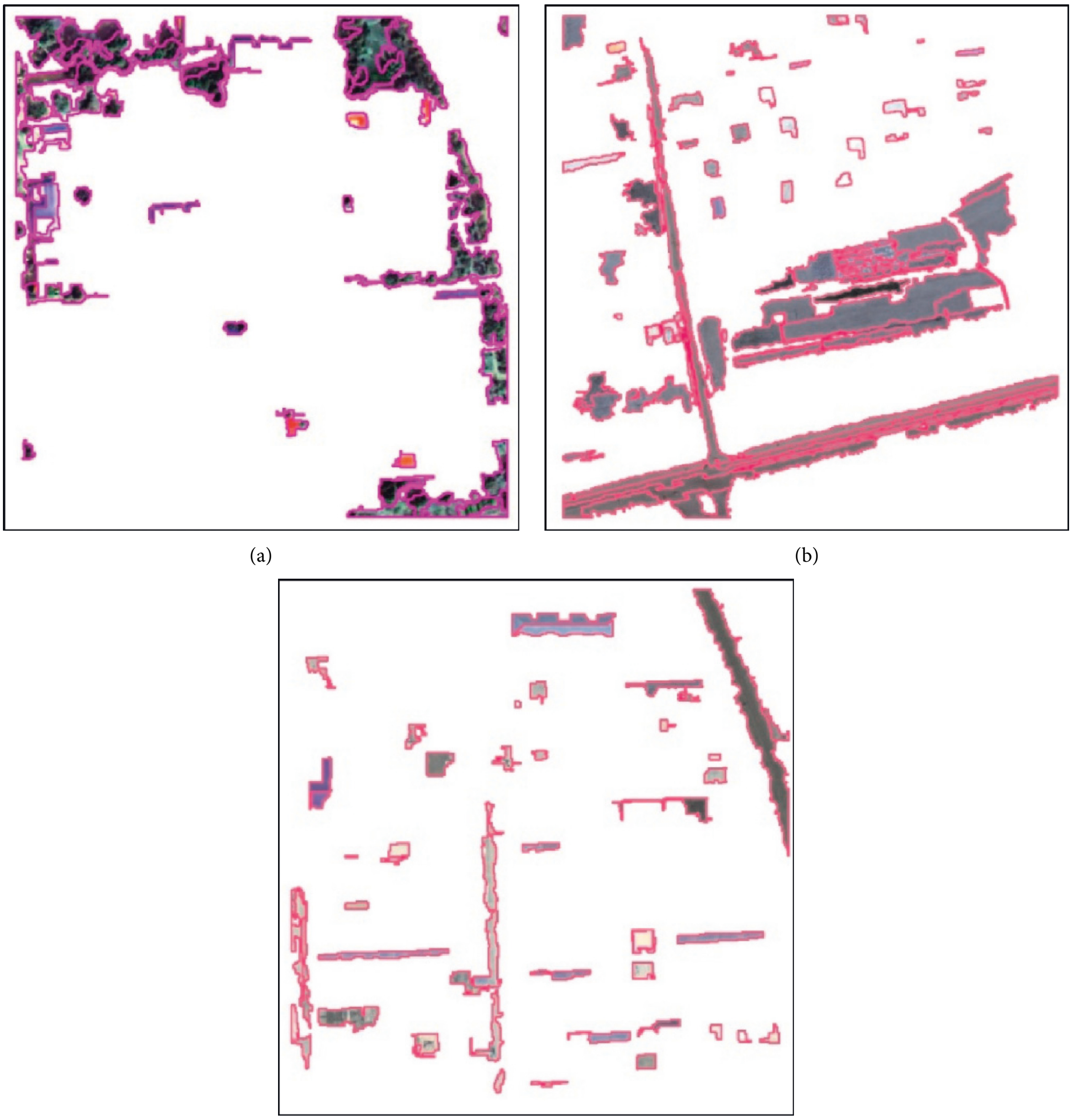


Figure 6: Multi-perspective ecological building edge space information fusion results.

According to the fusion results of multiview ecological building edge spatial distribution images in Figure 6, combined with the edge contour detection of ecological building remote sensing images, the dynamic planning of multiview ecological building remote sensing images under the background of rural revitalization is realized, and according to the comparison of other methods, the multiview ecological building edge spatial planning output is obtained as shown in Figure 7.

Ecological buildings and the accuracy of edge space detection of ecological buildings is better, which reduces the probability of missing detection of edge space of ecological buildings. The comparison results are shown in Table 1.



(a) (b) (c)

Figure 7: This method can effectively locate the edge space of multiview. (a) Appearance observation. (b) Structural observation. (c) Fusion observation.

Table 1: Comparison of positioning accuracy of multi-perspective ecological building edge space planning.

Iterative steps	Methods of this paper	Reference [10]	Reference [11]
10	0.899	0.592	0.773
20	0.893	0.591	0.78
30	0.905	0.593	0.785
40	0.902	0.596	0.789
50	0.903	0.598	0.789
60	0.901	0.597	0.795
70	0.897	0.589	0.796
80	0.893	0.594	0.802
90	0.916	0.593	0.807
100	0.913	0.594	0.81

According to the analysis of Table 1, the accuracy of this method for the spatial distribution planning of the edge of multi-perspective ecological buildings is higher than 0.899. The highest values of 0.594 and 0.810 are higher than those of reference [10] and reference [11]. This proves that the planning and design method of multi-perspective ecological building edge space under the background of rural revitalization proposed in this paper has a good planning effect.

6. Conclusion

In this paper, the planning and design method of multi-perspective ecological building edge space under the background of rural revitalization is proposed. On the basis of remote sensing visual detection, multiple feature points of multiview ecological building edge spatial distribution are extracted. Through background difference and edge contour detection, the edge space planning and design of ecological buildings are completed. Simulation results show that the proposed method has good planning performance.

Data Availability

The data are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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Research Article

Multi-Dimensional Post Competency Evaluation Model in Human Resource Management under the Background of Artificial Intelligence

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In order to evaluate the competence of candidates in human resource management and select the most suitable talents, the behavior time interview method is used to build a personnel competency model, and various competency indicators are determined. According to the existing mature traditional analysis methods, we calculate the weight of each index and give the competency score. Based on the traditional competency model, the parameters of the training content of BP neural network are obtained. After the training results are tested, a new competency evaluation model based on artificial intelligence is proposed. The results show that the relative error between the model training results and the expected output is very small, the maximum value is −0.12%, and the maximum relative error between the output value obtained by BP neural network and the expected value is 3.8%. Therefore, the personnel competency model based on BP neural network constructed in this paper has accurate calculation results, and its application in the company's human resource management is feasible and has strong applicability.

1. Introduction

With the continuous development of social economy, in the complex economic activities, human resources, as the first resource, play a core role in the efficiency of resource allocation [1, 2]. At the same time, with the continuous deepening of China's market economic reform, managers are the key human resources in the organization, affecting the role of other human resources. People are increasingly aware of the importance of talent selection [3–6]. Therefore, using the correct competency model to study the selection of human resources is very important for the development of enterprises [7–9]. It has not only theoretical significance but also practical significance to improve the human resource management level of many enterprises.

The research of competency theory and the practical application of competency model originated in the United States, but in recent years, scholars at home and abroad have made many research achievements on the competency model [6, 10–12]. Miiller-Frommeyer et al. [13] believe that competency is an indispensable internal drive for individuals, which can promote individuals to acquire more professional abilities through learning and practice and form a competency model on this basis. Li et al. [14] mentioned that the success of a team depends on the theoretical knowledge and work attitude of employees under certain conditions. Scott et al. [15] reinterpreted competence in combination with practical research and believed that it is an important indicator to measure the contribution of an individual in the group. For individuals, competence plays a guiding role and contributes to the improvement of human resource management results. Culhane [16] analyzed enterprise managers and affirmed the importance of competency model in combination with enterprise crisis events. Leekitchwatana et al. [17] believe that specific competency factors include employees' work attitude, employees' theoretical knowledge reserve, and so on. Combined with the competency model, this model can improve the relationship between individuals and work performance and pave the way for the orderly promotion of various work and the smooth realization of organizational goals. Charles [18] explored the key factors of employee performance based on competency model, aiming to deeply tap the internal potential of employees.

From the above research results, it can be concluded that many foreign scholars studied the concept of competence based on different environments and perspectives [19–23]. However, many mathematicians believe that competence refers to some abilities that a certain type of staff has based on job requirements, job task requirements, industry norms, etc. In the research of competency model, foreign scholars have made great achievements, put forward the iceberg model, and tried to apply it to practical activities [24–27]. In terms of determining the dimensions of competency models, many scholars have created many new competency models based on existing theories. Based on the exploratory and confirmatory results, Jian [28] created a competency model for the Secretary General of the foundation with his own management dimension and employee management dimension as the entry point, including 20 directional evaluation indicators. Dingwei et al. [29] created a competency model for intelligence personnel, subdivided the model factors into 16, and completed the preparation of specific competency measurement tables in combination with his work profile. Patterson [30] and others analyzed the grassroots directors of high-tech enterprises, started the matching test based on the relevant competency model, and built a feasible competency model for this position. Hazim [31] and others regarded the head of the college as the research object and built a competency model matching it according to their job requirements.

This paper presents a new competency evaluation model based on BP neural network on the basis of analyzing the concept, form, and composition principle of the competency model. The establishment method of BP neural network is emphatically studied. It uses traditional methods to build a multi-dimensional competency model and successfully applies it to the neural network analysis of MATLAB. The calculation results show that the calculation results of the modified model are correct, and the error range is very small. It has high applicability to the follow-up human resource management problems and can be directly used by enterprise managers.

2. The Construction of Competency Model

2.1. Competency Overview. David McClelland, a professor at Harvard University, first proposed the concept of competency characteristics in 1973 [32]. He demonstrated the post-performance from two aspects: individual quality and work ability. Spencer, a scholar, pointed out in the concept of competency for the first time that measurable and determinable properties should be covered at the same time, and it is also the first time to summarize the main content of competency elements [33]. Therefore, experts in human resource management usually divide competency into six levels: knowledge, skills, social roles, self-concept, traits, and motivation. The competency evaluation model refers to the synthesis of competency characteristics that must be possessed by each work. Its essence is to shift the attention from hard indicators such as education and experience diploma to soft indicators and focus on observing the adaptability, adaptability, endurance, and creative thinking ability of candidates to environmental changes in human resource management.

The proposed competency model is the most widely used and classic one with the highest recognition at present. Therefore, this paper is a further study based on Spencer's competency definition. Meanwhile, in the declining background of artificial intelligence, the application of post competency evaluation model to talent selection will make human resource management function play a new role, and human resource professionals can seek talent characteristics that will bring higher performance, ensuring the scientific and reasonable talent selection system in the application of the competency model.

2.2. Competency Model. The definition of competency, characteristic elements of competency, and grade of behavior indicators can build a model. So far, there are two internationally recognized competency general models: iceberg model and onion model. The details of these three general models are as follows.

Spencer proposed competency iceberg model. As shown in Figure 1, the model divides competency into upper and lower structures. On the top is the part exposed above the iceberg level, which includes two competency characteristic elements: knowledge and skills, both of which belong to explicit competency characteristic elements. The second part is below the hidden level of the iceberg which includes social roles, self-image, personal characteristics, motivation, and so on, which are internal and implicit competency characteristic elements. In short, the dominant elements above the level are obvious, prominent, and easy to measure. However, the hidden attribute below the level often determines the level of job performance, but it is often ignored in the selection of human resource management. The iceberg model contains a good dialectical thought and reflects the relationship between internal and external causes.

In general, the competency characteristic elements above the level are obvious, prominent, and easy to measure. However, the factors that really determine individual job performance are often hidden below the level, and they are easy to be ignored. It is also relatively difficult to measure. The iceberg model contains good dialectical ideas and reflects the relationship between internal and external factors.

Boyatzis proposed the competency onion model [34]. As shown in Figure 2, it is basically similar to the principle of the competency iceberg model. The competency onion model explains the characteristics that each constituent element of competency characteristics can be observed and measured gradually from the inside to the outside. The explicit competency characteristic elements are placed on the outermost layer, and the potential, hidden, and internal

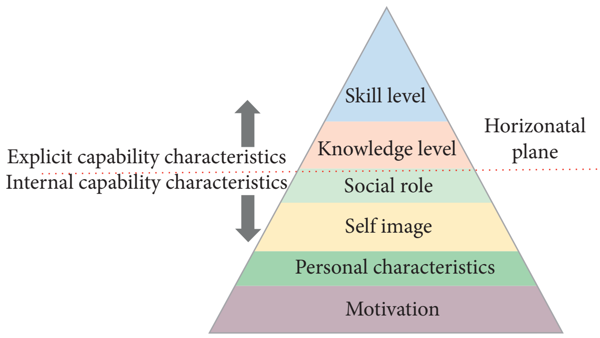

Figure 1: Iceberg model of competence.

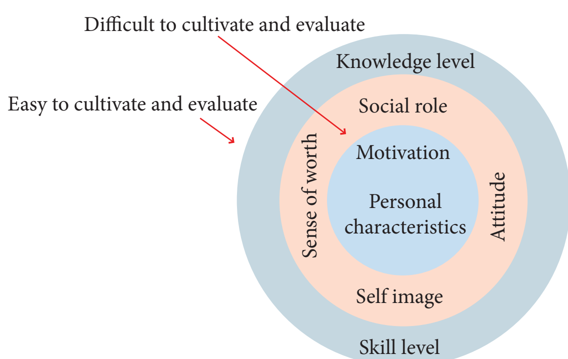

Figure 2: Onion model of competence.

competency characteristic elements are placed on the inside, so as to build a layer by layer competency model from the inside to the outside. From the outside to the inside, the difficulty of observing, cultivating, and evaluating competency characteristic elements gradually increases. The outermost competency characteristic elements are relatively easy to be observed and evaluated and also the easiest to be cultivated. However, the more the inner layer is, the more it can reflect the level of future work performance. The motivation and personal characteristics at the core layer are the most reliable and stable competencies.

The International Human Resource Institute (IHRI) proposed a competency ladder model [35]. As shown in Figure 3, the competency ladder model is divided into six levels from top to bottom, including knowledge, skills, social roles, self-concept, personal characteristics, and motivation. Among them, self-concept refers to the individual's perception and understanding of his own identity. Specifically, the top of the ladder is personal performance behavior, and the six levels at the bottom of the ladder affect the individual's response to the job objectives to varying degrees, thus determining the personal performance behavior at the top of the ladder.

Facing different industry fields, different enterprises, and different jobs, scholars at home and abroad have conducted in-depth research and developed various competency models, but most competency models are improved based on the above three classic competency models. In other words, although the job competency

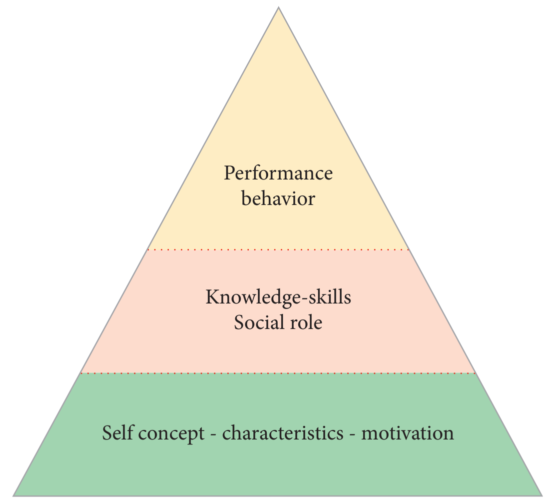

Figure 3: Trapezium model of competence.

model varies with the industry, enterprise, and job responsibilities, the basic principle remains the same. Similarly, this paper believes that the competency model is a combination of a series of competency elements that can be measured and developed and can decisively affect job performance under specific job situations, including knowledge, skills, self-concept, personal characteristics, motivation, and so on. Therefore, the competency model based on the management of P company in Laos to be developed in this paper is also based on the improvement of the above three classical models, and the principle is similar to the above three models.

2.3. Construction Principles of Competency Model. In order to let the enterprise human management leaders clearly know which aspects of the candidate are the selection indicators, this paper needs to establish a talent selection system based on the competency model, so as to make an objective, comprehensive, and accurate evaluation of the candidates' working ability in their applied positions, give the value method of each competency index, and make an in-depth exploration and definition from the qualitative method to the quantitative analysis step.

Therefore, when establishing the talent selection system of the multi-dimensional competency model, in addition to the construction principles of the general index system such as comprehensiveness, operability, accessibility, differentiation, and comparability, the following two special construction principles should be included.

The competency evaluation model established must correspond to the high level of work performance, that is, the talents selected according to the evaluation model must be employees with excellent work performance and should not just stay at the qualified level. This requires the development of student level features that can bring high performance. At the same time, it should be noted that the overall evaluation model must include the most basic competency indicators that meet the needs of each position according to different job analyses.

Enterprise culture is also an important factor that affects the ability evaluation model. Every enterprise has its own cultural charm. The unique cultural charm of the enterprise is the traditional customs that have always been preserved, such as the management style of the enterprise and the behavior style of employees. Then, in the competency evaluation model, the behavior and values represented by the description of self-concept, personal characteristics, and motivation not only are related to each position but also take into account the consistency of the overall cultural atmosphere and value system of the enterprise, so as to ensure that the recruited talents not only match the knowledge and skills with the post needs but also integrate into the corporate culture in the later work.

3. Application and Prospect of Machine Learning Methods

Machine learning method is the core of artificial intelligence, which can analyze data reasonably and correctly. Based on the existing cognitive experience, semi-automatic modeling or automatic modeling after the establishment of automatic learning machine has achieved the goal of reducing human intervention, and the machine operates, analyzes, learns, and solves problems by itself. With the diversification and complexity of data to be processed, machine learning methods still have many problems to be solved when dealing with complex problems, such as new challenges in learning objectives and classification efficiency.

3.1. Application of BP Neural Network. Because the most difficult step of machine learning is to refine the problems in actual production and life into machine learning problems, this requires researchers to deeply understand the actual problem itself. In addition, no matter how accurate the prediction of the machine is, if it cannot meet human needs, the result will be worthless. Therefore, applying BP neural network to the competency evaluation model of human resource management system and using machine learning method to solve the problems existing in talent management and selection is a new research method, which is of great value to human resource management. However, when using BP neural network for analysis, the most important thing is to establish a machine learning problem, that is, the problem in actual human resource management is abstracted into a machine learning problem for subsequent neural network training and parameter optimization. Use machine learning method to calculate human thinking problems, as shown in Figure 4.

3.2. Principle of BP Neural Network and Error Backpropagation. The training process of BP neural network includes data forward propagation and error backpropagation. The main workflow is as follows: the data are first transmitted from the input layer to the hidden layer and then transmitted to the output layer after the relevant data processing algorithm. At this time, if the error between the calculation result and the expected value is less than the specified range, the training will stop if it is qualified. If the error is too large, the error will be transmitted from the output layer to the hidden layer and finally return to the input layer. In this process, the network will correct and adjust the weights of nodes at all levels until the training results are perfect (see Figure 5 for the specific description of the algorithm).

BP neural network algorithm is a "backstepping" learning algorithm of multi-layer network. BP neural network algorithm structure is usually composed of three or more neural network layers connected in turn. These network layers are an input layer, an output layer, and multiple hidden layers (middle layer). Each layer of nerve contains multiple neurons, which are responsible for information processing and information transmission. The neurons in the same layer are independent of each other. The neurons in the adjacent two layers are fully connected by weight, and the neurons in each layer share parameters. Each nerve only receives the information input of the previous layer of nerve and is responsible for converting the information and outputs the converted information to the next layer of neuron, without getting feedback. The location of the hidden layer is between the input layer and the output layer. Usually, there is at least one hidden layer, and the number of hidden layers is not fixed, which is set by the designer. As an intermediate layer, the function of the hidden layer is to extract the feature of the information transmitted by the neurons in the input layer and transfer it to the output layer. The information extraction between each hidden layer is different. Therefore, the hidden layer can also be called the feature extraction layer. In the process of extracting features from the hidden layer, the hidden layer will "self-organize" the weights between the input layer and the hidden layer. In other words, the weights between the input layer, the hidden layer, and the output layer are gradually "automatically" adjusted from the initial random value during the training process of the BP neural network, so that the network can finally acquire the characteristics of the input mode and transmit it to the output layer. Figure 6 shows the multi-layer BP neural network.

Input P pairs of learning samples to BP network for training, and the sample input value is XP = (X1, X2,. . .XP). The network output value of the p th learning sample is y_k^p, $k = 1,2,3,\ldots$m, and the corresponding expected output value is t_k^p, $k = 1,2,3,\ldots$m, and the overall error of this sample is

$$\begin{aligned} E &= \sum_{p=1}^{P} E_p \\ &= \frac{1}{2}\sum_{p=1}^{P}\sum_{k=1}^{m}\left(t_k^p - y_k^p\right)^2, \end{aligned} \tag{1}$$

where $E_p = 1/2\sum_{k=1}^{m}(t_k^p - y_k^p)^2$, and E_p is the error of the p th training sample. The change of output layer weight is

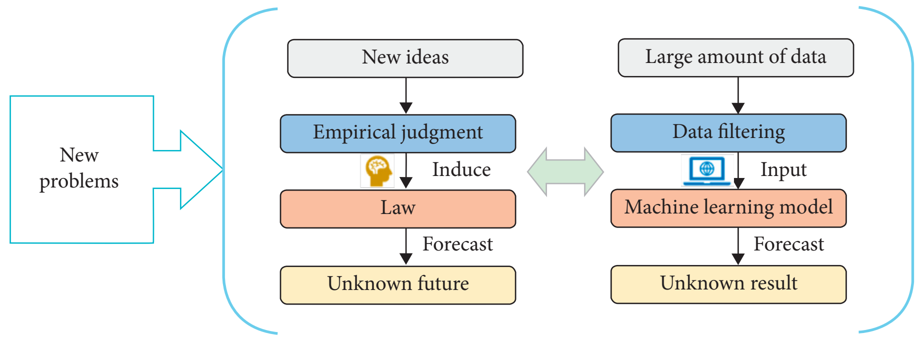

FIGURE 4: The difference between machine learning and human thinking: (a) machine learning; (b) human thinking.

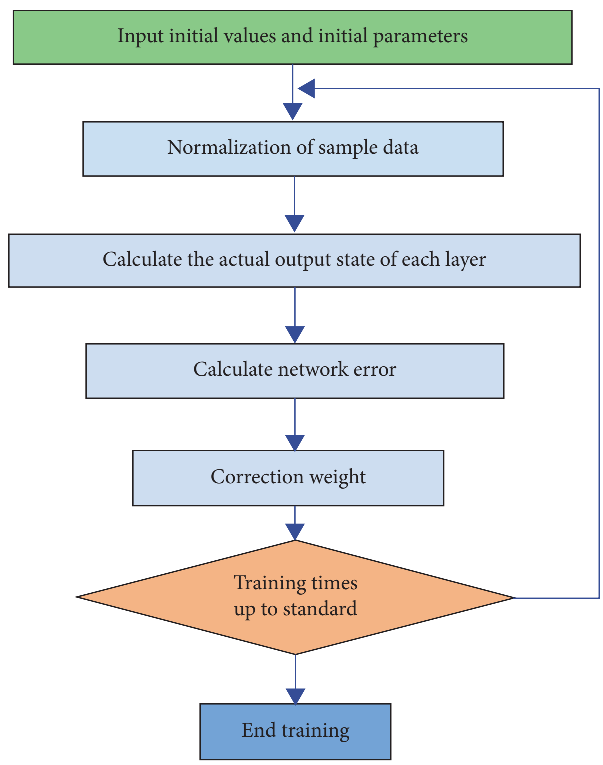

FIGURE 5: Optimal parameter solving process.

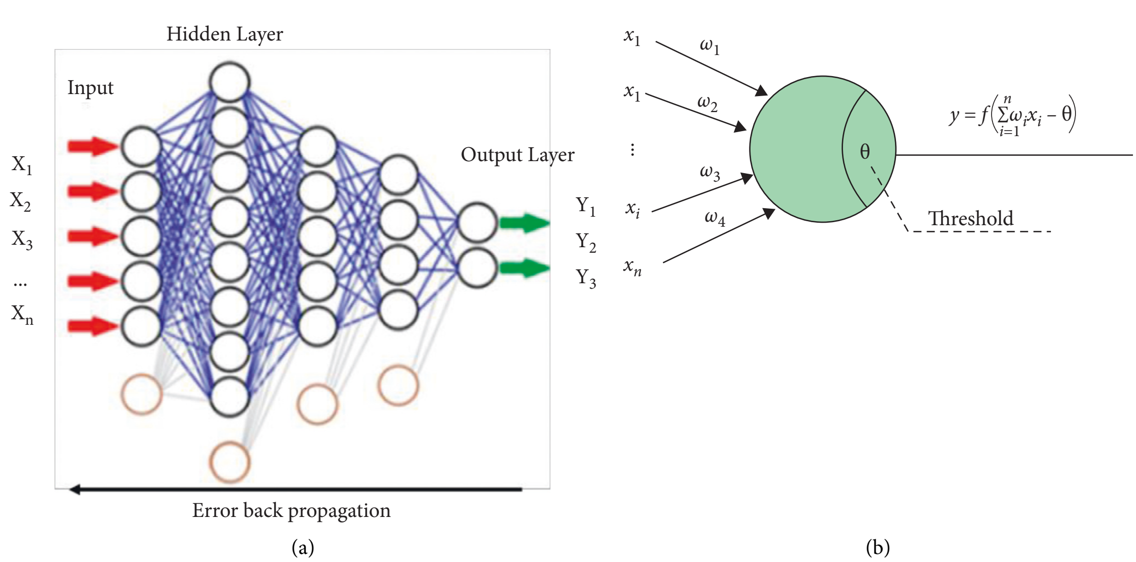

FIGURE 6: Schematic diagram of typical neural network structure. (a) BP neural network model. (b) Neuron topology.

$$\begin{aligned}\Delta v_{kj} &= -\eta \frac{\partial E}{\partial v_{kj}} \\ &= -\eta \frac{\partial}{\partial v_{kj}} \left(\sum_{p=1}^{P} E_p \right) \\ &= \sum_{p=1}^{P} \left(-\eta \frac{\partial E_p}{\partial v_{kj}} \right),\end{aligned} \tag{2}$$

where η is the learning rate. Define the error signal as

$$\begin{aligned}\delta y_k &= -\frac{\partial E_p}{\partial D_k} \\ &= -\frac{\partial E_p}{\partial y_k} \cdot \frac{\partial y_k}{\partial d_k},\end{aligned} \tag{3}$$

$$\begin{aligned}\frac{\partial E_p}{\partial D_k} &= \frac{\partial}{\partial d_k} \left[\frac{1}{2} \sum_{k=1}^{m} \left(t_k^p - y_k^p \right)^2 \right] \\ &= -\sum_{k=1}^{m} \left(t_k^p - y_k^p \right),\end{aligned} \tag{4}$$

$$\frac{\partial y_k}{\partial d_k} = f_2'(d_k). \tag{5}$$

Equation (5) is the partial differential of the activation function of the output layer. Combining the above formula, we can get the adjustment formula of the connection weight of each neuron in the output layer and the hidden layer.

$$\begin{aligned}\Delta v_{kj} &= \sum_{p=1}^{P} \sum_{k=1}^{m} \eta \left(t_k^p - y_k^p \right) f_2'(d_k) g_j, \\ \Delta w_{jt} &= \sum_{p=1}^{P} \sum_{k=1}^{m} \eta \left(t_k^p - y_k^p \right) f_2'(d_k) v_{kj} f_1'\left(s_j \right) x_i.\end{aligned} \tag{6}$$

It is easy to see that in BP learning algorithm, the weight adjustment formula of each layer is the same in form, which is determined by three factors, namely, the learning rate η, the proportion of error signals output by this layer δ, and the proportion of input signals Y or X. The error signal of the output layer is related to the difference between the expected output and the actual output of the network, and the hidden error signal of each layer is related to the error signal of the previous layer, which is transmitted layer by layer from the output layer. When the error is small enough, the sample training meets the accuracy requirements.

4. Construction of Personnel Competency Model Based on Machine Learning Method

4.1. Index System. In order to establish a suitable competency model, the model development and evaluation team is composed of human resource managers, human resource management professionals, and university consulting experts. This paper first carries out job analysis on the post, which adopts the method of combining questionnaire survey and key behavior event interview to clarify its job nature, job tasks, job responsibilities, job requirements, and performance standards. On this basis, the preliminary model of personnel competency is constructed. After that, the verification work was supplemented, and finally a competency model was established, including five first-class competency indicators and 13 second-class subcompetency indicators, including personality traits, interpersonal and cooperation, knowledge, technical ability, and learning ability. According to the idea of layering, the reduced model is shown in Figure 7. According to the model established by the survey, this paper uses the BP neural network method to evaluate the personnel competency of a company in Jiangsu, China, in the follow-up work.

4.2. BP Neural Network to Evaluate Personnel Competency Evaluation Model. Take the matrix group determined by the competency index data as the input data of BP neural network, the vector representing the corresponding evaluation results as the output neural network result, and the matrix data of analytic hierarchy process as the training sample, so that the weights and thresholds held by the neural network are the correct internal results of the network after adaptive learning, and the trained BP neural network can be used as an efficient tool. The objects other than the sample mode are evaluated accordingly, and the evaluation of BP network is carried out using MATLAB software.

4.2.1. BP Network Structure Design. The vector model of BP network in the model established in this paper is shown in Figure 8.

$IW^{1,1}$ is the connection weight vector between the hidden layer neuron and the input vector, and the size is 13×14:

$$IW^{1,1} = \begin{pmatrix} iw_{1,1}^{1,1} & iw_{1,2}^{1,1} & \cdots & iw_{1,14}^{1,1} \\ iw_{2,1}^{1,1} & iw_{2,1}^{1,1} & \cdots & iw_{2,14}^{1,1} \\ \vdots & \vdots & \ddots & \vdots \\ iw_{13,1}^{1,1} & iw_{13,2}^{1,1} & \cdots & iw_{13,14}^{1,1} \end{pmatrix}. \tag{7}$$

The threshold value of the output layer neuron, n^2, is the intermediate operation result of the output layer neuron, and the size is 1×1.

$$n^2 = LW^{2,1} a^1 + b^2. \tag{8}$$

a^2 is the output result of the output layer, and the size is 1×1:

$$\begin{aligned}a^2 &= f^2\left(n^2\right) \\ &= f^2\left(LW^{2,1} a^2 + b^2\right) \\ &= f^2\left[LW^{2,1} f^1\left(IW^{1,1} p + b^1\right) + b^2\right] \\ &= \operatorname{logsig}\left[LW^{2,1} \log\sin\left(IW^{1,1} p + b^1\right) + b^2\right].\end{aligned} \tag{9}$$

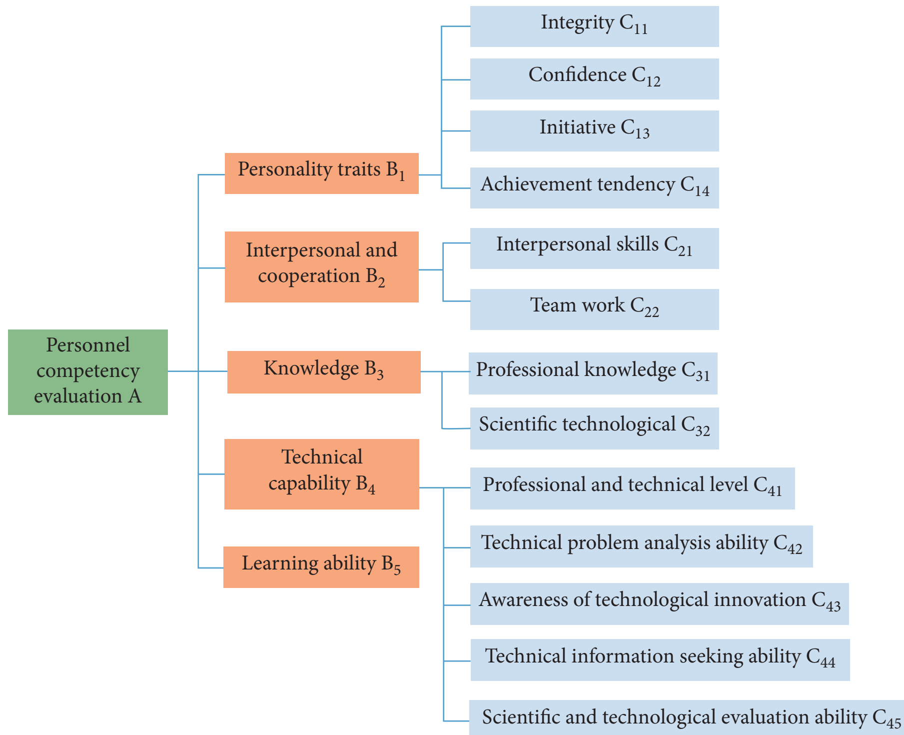

FIGURE 7: Personnel competency model.

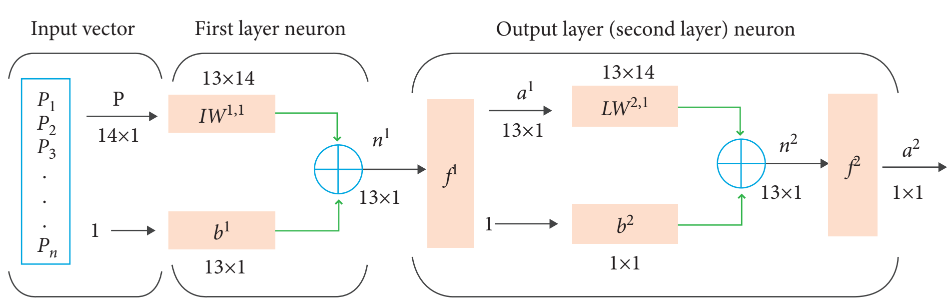

FIGURE 8: Vector model of two-layer BP network.

4.2.2. BP Network Learning Algorithm and Selection of Relevant Parameters. For the BP neural network diagram shown in Figure 7, Newton algorithm is used to correct the weight and threshold of each layer. Set K as the number of iterations, and then correct it according to the following formula:

$$x_{k+1} = x_k - A_k^{-1} g_k. \qquad (10)$$

k is the connection weight vector or threshold vector between the layers of iteration; $g_k = \partial E_k / \partial x_k$ is the gradient vector of the neural network output error to each weight or threshold value of the kth iteration, and the negative sign indicates the opposite direction of the gradient, that is, the fastest descending direction of the gradient; E_K is the neural network of the kth iteration. The design here is MSE (mean square error); A_K is the current weight and threshold of the error performance function value of Hessian matrix (second derivative).

Although the Newton iterative method has fast convergence speed, it needs to solve Hessian matrix in every operation. In this way, the amount of calculation will be very large. Quasi Newton algorithm introduces a group of matrices to replace Hessian matrix. It does not need to calculate the second derivative, and can be approximated well, which not only keeps the speed of Newton's algorithm, but also avoids the tediousness of Newton's algorithm. This paper adopts BFGS algorithm, whose function is named in MATLAB neural network toolbox.

4.2.3. BP Network Training and Testing. The competency indicators *C11*, *C12*, *C13*, *C14*, *C21*, *C22*, *C31*, *C32*, *C41*, *C42*, *C43*, *C44*, *C45*, and *B5* are used as the input vectors *P1*, *P2*,. . .*P14* of the neural network. The competency indicators *C11*, *C12*, *C13*, *C14*, *C21*, *C22*, *C31*, *C32*, *C41*, *C42*, *C43*, *C44*, *C45*, and *B5* are used as the input vectors *P1*, *P2*,. . .*P14* of the neural network. First, normalize the value of each competency index, that is, divide all the data by 10 to unify it to the range of (0, 1). The processed data are divided into two parts. The first 18 groups of data are used as network learning samples for training neuron connection weights, and the last 6 groups of data are used for testing. When the training times are 130, the training reaches the required accuracy.

The first 18 groups of data are used as network learning samples for training neuron connection weights, and the last 6 groups of data are used for testing. When the training times are 130, the training reaches the required accuracy.

As can be seen from Table 1, the relative error between the training results and the expected output is very small, and the maximum relative error is −0.12%. After the training, input the six groups of verification data to the trained BP network and get the corresponding competency evaluation results of six personnel, as shown in Table 2. It can be seen that the maximum relative error between the output value (test result) obtained by using BP network and the expected value is 3.8%. In the competency evaluation, this error range is completely acceptable. Store the trained BP neural network in the file; in this way, when encountering similar evaluation problems, as long as the competency index data of the personnel to be evaluated are input, the evaluation results can be obtained immediately by starting the network, and the network output results should be multiplied by 10 to restore to the competency evaluation score.

Table 1: Learning results.

Number	Training results	Expected output	Relative error (%)
1	0.8625	0.8624	−0.01
2	0.6752	0.6753	0.01
3	0.5144	0.5144	0.00
4	0.6752	0.6752	0.00
5	0.5204	0.5201	−0.06
6	0.5700	0.5693	−0.12
7	0.4872	0.4876	0.08
8	0.7991	0.7992	0.01
9	0.5192	0.5191	−0.02
10	0.5659	0.5663	0.07
11	0.6158	0.6158	0.00
12	0.4215	0.4215	0.00
13	0.8213	0.8212	−0.01
14	0.6197	0.6194	−0.05
15	0.5960	0.5965	0.08
16	0.6916	0.6918	0.03
17	0.5232	0.5232	0.00
18	0.7452	0.7452	0.00

Table 2: Test results.

Number	Training results	Expected output	Relative error (%)
1	0.4951	0.5155	4.20
2	0.6291	0.6603	4.70
3	0.5219	0.5289	1.30
4	0.5148	0.5063	−1.60
5	0.6836	0.6623	−3.20
6	0.7399	0.7379	−0.30

5. Discussion

This paper is a small part of the multi-dimensional post competency evaluation model in human resource management under the background of artificial intelligence. It applies the existing machine learning methods to a reasonable talent selection system. Consider the comprehensive quality of candidates from a multi-dimensional perspective.

In addition, facing the increasingly competitive market environment, enterprises especially need talents who can bring high performance in their jobs to control the development and growth of enterprises in the market competition. Therefore, the talent selection of enterprises is also particularly important. However, because the traditional talent selection pays too much attention to the educational background and knowledge and skill level of candidates, it cannot meet the needs of matching people with one job and one organization in the new era of enterprises, so the people selected are often only qualified employees of the position rather than having excellent performance. Based on this, this paper explores an objective and effective way of talent selection around the competency model theory, which provides a basis for enterprises to select and employ people scientifically and effectively. The research results can be used not only for the evaluation of job competency of external candidates but also for the promotion and selection of various talents within the enterprise. The research results created in this paper can be directly used by human resource management departments, not only for the evaluation of candidates' work ability, but also for the promotion and selection of all kinds of talents within the enterprise. The assessment process for the post competence of the company's top management can be roughly divided into three steps: preparation for the assessment, implementation of the assessment, and completion of the assessment. The analysis of the evaluation results of managers' post competence can achieve the purpose of distinguishing, evaluating, and developing the abilities of senior managers. Through the post competency assessment of senior managers, the gap between the tested and the standard post competency level requirements can be found, and then the weak elements or links of the tested can be found, and then targeted training can be carried out and targeted training plans can be formulated to improve the effect of training development.

6. Conclusion

Based on the analysis of the main principles and characteristics of competency model in current human resource management, this paper selects different level indicators of the model. Aiming at the human resource management goal of competency model, the modeling analysis is carried out based on the BP neural network method. The main conclusions are as follows:

(1) The competency model and talent selection system are described in detail, which lay a theoretical foundation for human resource management based on competency model.

(2) The model includes five competency indicators and 13 subcompetency indicators, including personality traits, interpersonal and cooperation, knowledge, technical ability, and learning ability.

(3) The personnel competency evaluation method based on BP neural network obtains the knowledge and experience of evaluation experts by learning the existing sample mode. When it is necessary to evaluate the personnel competency in the future, as long as the trained BP network is input with the corresponding competency index data matrix, the BP network will reproduce the expert's knowledge and experience and respond immediately without human intervention, so as to avoid human errors in the evaluation process. At the same time, the network system also has strong fault tolerance.

(4) The number of hidden nodes is the focus of BP network design. If there are too many nodes, the machine learning time is longer. On the contrary, the calculation time is short, but the fault tolerance is poor, and the ability to recognize the data that have not been learned and processed is poor. The number of hidden nodes is determined according to the plurality of results. For small-scale training, the quasi-Newton method has the advantage of fast convergence compared with other methods.

Data Availability

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

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

SAR Target Recognition via Monogenic Signal and Gaussian Process Model

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The monogenic signal and Gaussian process model are applied to synthetic aperture radar (SAR) target recognition. The monogenic signal is used to extract the features of the SAR image. The Gaussian process model is a statistical learning algorithm based on the Bayesian theory, which constructs a classification model by combining the kernel function and the probability judgement. Compared with the traditional classification model, the Gaussian process model can obtain higher classification efficiency and accuracy. During the implementation, the monogenic feature vector of the SAR image is used as the input, and the target label is used as the output to train the Gaussian process model. For the test sample to be classified, the target label is determined by calculating the posterior probability of each class using the Gaussian process model. In the experiments, the validations are carried out under typical conditions based on the MSTAR dataset. According to the experimental results, the proposed method maintains the highest performance under the standard operating condition, depression angle differences, and noise corruption, which verifies its effectiveness and robustness.

1. Introduction

Synthetic aperture radar (SAR) realizes the observation of the focused area through high-resolution imaging for intelligence interpretation. SAR target recognition classifies image chips of unknown targets through pattern recognition algorithms [1]. Generally, SAR target recognition methods first perform feature extraction to obtain effective feature vectors. In [2–8], the geometric shape features were used to design SAR target recognition methods, including target regions, shadows, and contours. In [9, 10], efficient dimensionality reductions were achieved through projection algorithms such as principal component analysis (PCA) and non-negative matrix factorization (NMF). Image analysis algorithms including the wavelet, empirical mode decomposition, and monogenic signal were employed for SAR image processing with application to target recognition [11–16]. In [17–19], SAR target recognition methods based on the attribute scattering centers were developed. The application of the classifier needs to be combined with the typical characteristics of the extracted features. At this stage, most of the classifiers used in SAR target recognition came from the traditional pattern recognition field. Representative ones are K nearest neighbors (KNN) [9, 20], support vector machine (SVM) [20–23], sparse representation-based classification (SRC) [23–29] etc. In recent years, traditional neural networks have gradually moved to a deeper level, promoting the rapid development of deep learning theory. In the field of SAR target recognition, deep learning algorithms represented by convolutional neural network (CNN) have been widely used [30–41], and their effectiveness has been verified.

In this paper, the monogenic signal and Gaussian process model are jointly applied to SAR target recognition. The monogenic signal can obtain an effective feature description through multilevel time-frequency decompositions of the original SAR image, which can better reflect the target characteristics [12–15]. The Gaussian process model [42–45] is a statistical learning algorithm based on the Bayesian framework, and all its statistical characteristics are determined by the mean and covariance functions. Therefore, the Gaussian process model is a nonparametric probability model. Compared with the traditional neural network, SVM, and other classification mechanisms, the Gaussian process model greatly reduces the parameter scale, simplifies the overall optimization process, and enhances the convergence of the model. In the application of Gaussian process model, prior knowledge can be represented as prior probability into the model, and the model's ability to describe actual problems can be improved by flexible selection of covariance functions. And the modeling and analysis of regression or classification problems can be realized. Therefore, this paper chooses Gaussian process model as the basic classifier for SAR target recognition. First, a binary classifier is designed, and then a multiclass classifier is promoted through a one-to-one voting mechanism to meet the multiclass decision-making problem in SAR target recognition. In the specific implementation process, the feature vectors of the training and test samples are first extracted from the monogenic signal. The Gaussian process classification model is trained with the feature set of the training sample as input. For the feature vector of the sample to be identified, it is input into the trained Gaussian process model to obtain its target label. In the experiment, typical scenarios are set based on the MSTAR dataset to test the proposed method, whose performance is compared with some existing methods. The experimental results prove the effectiveness and robustness of the proposed method.

2. Feature Extraction Based on Monogenic Signal

The monogenic signal is an expansion of the analytic signal in a high-dimensional space. In particular, for image data, the two-dimensional monogenic signal can be used for characteristic analysis [12–15]. The monogenic signal is the product of the combination of the signal itself and its Riesz transform. The Riesz transformation of the signal $f(z)$ is denoted as $f_R(z)$, where $z = (x, y)^T$ represents two-dimensional coordinates. The monogenic signal $f_M(z)$ is calculated as follows:

$$f_M(z) = f(z) - (i, j) f_R(z), \tag{1}$$

where both i and j are imaginary units. $f(z)$ and its Riesz transform correspond to the real part and imaginary part of the monogenic signal, respectively. Accordingly, the decompositions of the monogenic signal are defined as follows:

$$A(z) = \sqrt{f(z)^2 + \left|f_R(z)\right|^2}, \tag{2}$$

$$\varphi(z) = a\tan 2\left(\left|f_R(z)\right|, f(z)\right) \in (-\pi, \pi], \tag{3}$$

$$\theta(z) = a\tan 2\left(\frac{f_y(z)}{f_x(z)}\right) \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right]. \tag{4}$$

In the above equations, $f_x(z)$ and $f_y(z)$ correspond to the i-imaginary part and j-imaginary part of the monogenic signal, respectively; $A(z)$ represent the amplitude information; and $\varphi(z)$ and $\theta(z)$ correspond to the local phase and azimuth information, respectively.

The three types of features obtained based on monogenic signal have different characteristics. Among them, $A(z)$ mainly reflects the intensity distribution of the image. $\varphi(z)$ and $\theta(z)$ reflect the local detail information and shape characteristics of the image. Therefore, the joint use of the decompositions from the monogenic signal is conducive to construct more informative features.

3. Gaussian Process Model for Classification

Gaussian process model is a new kernel method developed on the basis of Bayesian neural network, which can be used to deal with classification and regression problems in machine learning. Due to its superior robustness, the Gaussian process model has been applied and verified in pattern classification and recognition problems [42–45].

3.1. Binary Classification. Generally, the Gaussian process model includes three parts: likelihood function definition, hidden variable function definition, and posterior probability calculation. The classification algorithm based on Gaussian process model uses Gaussian function to approximate the hidden variable function of the classification process. Representative methods include Laplace method, Expectation Propagation method, and Kullback-Leibler divergence minimization method.

For a training set D containing N observations, $D = \{(x_i, y_i)\}_{i=1}^{N}$, where $x_i \in R^d$ is the ith input sample, d is the dimension, and its corresponding binary category label is denoted as y_i, in which $y_i = 1$ represents the positive class, and $y_i = -1$ represents the negative class. $X = [x_i, \cdots, x_i, \cdots, x_N]$ represents a $N \times d$- dimensional matrix. For the input sample x_i, an implicit function f_i is defined accordingly. $f = [f_1, \cdots, f_N]$ contain the implicit functions of all input samples. At the same time, with the Sigmoid function $\rho(\cdot)$, $\rho(f_i) = p(y_i = 1/f_i)$, the output of each implicit function is constrained between $[0, 1]$. Assuming that each sample is independent and identically distributed, their joint probability distribution can be calculated as follows:

$$p\left(\frac{y}{f}\right) = \prod_{i=1}^{N} p\left(\frac{y_i}{f_i}\right) = \prod_{i=1}^{N} \rho(y_i, f_i). \tag{5}$$

Assuming f_i a zero mean Gaussian distribution, the prior probability $p(f/X)$ is described as follows:

$$p\left(\frac{f}{X}\right) = N(0, K) = \frac{1}{(2\pi)^{L/2}|K|^{1/2}} \exp\left\{-\frac{1}{2} f^T K^{-1} f\right\}. \tag{6}$$

In (6), K refers to the covariance matrix of f. The posterior probability of implicit function is calculated as follows:

$$p\left(\frac{f}{X, y, \theta}\right) = \frac{p(y/f)p(f/X)}{p(y/X, \theta)}, \tag{7}$$

where $p(y/f)$ is the likelihood function and $p(y/X, \theta)$ represents the marginal probability. The Laplace approximation algorithm can be used to solve the posterior probability $p(f/X, y, \theta)$ and obtain the corresponding estimated value $q(f/X, y, \theta)$. The second-order Taylor series will be expanded at the maximum posterior probability $\log p(f/X, y, \theta)$, and the results are as follows:

$$q\left(\frac{f}{X, y, \theta}\right) = N\left(\hat{f}, A^{-1}\right) \infty \exp\left(-\frac{1}{2}(f - \hat{f})^T A (f - \hat{f})\right), \tag{8}$$

where $\hat{f} = \operatorname{argmax}_f p(f/X, y, \theta)$, $A = -\nabla\nabla p(f/X, y, \theta) |f = \hat{f}$.

$p(y/X, \theta)$ and f are independent of each other, so the problem can be reorganized as follows:

$$\begin{aligned} \varphi(f) &= \log p\left(\frac{y}{f}\right) + \log p\left(\frac{f}{X}\right) \\ &= \log p\left(\frac{y}{f}\right) - \frac{1}{2} f^T K^{-1} f - \frac{1}{2}\log|K| - \frac{L}{2}\log 2\pi. \end{aligned} \tag{9}$$

The posterior probability can be obtained as

$$\begin{aligned} p\left(\frac{f}{X, y, \theta}\right) &\approx q\left(\frac{f}{X, y, \theta}\right) \\ &= N\left(\hat{f}, A^{-1}\right) = N\left(\hat{f}, \left(W + K^{-1}\right)\right). \end{aligned} \tag{10}$$

In addition, the marginal probability distribution can be expressed as

$$\log p\left(\frac{y}{X, \theta}\right) = -\frac{1}{2} f^T K^{-1} f + \log p\left(\frac{y}{\hat{f}}\right) - \frac{1}{2}\log|B|. \tag{11}$$

In equation (11), $|B| = |K| \cdot |K^{-1} + W| = |I_n + W^{12} K W^{12}|$. θ represents hyperparameters, which can be solved by maximizing (11). For a given test sample x, the probability distribution of the corresponding implicit function f_* is

$$\frac{f_*}{X, y, x_*} \sim N\left(K_* K^{-1}\hat{f}, K_* - K_* \tilde{K}^{-1} K_*^T\right), \tag{12}$$

where $\tilde{K} = K + W^{-1}$. The probability of the output corresponding to $y_* = 1$ is

$$\overline{\rho}(f_*) = \int \rho(f_*) p\left(\frac{f_*}{X, y, x_*}\right) df_*. \tag{13}$$

According to the probability of the corresponding classes, the target label of the test sample can be determined using the binary classification.

3.2. Multiclass Classification. The traditional Gaussian process model can be directly used for binary classification, but practical problems often involve the discrimination of multiple classes. Therefore, it is necessary to extend the binary classification to multiple ones in order to realize the direct classification of multiple classes. Among them, a representative method of extending binary classification to multiple classifications is the one-to-one voting mechanism. This paper uses this method to extend the traditional binary classifier based on Gaussian process mode for multiclass classification. The implementation process is as follows:

(1) In the training stage, the training samples of class 1~k are combined in pairs to obtain $C_k^2 = k(k-1)/2$ combinations. The Gaussian process model is used to train each combination to obtain the corresponding binary classifier $C_{i,j}$, where $i \in \{1, \cdots, k\}, j \in \{1, \cdots, k\}$.

(2) In the classification stage, the target label of unknown samples is judged through the voting mechanism. First, the initial number of votes is set for each class to 0; then, the $k(k-1)/2$ binary classifiers which have been trained are used to classify the test samples. When the classifier $C_{i,j}$ determines the ith class, the number of votes for the ith class is increased by 1. If the classifier $C_{i,j}$ judges the test sample to be the jth class, the number of votes for the jth class is increased by 1. Finally, the total number of votes obtained for each class is counted, and the category with the highest number of votes is judged to be the target label of the test sample.

In this paper, the binary classification mechanism of the Gaussian process model is combined with the one-to-one voting mechanism to obtain a multiclass classifier.

3.3. Target Recognition Procedure. In this paper, the monogenic signal and Gaussian process model are applied to SAR target recognition, which are used for feature extraction and classification, respectively. Figure 1 briefly shows the basic process of the proposed method. The main body is divided into two stages: training and testing. The main implementation steps are summarized as follows:

Step 1: The monogenic signal is used to perform feature extraction on all training samples.

Step 2: The monogenic feature vectors of the training sample are used as inputs and the corresponding target labels as output to train a multiclass Gaussian classification model.

Step 3: The monogenic signal is used to perform feature extraction on the test sample to be classified.

Step 4: The monogenic feature vector of the test sample is input into the Gaussian process model after training, and the posterior probability of each class is calculated.

Step 5: The target label of the test sample is determined according to the principle of the largest number of votes.

Compared with the traditional SAR target recognition methods, the proposed one introduces Gaussian process

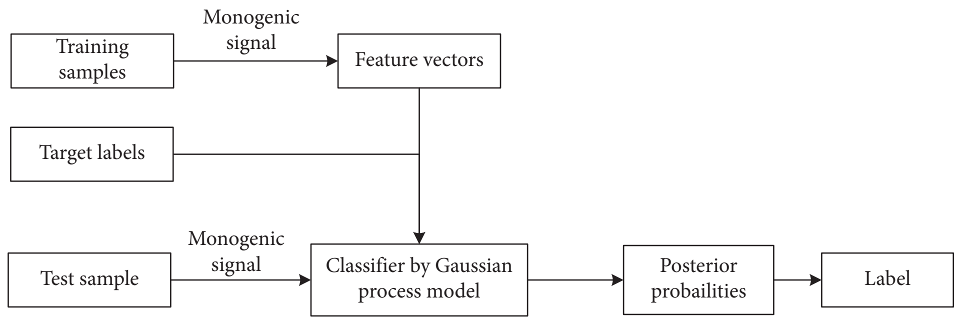

Figure 1: Procedure of target recognition method.

model, which provides a statistical way for decision. Therefore, it can obtain the optimal decision in the sense of probability. By combining the decision criteria of the maximum posterior probability and the maximum number of votes, it is helpful to obtain more reliable target recognition results.

4. Experiments

4.1. Description of the Dataset. The MSTAR dataset is employed to set up typical test scenarios to carry out experiments and verification. The appearances of the targets included in the dataset are shown in Figure 2.

Some existing SAR target recognition methods are selected in the comparison algorithms, including NMF [10], Mono [12], BEMD [16], and ESENet [136]. These four types of reference methods basically cover the most commonly used features and classifiers in existing SAR target recognition. In the subsequent experiments, three experimental scenarios are set to investigate the proposed method, namely: Scenario 1: standard operating condition, involving 10 types of targets, Scenario 2: depression angle differences, involving 3 types of targets, and Scenario 3: noise corruption, involving 10 types of targets.

4.2. Results and Discussion

4.2.1. Scenario 1. Table 1 gives a description of the standard operating condition in Scenario 1, including 10 types of targets. The training set uses SAR images at 17° depression angle, and the classifier is obtained to test the samples at 15° depression angle. The comparison shows that the target configurations between the two sets remain the same, with only a 2° depression angle difference, so their overall correlation is strong. Figure 3 shows the results of the proposed method in the current scenario, the single-class recognition rate is higher than 98.5% (shown in diagonal elements), and the average recognition rate of 10 classes reaches 99.32%, which reflects the effectiveness of the proposed method. The average recognition rates of various methods under Scenario 1 are shown in Table 2. The recognition rates of NMF, monogenic signal, BEMD, and ESENet methods are 98.26%, 98.69%, 99.02%, and 99.12%, respectively, which are all higher than 98%. It can be seen that the recognition problem under the standard operating condition is relatively simple. By comparing the average recognition rates of various methods, it can be seen that the method in this paper has some performance advantages. The recognition rate of the ESENet method under the current condition is second only to the proposed method, which benefits from the classification ability of the deep learning model. In this paper, the discriminative features of the target in the SAR image are obtained through the monogenic signal, and the statistically optimal classification model is obtained by introducing the Gaussian process model, which effectively improves the target recognition performance under the standard operating condition.

4.2.2. Scenario 2. The extended operating condition refers to the large differences between the test sample and the training sample due to the changes in the SAR data acquisition conditions. Typically, the extended operating conditions in SAR target recognition include target configuration differences, depression angle differences, and noise corruption. In this experiment, the proposed method is tested under the condition of different depression angles, and Scenario 2 shown in Table 3 is set. Among them, the samples at 17° depression angle are used for training; the samples at 30°, and 45° depression angle are used for classification, which shows that there are large depression angle differences between the training and test samples. Different methods are examined on the two test sets, and the recognition results are obtained as shown in Figure 4. Comparing the results at the two depression angles, the overall performance at 30° is significantly better than 45°, indicating that large depression angle differences will lead to greater image differences. From the results at the two depression angles, the method in this paper has achieved the highest average recognition rate, showing its better robustness. The monogenic signal can better analyze the relevant characteristics of the SAR images. The Gaussian process model can more effectively explore the internal correlation between the real target labels by deriving the best statistical model, so the robustness of the recognition method to the depression angle difference can be improved.

4.2.3. Scenario 3. Noise corruption is another typical extended operating condition, mainly because the signal-to-noise ratio (SNR) of the SAR image to be identified is

Figure 2: Targets in the MSTAR dataset for experiments.

Table 1: Description of the Scenario 1.

Type	Training set (17°)		Test set (15°)	
	Configuration	Samples	Configuration	Samples
BMP2	9563	232	9563	194
BTR70	C71	232	c71	195
T72	132	231	132	195
T62	A51	298	A51	272
BRDM2	E-71	297	E-71	273
BTR60	7532	255	7532	194
ZSU23/4	d08	298	d08	273
D7	13015	298	13015	273
ZIL131	E12	298	E12	273
2S1	B01	298	B01	273

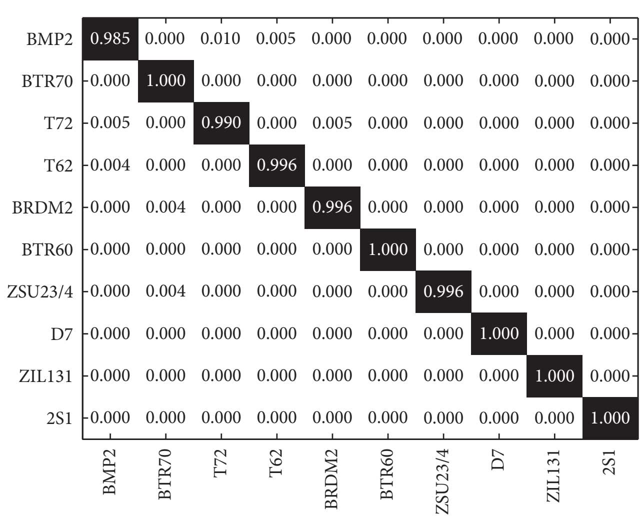

Figure 3: Recognition results under Scenario 1.

Table 2: Comparison of results under Scenario 1.

Method	Average recognition rate (%)
Proposed	99.32
NMF	98.26
Mono	98.69
BEMD	99.02
ESENet	99.12

Table 3: Description of Scenario 2.

	Depression	2S1	BDRM2	ZSU23/4
Training set	17°	299	298	299
Test set	30°	288	287	288
	45°	303	303	303

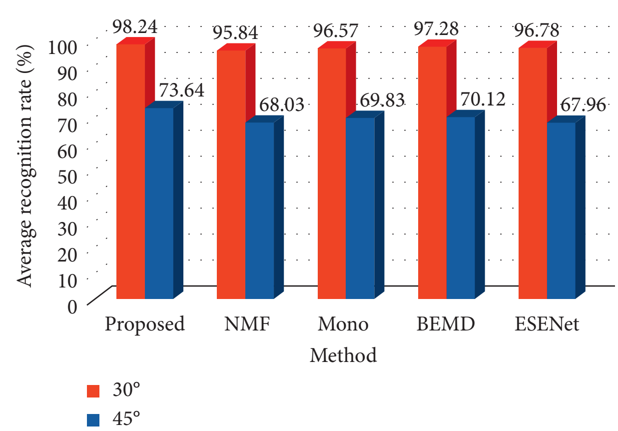

Figure 4: Comparison of results under Scenario 2.

relatively low, resulting in a large difference from the training sample. Based on the test and training samples in Table 1, different degrees of noises are added to the test samples, so as to construct test sets with multiple SNRs in Scenario 3. Specifically, according to the test sample's own energy, the additive Gaussian noise is obtained according to the preset SNR, and it is mixed into the original test sample to obtain the noisy test sample corresponding to the noise level. Then, various methods are tested at each noise level, and the recognition results shown in Figure 5 are obtained. It can be seen that as the noise level continues to decrease, the average recognition rates of various methods show clear downward trends. The comparison shows that the method in this paper achieves the highest recognition rate at each noise

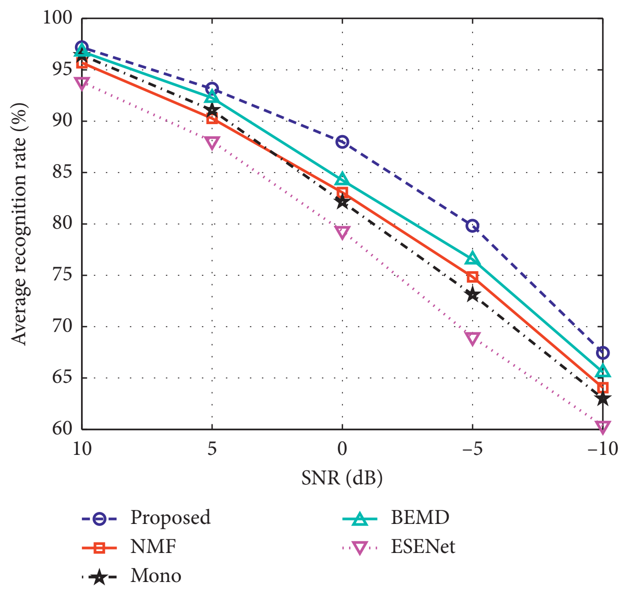

Figure 5: Comparison of results under Scenario 3.

level, reflecting its stronger noise robustness. In the time-frequency decomposition of the monogenic signal, the possible influence of noise is fully considered. Therefore, the feature vector finally obtained has certain noise robustness. In the derivation of the Gaussian process model, the possible noise influence is fully considered. Therefore, the resulting feature vector has certain noise robustness. The classification model has strong robustness to noise. Similar to the case of the depression angle differences, the performance of the ESENet method under the condition of noise interference is the most severe mainly due to the large image difference between the training sample and the test sample, which leads to a significant decrease in the performance of the final classification model.

5. Conclusion

In this paper, the monogenic signal and Gaussian process model are applied to SAR image target recognition. The Gaussian process model constructs a Bayesian learning model by combining the kernel function and probability discrimination to obtain the best regression model in the statistical sense. The monogenic feature vector of the SAR image is used as the input, and the target label is the output. The regression mapping relationship between the two is constructed, so as to obtain a robust classification model. Based on the MSTAR dataset, three typical scenarios are set to test the proposed method and compared with the existing methods. The experimental results are as follows: In Scenario 1, i.e., the standard operating condition, the average recognition rate of the proposed method for 10 types of targets reaches 99.28%, which is higher than the four types of reference methods, verifying its effectiveness for multiclass target recognition problems under the standard operating condition. Under the condition of Scenario 2, i.e., depression angle differences, the average recognition rate of the proposed method for the test set at 30° and 45° depression angles is 98.04% and 73.13%, respectively, which is higher than the reference methods, verifying its robustness to the depression angle difference. In Scenario 3, i.e., noise corruption conditions, the proposed method maintains the highest average recognition rate under each noise level, showing its noise robustness.

Data Availability

The dataset can be accessed upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

Short-Term Prediction Method of Solar Photovoltaic Power Generation Based on Machine Learning in Smart Grid

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In order to improve the accuracy of ultra short-term power prediction of the photovoltaic power generation system, a short-term photovoltaic power prediction method based on an adaptive k-means and Gru machine learning model is proposed. This method first introduces the construction process of the model and then builds a short-term photovoltaic power generation prediction model based on an adaptive k-means and Gru machine learning models. Then, the network structure and key parameters are determined through experiments, and the initial training set of the prediction model is selected according to the short-term photovoltaic power generation characteristics. And the adaptive k-means is used to cluster the initial training set and the photovoltaic power on the forecast day. The Gru model is trained on the initial training set data of each category, and the generated power is predicted in combination with the trained Gru model. Finally, considering three typical weather types, the proposed method is used for simulation analysis and compared with the other three traditional photovoltaic power generation single prediction models. The comparison results show that the proposed short-term photovoltaic power generation prediction method based on an adaptive k-means and Gru network has better effect, better robustness, and less error.

1. Introduction

In the 21st century, with the increasingly fierce global economic competition, the demand for energy in various countries is increasing, and the energy problem has become a key factor affecting the international influence of countries [1]. However, with the continuous growth of social and economic development demand, the use and consumption of traditional fossil energy are also increasing, which not only causes the global shortage of traditional fossil energy but also causes a lot of pollution to the environment, and these pollution are serious and difficult to control. There is no doubt that this will run counter to China's proposal to build a resource-saving and environment-friendly society [2–4].

There are many renewable energy sources on Earth, including solar energy, wind energy, and many other energy sources, but all renewable energy sources have a common feature, that is, it is not easy to collect, and there is great inconvenience. Compared with other energy sources, solar energy is easy to obtain, the use conditions are unlimited, and there are no major technical barriers to its application. At the same time, it is inexhaustible. It is a new type of green energy widely used in the world at present. The most direct use of solar energy is photovoltaic power generation [5–7].

As the largest developing country, China's annual total solar radiation is between 928 kWh/m^2–2333 kWh/m^2, and the annual average solar radiation is 1626 kWh/m^2. In most regions of China, the daily average radiation can reach 4 kWh/m^2, which shows that China has superior natural conditions for photovoltaic power generation [8–11]. Globally, the newly added PV installed capacity increased from 39.6 gw in 2010 to 580.16 gw in 2019. The specific growth of each year is shown in Figure 1.

With the policy support of encouraging the development of photovoltaic power generation in various aspects, China has made breakthroughs in photovoltaic power generation technology in recent years. Especially for some central and western regions of China, affected by other energy structures, they have to transform in this direction. At the same

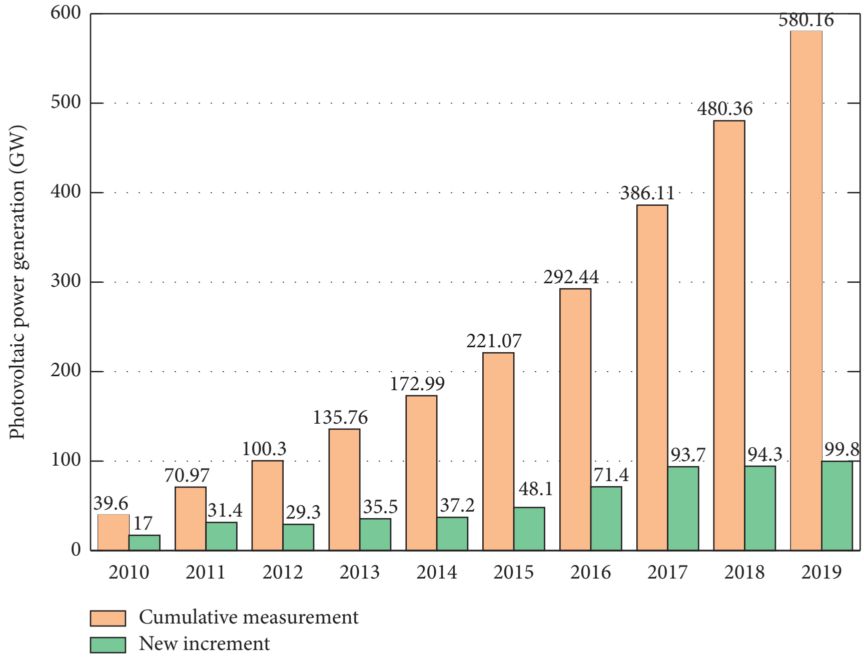

Figure 1: Global cumulative and newly added PV installed capacity (2010–2019).

time, more and more difficulties are faced, and the research on the prediction of photovoltaic power generation is also increasing year by year.

Photovoltaic power generation is the most important way for humans to use solar energy at present. It will not affect the environment during this utilization process but it has the advantages of short construction period, mature technology, large-scale development, and sustainable development. It has broad development prospects and is more and more valued by people [12]. Since photovoltaic power generation can only be carried out under sunshine, and there are weather changes such as day and night alternation and cloudy, sunny, rainy, and snowy on Earth, the photovoltaic power station can only generate electric energy during the day. It is a typical intermittent power supply. Its power generation is affected by meteorological conditions such as solar irradiation intensity and ambient temperature and has great volatility and randomness [13–16].

These characteristics of photovoltaic power generation will have a severe impact on the stable operation of the power grid when large-scale photovoltaic power generation is connected to the grid and have a negative impact on the entire power system, which is one of the important challenges faced by large-scale photovoltaic power generation. Relevant research shows that when the grid-connected capacity of photovoltaic power generation accounts for more than 15% of the total power generation of the power system, its fluctuation may cause the paralysis of the power system [3]. If the photovoltaic power generation power can be predicted timely and accurately, the impact of the fluctuation of photovoltaic power generation on the power grid will be greatly reduced, which is of great significance to the power grid dispatching and the operation of photovoltaic power stations [17, 18]. It is an important topic for researchers in relevant fields at home and abroad to use some energy transfer equations or mathematical statistical algorithms to predict the photovoltaic power generation power in the future, know the output of photovoltaic power stations in advance and provide a reference for power grid dispatching and power station operation [19–24]. However, errors will inevitably occur in the prediction of photovoltaic power generation. If the error of the prediction method used is too large, it will pose a serious threat to the reliability of the photovoltaic output prediction system developed and cannot be popularized. As the proportion of photovoltaic power generation capacity in the total power generation capacity of the power system increases, the impact of these prediction errors on the stability of the power system also increases. Therefore, in order to increase the proportion of photovoltaic power generation capacity in the power system and improve the scale of photovoltaic power generation to expand its economic and social benefits, it is of great significance to make a short-term prediction of photovoltaic power generation [25–27].

The existing short-term photovoltaic power prediction methods can be roughly divided into two kinds, one is the physical method, the other is the statistical method. The physical method is generally to establish the prediction model through the solar radiation transfer equation and the operation equation of photovoltaic equipment; Statistical methods use the relationship between historical operation data to establish prediction models [28]. Because the physical prediction model needs to know the specific parameters of solar radiation equation and photovoltaic modules, its generalization ability is not strong, and the prediction accuracy is significantly lower than that of statistical methods, which have been less used. With the continuous breakthrough of human beings in the process of intellectualization and the continuous investment in research, scholars from various countries began to extend the research on photovoltaic power prediction methods from traditional statistical methods to artificial intelligence algorithms and achieved good results in photovoltaic power prediction research based on the neural network. Now the process of intellectualization has been deeply rooted in the hearts of Chinese and foreign people. No matter in any field or anywhere, people expect to realize intellectualization as soon as possible. This is also an important field of current research, and its performance is more superior and advanced than other methods. However, the traditional ANN is easy to fall into a trap called local extremum during training, and its accuracy still has great room for improvement. Moreover, the existing high-precision ANN prediction methods need high-precision input data, and it needs to manually select the factors that have a great impact on the photovoltaic power as the input samples, and a lot of preprocessing work needs to be performed on the sample data before training the neural network. When the sample is complex and the feature density is low, the shallow Ann may not be able to effectively learn the internal relationship between the input data and the output data, resulting in low prediction accuracy [29].

By comprehensively analyzing the research status of the above two different directions of point prediction and interval prediction, it can be found that the research and prediction with the increasing demand for photovoltaic in the world, and the research results emerge in endlessly. Among them, the model established by using the deep learning method has high prediction ability, and it is also one of the main directions of photovoltaic generation point prediction in the future.

2. Theoretical Basis of Photovoltaic Power Prediction

2.1. Adaptive k-Means Theory. In the case of three typical weather types, clustering the photovoltaic output power, respectively, can build a more targeted prediction model and further improve the prediction accuracy. Traditional k-means cannot actively determine the number of clusters without knowing the data set, so it is not suitable to cluster the input data set directly. Therefore, this paper introduces an adaptive k-means, which can automatically set the number of clusters according to the input data set. Its main idea is an iterative process based on distance [30]. The steps of k-means algorithm are as follows:

(1) First, according to our prediction needs, we build targeted models, mainly to determine the number of inputs, outputs, and interneurons
(2) The second step is to screen the constructed data set and randomly select k data as a center of our initial blood drug clustering, which is recorded as: $\{\lambda_1, \lambda_2, \ldots, \lambda_k\}$
(3) The third step is to calculate the Euclidean distance between the remaining samples and the cluster center through the algorithm and assign it to the nearest cluster center to form K clusters. The distance measurement formula is given in the following formula:

$$D(a,b) = \sqrt{\sum_{k=1}^{n} (a_k - b_k)^2}. \tag{1}$$

(4) In the fourth step, the cluster center is updated by the distance measurement method to be the mean value of all the samples belonging to the cluster
(5) After the above four steps are completed, a basic unit step is completed. After that, only steps (1), (2), and (3) need to be repeated until the algorithm converges

In addition, in order to reduce some unnecessary errors caused by manual operation to the calculation of the model, we have also made appropriate improvements to this method, mainly through some optimization methods of quantitative search samples to realize the automatic optimization of clustering. K-means selected in this paper is one of these methods, and its specific definition is shown in the following formula:

$$DBI = \frac{1}{k}\sum_{i=1}^{k} \max_{j\neq i}\left(\frac{C_i + C_j}{D_{i,j}}\right). \tag{2}$$

In order to avoid generating too many clusters, a threshold is used to limit the number of clusters, which is recorded as $k_{\max}$. The adaptive k-means clustering process is shown in Figure 2.

The strong randomness and large fluctuation of photovoltaic power generation are largely related to meteorological and environmental factors. Temperature, humidity, wind speed, total radiation, air pressure, and other factors have varying degrees of influence on photovoltaic power generation. Therefore, in this process, it is important to choose the right method, and this method can correctly express our impact on the short-term prediction of photovoltaic power generation. Through the expression of reference 28, we can find that this kind of influence factors are numerous and vary greatly and are related to various factors such as regions, among which the biggest influence factor is climate, which is mainly reflected in the variable factors of sunshine in the region. If the sunshine is sufficient and long, the photovoltaic power generation efficiency is high, otherwise the opposite is true. Therefore, when we choose variables and determine factors, we mainly rely on the above views.

2.2. GRU. GRU is a new neural network model developed from the deficiency of LSTM. The proposal of LSTM solves the problem of the RNN model. There is also a gated cyclic unit network in the cyclic neural network, which also solves the problem that RNN cannot deal with the dependence of large time step distance. GRU is a variant of LSTM and can also well capture long-distance dependency problems. The difference between GRU and LSTM lies in the number of gate units. GRU network simplifies the three gates of LSTM into gate units: the update gate and the reset gate. The reset

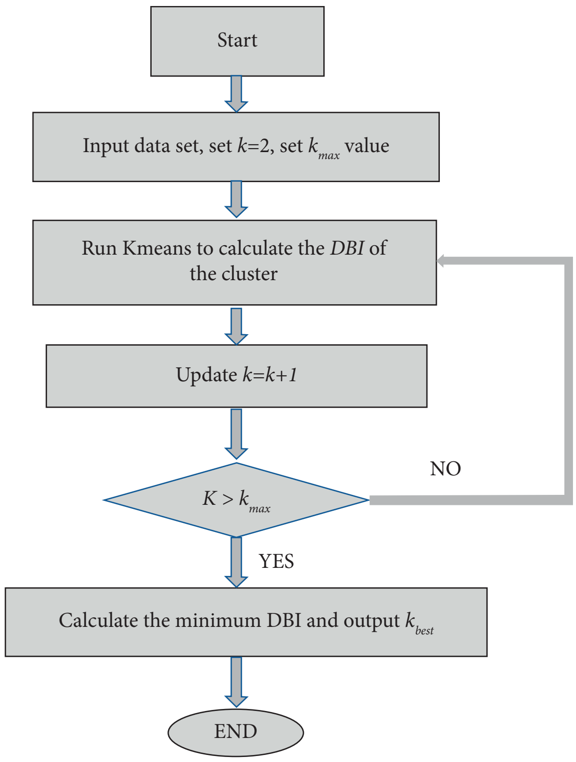

Figure 2: Adaptive k-means clustering flow chart.

gate is a combination of a memory cell and a hidden layer. Its function is to control the transmission of the hidden state information of the previous time to the candidate hidden state of the current time and then reset the candidate hidden state information at the current time. The update gate is a combination of the forgetting gate and the input gate. Its function is to realize the hidden function that the original structure does not have through its own designed structure and to update this hidden information through its own special structure. By simplifying the gate structure, the network model parameters are reduced, the operation becomes simpler, and the performance of the network model is improved. GRU network structure is shown in Figure 3.

As shown in Figure 3, GRU network is divided into reset gate r_t, update gate z_t, $\widetilde{H}_t$, and H_t. The calculation expressions for updating doors, resetting doors, and hidden states are as follows.

2.2.1. Update Gate. The input is the input X_t at the current time and the $\widetilde{H}_{t-1}$ at the back time, and the output of the update gate is z_t. z_t is the linear combination of X_t and H_{t-1}, and then input to Sigmoid function to get a value from 0 to 1.

$$z_t = \sigma\left(W_z X_t + U_z H_{t-1} + b_z\right). \tag{3}$$

2.2.2. Reset Gate. The input is still the input X_t at the H_{t-1} at the back time, and the output of the reset gate is r_t. r_t is the linear combination of X_t and H_{t-1}, and then input to Sigmoid function to get a value from 0 to 1.

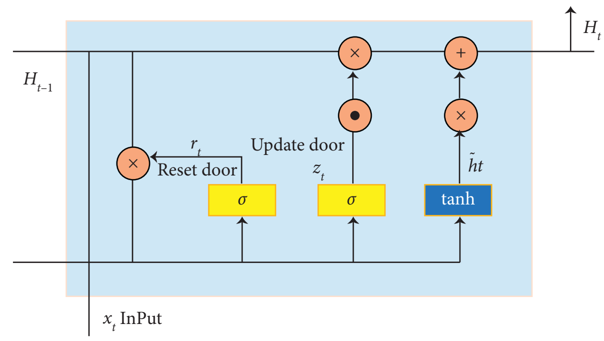

Figure 3: GRU network structure.

$$r_t = \sigma\left(W_r X_t + U_r H_{t-1}\right). \tag{4}$$

2.2.3. Candidate Hidden State. Multiply the reset gate output r_t and the H_{t-1} at the previous time by elements, and input the operation result into the tanh function after linear combination with the current input X_t, so that the value of the $\widetilde{H}_t$ is between −1 and 1.

$$\widetilde{H}_t = \tanh\left(W X_t + U\left(r_t \odot H_{t-1}\right) + b_h\right). \tag{5}$$

From the above formula, we can see the function of reset gate r_t. When $r_t = 0$, the result of element multiplication between the reset gate output r_t and the previous hidden state H_{t-1} is 0. It means that the H_{t-1} has no effect on the $\widetilde{H}_t$, which is equivalent to discarding the H_{t-1} information. Then the H_t at the current time is only related to the input X_t at the current time, which resets the hidden state. Because of this, resetting the gate at this time helps to capture short-term dependencies.

2.2.4. Hidden State. The update gate output z_t is linearly combined with the H_{t-1} at the previous time and the candidate hidden state at the current time.

$$H_t = \left(1 - z_t\right)\widetilde{H}_t + z_t \odot H_{t-1}. \tag{6}$$

From the above formula, we can see the function of the update gate z_t. When $z_t = 1$, then 1- $z_t = 0$. At this time, the hidden state H_{t-1} of the previous time completely gives the hidden state H_t of the current time and completely retains the hidden state of the current time. At this time, if there is a long-term dependency, the hidden state information can also be transmitted and retained. Because of this, GRU can capture long-term dependencies, which is also the most critical part of the GRU network. Then updating doors helps capture long-term dependencies.

3. Construction of the Joint Prediction Framework Based on Adaptive K-Means and GRU

3.1. Construction of the Joint Prediction Model. Because the photovoltaic output power curve has obvious similarity characteristics under similar weather conditions, this paper forecasts the photovoltaic output power under three typical weather conditions. The main steps of model construction are as follows:

Step 1: according to the input and output of the model, determine the basic input and output units of the model, as well as the number of neurons and the type of activation function;

Step 2: considering the weather conditions of the day to be predicted, select the historical similar day data as the initial training set;

Step 3: normalize all data to obtain the training set and the test set;

Step 4: use adaptive k-means for clustering analysis of historical data and predicted daily data under each weather and combine Gru for training and prediction;

Step 5: get the results of the photovoltaic power generation prediction model through model training.

The specific process of the model constructed by this process is shown in Figure 4.

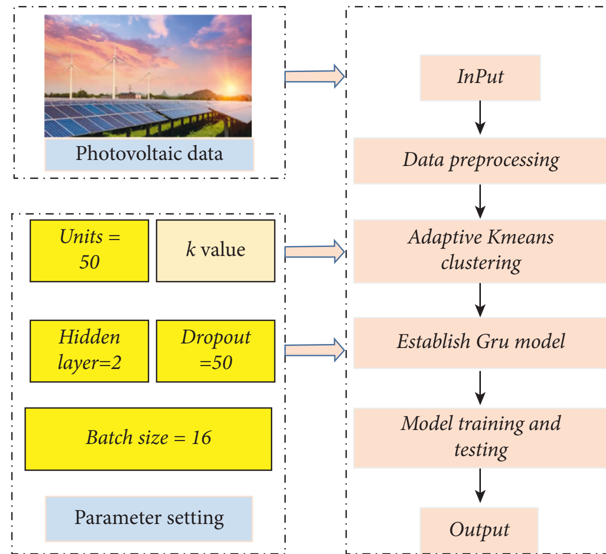

FIGURE 4: Prediction framework of photovoltaic output power based on adaptive k-means and GRU.

3.2. Establishment of the Photovoltaic Power Generation Prediction Data Set

3.2.1. Introduction to Original Data. The experimental data set in this paper is a photovoltaic power generation data set in a certain region. This data set records the relevant power generation data of more than 100 users equipped with solar power generation devices in 2020, and the data sampling frequency is 1 hour. That is, taking the power station as the unit, the respective power and meteorological data are recorded. The fields used in the power generation data table are shown in Table 1. The relationship between the three is: use = gen + grid. Use is the total power consumption of each part of the photovoltaic power station; Gen refers to the power generated by solar photovoltaic power generation itself; Grid refers to the power that the power station is connected to the power grid. A positive value indicates that it is connected to the power grid, and a negative value indicates that it is output to the power grid. The other two powers are always positive.

The format of the above power generation data set is different due to the different types of sensors configured by each household, and the format of the power consumption field is also different. When the time information is recorded, it mainly includes some data sets in the following three formats: type I data set contains a Gen (generated power) field, which can be directly used in the prediction experiment of photovoltaic output; Type II does not contain a Gen field, which needs to be obtained by subtracting grid data from use field; The third type is automatic accumulation during recording. To obtain the generated power of this period, you can obtain it by subtracting the data of adjacent periods. The unit of the three is kW, so the unit of photovoltaic output power in the full text is also kW.

The weather data matches the power generation data, and its specific description is shown in Table 2.

TABLE 1: Field description of photovoltaic power generation data.

Category	Full name
Date & time	Time
Use (kW)	Power consumption
Gen (kW)	Generating power
Grid (kW)	Grid power

Figure 5 shows the photovoltaic output power in one week. It can be seen that photovoltaic power generation has obvious diurnal periodicity, volatility, and randomness. Therefore, we will rely on the powerful feature learning ability of the deep learning algorithm to analyze and predict it and realize the effective capture of its characteristics.

3.2.2. Data Preprocessing. It can be seen from Figure 5 that the power generation data generally has the characteristics of stable change trend and relatively concentrated values. However, in some special times and stages, a part of the data is usually incomplete (lacking some interesting attribute values), inconsistent (including code or name differences), and vulnerable to noise (errors or abnormal values). At the same time, when the database is too large, the data sets often come from multiple heterogeneous data sources, showing low-quality data, and the results obtained from network training are often poor. Therefore, it is necessary to preprocess the original power generation data to eliminate the influence of the dimension of the data itself and other useless features to ensure the effectiveness of the sample data training, and it is necessary to carry out standardized processing.

At present, the normalization of maximum and minimum values based on numerical linear transformation is often adopted at home and abroad, which restricts the

Table 2: Description of meteorological data.

Category	Temp	Dewpt	Hum	Wgust	Wdird	Wdire
Description	Temperature	Dew time	Humidity	Wind speed	Wind direction azimuth angle	Wind direction
Category	Vis	Press	Windchill	Heatindex	Precipm	Conds
Description	Visibility	Pressure	Wind-chill index	Calorific value	Precipitation	Weather type

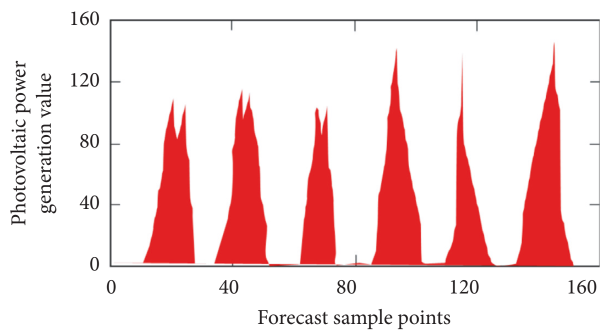

Figure 5: Actual output power of photovoltaic power generation.

Table 3: Description of meteorological data.

Evaluation value	Evaluation results
<15%	Excellent accuracy
16%–25%	Good accuracy
25%–50%	Average accuracy
>50%	Unreasonable accuracy

original data values to [0,1], that is, normalizing the data through the following formula:

$$X^* = \frac{X - X_{\min}}{X_{\max} - X_{\min}}, \quad (7)$$

where $X_{\max}$ and $X_{\min}$ and X^*, respectively, represent the maximum and minimum values of photovoltaic data types of the overall data set, as well as the standardized data obtained from the standardization of this formula, whose size is not greater than 1 and not less than 0.

3.3. Selection of Prediction and Evaluation Indicators for Photovoltaic Power Generation. The evaluation methods of the prediction algorithm mainly include: root mean square error RMSE, average absolute percentage error MAPE, square sum error SSE, mean square error MSE, and average absolute error MAE. In this paper, the root mean square error RMSE and average absolute percentage error MAPE are used to evaluate the prediction results.

(1) The formula of root mean square error RMSE is as follows:

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{N}\left(P_f' - P_a'\right)^2}{N}}, \quad (8)$$

where N is the predicted quantity; P_f' is the prediction data; P_a' Is the actual data; i is the prediction time.

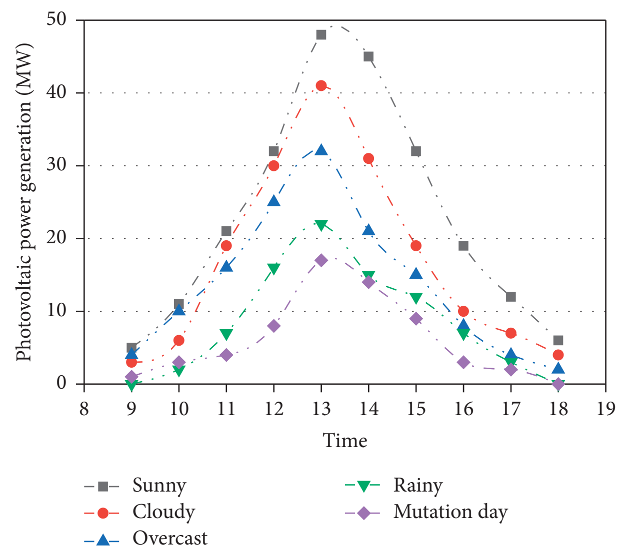

Figure 6: Photovoltaic power generation under different weather conditions.

(2) The average absolute percentage error MAPE, whose formula is as follows:

$$\text{MAPE} = \frac{100}{N}\sum_{t=1}^{N}\frac{\left|P_f' - P_a'\right|_0}{P_a'}\%, \quad (9)$$

where N is the total number of sample data; P_f' is the ith predicted value; P_a' is the ith actual value. The MAPE evaluation criteria for evaluating the prediction accuracy are shown in Table 3.

3.4. Model Input Feature Selection. This paper selects the photovoltaic power data in a certain interval of a photovoltaic power generation system and collects 24 sample points every day. It can only select the period of stable output of photovoltaic power for analysis. The photovoltaic power generation power under different weather is shown in Figure 6. When the weather is relatively stable, the photovoltaic power generation power is the highest in sunny weather, and the others are cloudy, cloudy and rainy, and snowy weather in turn. In stable weather, the power fluctuation of the photovoltaic system is small, and the output is relatively stable, which is close to the parabola as a whole. In sudden change weather, photovoltaic power generation fluctuates greatly, which has a great impact on the stable operation of the entire power grid. Therefore, distinguishing weather types is of great significance for the prediction of photovoltaic power generation.

To sum up, we can know that there are many factors that can affect photovoltaic power, but it mainly includes weather and time period. Therefore, the characteristic input of photovoltaic power prediction in this paper mainly includes the above two kinds.

3.5. Prediction Steps of Photovoltaic Short-Term Power Generation. The combined neural network prediction model established in this paper mainly highlights the impact of day type on the output power of the photovoltaic power generation system. When establishing the model, we need to focus on this point and improve the weight of day type index and do not need to consider the impact of weather factors when predicting. It can adapt to all kinds of weather and has strong adaptability and good prediction ability.

3.5.1. Determining Input Data. The number of nodes in the input layer corresponds to the input variables of the prediction model. The prediction model in this paper has a total of 12 input variables. Considering the specific geographical location of the photovoltaic power station selected in the paper, combined with historical data, the power generation between 18 : 00 a.m. in a day and 8 : 00 a.m. in the next day is almost 0, so the power generation of 10 power generation time series from 9 : 00 a.m. to 18 : 00 a.m. on the day before the prediction day is selected as the input to the prediction model.

In the prediction of photovoltaic power generation output, it is usually necessary to divide the sub models skillfully according to the type of day, otherwise the prediction model may fail. According to the factors that affect the photovoltaic power generation system, because the type of day has a large influence factor in the influencing factors of photovoltaic power generation output, the paper further increases the weight of the type of day index when establishing the prediction model.

3.5.2. Determining the Output Layer. The prediction result is to predict the generation output power in each period of the day, so there are n nodes at the output end, corresponding to the hourly output power between 9 : 00 and 18 : 00, respectively.

4. Case Analysis

4.1. Sample Data Selection. Considering the weather type, the photovoltaic power in sunny, cloudy, and rainy days is predicted by using the prediction model in this paper. The data comes from the field measured data of a city in China, including total radiation, humidity, temperature, and photovoltaic power generation. The data is the real data of 2020. The selected time period is between 9 : 00 and 18 : 00, and the sampling interval is 15 minutes, that is, the number of sampling points in a day is 40. The predicted days are the first period in the period, i.e., sunny days. The second period was cloudy and the third period was rainy. Due to the lack of snow data, it is not included in the analysis and prediction. The power fluctuation caused by meteorological factors in adjacent periods is small. Therefore, the data of similar days with the same weather similar to the forecast day is selected as the initial training set. According to the type of forecast days, the similar 10 days are selected as the initial training set.

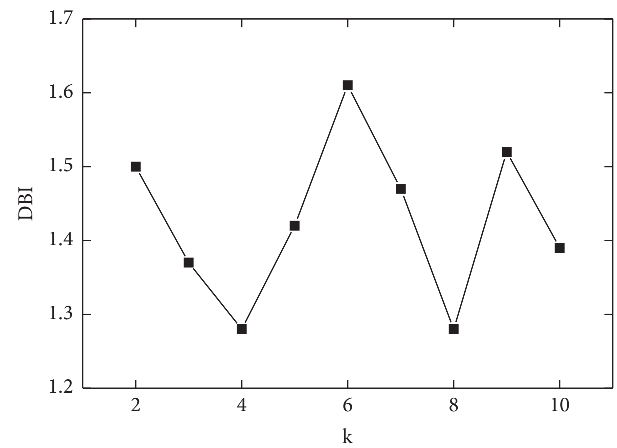

Figure 7: *DBI* with different k values.

4.2. Cluster Analysis. Taking the total radiation, humidity, and temperature of similar days and forecast days as inputs, the photovoltaic power generation power under three weather types is clustered, respectively. The initial training set is 400 time sampling points, plus the data of the forecast day, a total of 520 data. According to the previous analysis, adaptive k-means are used for clustering. Considering the length of the data, k_{max} is set to 10. Take time period 1 (sunny) as an example for analysis. The value range of K is [2, 10]. DBI when k takes different values is shown in Figure 7.

According to Figure 7, when k is taken as 6, DBI is the largest, which is 1.61; When k takes 4 and 8, DBI is the smallest, which is 1.28. At this time, the clustering effect is the best. Therefore, the data of the initial training set and the forecast day on sunny days are divided into three categories, which are called class 1, class 2, and class 3 here. Similarly, adaptive k-means are used to cluster the data of the initial training set and the predicted day in cloudy and rainy days, respectively. When k is taken as 4 when it is cloudy, DBI is the smallest, which is 1.12. In rainy days, K is taken as 4, and DBI is the smallest, which is 1.46.

4.3. Analysis of Prediction Results. In order to compare the advantages of the model constructed in this paper, in addition to the training of the constructed model, this paper also selects two other commonly used short-term prediction models (LSTM and BP) and a single GRU model for comparative analysis.

Among them, the photovoltaic power prediction results in sunny weather are shown in Figure 8, and the prediction

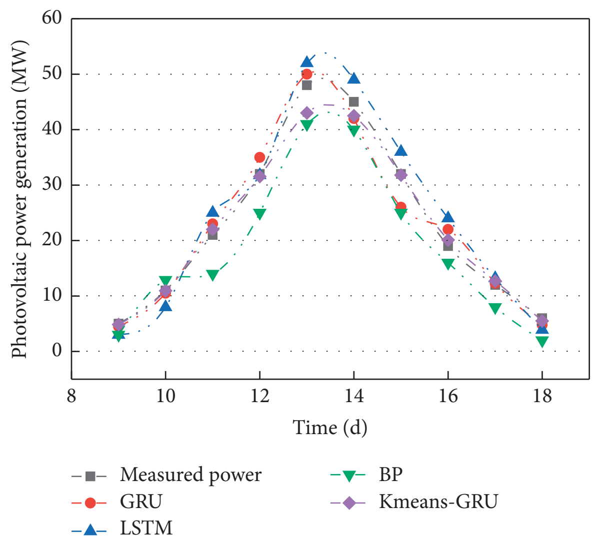

Figure 8: Photovoltaic power prediction results of different models on sunny days.

Table 4: Photovoltaic power prediction error in sunny weather.

Model	RMSE	MAPE/(%)
GRU	16.33	0.13
LSTM	19.24	0.21
BP	27.18	0.37
Kmeans-GRU	8.15	0.04

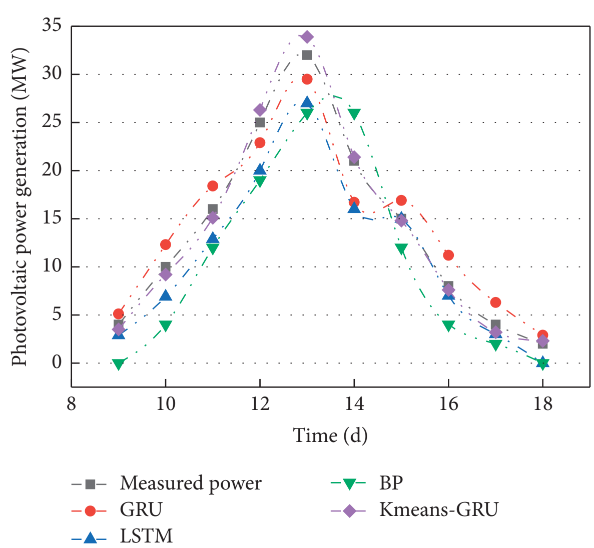

Figure 9: Photovoltaic power prediction results of different models for overcast world.

error is shown in Table 4. In sunny, the fluctuation of photovoltaic output curve is small, and the power change has a certain regularity. The four models show good prediction results. By analyzing MAPE and RMSE, it can be found that the error of the proposed adaptive k-means GRU prediction model is smaller than that of the single prediction model and the other two models, and the accuracy of the single model prediction is slightly reduced when the power curve fluctuates slightly at noon. Compared with GRU, LSTM, and BP model, the proposed prediction model based on adaptive k-means GRU can be better close to the actual power curve as a whole, and the fitting effect is the best.

Table 5: Photovoltaic power prediction error in cloudy weather.

Model	RMSE	MAPE/(%)
GRU	19.17	0.17
LSTM	23.16	0.27
BP	35.44	0.42
Kmeans-GRU	10.12	0.08

The photovoltaic output power prediction results and RMSE and MAPE results under cloudy weather conditions are shown in Figure 9 and Table 5, respectively. In cloudy weather, the sunshine is obviously lower than that in sunny weather due to the influence of weather. It is also due to the change of such complex factors that it is difficult for each model to control such variable factors, thus it is easy to lead to a series of prediction errors. The prediction results and RMSE and MAPE results are prone to large deviations, and the comparison of the prediction accuracy of various models is thus revealed. It reduces the influence of power data fluctuation on the accuracy of the model and improves the prediction performance of the model during the period when weather conditions fluctuate. In cloudy weather, the MAPE value of k-means Gru is lower than that of Gru, LSTM, and BP, and the values of each model are 0.04, 0.13, 0.21, and 0.37, respectively. It can be seen that the error value of the k-means Gru model is significantly lower than that of other models and is 10.81% of that of the BP traditional neural network model. Therefore, according to the above, it can be concluded that the prediction performance of the k-means Gru model for photovoltaic is better and the prediction deviation is the lowest.

The prediction results of photovoltaic output power and RMSE and MAPE results under rainy weather conditions are shown in Figure 10 and Table 6. Under the condition of rainy weather, the influence of weather is more obvious than that of overcast weather, and its sunshine is significantly lower than that of overcast weather, accompanied by the interference of rain. Under the change of this more complex factor, the conditions for controlling this variable factor are more stringent, which leads to more prediction errors, and its prediction results and RMSE and MAPE results are prone to large deviations. The comparison of the prediction accuracy of various models is thus easier to show. When weather condition fluctuates from time to time, it is also called sudden change weather, which is found through the prediction results. Under the sudden change weather of rainy days, the MAPE value of k-means Gru is lower than that of GRU, LSTM, and BP, and the values of each model are 0.08, 0.17, 0.27, and 0.42, respectively. In contrast, other models jump out of the predictable range and the acceptable error range. Only the model error constructed in this paper is still within the controllable range, and the intelligent k-means Gru model has a better prediction performance for photovoltaic, with the lowest prediction deviation.

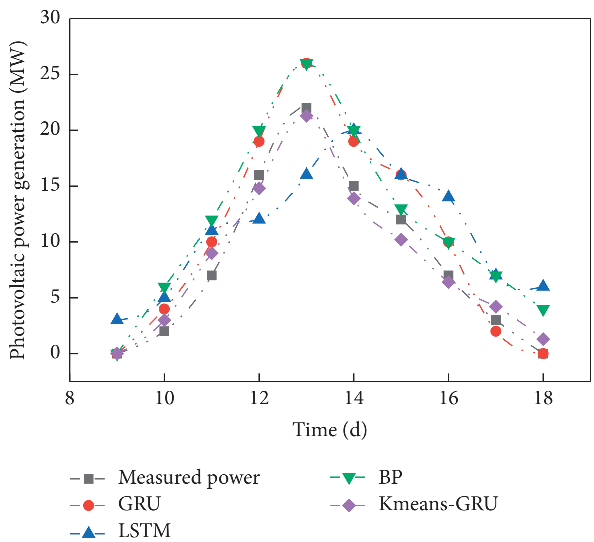

Figure 10: Photovoltaic power prediction results of different models in rainy days.

Table 6: Photovoltaic power prediction error in rainy days.

Model	RMSE	MAPE/(%)
GRU	23.28	0.21
LSTM	42.36	0.33
BP	55.54	0.57
Kmeans-GRU	14.29	0.16

Based on the short-term prediction results of the above four models for photovoltaic power generation, it can be found that the adaptive k-means Gru model constructed in this paper has better advantages than other models in terms of the prediction of sudden weather, such as sunny, cloudy, or rainy days. Its errors are lower than other models, and its accuracy is higher, which verifies the effectiveness of the adaptive k-means Gru short-term photovoltaic power generation prediction model constructed in this paper.

5. Conclusion

In order to solve the short-term prediction accuracy temperature of photovoltaic power, this paper divides the weather types and proposes a photovoltaic power ultra-short-term prediction model based on the adaptive k-means GRU method. The adaptive k-means is directly used to cluster the initial training set and the photovoltaic power of the prediction day and find out the local characteristics of the data and predict the power. Three single models are established to compare with the proposed model, and the prediction error is evaluated according to MAPE and RMSE. The proposed model solves the problem of low accuracy of traditional prediction methods in power fluctuations. The main conclusions are as follows:

(1) Photovoltaic output power has great randomness, among which there are many influencing factors, including injection time and weather, especially the weather type has a great impact on photovoltaic output power.

(2) By using the combination of adaptive k-means and Gru models, the data preprocessing and clustering analysis of the initial training set and the photovoltaic power generation on the forecast day can significantly improve the prediction accuracy of the model.

(3) Through comparison with other models, it is found that the prediction performance and stability of the model proposed in this paper are better in sunny days and cloudy days, and the prediction performance is improved in rainy days. The prediction error value of the model is significantly lower than that of other neural network models, and only 10.81% of that of the BP neural network, thereby indicating the reliability of the model.

(4) According to the prediction results of sunny, cloudy, and rainy days, the prediction accuracy of the adaptive k-means and Gru combined model meets the ultra-short-term prediction requirements of the output power of the photovoltaic power generation system. The difference between predicted power and actual power is small, and the prediction error value does not affect the normal operation of the system.

Data Availability

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

Conflicts of Interest

The author declares that they have no conflicts of interest.

Acknowledgments

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Research Article

Evaluation of Logistics Efficiency of Paper Skin Walnuts in Northwest China Based on DEA-Malmquist

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In recent years, with the rapid development of the Internet industry, the publicity effect of paperbark walnuts has been substantially increased, and the consumption and demand of paperbark walnuts have been rising, and the output of paperbark walnuts in China has also increased year by year. This paper takes the panel data of the top three prefecture-level cities in each GDP ranking of five provinces in northwest China from 2012 to 2021 as the sample and combines the DEA model with Malmquist to evaluate and analyze the logistics efficiency of paper walnuts in northwest China. It is found that the overall logistics efficiency of paperback walnuts in Northwest China has been improved in recent years, but there are still areas that need to be improved, such as the factor distribution is not reasonable enough; the logistics efficiency of paperback walnuts in Northwest China from 2012 to 2021 is in a fluctuating state; the logistics efficiency of paperback walnuts in Shaanxi Province is better than the other provinces and is in the leading position; the improvement of technological progress has a key role in the total factor productivity improvement. As a result, this paper puts forward five specific suggestions based on the research results to help accelerate the improvement of paper walnut logistics efficiency in Northwest China.

1. Introduction

Paper-skinned walnuts are famous for their paper-thin shells, and the process of removing walnut kernels is much easier than that of ordinary walnuts, which are rich in protein, phosphorus, calcium, and other elements. Northwest China, as a place where paper walnuts are produced in abundance, has seen the development of the paper walnut logistics and transportation industry in recent years, while also facing the serious challenge of modernization and transformation. Therefore, it is necessary to accelerate scientific and technological innovation in the logistics industry, accelerate the efficiency of paperbark walnut logistics, and then improve the revenue of paperbark walnut industry and national economic development. Although the current circulation number of paper walnuts is large, the overall logistics industry has a poor foundation, resulting in high product loss costs and low logistics efficiency in the logistics process. The direct result of low logistics efficiency is serious waste of resources, which not only reduces the market competitiveness of paper skin walnuts, but also hinders the development of national economy and industrial structure upgrading to a certain extent. Therefore, accurately evaluating the logistics efficiency of paper skin walnuts in northwest China and finding its influencing factors will greatly promote the upgrading and development of paper skin walnut industry in northwest China. The global economic development pattern is changing, international economic and trade rules are being questioned, the global economy is not optimistic in the post-epidemic era, and the growth points are harder to find. How to achieve economic growth has become a more complex global issue. China, as the world's second largest economy and the world's second largest consumer market, is also a key issue to be addressed: how to promote a strong economic recovery and maintain a high level of public confidence in the state of our economy. The logistics chain plays a relatively good role in achieving supply stability as well as industry chain stability, and has a strong positive effect on the dual domestic and foreign cycle strategy. As a producer of paper walnuts in China, Northwest China needs to grasp the current opportunities and challenges in order to achieve better development.

The production, packaging, storage, transportation, circulation, and handling of agricultural product information is the recycling process of agricultural products, which supports and enhances the value of agricultural products. China is a large agricultural country, the current stage of agricultural products logistics infrastructure is not perfect, and the logistics is unique. According to statistics, China's agricultural logistics has been hit hard throughout the cycle; therefore, it is urgent to improve the efficiency of China's agricultural logistics. The "Thirteenth Five-Year Plan" clearly states, "Develop rural e-commerce, actively explore new modes of agricultural logistics, vigorously develop cold chain logistics for agricultural products, build a data sharing platform, and comprehensively promote agricultural modernization." In addition, the Ministry of Commerce issued in 2015, "stressed the need to establish a comprehensive information platform based on information technology, accelerate the development of rural e-commerce, improve the efficiency of agricultural transport, and should pay more attention to the efficiency of the cycle of agricultural products. Logistics is a key element in the flow of paper walnuts, and studying the efficiency of logistics can make an effective contribution to the sales and transportation of paper walnuts in the region. China's paperbark walnut light agricultural products flow industry is still in a sustainable development stage, and there are many problems in management and technology that need to be improved. In order to evaluate the logistics performance more comprehensively and accurately, this paper comprehensively discusses the concept and content of logistics efficiency evaluation. The current logistics performance evaluation method is relatively simple, and there is less research on paperbark walnuts in Northwest China. This paper uses DEA model to evaluate the logistics efficiency evaluation of paper skinned walnuts in Northwest China, and presents new ideas for further research on the logistics performance of agricultural products.

2. Research Background

Logistics is the "third source of profit" today. At present, a large number of scholars and experts in the academic field still focus on the analysis of logistics efficiency of traditional products, but there is little research on the evaluation of logistics efficiency of paper skin walnuts. When scholars study logistics efficiency, they mainly focus on the qualitative analysis of the current situation of logistics development and optimization measures and the quantitative analysis of logistics efficiency evaluation and influencing factors.

Regarding the current situation of logistics development and its optimization measures, some scholars have analyzed and compared five types of distribution modes for many types of agricultural products, such as fruits and vegetables, and finally concluded that the product logistics efficiency can be most effectively improved in China's road freight industry [1]. Some scholars have experimented with various logistics solutions and come up with the best solution for coordinating logistics objectives and circulation processes along the Belt and Road in order to improve logistics efficiency under existing circumstances. They also summarized the problems that China's logistics industry is facing or will face in the development process after the urbanization phenomenon, and tried to give specific measures to solve them [2]. Some scholars researched and established a gray correlation model of Shandong province region to explore the factors affecting logistics efficiency, and created a relatively effective logistics operation model based on the conclusions [3].

In terms of logistics efficiency evaluation and influencing factors, some scholars used the DEA method to analyze the production areas along the new western land and sea corridor in China, and concluded that the China's logistics industry should move forward in the direction of intensification and technology development [4]. Some scholars also made a comprehensive evaluation of the logistics efficiency of the pilot cities of the supply chain in the Yangtze River Delta region based on the DEA-PC method [5]. Using the super efficiency model, a complete empirical analysis of logistics efficiency and related influencing factors was made based on the data of agricultural products in China and Mongolia road ports [6]. Some scholars conducted a multi-factor regression analysis on the influencing factors of logistics efficiency in the food industry, followed by relevant comments and suggestions [7]. Some experts and scholars used DEA models in the context of the Yangtze River Delta integration strategy to analyze the differences in logistics efficiency levels between different provinces based on panel data of agricultural products from multiple provinces [8]. Some scholars also used SFA analysis to evaluate logistics efficiency and found that the overall logistics efficiency level in Henan Province was low [9]. Malmquist model was used to analyze and calculate total factor productivity, and through further exploration it was concluded that the technological innovation has an important role in low carbon logistics efficiency [10]. Some scholars also used DEA-Malmquist method to study the changes in logistics efficiency and the reasons for its changes based on China's logistics panel data, and explored the changes in logistics efficiency after industrial structure upgrading [11].

Based on the existing research results, it can be seen that most of them are mostly logistics efficiency evaluations in agricultural products and foodstuffs, etc., while few logistics efficiency evaluations for paper walnuts in Northwest China have appeared. At present, in many research methods on logistics efficiency, scholars tend to use stochastic frontier method (SFA), gray correlation method, or data envelopment method (DEA), etc., but few experts and scholars consider the process and law of how logistics efficiency changes over time from a dynamic perspective, and do not touch on the deeper reasons of logistics efficiency changes. Based on the above multiple factors, this paper combines DEA model and Malmquist index to analyze the logistics efficiency of paper walnuts in Northwest China from static and dynamic multiple perspectives, respectively, and explore the influencing factors and put forward reasonable suggestions.

3. Research Methods and Materials

3.1. Model Construction and Index Selection

3.1.1. Model Description. (1) DEA Model. The data envelopment analysis method (DEA) uses the principle of optimality to evaluate each decision making unit (DMU) with multiple indicators of input and output, and has been widely used in the research of logistics efficiency measurement. However, the traditional DEA model can only provide a static analysis of logistics efficiency [12].

In 1978, Charles et al. proposed a method to evaluate the effectiveness of similar operations management modules with a large amount of input data, such as data package analysis (DEA). After Charles introduced the first DEA model, DEA models were divided into BC2, FG, and ST models, which describe DEA models with different metrics. Through the unremitting efforts of scholars at home and abroad, DEA methodology has been improved and become a more mature and important method. DEA model is an objective decision model based on relative efficiency, which is one of the most common methods to assess the relative effectiveness of policy modules. It is usually used to assess the relative efficiency of multiple input–output modules and multiple effective decision modules. Using the collected data, a linear method is used to calculate the effective production limit for each decision participant, which is then used as the raw material for analyzing the relative cost-effectiveness of the study population. The relative efficiency of each decision-making body is then reached. Based on the data of the evaluated object, it is evaluated by comparing the difference between the evaluated object and the previous one [13]. The classification of DEA models is shown in Figure 1.

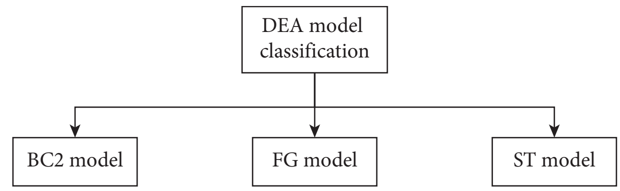

Figure 1: Classification of DEA models.

(2) DEA-Malmquist Index Model. Malmquist index was originally proposed by Malmquist as a consumption index structure. The Malmquist index was designed based on a distance function and was first used to measure the performance changes, so the method was not widely used. With the introduction of the DEA model, which describes the relative validity of dynamic simulations, it has attracted the attention of scientists. The DEA-Malmquist index method was designed based on the DEA model and Malmquist index, and the Malmquist index was divided into process efficiency and process variation [14]. Since then, the DEA-Malmquist index method has been increasingly used. The Malmquist index was introduced in 1953, but few empirical studies on this index were conducted in the following years. It took more than four full decades before the Malmquist index was incorporated into the DEA model, bringing the application of the index back into the limelight [15]. The Malmquist index model can measure multiple inputs and outputs in multiple periods at the same time, evaluate the dynamic changes in each decision unit, and also decompose the Malmquist index to precisely determine the main factors causing the changes. In this paper, to study the logistics efficiency of paper walnuts in Northwest China, each prefecture-level city selected in the five Northwest provinces is taken as a DMU, and it is assumed that there are n decision units and T units of time, with t and $t+1$ denoting the current period and the next period, respectively, and X_r^t the Y_r^t inputs and outputs of decision unit r at time t, respectively, denoting the DEA $D_r^t(X_r^{t+1}, Y_r^{t+1})$ efficiency of the production of decision unit r in period $t+1$ measured by t as the base period, from which the DEA efficiency is obtained in t period.

The value of efficiency change from period t to period $t+1$ under the condition of period $t+1$ is

$$M^{t+1} = \frac{D_r^{t+1}\left(X_r^{t+1}, Y_r^{t+1}\right)}{D_r^{t+1}\left(X_r^t, Y_r^t\right)}. \tag{1}$$

The Malmquist index, which represents the dynamic change in logistics efficiency from moment t to $t+1$ for each decision unit, i.e., total factor productivity (tfpch), is obtained by calculating the geometric mean of

$$\begin{aligned}
\text{tfpch} &= M\left(X^t, Y^t, X^{t+1}, Y^{t+1}\right) \\
&= \left(M^t \times M^{t+1}\right)^{\frac{1}{2}} = \left[\frac{D_r^t\left(X_r^{t+1}, Y_r^{t+1}\right)}{D_r^t\left(X_r^t, Y_r^t\right)} \times \frac{D_r^{t+1}\left(X_r^{t+1}, Y_r^{t+1}\right)}{D_r^{t+1}\left(X_r^t, Y_r^t\right)}\right]^{\frac{1}{2}} \\
&= \frac{D_r^{t+1}\left(X_r^{t+1}, Y_r^{t+1}\right)}{D_r^t\left(X_r^t, Y_r^t\right)}\left[\frac{D_r^t\left(X_r^{t+1}, Y_r^{t+1}\right)}{D_r^{t+1}\left(X_r^{t+1}, Y_r^{t+1}\right)} \times \frac{D_r^t\left(X_r^t, Y_r^t\right)}{D_r^{t+1}\left(X_r^t, Y_r^t\right)}\right]^{\frac{1}{2}} \\
&= \text{effch} \times \text{techch}.
\end{aligned} \tag{2}$$

It can be seen that total factor productivity (tfpch) can be decomposed into the integrated technical efficiency change index (effch) and the technical progress index (techch). And when the payoff of scale is variable, the effch index can be decomposed into the pure technical efficiency change index (pech) and the scale efficiency change index (sech), i.e.,

$$\text{effch} = \text{pech} \times \text{sech}. \tag{3}$$

In summary, it is obtained that

$$\text{tfpch} = \text{effch} \times \text{techch} = \text{pech} \times \text{sech} \times \text{techch}. \tag{4}$$

In this paper, the DEA software is used to calculate the relevant index data, $\text{tfpch} > 1$ if, then the logistics efficiency of paper walnut in Northwest China $\text{tfpch} = 1$ increases; the efficiency remains $\text{tfpch} < 1$ unchanged , the efficiency decreases. And for the four indices obtained, and, effch if pech greater sech than techch 1, it means that the productivity of the decision unit has been improved in the time period, which has a facilitating effect on the efficiency improvement; if the index obtained is less than 1, it means that the productivity of the decision unit is declining in the time period, which hinders the efficiency improvement.

(3) DEA-Malmquist Stage. DEA methods have obvious advantages when considering the performance evaluation of multi-indicator systems, and they are optimized considering the validity of the evaluation and the lack of evaluation results, and taking into account the differences in the external decision-making environment. The random error in the regression equation is evaluated on the basis of the DEA model and decomposed into statistical error and control efficiency, which achieves the purpose of integrating environmental factors, random error, and control efficiency into the performance analysis framework, and the evaluation results become more weighted [16]. The three stages of the DEA-Malmquist process are shown in Figure 2.

Stage 1. Traditional DEA model: The validity of the decision term is calculated using input and output indicator data. Given that input relaxation cannot be used for efficiency evaluation, the inactive and unconstrained limit method is used to calculate the efficiency in this paper [17].

Phase 2. Establishing the management model: The main purpose of this phase is to adjust the initial input variables so that different decision modules can reflect the actual efficiency gap in a relatively coordinated external environment [18]. First, slack is entered as a variable and environmental elements are selected as independent variables to create the model.

Step 3. Adaptation of the DEA model: Using its own input data instead of the original input data and reassessing it using a non-radiometric, angular approach, the technical efficiency of the rated objects can be reflected more accurately [19].

3.1.2. Index Selection. The selection of the evaluation index system directly determines the later evaluation effect, and in the DEA analysis method, two kinds of data, input and output, are needed. Referring to the selection of indicators in many scholars' studies on logistics efficiency evaluation, and combining with the research perspective of this paper, the selected indicators and their descriptions are as follows.

(1) Input Indicators. According to the Cobb–Douglas production function, the input factors mainly include technology, labor and capital, etc. However, in the process of logistics performance evaluation and research, the technology factor is often not effectively measured, so only the labor and capital factors are considered. Combined with the availability of data as well as operability, since the data related to the logistics industry cannot be subdivided into paper walnut related, and since transportation, warehousing, and postal industries account for about 85% of the total logistics industry, the data of transportation, warehousing, and postal industries are processed to represent the input–output situation of paper walnut logistics. The input indicators selected in this paper are as follows: one is the number of employees in the paper walnut logistics. The labor input is expressed by multiplying the total number of employees in transportation, storage, and postal industry by a factor k, where k is obtained from the product of national consumption ratio, citizen consumption ratio, and Engel's coefficient to reflect the proportion of the number of employees in paper pecan logistics. The other is the amount of investment in fixed assets in paperback walnut logistics. Similarly, the capital input is expressed by the amount of investment in fixed assets in transportation, storage, and postal industry multiplied by the coefficient k to obtain the amount of investment in fixed assets in paperback walnut logistics.

(2) Output Indicators. The output level is mainly considered in terms of social and economic benefits, so two indicators were selected to measure the output in terms of quality and quantity, respectively. One is the value added of paper walnut logistics. The quality of the output is expressed by the value added of the output value of transportation, storage, and postal industry multiplied by the coefficient k to obtain the value added of paper walnut logistics. The reason for choosing the value added is that the value added can eliminate the influence of the total value of the previous period and put the focus on the value-added process. The other is the freight turnover of paperbark walnuts. Freight turnover = transport weight × average transport distance, which reflects both the quantity of output and the distance of transport, and better reflects the efficiency of logistics. The indicator data of paperbark pecan freight turnover is also obtained according to the treatment of the indicator of the number of employees in paperbark pecan logistics.

3.1.3. Data Sources. In order to facilitate the dynamic analysis and research of the real-time changes and conditions of the paper pecan logistics efficiency index in Northwest China, and also considering the difficulty of collecting relevant data accurately, this paper takes the top three prefecture-level cities in Northwest China in terms of GDP ranking in 2019 as the main decision-making units in each of the five provinces and municipalities directly under the central government in Northwest China, and analyzes and compares them in a comprehensive manner. The time period selected is from 2012 to 2021. The data in this paper are obtained from the statistical yearbook of each city in each province from 2013–2022, China Paperback Walnut Market Survey Research and Development Prospect Analysis Report, China Statistical Yearbook and China Logistics Statistical Yearbook.

3.2. Evaluation of Logistics Efficiency

3.2.1. Concept. Logistics efficiency evaluation is defined as the use of relevant performance indicators, standards, and methods, as well as the evaluation system established by relevant institutions, and the acquisition of evaluation results. Logistics efficiency evaluation is defined as "quantifying the efficiency and impact of past actions by collecting, processing, classifying, analyzing, interpreting, and disseminating relevant data, making appropriate decisions and taking appropriate actions" [20]. The logistics efficiency evaluation process is shown in Figure 3.

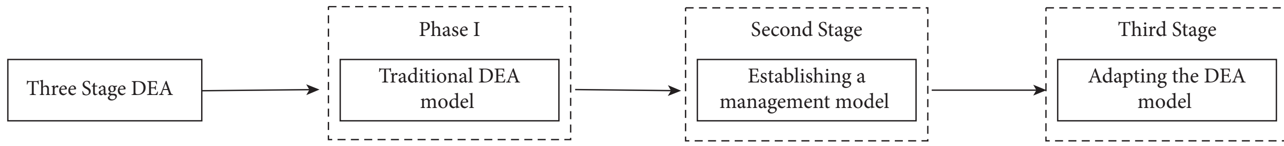

Figure 2: Three stages of the DEA-Malmquist process.

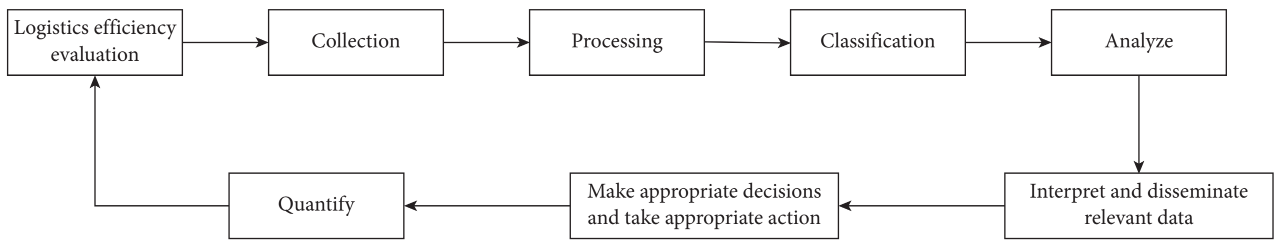

Figure 3: Logistics efficiency evaluation process.

3.2.2. Content. Logistics efficiency evaluation includes not only pre-monitoring mechanisms, operational activities, and post-evaluation, but also evaluation contents, which must be comprehensive and specific. The performance evaluation varies from discipline to discipline: according to the characteristics of individual disciplines, it can be divided into different aspects of logistics evaluation, including logistics, equipment, and financial evaluation. The evaluation content is also widely used according to the characteristics of the evaluation object, the workflow of the relevant subjects, and the internal and external environment. The contents of logistics efficiency evaluation are shown in Figure 4.

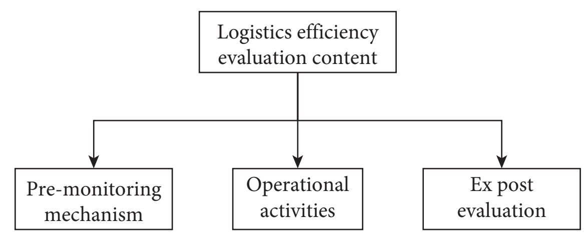

Figure 4: Content of logistics efficiency evaluation.

4. Results and Discussion

Based on DEA-Malmquist index model, this paper uses software DEA to measure the change value of logistics efficiency of paper walnuts in northwest China, and the Malmquist index and its decomposition of paper walnut logistics in the five provinces of northwest China from 2012 to 2021 are shown in Tables 1 and 2, respectively.

Table 1: The results of DEA-Malmquist analysis for each prefecture-level city in five northwestern provinces.

Prefectural cities	Effch	Techch	Pech	Sech	Tfpch
Xian	1.076	1.274	1.032	1.043	1.371
Yulin	1.089	0.997	1.042	1.045	1.086
Baoji	0.873	1.246	0.870	1.004	1.088
Shaanxi mean	1.013	1.172	0.981	1.031	1.182
Lanzhou	0.982	1.173	1.022	0.961	1.152
Qing Yang	1.000	0.943	1.000	1.000	0.943
Tianshui	0.869	1.181	0.880	0.987	1.026
Gansu mean	0.950	1.099	0.967	0.983	1.040
Xining	0.844	1.295	0.849	0.994	1.093
Haixi	0.936	1.158	1.027	0.911	1.083
Haidong	0.935	1.133	1.000	0.935	1.059
Qinghai mean	0.905	1.195	0.959	0.947	1.079
Yinchuan	0.898	1.357	0.933	0.963	1.219
Shizuishan	0.940	1.029	0.970	0.969	0.967
Wu Zhong	0.895	0.992	1.000	0.895	0.888
Ningxia mean	0.911	1.126	0.968	0.942	1.025
Urumqi	0.926	1.174	0.977	0.948	1.087
Changji	1.040	0.965	1.091	0.953	1.003
Aksu	0.870	1.272	0.928	0.938	1.107
Xinjiang mean	0.945	1.137	0.999	0.946	1.066
Northwest mean	0.945	1.146	0.975	0.970	1.078

4.1. Holistic Analysis. From the spatial perspective, except for Shaanxi Province, the decomposition of Malmquist index of logistics efficiency in the other four provinces is similar, and the mean value of total factor productivity in Shaanxi Province and Qinghai Province is higher than the mean value in Northwest China, while the total factor productivity of all five provinces is greater than 1. This indicates that the overall efficiency of paper walnut logistics in the five Northwest provinces has improved between 2012 and 2021, among which Shaanxi and Qinghai province have the most significant improvement.

For the composite technical efficiency change index and scale efficiency change index, only Shaanxi Province is DEA effective, indicating that the logistics organization and management and industrial structure of the other four provinces and the Northwest region as a whole have not been optimized under the existing technical conditions. For the pure technical efficiency change index, all five provinces are DEA invalid, but the total factor productivity of the five northwestern provinces as well as the whole northwestern region is improved, indicating that the regression of integrated technical efficiency, pure technical efficiency, and scale efficiency will have some effect on the total factor productivity but not too significant. The results are shown in Table 1.

Table 2: 2012–2021 indices.

Year	Effch	Techch	Pech	Sech	Tfpch
2012–2013	0.920	1.531	0.983	0.936	1.409
2013–2014	0.928	1.145	0.955	0.972	1.063
2014–2015	1.029	0.842	1.001	1.028	0.866
2015–2016	1.056	0.932	0.966	1.093	0.984
2016–2017	0.944	0.817	0.907	1.041	0.771
2017–2018	0.941	1.109	1.014	0.928	1.044
2018–2019	0.795	0.997	0.873	0.911	0.793
2019–2020	0.883	1.527	0.908	0.972	1.348
2020–2021	0.993	1.419	1.167	0.851	1.409
Mean value	0.945	1.146	0.975	0.970	1.078

For the technological progress index, the average value of the five provinces and the overall average value of the northwest region are greater than 1. The average values of Shaanxi and Qinghai provinces are also greater than the overall average value of the northwest region, indicating that the introduction of new logistics technologies has a catalytic effect on the improvement of overall efficiency, with Shaanxi and Qinghai provinces having the most obvious promotion effect.

From a temporal perspective, the data for each index are shown in Table 2, and the trend of change is shown in Figure 1. It can be seen that the overall changes of each index are more volatile from 2013 to –2015 and 2019 to 2021, while the changes of each index are more stable from 2015 to 2019. The changes of the technological progress index are almost the same as the changes of total factor productivity, which indicates that the Malmquist index is mainly influenced by the technological progress index, and the technological progress has a great role in the improvement of the logistics efficiency of paper-skinned walnuts in Northwest China. Among them, the decline of total factor productivity from 2013 to 2015 is mainly influenced by the negative pull of technology, while the total factor productivity has been improved since 2019 because the five northwestern provinces have promulgated a number of policies to promote the technological development of logistics industry since 2017, as shown in Figure 5.

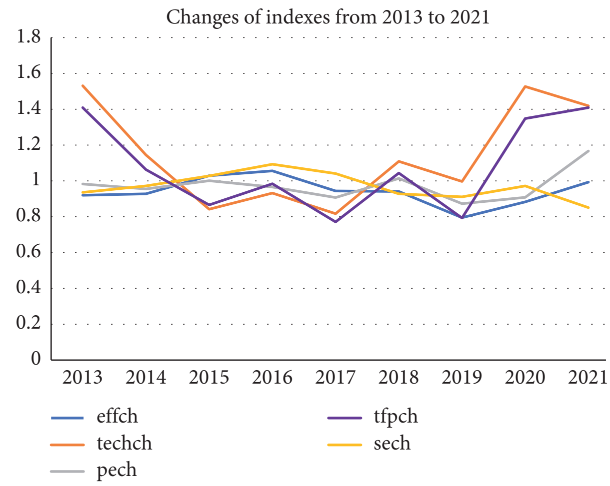

Figure 5: Change of each index from 2013 to 2021.

4.2. Analysis of Variability. In terms of the change of total factor productivity, all three cities in Shaanxi Province are in a state of growth, among which Xi'an has the largest growth rate of about 37.1%, and this rate exceeds the remaining 14 prefecture-level cities including other provinces, making it the fastest growing city in terms of total factor productivity change; Shaanxi Province also has the highest growth rate of total factor productivity among the five northwestern provinces, which is about 18.2%. The total factor productivity of three cities in Gansu Province showed an overall growth trend, but the growth level was not high, about 4.0%, among which the total factor productivity of Lanzhou City increased more, about 15.2%, while the total factor productivity of Tianshui City showed a slight upward trend and the total factor productivity of Qingyang City decreased about 5.3%; the total factor productivity of three cities in Qinghai Province all had more or less growth, among which the total factor productivity of Xining City had the fastest growth of about 9.3%. The average increase of total factor productivity in the three cities of Ningxia Hui Autonomous Region is the smallest among the five provinces, only 2.5%. Except for the change of total factor productivity in Yinchuan City, which increased by 21.9%, the total factor productivity in Shizuishan and Wuzhong City both showed a decreasing trend. The total factor productivity of all three cities in Xinjiang Uygur Autonomous Region increased, with the largest increase of about 10.7% in Aksu and only 0.3% in Changji, basically the same as before. As far as the five provinces in the Northwest region are concerned, Shaanxi Province has the most logistics development potential and advantages, while Ningxia Hui Autonomous Region is the shortcoming of the Northwest region. Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region, and Xinjiang Uygur Autonomous Region total factor productivity growth, are shown in Figure 6.

In terms of the change of technological progress rate, among the 15 cities in Northwest China, only four cities, namely, Yulin, Qingyang, Wuzhong, and Changji, have experienced a decline in the rate of technological progress, while the rate of technological progress in the remaining 11 cities has steadily increased, among which Yinchuan has the largest increase of 35.7% and Qingyang has the largest decrease of about 5.7%. It is worth noting that the rate of technological progress and the level of change of total factor productivity are basically the same, which indicates that the development of scientific and technological innovation is the key to the progress of logistics industry as shown in Figure 7.

In terms of the change of comprehensive technical efficiency, Shaanxi Province's comprehensive technical efficiency is the only province whose average value is on an increasing trend. The average comprehensive technical efficiency index of the remaining four provinces in Northwest China is below 1, and the degree of decline is obvious, among which the average comprehensive technical efficiency of Qinghai Province has dropped the most, by about 9.5%. Broken down into cities, except for Xi'an, Yulin, and Changji

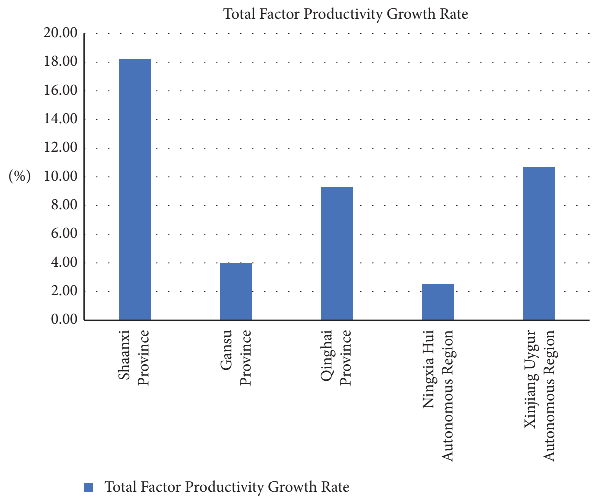

FIGURE 6: Total factor productivity growth rate of five provinces.

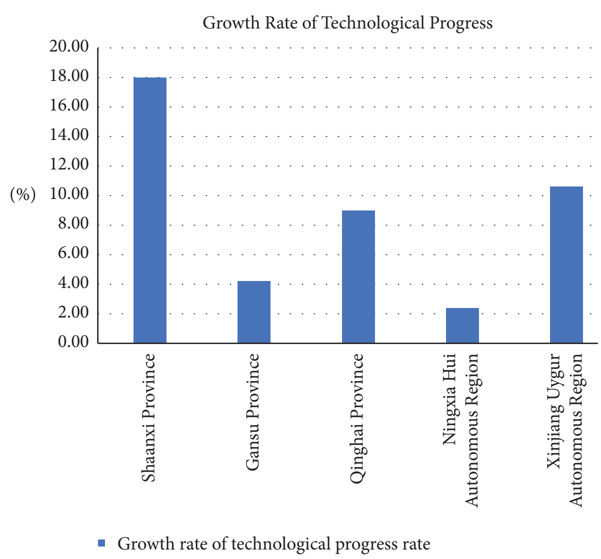

FIGURE 7: Growth rate of technological progress rate in five provinces.

City, where the comprehensive technical efficiency has increased slightly, and Qingyang City, where the comprehensive technical efficiency has remained basically unchanged, the comprehensive technical efficiency of the remaining 11 cities has shown different degrees of decline, among which, the decline of comprehensive technical efficiency of Xining City is the highest, about 15.6%. The overall change level of comprehensive technical efficiency indicates that the management level of the paper skinned walnut logistics industry in the northwest region still needs to be improved. Decomposing the comprehensive technical efficiency, the comprehensive technical efficiency grows with the growth of scale efficiency, and the change trends of the two basically coincide, so in order to improve the comprehensive technical efficiency of paperbark walnuts in Northwest China as soon as possible, we should first focus on improving the scale effect of paperbark walnut logistics industry as shown in Figure 8.

In this paper, the total factor productivity of 15 cities in five provinces in the Northwest region Figure 9 is decomposed as shown, producing four major categories of cities.

The first category, i.e., cities where both the rate of technological progress and comprehensive technical efficiency have increased, such as Xi'an; this indicates that the input of each factor in the paper pecan logistics industry in Xi'an is more reasonable, and the overall industry has high logistics technology and leading management level. In recent years, Xi'an has focused on developing the economic market, responded to the national policy, and actively encouraged the logistics development of the production and planting industry, which has led to a leap forward in the level of paperbark pecan logistics in the city. The second category, namely, cities with rising comprehensive technical efficiency but declining technological progress rate, such as Yulin and Changji City; this category of cities at present, the most important need is to maintain their great advantage of effective resource utilization and pay attention to the leading role of technological innovation. The third category, i.e., cities with rising rate of technological progress but declining comprehensive technical efficiency, such as Xining, Yinchuan, and many other cities, indicates that these cities need to maintain the introduction of advanced technology based on efforts to promote the improvement of the management level and the efficiency of the distribution of production factors, and to promote the optimal allocation of paper skin walnut logistics resources. The fourth category, i.e., cities with declining overall technical efficiency and technological progress rate, such as Wuzhong; these cities lack the development and research of paperbark pecan logistics technology, and also have low technological innovation capability, and are cities with low overall logistics efficiency and in urgent need of improvement and development.

4.3. Research Conclusions and Policy Recommendations

4.3.1. Research Conclusions. Based on the DEA-Malmquist index model, this paper measured the logistics efficiency of paper walnut in Northwest China from 2012 to –2021, and analyzed the reasons for the changes through index decomposition, and obtained the following main conclusions. The logistics efficiency of paperbark walnuts in Northwest China from 2012 to 2021 is improved in fluctuation, and the main driving force of which is the progress of technology, while the low level of scale efficiency and logistics industry management hinders the improvement of logistics efficiency to some extent. From the perspective of time, the government's support and the correct guidance of policies have obvious effects on the progress of logistics efficiency. From the spatial perspective, the logistics efficiency of the five northwestern provinces has been improved, among which the effect of Shaanxi Province is the most significant.

4.3.2. Policy Suggestions. (1) Enhance Technological Innovation Capability to Improve Total Factor Productivity. With the rapid development of modern science and technology, innovation capability has gradually become a key driving

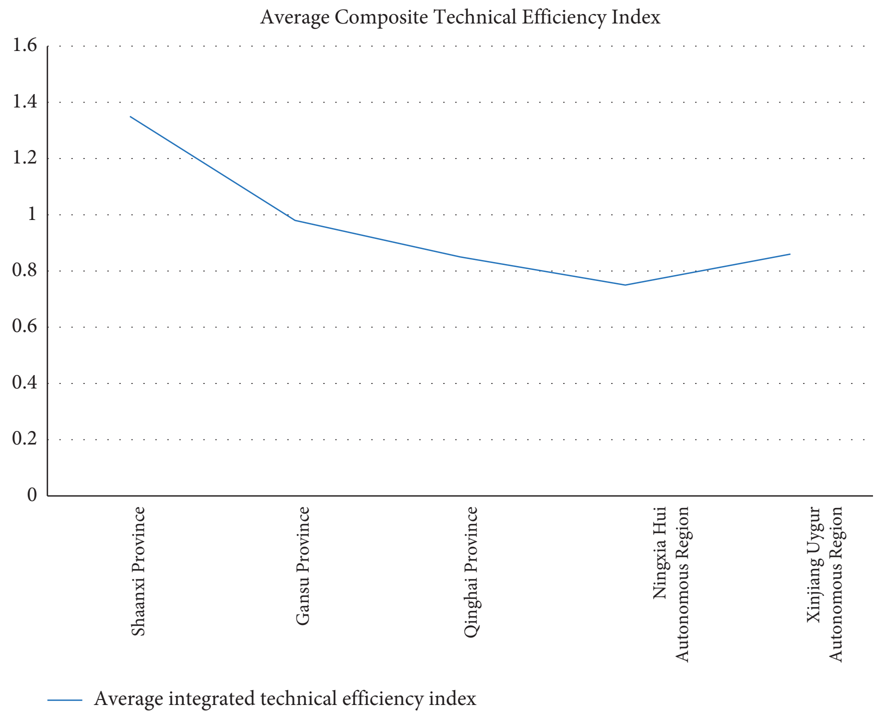

Figure 8: Average comprehensive technical efficiency index of five provinces.

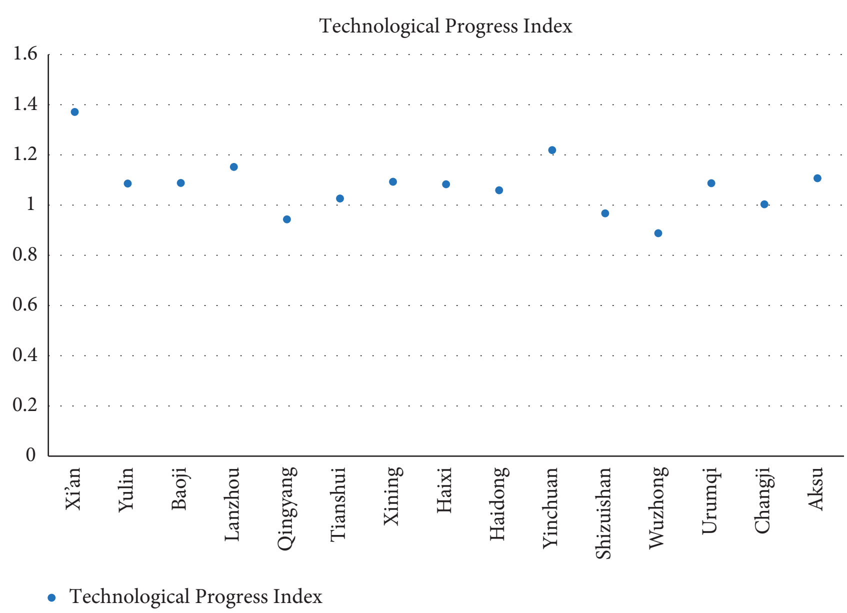

Figure 9: Decomposition of total factor productivity indices of prefecture-level cities in northwest China.

force for the development of various industries in China. The improvement of logistics efficiency of paper walnut in Northwest China cannot be separated from the continuous innovation and development of logistics industry technology. Innovation alliances, as emerging science and technology innovation platforms, are able to integrate technological innovation and results transformation. By creating a logistics innovation alliance for paperbark walnut products, Northwest China can apply scientific research results to logistics technology, accelerate the practice of innovation results, and achieve the ultimate goal of enhancing technological innovation in paperbark walnut logistics. While building an innovation alliance for walnut industry, give full play to the function of market regulation to improve the efficiency of resource allocation. The government should cooperate to do a good job of function transformation, introduce relevant protection policies, and strengthen the supervisory role of the market, so as to provide a stable and good objective environment for the logistics efficiency improvement of the walnut industry in Northwest China. Secondly, the emergence of new technologies such as 5G technology can also be used to help optimize the logistics technology of paper-skinned walnuts. Combining the two advantages of ultra-low energy consumption and ultra-high speed, 5G technology can be widely used to develop smart logistics and build out a high-quality logistics system.

(2) Rational Allocation of Resources to Improve Scale and Management Efficiency. The development mode of paper walnut logistics system in Northwest China is crude and the level of decision making and management is low. Although the current stage has not yet shown a big obstacle, in a long-term perspective, this will expand the difficulty of coupling modern technology and logistics industry, causing a double waste of logistics resources and value. Therefore, the northwest region needs to reasonably allocate the many resources of the logistics industry, promote the optimal combination of all influencing factors, promote the scale and specialization of the logistics industry, and improve the comprehensive technical efficiency. To achieve such a transformation, specific measures include: bringing scattered paperbark walnut growers together, launching agricultural cooperation, promoting the scale and intensification of paperbark walnut production, and ultimately achieving the purpose of improving scale efficiency; actively responding to national policies to introduce scientific and technological talents, while formulating a reasonable allocation plan for logistics management personnel, and ultimately achieving the purpose of improving management efficiency.

(3) Optimize the Spatial Layout of Paper Walnut Logistics Industry. At present, the government of Northwest China has issued a number of policies to support the production, planting, and transportation of paper skin walnuts. The logistics practitioners must grasp the advantages of these favorable policies, stabilize the production and transportation chain of paper skin walnuts, expand the circulation market of paper skin walnuts in the country, and help revitalize the economy of Northwest China. Secondly, they should also create and improve new logistics and transportation infrastructure, unify planning and rational layout, further optimize the overall spatial layout of paperbark walnut logistics in the northwest, ensure the normal articulation of all links in the logistics and transportation process, and effectively improve logistics efficiency.

(4) Learning from Excellent Experience and Making Improvements According to Local Conditions. Northwest China is deep inland, due to geographical constraints, it is necessary to strengthen the logistics links and cooperation with the central and eastern regions, and learn from the development experience of cities with high logistics efficiency at home and abroad. The provinces in the northwest region should strengthen logistics cooperation, learn from each other's excellent experience, reduce logistics technology barriers, narrow the logistics technology gap, and create opportunities for regional economic development. Secondly, based on the existing logistics technology and experience in each province, each province should take into account the actual logistics conditions in the region, transform the experience of other regions reasonably before making use of it, take the essence and remove the dross, and promote the high-speed development of the local paperbark walnut logistics industry.

(5) Create a Logistics Information Technology Platform for Paper Walnuts. Information technology platform is an important cornerstone to support the modern development of logistics nowadays, and the emergence of block chain also provides a brand-new opportunity for the development of information technology platform. Building a logistics information technology platform for paperbark walnuts in Northwest China can share logistics information in real time, track logistics dynamics, and make the logistics industry more standardized and specialized. The Northwest region should strengthen the construction of blockchain more, so that blockchain can be better and faster integrated into the information technology platform of papery pecan logistics and make logistics data sharing more secure. Using the information technology platform to integrate the scattered paperbark walnut logistics information and resources can not only effectively reduce paperbark walnut transportation costs, but also improve the logistics rate.

5. Conclusion

Based on the DEA-Malmquist index model, this paper measured the logistics efficiency of paperbark walnuts in Northwest China from 2012 to 2021, and analyzed the reasons for the changes through index decomposition, and obtained the following main conclusions. The logistics efficiency of paperbark walnuts in Northwest China from 2012 to 2021 is improved in fluctuation, and the main driving force of which is the progress of technology, while the low level of scale efficiency and logistics industry management hinders the improvement of logistics efficiency to some extent. From the perspective of time, the government's support and the correct guidance of policies have obvious effects on the progress of logistics efficiency. From the spatial perspective, the logistics efficiency of all five provinces in Northwest China has improved, with the most significant effect in Shaanxi Province. The following is an outlook on the logistics development of paper walnuts in Northwest China.

(1) the northwest region to promote the application of high-tech in logistics. New and emerging technologies are important for the sustainable development of the logistics industry and can improve the efficiency of the logistics industry. Strengthen the application of advanced new technologies in logistics. Combined with the current development trend of intelligent logistics, no one in the intelligent logistics industry is closely linked to modern logistics to reduce the time and cost caused by human beings. At the same time, to accelerate the practical application of scientific and technological achievements in logistics, improve the efficiency of logistics, and drive the development of regional logistics.

(2) the northwest region to strengthen the national support for regional logistics. Government authorities should take appropriate measures and measures to regulate and support some logistics SMEs, encourage them to establish their own logistics infrastructure, and increase policy support for large regional logistics companies, so that they can: take the lead in establishing industrial mutual aid mechanisms. Communication and cooperation among companies. At the same time, the relevant departments should strengthen the supervision of the logistics market, respond positively to the requirements of the times, continuously optimize and improve the logistics supervision system, and create a good market environment.

(3) promote regional cooperation and the use of geographical advantages. As the main output place of China's paper walnuts, Northwest China should give play to its regional advantages, strengthen coordination and cooperation with neighboring provinces and cities, develop together with neighboring provinces, build inter-city interconnection platform, strengthen interconnection between cities, realize complementary interests, reasonably allocate logistics resources, improve regional logistics efficiency, and realize high-quality development of regional logistics.

(4) the northwest region to strengthen the development of talent logistics. With the development of the times and the increase in market demand, logistics demand for high-tech talent is also growing. Cultivating complex logistics talents with professional quality and skills is the inevitable development of the times. The combination of industry and education deepens the combination of industry and education, cultivates high quality talents who can apply in the actual work, and improves professional skills and comprehensive quality.

Data Availability

The dataset can be accessed upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Robot Trajectory Planning Based on the Energy Management Strategy

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With the increasing demand for automated production technology in national defense, industry, agriculture, and other fields, the status and role of mobile robots are becoming more and more pivotal. The intelligent technology of robots is becoming more and more demanding in terms of reliability, stability, efficiency, and adaptability, and the autonomous navigation technology of mobile robots is facing new challenges. This paper introduces the basic principle of traditional A^* algorithm, points out the problems of this algorithm such as cumbersome calculation, large turning angle, and unsmooth derived trajectory planning, and proposes an improved A^* algorithm. The improved algorithm introduces a two-way alternating search mechanism to improve the efficiency of the search path, and the improvement of the heuristic function solves the problem that the two-way alternating search A^* algorithm takes more time when there are obstacles perpendicular to the path on the way to the encounter. Simulation experiments in different raster environments prove that compared with the traditional A^* algorithm, genetic algorithm, and simulated annealing algorithm, the improved A^* algorithm can significantly improve the search path speed, while overcoming the disadvantages of many path turning angles and large turning angles and is an efficient and feasible algorithm for raster map environments.

1. Introduction

In recent years, only industries have flourished, and the robotics industry has received increasing attention, and its related technologies have received unprecedented attention [1]. The huge economic benefits embedded in the mobile robot industry have led countries around the world to carry out their own blueprints for the development of mobile robots; for example, in 2018, the United States issued the National Artificial Intelligence Research and Development Strategy, proposing that the United States will continue to increase scientific research investment in mobile robots in the future [2]; Japan also explored more extensively in the field of artificial intelligence, and then released the "Artificial Intelligence in Core Technology requirements," indicating the important position of intelligent robots in Japan's national strategy of artificial intelligence [3]; in order to accelerate the construction of a strong science and technology country, China also clearly pointed out in "China Smart 2025" to vigorously develop the intelligent robotics industry, putting forward new requirements to accelerate the promotion of mobile robotics in China [4].

In recent years, with the support of intelligent technologies such as Internet technology, computer technology, and hardware technology, China's intelligent mobile robot industry has grown very rapidly, and since 2013, the development of China's robot industry has entered an explosive period, and in 2016, China's mobile robot industry has accounted for more than 30% of the global robot market, occupying the largest mobile robot market in the world. At present, the development of China's mobile robotics industry has surpassed that of many developed countries [5], but the demand gap for new technologies in China's mobile robotics industry is still very huge, so the core technology of mobile robots in China is still in urgent need of new breakthroughs.

Robotics involves multiple disciplinary technologies such as robot kinematics, artificial intelligence, and mechanics [6]; therefore, enhancing mobile robotics-related technologies cannot be confined to one aspect and requires more advanced technology integration methods. Autonomous navigation technology for mobile robots is the use of sensor technology and various advanced algorithms in a certain environment to complete robot localization and environment map building and to help mobile robots move safely and autonomously toward a target point.

Robot action and navigation is the core technology to be continuously developed, which consists of three main parts: localization, environment map building, and path planning, among which, trajectory planning is particularly important, and localization and environment map are the basis of path planning [7]. Trajectory planning is fundamentally to have a reliable action route and way for the robot to act autonomously, i.e., to provide the robot with a safe path from the starting position to the target position, which can avoid obstacles and try to ensure the optimality of the path in a certain environment for a certain index [8]. So far, path planning technology has been developed for more than fifty years, but for different planning requirements and some special scenarios of applications, there is still much room for improvement in the overall path planning in terms of comprehensiveness [9], and path planning algorithms are still in need of new breakthroughs in terms of advancedness, applicability, and efficiency. Today's global robots are becoming more and more important with increasing sales, as shown in Figure 1.

At present, mobile robots can be seen in various fields instead of manual work, and the position of mobile robots in social production and services is becoming more and more important, while autonomous navigation, as the core requirement and basic embodiment of intelligent mobile robots will naturally have higher and higher technical requirements, and path planning technology, as the core technical composition of autonomous navigation, has a important research value for the field of mobile robots. It goes without saying that the challenge of path planning technology innovation is also very great, as shown in Figure 2.

2. Research Background

The first robot that could "move," Shakey, was successfully introduced in 1972 under the leadership of Stanford professor Charlie Rosen [10]. The success of Shakey opened the beginning of research in the field of mobile robots and started the boom of research on autonomous navigation of mobile robots, which is a very important inspiration for the present and future research in the field of mobile robots.

With the new breakthroughs in sensor technology, artificial intelligence technology, and information technology in the 80s and 90s, the development of intelligent mobile robots was greatly accelerated, and a large number of scholars and funds were invested in the research and development of mobile robots, which made the development of mobile robots step into the explosive growth stage, and mobile robots also began to enter the industrialization stage, and various different kinds of mobile robots, a variety of different kinds of mobile robots, have sprung up into the public's view, which can be classified according to the different functional roles, application environments, movement modes, and working conditions, as shown in Figure 3.

So far, mobile robots have been developed for more than 50 years and account for a very large market share in the global intelligent energy industry. The rapid development of mobile robots needs to rely on various hardware technologies and software technologies, and the rapid development of sensor devices and software technologies has, on the one hand, promoted the development of mobile robotics and, on the other hand, caused the problems of low reuse of R&D codes and incompatibility of new sensors due to the increasing complexity and diversity of mobile robot software platforms and hardware devices [11]; therefore, the development of mobile robots encountered considerable difficulties in terms of systematization, modularity, and iterability.

To solve this problem, the Robot Operating System (ROS), a mobile robot development system was born, which originated from the Switchyard AI project at Stanford University and is now taken over by Willow Garage [12]. The ROS system is characterized by open source, interfaces in multiple languages, rich functional components to accomplish communication between programs, upper-layer software and underlying hardware, and various visualization tools to facilitate development [13].

At present, the ROS system has experienced more than a decade of development, and it not only has a very superior mobile robot development ecological environment, which improves the code reuse rate of mobile robot development and reduces the development cycle but also provides a very active communication community, which creates a benign communication platform for the development of machine mobile robots and accelerates the technology sharing in the field of mobile robots, and now, the ROS system is the most mainstream global mobile robot system development platform, and most of the robot development systems are ROS systems [14]. In recent years, in many enterprises and universities in China, the basic systems for mobile robot development are also ROS systems, and at present, China is the country with the most number of users of ROS systems in the global mobile robot development field, as shown in Figure 4.

At present, mobile robot functions have been more perfect, and product types have become more and more abundant, such as the service mobile robot PR2, which was developed by Stanford Research Institute and designed and manufactured by Willow Garage in 2010 [15]; several mobile robots applied to service, education, industry, and other fields were independently developed by Harbin University Robotics Group [16]; the first mobile robot was developed by Boston. The first bionic quadruped mobile robot that can be applied to complex scenarios, Big Dog, was developed by Boston Dynamics in 2005 [17]. At present, China's bionic quadruped mobile robot research has also made great breakthroughs, and the Cyber Dog [18], independently developed by Xiaomi in 2021, is not only functional but also priced to be accessible in ordinary families.

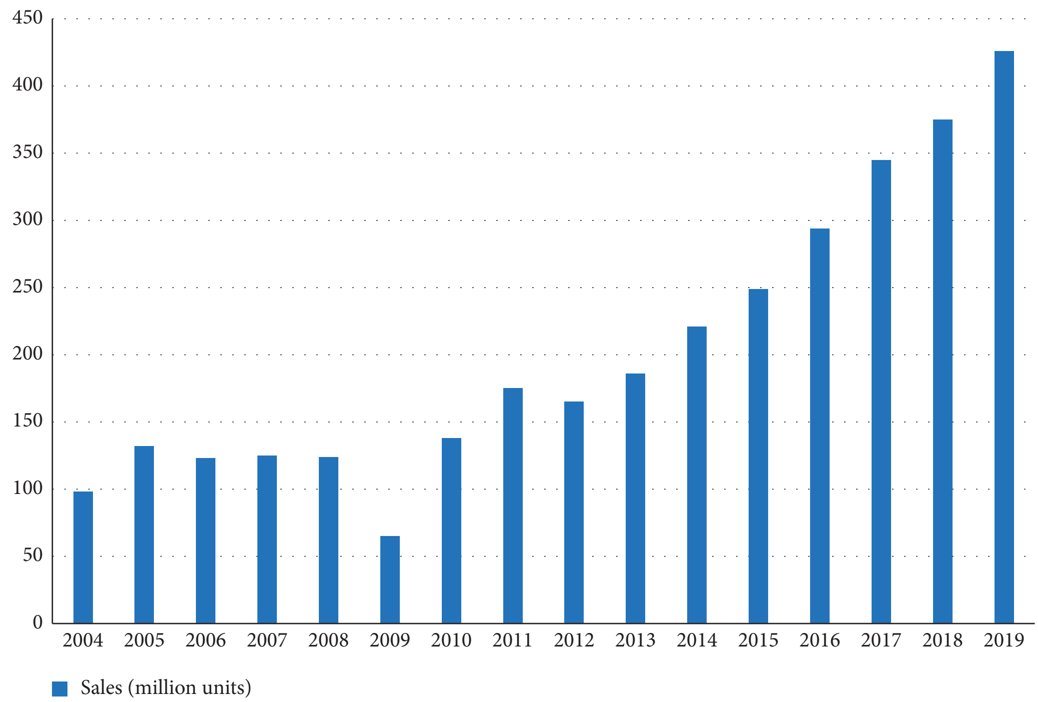

Figure 1: Global industrial robot sales from 2004 to 2019.

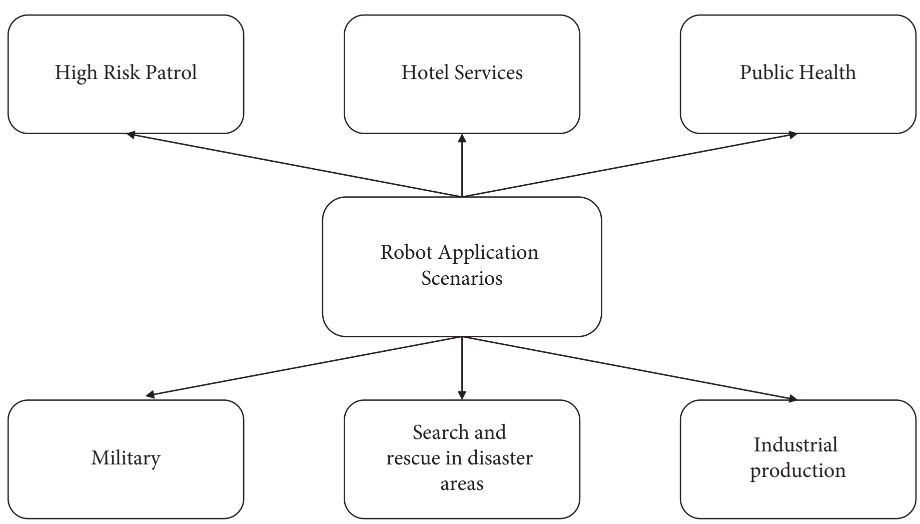

Figure 2: Robot application scenario.

Self-driving cars belong to the category of wheeled mobile robots, and self-driving technology is one of the core competencies of the future automobile market [19]. In the 1940s, foreign countries took the lead in launching research in the field of self-driving cars, and in the field of autonomous driving, China has achieved independent research and development of self-driving cars, equipped with unmanned vehicles on Baidu's self-developed Apollo autonomous driving platform, and currently, unmanned vehicles developed based on this platform can reach Leve4 level of autonomous driving, which is at the world leading level [20].

In summary, from the current types, functions, application scenarios of mobile robots, and the development status of various types of mobile robots at home and abroad, the future development trend of mobile robots must be more and more inclined to be highly automated and intelligent, and the characteristics of bionic will also become more and more significant. As the functions of mobile robots become more and more perfect and the types of mobile robots increase, the applications of mobile robots in various complex or dangerous environments and in daily life will become more and more common.

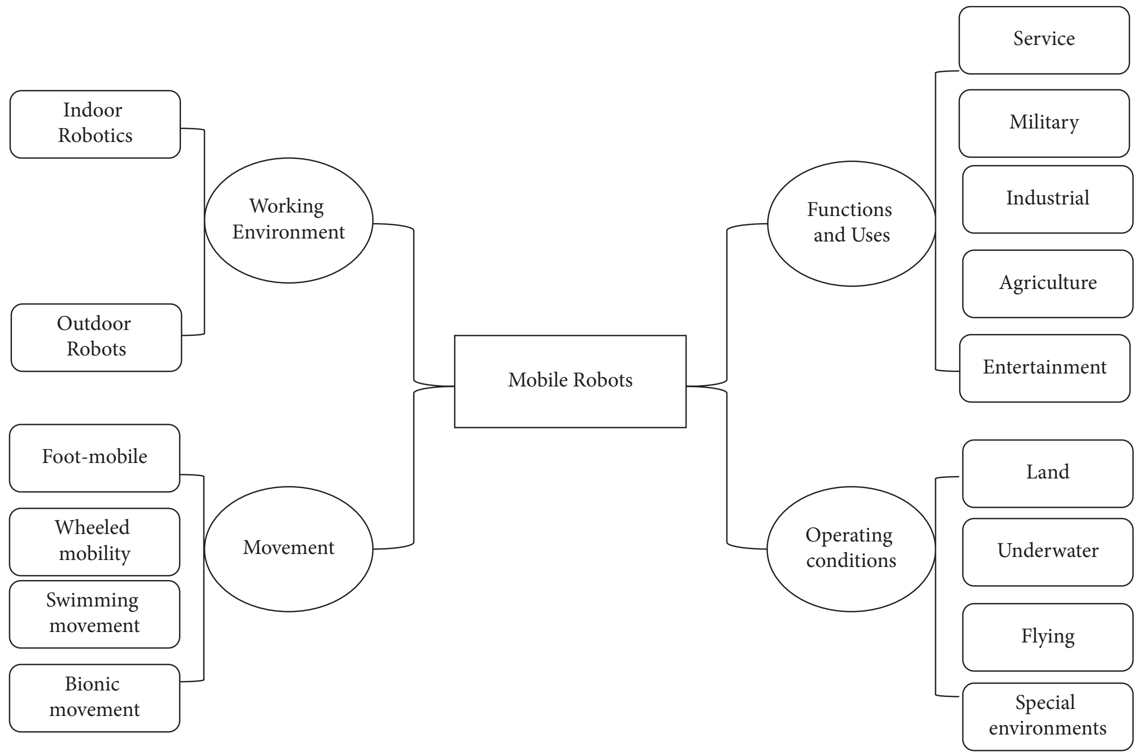

Figure 3: Classification of movable robots.

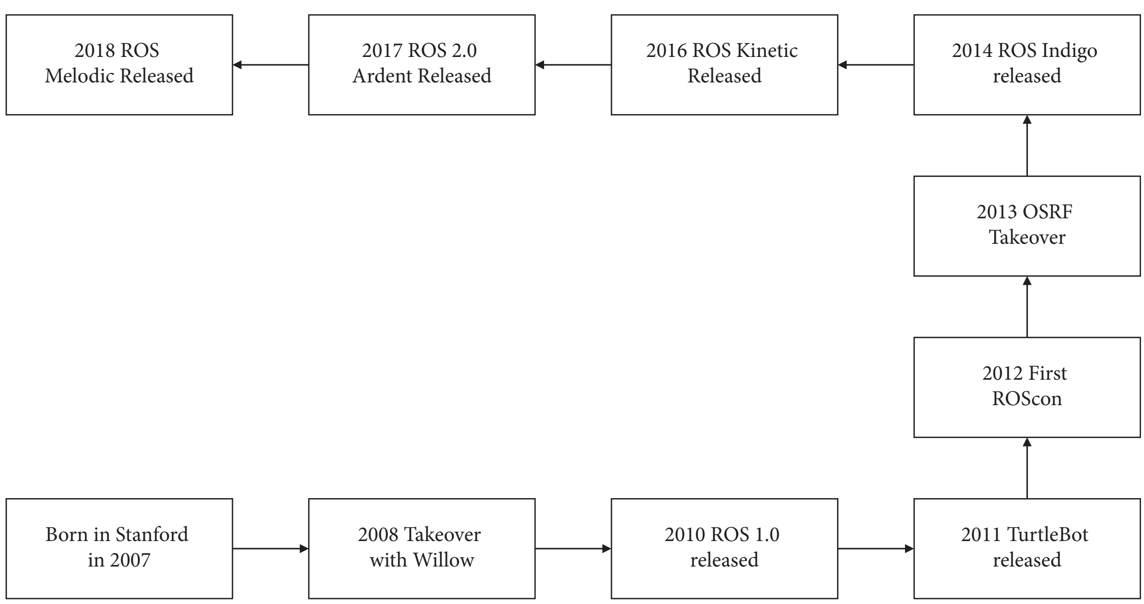

Figure 4: Development of the mobile robot development system.

3. Materials and Methods

3.1. Basic Theory

3.1.1. Simultaneous Robot Localization and Map Building Techniques. Simultaneous localization and mapping (also known as SLAM) is a collective term for localization and map building, a concept first proposed by Durrant-Whyte et al. In the field of autonomous navigation for mobile robots, the SLAM problem has been graphically described as "where am I" and "where am I going." SLAM technology relies on various sensor technologies to obtain environmental information, and simultaneous localization and map building technologies are divided into laser simultaneous localization and map building and vision simultaneous localization and map building, of which

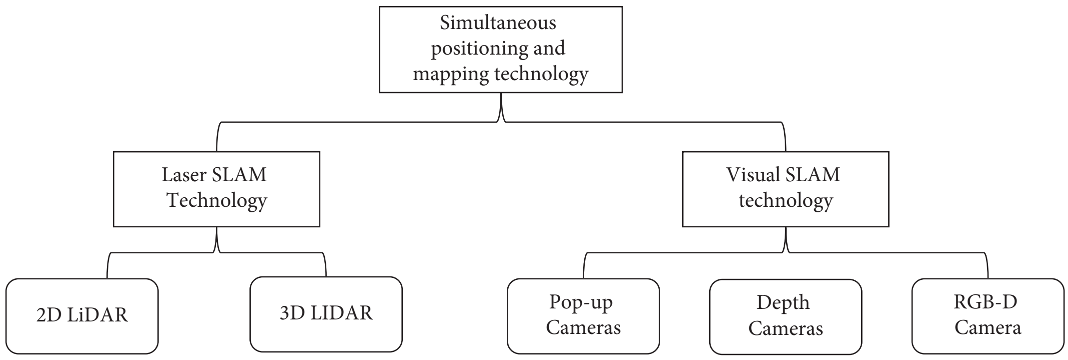

Figure 5: SLAM technology classification.

LIDAR is used for laser simultaneous localization and map building, while the latter is camera-based, as shown in Figure 5.

Robot localization is one of the purposes of SLAM technology, which refers to the use of motion sensors to obtain robot motion information and estimate the robot's position and pose information from the robot's overall and local motion information. At present, the positioning technology of mobile robots has reached a relatively advanced level, which can meet the positioning requirements of mobile robots in various complex environments. In addition, the positioning methods include relative positioning and absolute positioning, among which, relative positioning, i.e., positional tracking, often uses sensor information such as encoders, gyroscopes, and inertial sensors (IMU) to project the displacement and attitude information of mobile computing robots and is currently a common positioning method for mobile robots.

Map construction is also the purpose of SLAM technology, which refers to the use of sensors to obtain environmental information and build a map that precisely matches the actual environment, with the main purpose of providing a sufficiently rich and reliable judgment basis for mobile robots' motion decisions. SLAM technology was first presented at the International Conference on Robotics and Automation (IEEE Robotics and Automation Conference) in the 1980s. Smith developed the Kalman filter method to address the problem of map building and achieved groundbreaking research results. The particle filtering method is a filtering method with nonlinear sequential importance sampling. At present, based on the two filtering algorithms, combining various optimization and improvement methods is the mainstream trend of research in the field of SLAM algorithm.

The key problems of SLAM technology mainly include two major categories, one is the environmental information consistency and the other is the map building drift problem, among which, the environmental information consistency problem is also known as the data correlation problem, that is, the determinacy of the sensor to acquire the sensory information of an object in the environment, which is simply the consistency of the environmental information acquired by the mobile robot when it is in different positions. This problem has a very important impact on the accuracy of mobile robot positioning. Some intelligent algorithms such as the neural network method and fuzzy algorithm are also used to solve this problem.

The map building drift problem refers to the problem that the environmental information recognized by the sensor in the previous frame is in error with the environmental information recognized in the next frame during the map building process, resulting in the inability to align the scale of the two environmental map frames. The common method to solve this problem is loopback testing, and currently, loopback testing methods include violent matching loopback testing method. SLAM technology for mobile robots needs to combine technologies from several disciplines, and future research trends in SLAM technology need to focus on multisensor fusion, recognition of dynamic environments, and multirobot cooperation.

3.1.2. Energy Management. The goal of energy management is to rationally distribute power between the engine and the motor to improve fuel economy while optimizing emission performance. In today's robotic applications, the power to drive the robot is provided by the engine and the battery together or separately, using energy management strategies to keep the engine working in the high efficiency region. Since the motor can act as a generator, it can also act as an electric motor. For sustained hybrid robots, it is also necessary to ensure the maintenance of the battery charge (state of charge, SOC).

The energy management strategy distributes the torque between the engine and the motor in real time while satisfying the soft and hard constraints of the system. The rule-based energy management strategy ensures the operational efficiency of the system by setting threshold value control rules for the operating area of each component. These control variables used as threshold values usually include vehicle speed, motor torque, and battery SOC. These threshold values are usually determined after tuning the parameters. In addition, they can be combined with fuzzy logic control to improve the robustness of the algorithm.

3.2. Research Method for Mobile Robot Path Planning Techniques. In the process of autonomous mobility of mobile robots, path planning plays an important role in decision control, and in the field of mobile robot research, the problem has also been formulated as "how do I get there." When a robot plans a path, it is important to ensure that the path is as safe as possible, efficient in planning time, and smooth. After the emergence of graph-based search algorithms, a variety of intelligent planning algorithms have emerged. Although significant research results have been achieved in the current field of path planning technology, there are still many problems and shortcomings in the comprehensive performance of planning algorithms in practical applications, and therefore, improvement and optimization of path planning algorithms for path planning is a popular current research trend. According to the different types of maps used, path planning can be divided into discrete-domain path planning and continuous-domain route planning, and currently, the latter is the mainstream division of path planning algorithms.

Global path planning is mainly applied in relatively stable static environment; therefore, the requirement for real-time map is low and the requirement for map pervasiveness is high. The variety of global path planning algorithms is relatively rich, and they are divided into different search methods.

3.2.1. Algorithms Based on Graph Search. The graph search algorithm is to search an optimal global path from the starting point to the end point in the completed environment skeleton map (such as raster map, viewable map, and topological map) according to the different map information. The commonly used graph search algorithms include BFS, DFS, Dijkstra, and A^*.

For the limitations of the algorithms, scholars at home and abroad had proposed many improvement methods, the A^* algorithm has a certain purpose, and the planning efficiency of the algorithm is naturally higher. To further improve the performance of all aspects of the A^* algorithm, LINM et al. introduced parent node information in the A^* algorithm to reduce the number of extended nodes and shorten the planning time; Hua Hong et al. proposed a multiple A^* algorithm, designed a new node management criterion, improved the search efficiency, performed path smoothing, and obtained paths that conform to the robot motion characteristics.

Such algorithms, first, perform cluster analysis of the data by certain algorithms, so as to obtain the central part of the hidden neural network, and then use the results of this step to perform calculations to figure out the width value of the number. The specific width values are calculated as follows (1)–(3):

$$\sigma_j = \frac{c_{xy}}{\sqrt{2h}}. \tag{1}$$

In the c_{Xy} formula, start calculating the maximum distance to the centroid, and h the specific is the number of nodes.

After the input data are analyzed in the implied layer with the output layer for the relevant data, the output x_i of the first node j of the input sample in the implied layer is calculated by the following equations (2)–(3):

$$\phi(x_i, j) = \exp\left(-\frac{1}{2\sigma_j^2}x_i - c_i\right). \tag{2}$$

In the formula, c_j is the centroid of the node in the first layer, and the σ_j is the width value of the node in the first layer.

The output of x_i the first node of j the input sample in the output layer is calculated by the following equation (3):

$$y_m = \varphi(\phi(x_i, j) * w_m). \tag{3}$$

In the w_m formula, φ is the function of the involved weights.

3.2.2. Sampling-Based Planning Algorithm. The sampling-based planning algorithm is to find the end point in the built environment skeleton map by probabilistically sampling a certain indicator (such as roadmap information and spatial pose) in order to continuously reduce the search space, which can be divided into comprehensive query method and single query method according to the order of building roadmap, and the PRM algorithm and RRT algorithm are typical sampling planning algorithms.

Probabilistic road map (PRM) is the first sampling-based planning algorithm, which was proposed by Lydia Kavraki and Jean-Claude Latombe in 1994, and then foreign scholars SWilmarth and NAmato proposed derivative algorithms for the drawbacks of the algorithm, respectively, MAPRM and OBPRM, and domestic scholars Hongqing Tian and Jianqiang Wang also integrated the artificial potential field method based on PRM, i.e., APFPRM fusion algorithm, which improved the planning efficiency of the algorithm and the overall safety of the path.

The decision speed let random tree algorithm (RRT) is based on the incremental sampling planning algorithm proposed by American scholars SMLaValle, and in 1998, the algorithm is mostly applied in the environment with many obstacles, with the increasing application requirements of the algorithm, many improvements of the RRT algorithm have been proposed, such as the RRT proposed by Kuffner and the LaValle connect algorithm, which improves the planning efficiency of the algorithm by speeding up the growth tree expansion; Weimin Zhang improved the RRT algorithm by taking the target about and target bias as the starting point, which solves the problem of low planning efficiency of the traditional RRT algorithm in narrow maps.

The local path planning algorithm appeared relatively late, and the algorithm is mainly applied in variable dynamic environments, so it is necessary to build dynamic maps with high real-time performance; that is, it relies on higher sensor technology to identify dynamic obstacles in the environment and ensure the safety of mobile robots in dynamic environments. For example, the artificial potential field (also known as APF) method was proposed by Khatib in 1985. For example, foreign scholar Lazarowska proposed the DAPF algorithm, which constructs a discrete potential field based on the traditional APF to improve the planning efficiency and shorten the path length; domestic scholar Luo Qiang et al. introduced the robot-target distance factor and tangent method in the repulsion function of the traditional APF algorithm, which solved the problem that the traditional APF algorithm cannot reach the end point.

Compared with the APF algorithm, the dynamic window approach (DWA) appeared much later, and naturally, the algorithm is more advanced. The DWA algorithm was born in 1997 and proposed by foreign scholars DieterFox and SebastianThrun. It is a local planning algorithm based on the sampling of motion variables, so the algorithm also belongs to the sampling planning algorithm, and the path planned by the DWA algorithm is more in line with the actual motion characteristics of mobile robots. The DWA is the most widely used algorithm in the field of local path planning for mobile robots.

To summarize the above, although there are many kinds of path planning algorithms, each algorithm has certain limitations, and so far, there is still no planning algorithm in the absolute leading position, so there is still some room for improving and improving the path planning technology of mobile robots. The future development of path planning algorithms should focus on the improvement of traditional algorithms, the integration of multiple algorithms, and the application of complex and multidimensional environments.

4. Results and Discussion

4.1. Improved Global Path Planning. The optimal path between the starting and ending points must be identified without running into any obstacles, given a mobile robot and an environment model. Establishing the environment model and the path planning algorithm are the two main components of global path planning, and the choice of algorithm has a significant influence on the effectiveness of the path planning process. The conventional A^* algorithm has been explored and is advantageous due to its straightforward premise, high path planning efficiency, and high success rate when looking for the best path. Although numerous researchers have made some progress in the A^* algorithm's performance, they typically only enhance one aspect of the algorithm's path planning effectiveness, path length, or path turning angle. In some instances, they also fail to fully take into account the robot's safety in relation to the obstacle distance. In order to increase the robot's visualization, path discrimination accuracy, overall efficiency, minimized redundant paths provide smoother global paths; thus, this work offers an updated A^* algorithm. The modified A^* algorithm is more effective than the A^* method, the genetic algorithm (GA), and the simulated annealing process according to simulation data (SA).

4.1.1. Principle of A^* Algorithm. The traditional A^* algorithm searches for the target location by heuristics and can find the shortest path by using the edge cost (edgecost) and Euclidean distance-based heuristics. Usually, the traditional A^* algorithm searches for four neighboring nodes in each expansion. However, fixing and limiting each steering angle to 90° affects the search efficiency and increases the path length and turning angle. In order to increase the effectiveness and quality of the path design process, we use an 8-connected technique in this study. For each expansion, the number of neighboring nodes has risen from 4 to 8, and the steering angle is either 45° or 90°.

The classic A^* algorithm's flow diagram is more complex, and when it searches for paths using this technique, it simply looks for the best path nodes, which significantly reduces processing. The commonly used heuristic functions h include Euclidean distance function, Manhattan distance function, and Chebyshev distance function. The path calculated using the Euclidean distance function as the heuristic function in this study is closer to the actual path since the A^* method searches eight nearby nodes in each expansion.

4.1.2. Raster Method Environment Modeling. Since the traditional A^* algorithm is a raster traversal search algorithm, it treats the robot's size as if it were a prime point when determining its actual path. This causes the robot to take more redundant paths, which increases its overall energy consumption and makes it easier to run into obstacles. The enhanced methodology described in this study uses an optimization strategy to overcome this issue by creating an enlarged obstacle layer surrounding the obstacles, and the number of layers of which may be changed depending on the size of the robot. The number of growing obstacle layers is assumed to be 1 as the mobile robot is modeled as a square grid with a side length of 1. This optimization technique maintains a set distance between the path and the barriers to save energy and enhance obstacle avoidance.

There are three integers in the lattice that exist in representing $f(n)$, $g(n)$, and $h(n)$, and the corresponding spots in the lattice are at the top left, bottom left, and bottom right. The traditional A^* method plans the g, h, and f values of each node. Every node also includes a pink arrow pointing to its parent node. The path is initially plotted from the starting location in one direction toward the goal point. Since the 8-neighborhood search algorithm is used in this research, there are three unsearched sites that can be chosen for the following step. These locations are spread to the bottom right of the beginning point. To get the orange raster route, which corresponds to the blue path, the $f(n)$ of these three locations is calculated, and the point with the smallest $f(n)$ is chosen as the next site, which is the current lowest generation value node. In the traditional A^* algorithm one-way pathfinding process, after searching a portion of the nodes toward the target point, the algorithm then begins to search the nodes close to the starting point again, which will result in a lower obstacle avoidance rate, longer running times, better energy consumption, and decreased overall robot performance. This is because the searchable nodes close to the starting point have high h values (far from the target point) and low g values (only a few points are accumulated); after the traditional A^* algorithm has planned toward the target point for a while, the search nodes gradually approach the target point, and the h values decrease (close to the target point), while the g values gradually increase with accumulation, causing the algorithm to restar.

4.1.3. Improving the A^* Algorithm. The conventional A^* method is a one-way search that takes a lot of time to plan paths since it searches a lot of pointless nodes back and forth. In order to address this issue, the traditional A^* algorithm is given a two-way alternating search mechanism in this paper. This mechanism alternately searches the path from the starting point and the target point until they intersect, and it can significantly cut down the amount of time spent searching for pointless nodes and increase the effectiveness of path planning. The Euclidean distance function is employed as the heuristic function for both the forward search and the reverse search. The forward estimation function targets the reverse current node, and the reverse estimation function targets the forward current node.

By exchanging the respective current target points of the forward and reverse searches, we employ the technique of alternating the best current node in this study to make sure that the bidirectional search comes together close to the geometric center of the beginning point and the destination point. The alternating bidirectional searches the 15×15 raster map's path which is planned using the A^* algorithm. Continue iterating until the encounter ends.

The two-way alternating search's precise methodology here is a description of the path search A^* algorithm: (1) create the environment map first; (2) initialize the forward search and reverse search open lists, closed lists, and father lists, adding the starting point to the forward search open list and the target point to the reverse search open list, respectively; (3) determine whether the forward search and reverse search open lists are not empty; if so, go to next step ; if not, the path search fails because the forward or reverse search has exhausted all of the nodes that it is capable of searching but has not yet met; (4) change the total cost F minimum point from the forward open list's forward closed list's forward current point S to the reverse open list's reverse closed list's reverse current point G; (5) determine whether the nodes are exactly visible; if so, the forward search and reverse search have met, and the path points are output by the forward and reverse father lists; otherwise, forward search is carried out; (6) begin forward search with the reverse current point S as the target, and determine each time whether the neighboring points m_i $(i = 18)$ of the forward current point are obstacle points or already in the closed list; if not, then the generation value of m_i and the father node are updated, and the forward open list is updated, and the forward current point is updated, and it becomes S1; and (7) restart step 3 until the forward search and the reverse search have met. Reverse search, with the forward current point as the target S1, uses the same search methods as the forward search and updates the reverse current node as G1.

This work compares the enhanced A^* algorithm with the A^* algorithm and performs simulation experiments in various obstacle contexts ($30 * 30$, $50 * 50$, $100 * 100$, and $200 * 200$ raster maps) to demonstrate the efficacy of the two-way alternating search A^* algorithm. The bidirectional alternate search A^* method searches fewer nodes in each map than the classic A^* algorithm , thereby proving that it can locate the path more quickly. The nodes that are searched are shown in green on the maps. The simulation experimental results of the two-way alternating search A^* method and the conventional A^* algorithm is compared to the classic A^* algorithm, then the A^* algorithm reduces search time by 51%–95% and the number of program cycles by 91%–98% in addition to the two-way alternating search, As the map size grows, the A^* algorithm cuts down the search time more than the original A^* algorithm. Figure 6 compares the enhanced A^* algorithm to the original A^* method.

The two-way alternating search A^* algorithm typically finds paths with great efficiency. The two-way alternating search A^* algorithm, however, will have a round-trip search for unnecessary nodes and even searches more nodes than the traditional A^* algorithm, resulting in a significant increase in computation and seriously affecting the path planning efficiency when there are obstacles perpendicular to the path on the way to meet the forward and reverse paths and the obstacles cannot be easily bypassed. Given that the cost function plays a crucial role in the two-way alternating search A^* algorithm, finding a good cost function can help solve this issue by ensuring that the algorithm explores the best path while simultaneously minimizing the number of search nodes and increasing algorithm efficiency. When $g(n) = 0$, the cost function transforms into a heuristic function h that calculates the forward current node to the reverse current node, and the greedy two-way BFS algorithm replaces the two-way alternating search A^* method. However, the planned route may not always be the best one. When $h(n) = 0$, the cost function $f(n)$ changes to the real cost function g, which determines the beginning point to the current node $n(n)$, and then the two-way alternating search is used. The A^* algorithm is converted into a two-way Dijkstra algorithm, which seeks for a short path but inefficiently calculates a lot of nodes. The two-way A^* will only search for the best path node without expanding any other nodes, which will greatly reduce the amount of computation and result in very high pathfinding efficiency, improving the heuristic function of the two-way alternating search A^* algorithm. Ideally, $h(n)$ is exactly equal to the cost from the forward current node to the reverse current node.

The estimated surrogate for the bidirectional alternating search between the forward current node and the reverse current node is the straight-line distance between the two points, which is usually less than the actual path cost. The A^* algorithm takes into account the proportion of the actual path cost with the position between the forward and reverse current nodes. The estimated value should be smaller when the forward current node is far from the reverse current node because the estimated generation value is much lower than the actual generation value. Conversely, when the forward current node and the reverse current node gradually get closer to one another, the estimated value should be smaller because the estimated generation value is getting closer to the actual generation value. In this sense, the cost function's heuristic function, $h(n)$, is weighted by exponential decay in this paper.

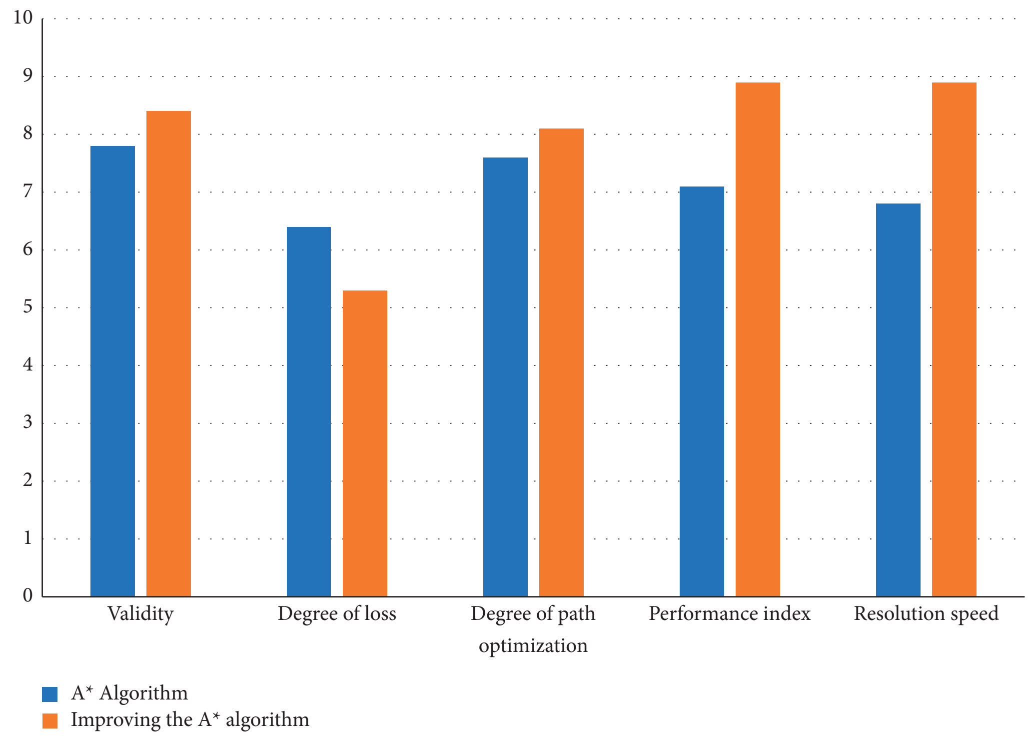

FIGURE 6: Comparison of the improved A* algorithm with the A* algorithm.

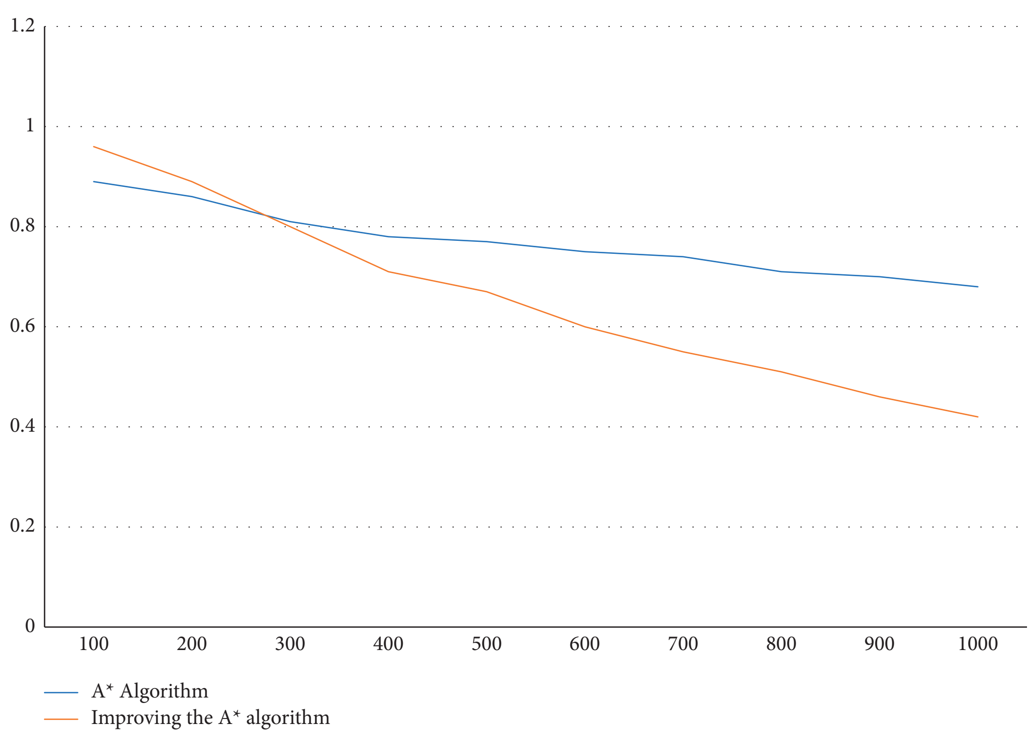

FIGURE 7: Comparison of improved A* algorithm and A* algorithm energy management.

When the forward current node and the reverse current node are separated by a great distance, $h(n)$ is greater and the weight e is greater, causing the two nodes to soon collide. The estimated cost is closer to the actual cost when the forward current node and the reverse current node are close to one another. When the forward current node meets the reverse current node, $h(n)$ is close to zero and the weight e is close to one, ensuring that the forward path intersects the reverse path.

The simulation's experimental findings explain the classic A* method, the bidirectional alternating search A*

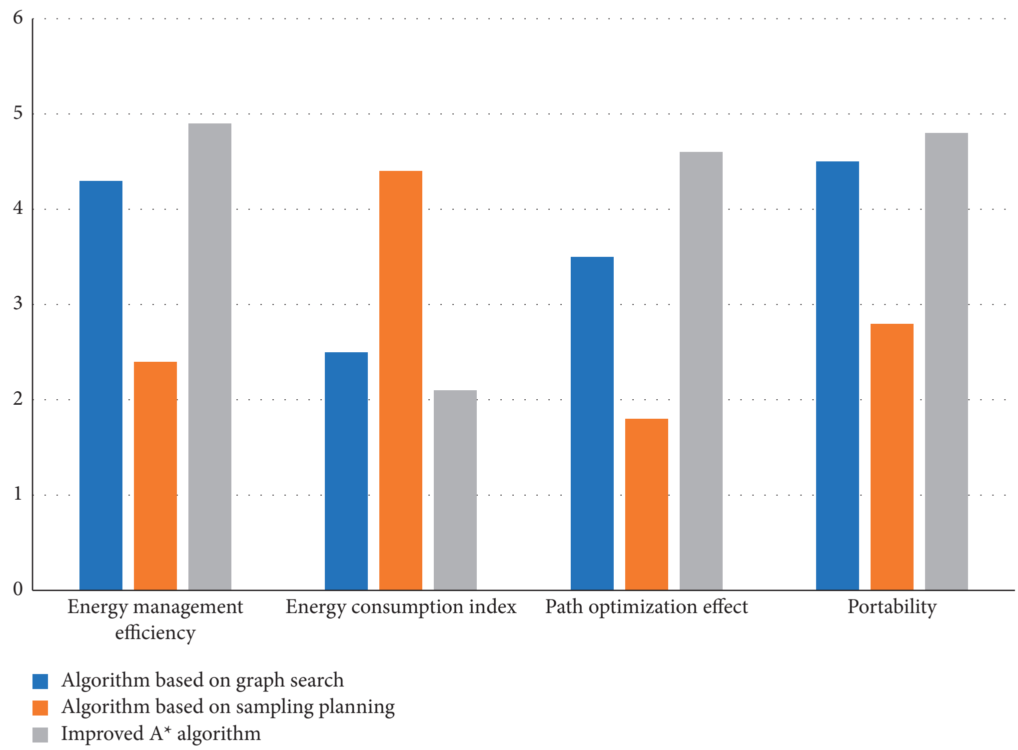

FIGURE 8: Comparison of energy management efficiency of three algorithms.

algorithm, and the bidirectional alternating search. The bidirectional alternating search uses the A^* algorithm and raster maps of 15 by 15 and 100 by 100 pixels. In comparison to the bidirectional alternating search, the A^* algorithm, and the standard A^* algorithm, the A^* algorithm with improved heuristic function $h(n)$ examines fewer path nodes although paths will be extended. The two-way alternating search A^* algorithm with improved heuristic function in the 1515 raster map reduces the average search time by 64.6 percent and 44.0 percent, respectively, and the turn angle by 33.3 percent when compared to the two-way alternating search A^* algorithm, but the path length increases by 20.9 percent when compared to the traditional A^* algorithm; in the 100100 raster map, the turning angle is reduced by 86.7% than the two-way alternating search A^* algorithm, but the path length is increased by 19.6% than the traditional A^*. It demonstrates that when there are obstacles in the way of the encounter that cannot be easily avoided, the two-way alternating search A^* algorithm with improved heuristic function $h(n)$ can effectively reduce the search path time and path turning angle of the two-way alternating search A^* algorithm. However, the path length will increase.

4.2. Robot Path Planning Energy Management Research. In this paper, in addition to improving the A^* algorithm for global path planning, two algorithms are used to study the robot path planning energy management. First, the overall performance of the two algorithms is compared over two years with 1000 iterations. It is found that the energy consumption of the improved A^* algorithm is much higher than that of the traditional A^* algorithm after continuous iterations in the case where the initial energy consumption of the A^* algorithm prevails, and therefore, the improved A^* algorithm has a comparative advantage in robot path planning energy management. Therefore, the improved A^* algorithm has a greater advantage in robot energy management, as shown in Figure 7.

This paper also makes a relevant comparison between the first two algorithms introduced in this paper and the algorithm studied in this paper. The comparison mainly involves four aspects, which are energy management efficiency, energy consumption index, path optimization effect, and portability. It is found that both the improved A^* algorithm studied in this paper and the A^* algorithm have good results, as shown in Figure 8.

5. Conclusion

The fundamental idea behind the conventional A^* algorithm is introduced in this study,along with some of its drawbacks, including its laborious calculation process, huge turning angles, and unreliable trajectory planning. A better A^* method is also suggested. The two-way alternating search mechanism introduced by the improved algorithm increases the effectiveness of the search path, and the heuristic function improvement addresses the issue that the two-way alternating search A^* algorithm requires more time when obstacles perpendicular to the path are present on the way to the encounter. Simulation tests in various raster environments show that the improved A^* algorithm outperforms the traditional A^* algorithm, genetic algorithm, and simulated annealing algorithm in terms of search path speed while overcoming the drawbacks of numerous path turning angles and large turning angles. This makes it a practical and effective algorithm for raster map environments.

Data Availability

The dataset is available upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

Temporal and Spatial Distribution of Food Security Production and Total Water Resources in Western Jilin: Based on Center of the Gravity Model

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In recent years, the main grain-producing areas in the west of Jilin have gradually concentrated in the perennial irrigation areas and supplementary irrigation areas in the north, and the stress degree of grain irrigation water resources is gradually increasing. Therefore, this paper selects the arid and semiarid area in the west of Jilin Province as the research area and compares and analyzes the modeling process and simulation accuracy of the temporal and spatial distribution of food security production and total water resources. Based on the center of gravity model, this paper studies the temporal and spatial distribution of food security production and total water resources in Western Jilin. It can be seen that after 2018, rice and wheat show a fluctuating upward trend, and their values rise from 0.612 to 0.786 and 0.356 to 0.612, respectively; the rise of corn is small, showing an inverted "U" trend, which first increases from 0.693 in 2018 to 0.701 in 2019 and then decreases to 0.671 in 2021; By comparing the precipitation statistics in different years, the inverted "U" trend of corn irrigation water efficiency may be related to the sudden increase of precipitation. The center of gravity model is used to analyze the evolution trend of the center of gravity of grain production and water resources in Western Jilin from the national and regional levels, and the spatiotemporal coupling degree of the center of gravity of grain production and water resources is explored through the two-factor center of gravity coupling situation model.

1. Introduction

Food security and water resources security are major issues affecting human survival and social development, and water resources security is an important basis for food security. China's total population and the total demand for grain in Western Jilin are huge, but the freshwater resources highly dependent on grain production are extremely limited. The per capita water resources only account for the world average. The continuous deterioration of the ecological environment and the low efficiency of agricultural water use also make the water resources constraints faced by grain production more and more prominent [1]. In recent years, the main grain-producing areas in the west of Jilin have gradually concentrated in the perennial irrigation areas and supplementary irrigation areas in the north, and the stress degree of grain irrigation water resources is gradually increasing. Irrigation water efficiency in grain production in Western Jilin Province, distinguishing different crops and regional differences, and analyzing the driving factors of water resource utilization efficiency have important guiding significance for putting forward effective water resource management suggestions under the background of grain water resource mismatch [2, 3]. The existing domestic and foreign literature on food production from the perspective of water resources constraints is rich. Starting from the level of food security in Western Jilin in the new era, many scholars pointed out that how to effectively ensure the national food supply security under the constraint of water resources is an important problem to be solved urgently. We must establish the concept of sustainable food security and promote the matching of food production with the carrying capacity of resources and environment [4]. The research on water resources efficiency in Western Jilin mainly focuses on agriculture, industry, and comprehensive fields. The evaluation research on agricultural water resources utilization efficiency has gradually changed from the research on the engineering efficiency of irrigation water transportation and field utilization to the research on the economic efficiency with water resources productivity as the index.

Therefore, in this paper, the arid and semiarid area in Western Jilin Province is selected as the research area, and the modeling process and simulation accuracy of the spatial and temporal distribution of food safety production and total water resources are compared and analyzed, so as to understand the advantages and disadvantages of them in groundwater simulation and prediction. By constructing the model of grain yield barycenter, taking the county as the basic statistical unit, the movement trajectory of grain yield barycenter in Western Jilin Province has been quantitatively studied, and the driving mechanism and regional effect of barycenter movement have been deeply analyzed [5, 6]. By measuring the spatial moving direction and geometric distance of the center of gravity of each index, the model can accurately judge the spatial evolution law of each element, and has unique advantages in measuring the matching degree between intensive land use and ecological environment. The analysis model of gravity center can intuitively reflect the moving track of spatial layout, but the effect is obvious only under certain conditions. Econometrics can study the driving factors well, but it cannot directly show the evolution of spatial layout. At the same time, the choice of driving factors is also limited by data. Comparative advantage model can better carry out regional advantage research and driving factor analysis. The research results can provide a theoretical basis for coordinating the regional contradiction between food production and resources and environment, increasing farmers' income, and formulating regional policies to ensure food security [7].

Based on the actual situation and existing research, this paper believes that analyzing the coupling degree or contradiction degree between food production and water resources from the national and regional levels is conducive to give full play to the advantages of regional water resources, promote the sustainable development of agricultural production, and ensure national food and ecological security by adjusting the layout of food production [8]. In view of the fact that the deviation degree of water use gravity center is greater than that of gravity center and the fact that the temporal and spatial distribution and utilization of food security production and total water resources in Western Jilin have not matched for many years, when designing and formulating regulatory policies to coordinate food security production and sustainable utilization of water resources, we should fully consider the reality of the mismatch between food security production and water resources spatial deviation, from strengthening food security production and water resources utilization planning relying on scientific and technological innovation and the optimization and upgrading of industrial structure, strengthen food safety production and water resources law enforcement and supervision [9, 10]. This paper starts with the analysis of the spatial and temporal distribution of grain resources and the change of water inflow; then, the center of gravity model is used to analyze the evolution trend of the center of gravity of grain production and water resources in Western Jilin from the national and regional levels, and the spatiotemporal coupling degree of the center of gravity of grain production and water resources is explored through the two-factor center of gravity coupling situation model [11]. The innovations are as follows:

(1) This paper puts forward the solution mechanism of the center of gravity model. With the acceleration of marketization and the improvement of living standards, people's food consumption structure has changed greatly, the direct consumption of rations has decreased, while the demand for meat, egg, milk, and alcohol has increased. The upper and lower limits of food safety production and the temporal and spatial distribution of total water resources constitute a multiobjective optimal allocation model of water resources in the study area, which is solved based on the gravity center model.

(2) The allocation efficiency of water resources in grain production was discussed. The natural attributes of water resources in grain production are mainly reflected in: first, limited quantity and recycling, water resources in China are scarce, the per capita water resources in Western Jilin account for 30% of the world average, and the per mu water resources in Western Jilin account for 52% of the world average. In grain production, water can realize the cycle of utilization, supply, consumption, and recovery through crops, thus participating in hydrological cycle, material cycle, and quantity flow of ecosystem.

The overall structure of this paper consists of five parts. The first chapter introduces the background and significance of food safety production and water resources. The second chapter mainly describes the research status of food safety production and water resources at home and abroad. The third chapter introduces the research methods and data sources. The fourth chapter carries out the experiment and analyzes the results. The fifth chapter is a summary of the full text.

2. Related Work

2.1. Research Status of Food Security Production and Water Resources at Home and Abroad. The research on food security production and water resources can be said to run through the development process of economics. Foreign research on the allocation of production factors can be traced back to the manufacturer theory of classical economics, in which the theoretical description of resource allocation using production function under the assumption of minimum cost and maximum output.

Zhang and Vesselinov put forward the survey data of 151 citrus farmers in Nepal and Tunisia and analyzed it by using the stochastic frontier function. The efficiency calculation results show that the surveyed citrus farmers can increase their output by 336% by effectively using the existing input factors, while at most, they can use less water resources by 46% when the output is unchanged [1]. Karabulut et al. proposed to calculate the irrigation water efficiency of potato planting in Minle County, Gansu Province, by SFA model based on Translog production function and considered that the expansion of production scale and farmers' failure to master the planting techniques of new varieties were the reasons for the low irrigation water efficiency of potato in the study area [12]. Mcneill et al. using the optimization principle of "equal marginal utility" and the principle of equal marginal loss of each crop, a mathematical model for optimizing the output value of planting industry caused by the loss of output value was established to solve the problem of allocating limited water to various crops to maximize the total output value [13]. Radmehr et al. proposed to use high spatial resolution data and world trade data to evaluate the global rice footprint of blue water, green water, and grey water from the perspective of irrigation. The results show that the global rice water footprint is 785 km^3/a, with an average of 1235 m^3/t, of which green water accounts for 46%, blue water accounts for 45% and grey water accounts for 7% [14]. Xu et al. put forward the method of superlog stochastic frontier production function, based on the survey data of farmers in Shijin Irrigation District of Hebei Province and made an empirical analysis on the production technical efficiency and water use efficiency and its influencing factors. It was found that the water use efficiency in Shijin area was far lower than the production technical efficiency, and the irrigation water consumption could be reduced by 23.34% when other inputs were constant [15]. He et al. proposed using the SFA model based on C-D production function; it was concluded that the irrigation water efficiency of wheat in Guanzhong area of Shaanxi Province was lower than the production technology efficiency and further judged its influence degree from four aspects: individual, family, irrigation, and cultivated land characteristics. DEA is a nonparametric statistical method that combines operations research, mathematical economics, and other disciplines to evaluate the efficiency of decision-making units through input and output [16]. Turner et al. believe that the difference of economic development level is the main factor of regional differences in water resources efficiency; in addition to exploring the drive of economic development level on water resource efficiency, it analyzes the impact of natural resource endowment [17]. Yuan et al. believe that the construction of farmland water conservancy facilities and the abundance of water resources have a significant impact on the efficiency of agricultural water resources [18]. Liu et al. pointed out that agriculture must seek development in water saving. On the basis of water saving, we can appropriately expand the irrigation area, improve the irrigation guarantee rate, implement deficit regulation irrigation on the basis of making full use of natural precipitation, and take the road of "water saving and yield increasing" [19]. Zhao et al. proposed to further raise awareness, clarify ideas, strengthen top-level design and overall planning, increase investment, speed up construction, improve mechanism, innovate development, and further pragmatic farmland and water conservancy foundation according to the requirements of the Central Committee and the deployment of the Party group of the Ministry of water resources, so as to provide solid support and guarantee for the development of modern agriculture and ensuring national food security [20].

2.2. Research Status of Food Safety Production and Water Resources under the Model of Gravity Center. The above research is aimed at the lack of research on the matching degree and constraint degree of water and soil resources elements in grain production. This paper puts forward a gravity center analysis model for research, and many scholars use it to analyze the shift of gravity center in grain crop production. However, the barycenter analysis model needs to assume that the region is a homogeneous plane. Therefore, when the provinces and regions are taken as the research units, the barycenter of grain production is concentrated in the geographical centers of each province. In addition, because the moving direction of the center of gravity of wheat is not obvious, the moving distance error will occur when using this model. This paper studies the allocation efficiency of water resources in grain production, the allocation characteristics of water resources in grain production between regions and industries, and the optimal allocation strategy design of water resources in grain production. However, the research on revealing the marginal effect difference of water resources allocation between grain crops and cash crops and the allocation efficiency of water resources among heterogeneous farmers is not deep enough. The exploration of the whole country through statistical data is mostly the calculation and factor analysis of agricultural or comprehensive water resources efficiency, but it cannot be refined to some kind of food crops. Moreover, the existing literature rarely analyzes the spatial differences of grain water resources efficiency in different major grain producing areas. Generally speaking, there are many researches on the characteristics and laws of water resources, and the research on the market mechanism of water resources allocation, the government's macro-control strategy, and the behavior of food and agriculture in water use needs to be further deepened. As a method to study the spatial distribution of food crops, the center of gravity model can intuitively show the changes of food production areas. In the future research, it should be applied scientifically according to specific research problems.

3. Research Methods and Data Sources

3.1. Temporal and Spatial Distribution of Water Resources in Grain Production Based on Gravity Center Model. The center of gravity model regards the city with water shortage as a point, takes its water demand as the index of the point, calculates the "center of gravity" of these points according to the index of these points, calls the connection between the

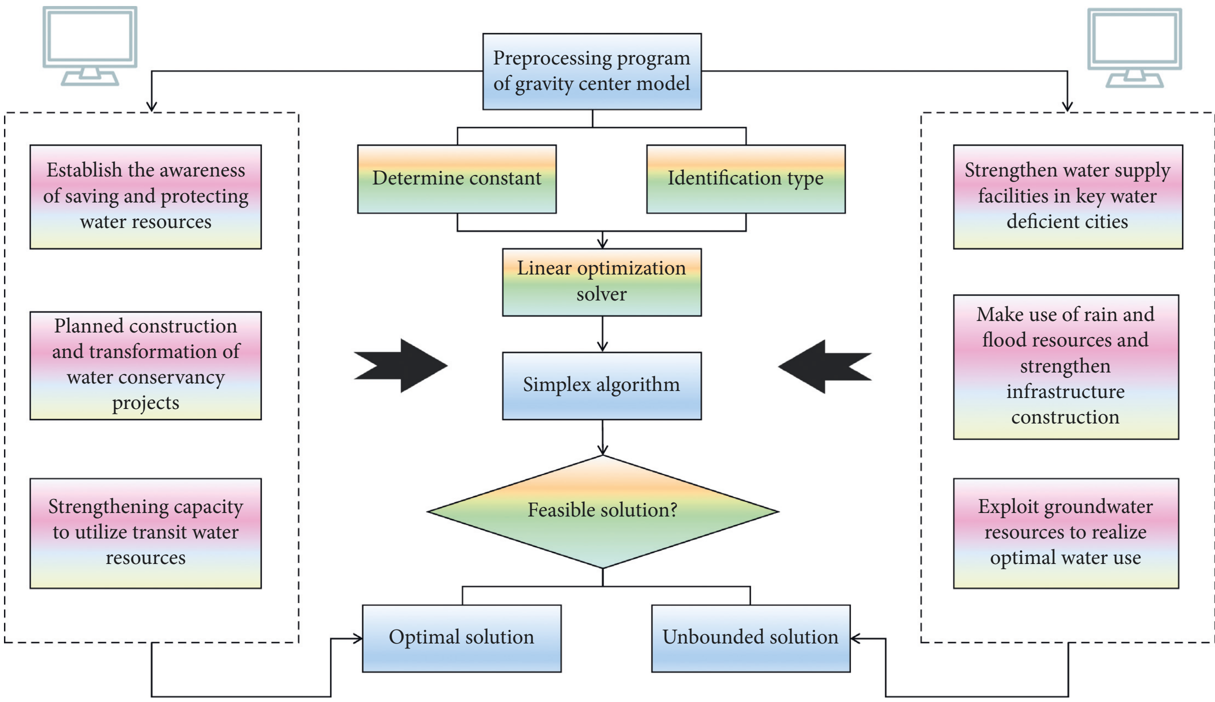

Figure 1: Solution mechanism of center of gravity model.

city and the river "water transport line," and regards these water transport lines as water transmission channels to be built [21]. The concept of center of gravity originates from physics, which means that there is a certain point in space, and the power contrast in the left and right directions around the point remains balanced. The development of irrigation in northern China has improved the ability of agriculture to resist natural disasters. At the same time, it has created conditions for the popularization and application of advanced agricultural technologies such as improved varieties, fertilization, and improved cultivation. Land productivity has increased significantly, and grain output has increased rapidly, driving the northward shift of the focus of grain production. In this way, the problem is transformed into the problem of minimizing the sum of weighted lengths from some points to a straight line [22]. The purpose of the model is to build the most suitable channel on the basis of the minimum total water volume and determine the direction and beginning and end location of the main channel. The model also gives the government macro suggestions in this regard. The more agricultural water consumption per capita, the more abundant water resources that farmers can use, the higher their perception of water resources, the lower their attention to water use efficiency in the process of grain production, and the lower their demand for the development of technologies to improve water use efficiency. The development of technologies often lags behind, so there is a negative correlation. The driving factors of temporal and spatial distribution evolution mainly include climate factors, technological progress factors, production input factors, and other social factors. Among them, the research on climate factors mainly focuses on climate warming and the change of light, heat, water, and other conditions. The change of climate factors affects the proportion of regional water and heat resources, thus affecting the production status of wheat in each region and ultimately the spatial layout of wheat; due to the natural suitability characteristics of grain crop growth, the change of grain supply structure will inevitably lead to the change of spatial pattern of grain yield. On the one hand, with the acceleration of marketization and the improvement of living standards, people's food consumption structure has changed greatly, the direct consumption of rations has decreased, and the demand for meat, egg, milk, and wine has increased [23]. The upper and lower limits of the temporal and spatial distribution of food security production and total water resources constitute a multiobjective optimal allocation model of water resources in the study area, which is solved based on the center of gravity model. The solution mechanism of the center of gravity model is shown in Figure 1.

The center of gravity model is an important analytical tool to study the spatial changes of elements in the process of regional development. Because regional development is a process of factor aggregation and diffusion, the position of the center of gravity of each factor is constantly changing, and the movement of the center of gravity of each factor reflects the spatial track of regional development. The gravity center model of regional grain output constructed in this study is expressed as follows:

$$x_j = \sum_{i=1}^{n} \left(T_{ij} \cdot x_l \right), \tag{1}$$

where $T_i\,(i = 1, 2, 3, \ldots, n)$ represents the grain yield of the i evaluation unit; $P_i\,(x_i, y_i)$ the geographical center coordinates of the evaluation unit; $P_i\,(x_i, y_i)$ is the National center of gravity coordinate of the j year of grain output.

The barycentric coordinates of national grain output are $P_k(x_k, y_k), P_{k+m}(x_{k+m}, y_{k+m})$, respectively, then the moving direction model of barycentric P_k to P_{k+m} is

$$\theta_m = \arctan(y_{k+m} - y_k). \tag{2}$$

The center of gravity moving distance model is

$$d_m = \sqrt{(x_{k+m} - x_k)^2 + (y_{k+m} + y_k)^2}. \tag{3}$$

Water will be diverted from the nearest river that can meet the water demand of all cities, and then water will be supplied to each city separately. The model needs to determine the location of the main river channel. Obviously, the shorter the river channel, the lower the cost. What we need to do is to reduce the water transport channels as much as possible. The following assumptions are made. If there is more than one river that can meet the water demand of the surrounding cities, we choose the river nearest to the city to establish the optimization model.

Objective function

$$\min y = \sum_j c_{ij} \times d_{ij}. \tag{4}$$

Let the coordinates of the center of gravity be X_0, where X_0 and Y_0 represent the latitude and longitude of the center of gravity, and its calculation formula is as follows:

$$X_0 = \frac{\sum_i c_i x_i}{\sum_i c_i}, Y_0 = \frac{\sum_i c_i y_i}{\sum_i c_i}. \tag{5}$$

Constraint condition

$$c_{ij} = \sum_j c_{ij}. \tag{6}$$

Under the above constraints, LINGO software is used to solve the value of c_{ij} that minimizes c_{ij}, and d_{ij} is a known number.

The adjacency matrix defining the water quantity of different rivers to different cities is C

$$C = \begin{pmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \end{pmatrix}. \tag{7}$$

Every element in D is a known quantity. Find C according to the following formula.

Objective function

$$\min Y = D \times C. \tag{8}$$

Constraint condition

$$\sum_{i=1}^{n} c_{ij} \le r_j. \tag{9}$$

We can solve it with lingo.

The shift of the center of gravity of food security production and water resources is mainly reflected in the continuous alternating change in the east-west direction. The moving range in the north-south direction is small, and its moving path has no obvious periodic characteristics. This is because the annual instability of the southwest monsoon and southeast monsoon brings the fluctuation of precipitation in the southwest region and the Yangtze River Basin, resulting in the strong unevenness and anomaly of the change of water resources [24]. By calculating the spatial overlap and change consistency of the center of gravity of the two elements, the spatiotemporal coupling degree of the two elements is analyzed. The center of gravity distance index, i.e. spatial overlap, represents the static perspective analysis of center of gravity coupling, and the consistency index of center of gravity direction change represents the dynamic perspective analysis of center of gravity coupling. The basic idea of the model is to minimize the total deviation from the target value under the condition of limited resources. The amount of water resources consumed by the production of crops mainly depends on the natural and geographical conditions of the growing area, the types of crops and irrigation methods, so the calculation of virtual water content of crops is a rough estimate of a specific area and a specific time. Generally speaking, the steps of calculating the virtual water content of a certain crop are shown in Figure 2.

Crop water demand refers to the amount of water needed to meet the evaporation loss of crops. This crop grows under the field soil conditions with suitable soil moisture and nutrients and gives full play to its productive potential under this environmental condition. The influencing factors of crop water demand mainly include meteorological conditions, including air temperature, precipitation, humidity, sunshine hours, and wind speed. We take the whole water shortage area as the research object. Taking the water shortage of each city as the index, the "center of gravity" of the whole water shortage area is calculated. We approximately think that all the water resources needed in water-deficient areas are concentrated in one "central point," so the problem is transformed into several rivers transport water to one point. The economy is developing rapidly, and the intensity of food safety production and water conservancy investment is moderate. For the western part of Jilin, where the economic strength is not strong, the pressure of capital demand is light. In addition, the total water consumption of food safety production and water resources in the whole region can basically be controlled within the range of available water supply, so that the limited food safety production and water resources can create the greatest economic benefits. A comprehensive matching model of water-soil-grain is established, and the damping coefficient model of water resources is introduced, which enriches the research methods of water resources allocation in grain production. Through quantitative analysis of the matching degree between water, cultivated land and other resource elements, and grain production, it is found that the Western Jilin Province is a province with extremely mismatched water and soil resource elements for grain production in China, and the matching coefficient is only 26.4% of the national average. The water and soil resource elements for grain production in the province present a matching pattern of water, soil, and food with "more grain but less water, and no matching between water and soil."

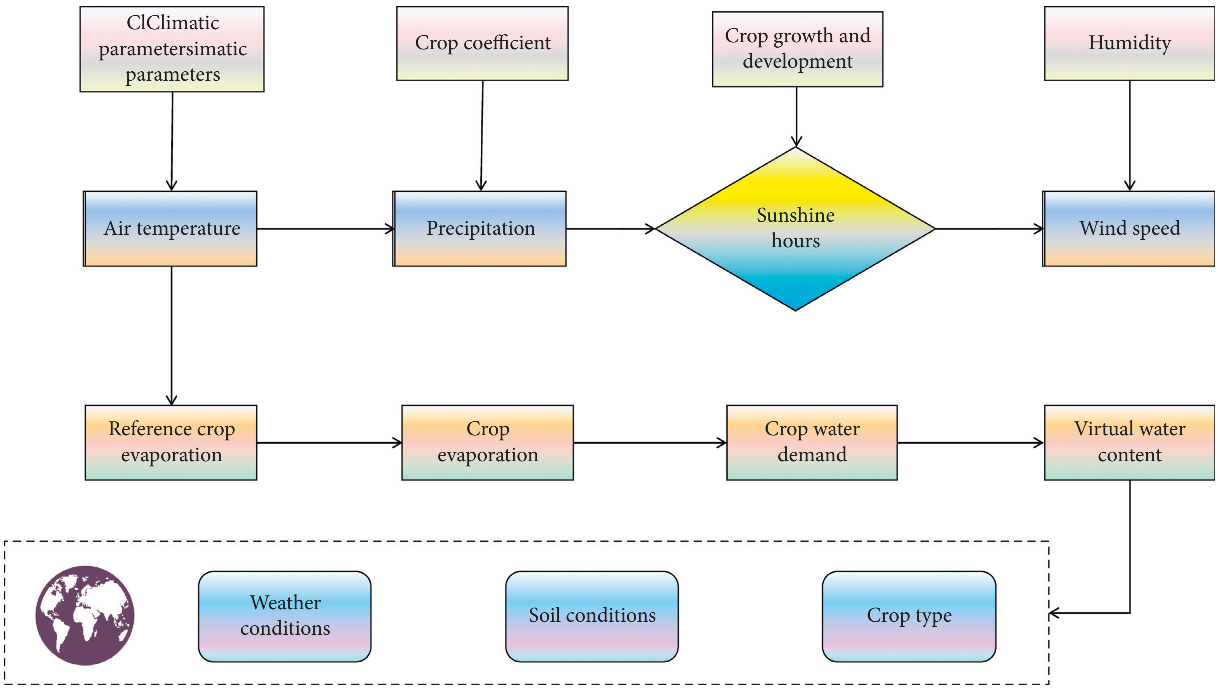

Figure 2: Flow chart of crop virtual water content calculation based on barycenter model.

3.2. Allocation Efficiency of Water Resources in Grain Production. In economics, the problem of the effectiveness of resource allocation originates from the contradiction between the limitation of resources and the infinity of human desire. The earliest widely recognized by the economic community is "Pareto efficiency," which refers to an economic situation, that is, there is no way to make anyone's situation better without making anyone's situation worse. The per capita amount of surface water resources in Jilin Province is 1613 m^3, which is lower than the national average. The spatial and temporal distribution of water resources is uneven, and the spatial distribution of surface water resources decreases from Changbai Mountain in the east to Songliao Plain in the west, which is generally divided into four levels. Nenjiang River, Taoer River, and Huolin River flow through or inject into the central and Western Jilin Province, and the hydrological division belongs to semiarid areas. The natural attributes of water resources in grain production are mainly reflected in first, the limited quantity and recycling. China's water resources are scarce. The per capita water resources in Western Jilin account for 30% of the world average, and the per mu water resources in Western Jilin account for 52% of the world average. Water resources can realize the cycle of utilization, supply, consumption, and recovery through crops in food production, so as to participate in the hydrological cycle, material cycle, and quantity flow process of ecosystem. However, in the research and practice of economic theory, efficiency does not only refer to Pareto efficiency. If the producer produces the maximum possible output with the minimum consumption of production resources, the rational allocation of production resources is realized at this time. Otherwise, the actual allocation and utilization of production resources can only be inefficient or inefficient. Songnen Plain in the west of Jilin Province is a continuously sinking area since Mesozoic. It is composed of quaternary, tertiary, and cretaceous strata, forming a double-layer aquifer system of phreatic water and weak confined water. The upper phreatic water is groundwater with salinity greater than 1G/L and fluorine ion content exceeding the standard.

Food production is the result of the joint action of land, water, machinery, fertilizer, and labor force, and water resources must act together with other factors to realize food production. The corn production in Jilin Province accounts for more than 70% of the total grain output, and it is the largest province in China. With the rapid development of corn industrialization, Jilin Province has gradually formed a commodity grain base in China, which is dominated by corn. The growth rate of grain production in the north has slowed down, and the center of gravity of grain production has shifted from north-south to small-scale east-west movement, which is more consistent with the change direction of the center of gravity of water resources, and the coupling between the two factors of grain production and water resources has slightly increased [25]. With its unique natural conditions, Jilin Province is called the "three golden corn belts" in the world along with the American corn belt and the Ukrainian corn belt at the same latitude. The effective allocation of water resources for grain production refers to the maximum possible output level of grain production that can be achieved by making the best use of existing water resources under certain market environment and production conditions, assuming that other input factors are fixed, separated from the input of agricultural water resources; among them, the irrigation coefficient of food crops is the ratio of the net irrigation water demand of

Table 1: Proportion of grain area and output in Western Jilin in China.

Particular year	Sown area (10000 hectares)			Total output (10000 tons)		
	Whole country	Jilin	Proportion	Whole country	Jilin	Proportion
2017	11057.4	695.5	6.56	52872	4262	8.05
2018	11120.6	903.1	6.52	53083	5615	9.13
2019	11195.3	708.6	6.45	54649	4335	7.92
2020	11272.4	714.5	6.44	57122	4425	7.74
2021	11303.5	720.3	6.45	58957	4512	7.65

certain food crops in different areas to the average net irrigation water demand of local main crops. The calculation formula of water resources input of grain crops in different years in each province is as follows:

$$\mathrm{IWR}_{i,t} = \mathrm{IAWR}_{i,t} \times 0.8 \times \frac{\mathrm{SAGC}_{i,t}}{\mathrm{SAC}_{i,t}}, \quad (10)$$

where: $\mathrm{IAWR}_{i,t}$ is the agricultural water resources input of i Province in t year; $\mathrm{SAGC}_{i,t}$ refers to the sown area of grain crops in i Province in t year; $\mathrm{SAC}_{i,t}$ is the total sown area of crops in i Province in t.

The traditional pattern of “transferring grain from south to north” is gradually being replaced by the pattern of “transporting grain from north to south,” which also means that the imbalance between grain production layout and water resources distribution is further aggravated. The uneven distribution of regional water resources and the relative shortage of regional water resources have become one of the bottlenecks of agricultural production and even national food supply security. It is particularly important to study the relationship between water resources endowment and food production. In the field of agriculture, some scholars have carried out research on the changing trend of single factor gravity center of grain production and the coupling degree between grain gravity center and economic gravity center. However, there are few literature concerned about the coupling situation between grain production and water resources, and the analysis on regional level is also insufficient. Production efficiency tends to reflect the allocation efficiency of resources, which is based on the systematicness of the actual production process and reflects the allocation and utilization of economic resources after considering the comparative relationship between input and output in an all-round way. Compared with only considering the utilization efficiency of input, it has a broader or more general connotation in describing the allocation of production resources.

4. Results and Analysis

In the west of Jilin Province, the total grain output and per capita share rank in the forefront of the country and play an important role in the regional and national food security pattern. In this experiment, the proportion of grain area and output in Western Jilin to the whole country was tested. The experimental results are shown in Table 1.

As can be seen from Table 1, from 2017 to 2021, the proportion of grain sown area in Western Jilin in the whole country was stable, accounting for 6.22% ~ 6.53%, with an average of 6.54%, and the proportion of grain output was between 7.31% and 7.98%. Since 2018, grain has achieved a “thirteen consecutive increases.” In 2019, the supply-side structural reform affected grain production.

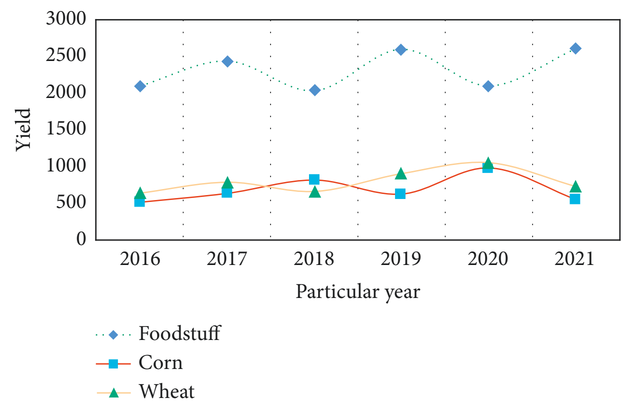

Figure 3: Yield variation characteristics of main grain crops in Western Jilin over the years.

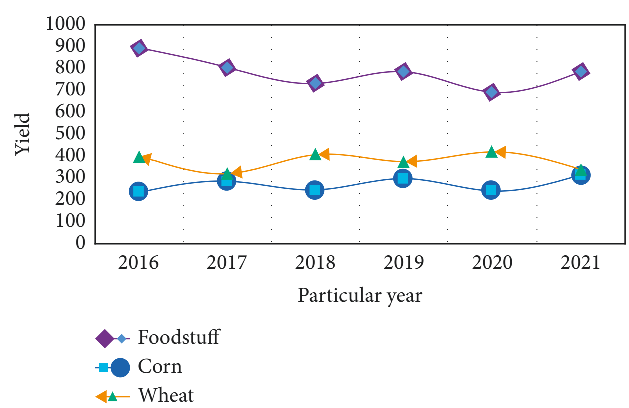

Figure 4: Variation characteristics of sowing area of main grain crops in Western Jilin.

In this experiment, the characteristics of grain crop yield change were studied. From the perspective of total output, since the reform and opening up, grain yield has generally shown an increasing trend. The characteristics of grain crop yield change in Western Jilin are shown in Figure 3.

The results show that wheat and corn are roughly the same in most years, but there is a significant difference between them in 2019. The wheat yield reached the highest level of 9.873 million tons in that year, while corn fell sharply

Table 2: Irrigation water efficiency of different planting areas of rice, wheat, and corn.

Paddy		Wheat		Corn	
Zone	Efficiency	Zone	Efficiency	Zone	Efficiency
Southwest mixed rice region	0.938	Northeast spring wheat area	0.886	Huanghuai summer corn region	0.887
Single-cropping rice area in northeast China	0.911	Huanghuai winter wheat area	0.854	Southwest mountainous corn region	0.856
Double-cropping rice area in central China	0.833	Northwest mixed wheat region	0.731	Northern spring corn region	0.741

to the lowest level since 2019. After 2020, the change trend of the two is consistent again.

Due to the continuous decrease of cultivated land area and the adjustment of planting structure, the sown area of grain in Western Jilin shows a fluctuating trend. The change characteristics of sown area of main food crops in Western Jilin are shown in Figure 4.

It can be seen from Figure 4 that in the past six years, there have been two troughs in the sown area of grain, namely, 2017 and 2019, which are closely related to the grain production policy. Due to the increase of unit yield, although the sown area is the lowest in 2020, the yield has increased compared with 2019. From 2020 to 2021, the grain sown area was stable. After 2019, the grain sown area showed a restorative growth. The grain sown area in 2019 increased by 25.8% compared with 2018, but there was still a certain gap compared with 2016. Table 2 shows the comparison results of average water efficiency of rice irrigation in different rice areas.

From Table 2, it can be seen that the rice irrigation water efficiency of 0.938 in the southwest mixed rice region, 0.911 in the northeast single-cropping rice region, and 0.833 in the central double-cropping rice region reaches or is higher than the national average of 0.663. The change of resources is more likely to drive the irrigation water efficiency of corn; Under the existing water-saving irrigation conditions, the driving effects of farmland water conservancy facilities variables on irrigation water use efficiency of different food crops are different; economic development has great driving force on irrigation water use efficiency of three food crops.

In this experiment, the time change of irrigation water efficiency of rice, wheat, and corn in China from 2016 to 2021 is tested. The experimental results are shown in Figure 5.

From Figure 5, it can be seen that after 2018, rice and wheat showed a fluctuating upward trend, with their values rising from 0.612 to 0.786, 0.356 to 0.612; however, the increase of corn is small, showing an inverted "U" trend, with its value first increasing from 0.693 in 2018 to 0.701 in 2019 and then decreasing to 0.671 in 2021; by comparing the precipitation statistics in different years, the inverted U-shaped trend of corn irrigation water efficiency may be related to the sudden increase of precipitation. The positive driving factors of rice irrigation water use efficiency are urbanization and grain breeding technology, while the negative driving factors are effective irrigation degree and water use intensity. The positive driving factor of wheat irrigation water efficiency is mainly urbanization, while the negative driving factor is disaster degree. The positive

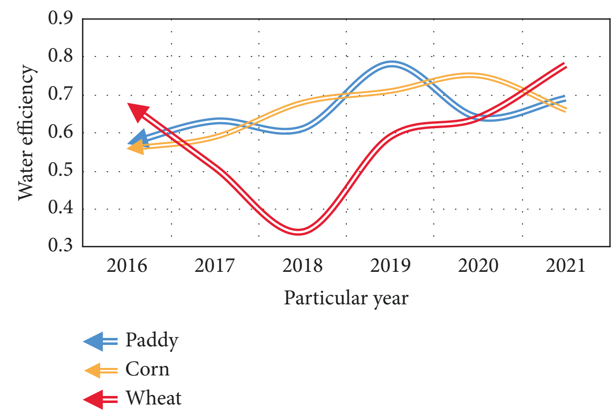

Figure 5: Irrigation water efficiency of rice, wheat, and corn in China, 2016–2021.

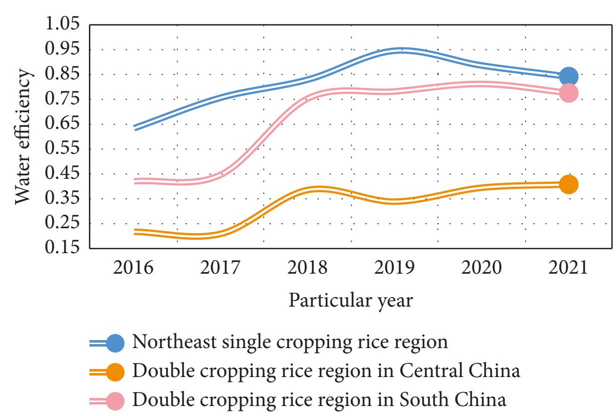

Figure 6: Irrigation water efficiency in different rice planting areas from 2016 to 2021.

driving factors of corn irrigation water use efficiency are mainly water resource abundance, mechanization degree, and grain breeding technology, while the negative driving factors are mainly precipitation intensity, disaster degree, and water use intensity.

According to the differences of rice varieties and planting systems, combined with the different regional natural and social conditions, the rice production areas in this study are divided into northeast single-cropping rice area, central China double-cropping rice area, and South China double-cropping rice area. The irrigation water efficiency of different rice planting areas is shown in Figure 6.

Figure 6 shows the time variation trend of rice irrigation water efficiency in different rice areas. The three rice areas show an upward trend, and the rising range of northeast

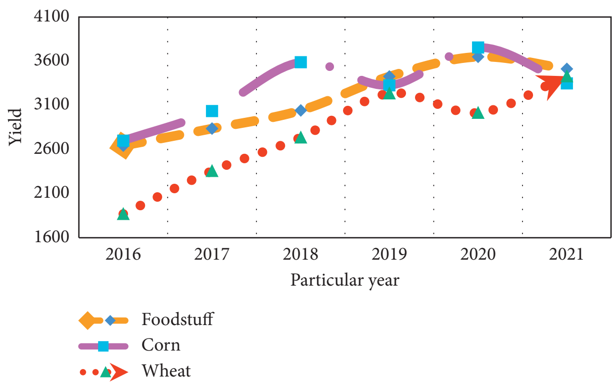

Figure 7: Variation characteristics of yield per unit area of main food crops in Western Jilin.

single season rice area in the study period is higher than the national average level.

On the whole, the change of total grain yield in Western Jilin is highly consistent with the change trend of grain yield per unit area. This shows that increasing grain yield per unit area is of great significance to increase the total grain yield, especially when the sowing area shows a downward trend, the contribution of per unit area yield growth to the increase of grain yield is more significant. The variation characteristics of yield per unit area of main grain crops in Western Jilin are shown in Figure 7.

As can be seen from Figure 7, while the grain yield per unit area is constantly increasing, the increase rate shows a downward trend. In 2016–2017, the average annual growth rate was 10.24%, while in 2018–2019, the average annual growth rate was only 3.75%. Especially in 2019–2020, it was basically stable between 6,238 and 6,480 kg/ha, with an average of 6,334 kg/ha. In 2021, it was slightly lower than that in 2020.

5. Conclusions

There are great differences in the virtual water content per unit mass of maize in different precipitation years in the west of Jilin Province. The drier the year, the greater the virtual water content per unit mass of maize. Strengthen the construction of water-saving irrigation projects and promote water-saving irrigation technologies such as sprinkler irrigation and drip irrigation on the basis of promoting large-scale grain planting. In addition, to improve the water efficiency of rice irrigation, we should continue to promote the policy of "invigorating agriculture through science and technology and giving priority to improved varieties," increase scientific research investment in grain breeding, take "water saving and high yield" as the breeding direction and breeding goal, and improve the grain output per unit of water. Based on the center of gravity model, this paper studies the temporal and spatial distribution of food security production and total water resources in Western Jilin. It can be seen that after 2018, rice and wheat show a fluctuating upward trend, and their values rise from 0.612 to 0.786 and 0.356 to 0.612, respectively; the rise of corn is small, showing an inverted "U" trend, which first increases from 0.693 in 2018 to 0.701 in 2019 and then decreases to 0.671 in 2021; by comparing the precipitation statistics in different years, the inverted "U" trend of corn irrigation water efficiency may be related to the sudden increase of precipitation. The virtual water volume of corn in different precipitation years in the central and western regions of Jilin Province presents different characteristics. The virtual water volume of corn is the largest in dry years due to the influence of meteorological factors and the increase of sowing area. In addition, based on the center of gravity model, we should strengthen the subsidy policy for grain production mechanization and improve the level of agricultural machinery and equipment by means of demonstration and guidance of "agricultural mechanization demonstration area," which can also be used as an effective measure to significantly improve the water efficiency of corn irrigation.

Data Availability

The dataset can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

GDP Economic Forecasting Model Based on Improved RBF Neural Network

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Among the existing GDP forecasting methods, time series forecasting and regression model forecasting are the two most commonly used forecasting methods. However, traditional macroeconomic forecasting models are unable to accurately achieve optimal forecasts of highly complex nonlinear dynamic macroeconomic systems due to the influence of multiple confounding factors. In order to solve the above problems, a GDP economic forecasting model based on an improved RBF neural network is proposed. First, the main traditional GDP forecasting methods are analyzed. Then, RBF neural networks are used to solve the problem that traditional forecasting technology methods cannot handle multi-factor complex nonlinearities well. Second, to further improve the convergence speed and accuracy of the RBF neural network learning algorithm, the Shuffled Frog Leaping Algorithm with global search capability and high practicality is fused into the RBF network training. Finally, the improved RBF neural network is used to build a GDP economic forecasting model. The performance of the Shuffled Frog Leaping Algorithm and the improved RBF neural network was tested using the approximation of Hermit polynomials and the Iris classification problem as simulation examples. The experimental results show that the improved RBF neural network-based GDP economic forecasting model achieves more accurate forecasting accuracy than other forecasting methods.

1. Introduction

Economic globalization is an important feature of economic development in today's world. An important indicator in the economic sphere—gross domestic product (GDP)—has also become a growing concern, and is an important economic indicator of a country's economic situation, providing an important basis for the health of the economy. GDP is the market value of all final goods and services produced within a country in a given period, and GDP growth is an important economic indicator of the health of a country's economy [1–6]. The famous American economist and Nobel Prize winner Paul Anthony called GDP "one of the greatest inventions of the century." In-depth research and analysis of GDP are of great importance to macroeconomic regulation and the formulation of economic policies.

Macroeconomics is the study of the entire national economic activity. The development and changes in macroeconomics are influenced by a variety of factors. These factors are interlinked and interact with each other, making the process of macroeconomic development trendy, cyclical, open, and nonlinear. With the development of economic statistics, econometrics, and other related techniques, forecasting has become an emerging practical and comprehensive discipline. Forecasting is to rely on historical information and the current situation and to explore the laws of the evolution of things according to certain theories, so as to form hypotheses and judgments. The past and present operation of the macroeconomic system is the basis for forecasting [7–9]. In macroeconomic forecasting, the traditional methods are mainly time series analysis and multiple regression methods.

The historical data collected in macroeconomic forecasting is generally time series data. Time series refers to the sequence formed by sorting the data of the same statistical variables according to the time sequence of occurrence. The purpose of studying time series is to discover the intrinsic links between data through the analysis of historical data, so that future data can be predicted. Most of the modeling and forecasting of time series use statistical regression models for continuous time series. Another analytical method that is more widely used is Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIM). For non-stationary time series, the series is made stationary by differencing it several times and then the series is represented as a combination of white noise and moving average [10–13]. Another mainstream forecasting method is multiple regression, also known as the Vector Autoregressive (VAR) method, which is a statistically based model that constructs a model from a function of the lagged values of all the endogenous variables in the system. VAR does not require any implementation constraints and has been widely used in economic forecasting in recent years.

The above traditional methods are the dominant approaches in the field of economic forecasting. Both methods use linear models to simulate real-life complex systems in order to make forecasts, and therefore often do not give a good result when dealing with complex non-linear systems [14]. A large number of researchers have noticed the limitations of linear models and have therefore turned their attention to non-linear models. At the beginning of the research on non-linear models, people still habitually rely on the traditional ideas of model research. The general idea of traditional forecasting methods is to set up a model by observing and analyzing the changes in the system, then to test the model for estimation and finally to select the best model. However, economic historical data usually has very complex non-linear time-series data and forecasting using traditional methods often faces many problems [15–17]. Traditional methods focus on the analysis of causality and the relationship between time series of the data. In the actual forecasting process, such methods lose the amount of information due to problems such as multicollinearity and error series, making the forecasting accuracy unsatisfactory. In fact GDP is influenced by multiple factors and the relationships between various factors are complex, presenting complex time series and non-linearity, which makes GDP forecasting very difficult.

In the face of unsolvable complex non-linear problems, people have started to look beyond traditional methods to find new ways of research. The human brain can handle a variety of complex non-linear problems very quickly, and researchers have been inspired by the idea of how to simulate the human brain to deal with complex non-linear problems. An artificial neural network (ANN) is an intelligent bionic model that mimics the function of neurons in the brain [18–21], and is a non-linear complex network system consisting of a large number of interconnected neurons. There are various learning algorithms for ANNs, but backpropagation (BP) is the most widely used weight correction algorithm for neural networks. ANNs have proven to be very effective in building predictive models, automatically learning from previous experience in a sample of data without the need for complex query and representation processes.

Currently, research on neural network-based forecasting has focused on time series forecasting and regression forecasting. Doucoure et al. [22] collected real-time series data and removed the most recent data in each series from the sample. These latest data were then predicted with reference to each prediction model. Finally, the obtained prediction results were compared with the real data. The results show that ANN has higher performance than ARMA. Wu and Lee [23] used a support vector machine based on principal component analysis to forecast regional economies. Haoret al [24] applied BP neural networks to CPI forecasting. Wang et al. [25] proposed a GDP forecasting model based on principal component analysis and Bayesian regularised BP neural networks. In addition, ANNs are also heavily applied to stock prices, stock market indices, exchange rates, commodity price forecasting, early warning of financial conditions, traffic flow forecasting, etc. Numerous research results have shown that ANN can be successfully applied to macroeconomic forecasting.

The advent of radial basis function (RBF) neural networks has brought new life to the research and application of ANNs [26–28]. The structure of RBF neural networks is similar to that of multilayer forward neural networks, but it is a three-layer feedforward network with a single hidden layer. BP networks are typically global approximation networks, whereas RBF networks can determine the appropriate network topology for the problem, learn quickly, and do not suffer from local minima. The research and application of RBF neural networks is also gaining importance. Due to the advantages of RBF neural networks, they are beginning to replace BP networks in an increasing number of fields.

Therefore, this study proposes an economic forecasting model for GDP based on an improved RBF neural network. In this study, a GDP forecasting model is built using a RBF neural network optimized by the Shuffled Frog Leaping Algorithm (SFLA). When training the network, a normalization process was used to preprocess the input and output data of the neural network to ensure that the data were of the same order of magnitude, and the forecasting results were compared with the traditional forecasting model. The experimental results show that the improved RBF neural network has better application in GDP forecasting. The main objective of this study is to use the improved RBF neural network as an alternative to traditional GDP forecasting methods (time series forecasting and regression model forecasting) in order to solve the problem of optimal forecasting of highly complex nonlinear dynamic macroeconomic systems.

The main innovations and contributions of this paper include:

(1) RBF neural networks are used to solve the problem of complex nonlinearities of multiple factors that cannot be well handled by traditional prediction technology methods.

(2) To further improve the convergence speed and accuracy of the RBF neural network learning algorithm, SFLA, which has global search capability and high practicality, is fused into the RBF network training.

The rest of the study is organized as follows: In Section 2, the problems with the main traditional GDP forecasting methods are studied in detail, while Section 3 provides the Improved RBF neural network. Section 4 provides the economic forecasting model for GDP based on SFLA-RBF neural network. Section 5 provides the experimental results and analysis. Finally, the paper is concluded in Section 6.

2. Problems with the Main Traditional GDP Forecasting Methods

Forecasting is the advanced estimation of things that have not yet occurred and is a comprehensive study of the interconnections of things. Economic forecasting methods can be divided into two main categories: qualitative forecasting and quantitative forecasting. The former is based on human experience and subjective judgment to obtain forecasts directly, while the latter is based on historical data to build mathematical models and then make quantitative forecasts. Among the classical quantitative forecasting methods are regression forecasting analysis, econometric model forecasting and random time series forecasting. In terms of the timing of forecasts, they can be divided into long-term forecasts, medium-term forecasts, and short-term forecasts.

2.1. Stochastic Time Series Forecasting. Time series analysis refers to the processing of data analysis of data series arranged in chronological order. ARMA is widely used in forecasting in the economic field. In terms of short-term forecasting, ARMA can achieve a high level of forecasting accuracy. In general, the ARMA model is defined as follows:

$$x_t = \varphi_1 x_{t-1} + \varphi_2 x_{t-2} + \cdots + \varphi_p x_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \cdots - \theta_q \varepsilon_{t-q}, \tag{1}$$

where p is the autoregressive order, q is the moving average order, φ is the autoregressive average coefficient, and φ is the sliding average coefficient. If we use the backward shift operator, we can obtain the new equation given as follows.

$$\varphi(B)x_t = \theta(B)\varepsilon_t, \tag{2}$$

where $e\varepsilon_t$ is a random interference error term, and B is a white noise sequence with mean value of 0.

The main contribution of the ARMA model is the discovery that the more pronounced changes in the economic time series are predictable and that such changes are derived from a particular type of non-linear dependence. From a forecasting point of view, the use of ARMA models not only improves the accuracy of the forecast values compared to ordinary least squares, but also the reliability of the forecast values is known. When the variance is large, the confidence interval for the predicted value is larger and therefore less reliable. Conversely, the reliability of the predicted values is better. Using this property, ARMA models are of great practical value when performing risk analysis on stocks, bonds, futures and options etc.

2.2. Regression Model Predictions. A regression model, also known as a causal model, is used to make forecasts based on the historical values of variables and the historical values of other relevant variables. The regression analysis has a very wide range of applicability, not only for micro-forecasting but also for macro-forecasting. Regression analysis methods are not only suitable for short-term forecasting but also for long-term forecasting. Linear regression models are the simplest econometric models.

$$Y_i = \beta_0 + \beta_1 X_i + u_i, \quad (i = 1, 2, \ldots, n), \tag{3}$$

where Y_i is the explanatory variable, X_i is the explanatory variable, β is the theoretical parameter, and u_i is the random perturbation term. Perturbation terms arise for two main reasons: (1) the stochastic nature of objective phenomena. The stochastic nature of human behavior, the stochastic nature of the social environment, and the stochastic nature of the natural environment dictate the need to introduce perturbation terms into the regression model. (2) Measurement error. When collecting and collating data, some subjective or objective measurement error always arises, resulting in the observed values of some variables not being equal to the actual values.

The assumptions of the regression model require that the explanatory variables are independent of the random error term.

$$\begin{aligned} E(u_i) &= 0, \\ \mathrm{Cov}(u_i, X_i) &= 0, \\ \mathrm{Cov}(u_i, u_j) &= 0\,(i \neq j), \\ \mathrm{Var}(u_i) &= \sigma_u^2. \end{aligned} \tag{4}$$

The estimation of the regression model parameters is achieved through ordinary least squares estimation. The least squares estimate is a linear function of the observed Y variable with a mean equal to the true value of the overall regression parameters.

2.3. Evaluation of Traditional GDP Forecasting Methods. Time series forecasting has the advantages of being simple, intuitive and easy to understand, and can easily remove interfering components from the data series. However, there are two problems with time series forecasting: firstly, when there are many forecast items, a large amount of data needs to be stored. Secondly, the most recent observations contain more information than earlier observations and should have a larger weight. In addition, many studies have shown that the prediction accuracy of time series forecasting is low. Time series forecasting assumes that changes in the predictor are only time-dependent. However, in fact, the forecasting object has a close and complex relationship with external factors. Time series forecasting is generally used for short-term forecasting as it relies heavily on the principle of inertia. The disadvantage of time series forecasting is that it is less able to identify changes in the forecast object.

Regression forecasting is a forecasting method based on the principle of correlation. As the forecast object is influenced by certain factors, changes in these factors will lead to changes in the forecast object. The basic idea of regression forecasting is to analyze and study the interrelationship between the forecast object and the relevant factors. As regression analysis has a more rigorous theoretical basis and more mature calculation and analysis methods, the regression forecasting method is more theoretical. Regression forecasting models can obtain relatively accurate forecasting results. In fact, there is a complex intrinsic relationship between the prediction object and the relevant factors. The correlation is a common socio-economic phenomenon and therefore regression forecasting is widely used. The disadvantage of regression forecasting is that the selection of correlates often depends on the knowledge and experience of the forecaster. Although some of the variables have a strong correlation with the predictor variables, they may actually have no effect on the outcome of the prediction.

3. Improved RBF Neural Network

3.1. Principle of RBF Neural Networks. In the study, the economic data are processed using the RBF neural network model. In the RBF neural network model, let the input samples be $X_k = (x_1, x_2, \ldots, x_n)$, $k = 1, 2, \ldots, m$, where m and n represent the total number of samples and the total number of features of one sample respectively. In general, the number of neurons and the total number of features in the input layer are equal. The number of neurons in the input layer is generally smaller than the total number of features after the sample features have been filtered [29]. The output of the k-th sample after the model is $Y_k = (y_1, y_2, \ldots, y_n)$, and n is the number of neurons in the output layer. A diagram of the radial basis function in the plane is shown in Figure 1.

An RBF network is usually a three-layer feedforward network with the structure shown in Figure 2.

First, the input samples are adjusted by the weighting coefficients to give the values of the first hidden layer [30].

$$S_{1j} = \sum_{i=1}^{n} W_{1ij} X_i - \theta_{1j}, \quad j = 1, 2, \ldots p. \tag{5}$$

The values of the first implied layer need to be feature transformed.

$$b_{1j} = \exp\left(-\frac{\left\| \sum_{i=1}^{n} W_{1ij} X_i - \theta_{1j} - c_j \right\|^2}{2\sigma^2} \right), \tag{6}$$

where σ is a real number greater than 0 and c_j is the j-th hidden layer centroid. The feature transformation function selected for the RBF neural network is the Gaussian function. The first hidden layer is used as input, and the values of the second hidden layer are obtained after adjustment of the weight coefficients.

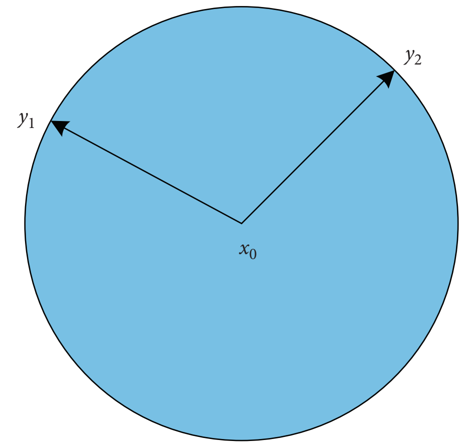

Figure 1: Schematic representation of the radial basis function in the plane.

$$S_{2j} = \left(\sum_{i=n+1}^{2n} W_{2ij} X_j + \theta_{1j} \right) + \sum_{i=n+1}^{2n} \sum_{j=1}^{p} W'_{ij}\, b_{1j} - \theta_{2j}. \tag{7}$$

The conversion function is then used to perform the solution operation.

$$b_{2j} = \exp\left(-\frac{\left\| \sum_{i=n+1}^{2n} W_{2ij} X_j + \theta_{1j} + \sum_{i=n+1}^{2n} \sum_{j=1}^{p} W'_{ij} b_{1j} - \theta_{2j} - c_j \right\|^2}{2\sigma^2} \right). \tag{8}$$

The output after all implied layers requires additional weights V_{jt}.

$$L_t = \sum_{j=1}^{p} V_{jt} b_{2j}. \tag{9}$$

The Gaussian function is solved to obtain the output of the whole model [31].

$$C_t = \exp\left(-\frac{\left\| \sum_{i=1}^{n} V_{jt} b_{2j} - c_j \right\|^2}{2\sigma^2} \right). \tag{10}$$

The error results for the k-th sample are shown as follows:

$$E_k = \frac{\sum_{t=1}^{q} \left(y_t^k - C_t^k \right)}{2}. \tag{11}$$

The errors for all samples are shown as follows:

$$E = \sum_{k=1}^{m} \sum_{t=1}^{q} \frac{\left(y_t^k - C_t^k \right)}{2}, \Delta V_{jt} = \frac{-\partial E_k}{\partial V_{jt}}. \tag{12}$$

Solve for the weights between the implied and output layers [32].

$$\Delta W_{jt} = \alpha d_t^k b_j, t, \quad j = 1, 2, \ldots, n;\ k = 1, 2, \ldots, m, \tag{13}$$

where, α is the learning speed and $d_t^k = (y_j^k - C_j^k) t (1 - C_t^k)$.

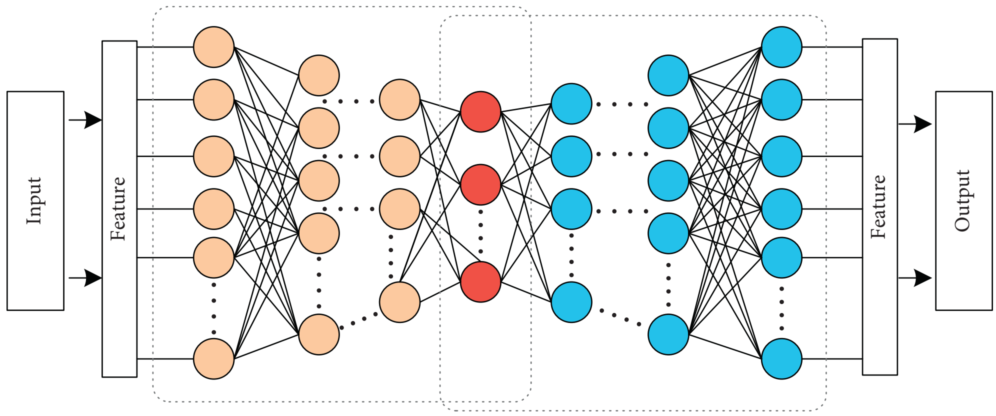

Figure 2: Structure of the RBF network.

3.2. Improved RBF Based on SFLA. There are two main ways to optimize the RBF neural network: firstly, by continuously optimizing the weights of the layers in the RBF neural network through the algorithm. By optimizing the weights, the output of the RBF neural network is brought closer to the actual result; secondly, the number of nodes and the distribution of nodes in the RBF neural network are continuously adjusted by the algorithm, so that the output of the RBF neural network is brought closer to the actual result. In practice, it is also possible to use a mixture of these two approaches to be able to obtain the global optimal solution.

In this study, SFLA is used to optimize the RBF neural network weights. The structure of the network model is generated based on the initial weights and random predefined nodes. Multiple weights are used as the input set for SFLA and the network structure model with the smaller error function is selected for optimization.

To further improve the prediction accuracy, SFLA was chosen to optimie the weight parameters of the RBF neural network. Let there be P frogs in the pond forming a frog population, denoted as $X^0 = [x_1^0, x_2^0, \ldots x_p^0]$. The Root Mean Square Error (RMSE) of GDP prediction was chosen as the fitness function and the fitness of all frogs was calculated. The frog with the highest fitness is recorded as x_g. Firstly, P frogs were randomly divided into M groups, *and* then the search for the maximum amount of food was conducted within each of the M groups.

$$\begin{aligned} d_i &= \text{rand} \times \left(X_b^k - X_w^{k,\text{old}}\right), \\ X_w^{k,\text{new}} &= X_w^{k,\text{old}} + d_i, \end{aligned} \tag{14}$$

where X_b^k is the best individual in the k group, $X_w^{k,\text{old}}$ is the worst individual before and after the move in the k group, $X_w^{k,\text{new}}$ is the worst individual after the move in the k group, rand is a random number, and d_i is the move step.

The main steps of SFLA are shown as follows:

Step 1: SFLA applies the results after the t-th iteration during the (t + 1)-th computational iteration, moving the frog $X_b(t)$ with the larger RMSE continuously closer to the frog $X_w(t)$ with the smaller RMSE.

$$\begin{aligned} \Delta_w(t) &= \text{rand}\left(X_b(t) - x(t)\right), \\ X_w(t+1) &= X_w(t)\Delta_w(t), R_{\min} \le \Delta_w(t) \le R_{\max}. \end{aligned} \tag{15}$$

Step 2: If the value of $X_w((t+1)$ solved at time t + 1 is larger than $X_w(t)$ (with better fitness), then replace $X_w(t)$ with $X_w(t+1)$. For the frog movement step problem, a step factor C can be introduced. For the k frog, the distance of the i movement is calculated as follows:

$$d_i = \text{rand} \times \left(X_b^k - X_w^k\right) \times C. \tag{16}$$

In this regard, the step factor is updated as shown as follows:

$$C = C_{\min} + i_{\text{now}}/G_{\text{global}} \times \left(C_{\max} - C_{\min}\right). \tag{17}$$

Where $C_{\min}$ is the minimum movement step of the frog in the current population and $C_{\max}$ is the maximum movement step of the frog in the current population. These two variables can be set as appropriate. G_{global} is the sum of the fitness values of all frogs in the population, and i_{now} is the number of times the frog has moved at the current moment [33].

Step 3: When the fitness values of all frogs in the population are close to $X_b(t)$ and the error is within the set threshold, the iteration of the algorithm stops. The distribution of all frogs at the current moment is output, which is the optimal solution.

After the optimal weight solution is obtained, the GDP prediction model of RBF neural network can be determined. The process of finding the optimal individual by SFLA is the process of solving for the optimal solution of the RBF neural network weights. The optimal result of the SFLA training is the optimal RBF neural network structure model.

Table 1: Raw data for GDP forecasts.

Year	GDP (billion yuan)	F1 (10,000 people)	F2 (billion yuan)	F3 (billion yuan)	F4 (billion dollars)	F5 (billion yuan)
1997	2918.83	3560.29	700.73	230.82	14.47	1041.6
1998	3118.09	3603.17	848.59	273.64	12.83	1125.33
1999	3326.75	3601.39	957.47	313.12	12.82	1229.21
2000	3691.88	3577.58	1066.27	347.83	16.53	1364.66
2001	3983	3607.96	1209.27	431.7	17.54	1511.07
2002	4340.94	3644.52	1355.87	533.02	17.95	1678.86
2003	4638.73	3694.78	1557	573.75	21.46	1816.3
2004	5612.26	3747.1	1981.29	719.54	30.98	2069.84
2005	6473.61	3658.3	2540.06	873.42	37.47	2459.12
2006	7568.89	3883.41	3242.39	1064.52	50.94	2834.22

Table 2: Normalized data for GDP forecasts.

Year	GDP (billion yuan)	F1 (10,000 people)	F2 (billion yuan)	F3 (billion yuan)	F4 (billion dollar)	F5 (billion yuan)
1997	0	0	0	0	0.0432844	0
1998	0.0428511	0.1327061	0.0581746	0.0513614	0.0002624	0.0467082
1999	0.0877236	0.1550508	0.1010127	0.0987166	0	0.1046569
2000	0.1662452	0.0535095	0.1438194	0.1403502	0.0973242	0.1802167
2001	0.2288508	0.1475303	0.2000818	0.2409499	0.1238195	0.2618904
2002	0.3058262	0.2606771	0.2577607	0.3624805	0.134575	0.3554908
2003	0.3698662	0.4162231	0.336894	0.411335	0.2266527	0.4321607
2004	0.5792248	0.5781443	0.5038282	0.5862061	0.4763903	0.5735962
2005	0.7644589	0.3033238	0.7236727	0.7707809	0.6466422	0.7907532
2006	1	1	1	1	1	1

4. Economic Forecasting Model for GDP Based on SFLA-RBF Neural Network

4.1. GDP Sample Data Processing. We selected the five most influential indicators on GDP: employed population F1, fixed asset investment F2, fiscal expenditure F3, total foreign trade exports F4, and total retail sales of social consumer goods F5 as the initial variables, as shown in Table 1. These five indicators were preprocessed as input variables for the SFLA-RBF neural network.

Therefore, before using neural networks for GDP forecasting, the raw data is normalized to avoid the effect of overloading the raw data.

$$y = \frac{x - \min}{\max - \min}, \tag{18}$$

where max and min are the maximum and minimum values in the sample data respectively, x is the original sample data and y is the transformed value. This not only avoids the input data falling into the saturation region, but also maintains the original characteristics of the data. When the neural network has finished processing, then the inverse normalization operation is done. The normalized data is shown in Table 2.

$$y = x * (\max - \min) + \min. \tag{19}$$

4.2. Implementation of the GDP Economic Forecasting Model. The flow of the SFLA-RBF neural network-based GDP economic forecasting model is shown as follows:

Step 1: Input of the normalized data GDP sample data, followed by initialization and vectorization.

Step 2: random generation of RBF neural network weights.

Step 3: Treat the weights randomly generated in step 2 above as separate individuals and set the fitness function to find J^i_{cc};.

Step 4: Iteration and migration process according to the SFLA algorithm and determine whether the cut-off condition is met, if so skip to the next step, otherwise continue the iterative operation.

Step 5: Arrange the J^i_{cc} values in descending order to obtain the weighted global optimal solution for the RBF network.

Step 6: The optimized RBF neural network structure model is obtained, which can effectively achieve accurate GDP prediction.

5. Experimental Results and Analysis

5.1. Experimental Setup. In this study, the neural network toolbox of MATLAB 7.0 software was selected for modeling. The GDP data from 1997 to 2016 was selected as the sample object for the experiment. The experimental data were mainly obtained from the website of the National Bureau of Statistics (http://www.stats.gov.cn/). In this experiment, 14 sets of data from 1997 to 2010 were used as training samples, and 4 sets of data from 2011th to 2014 were used as test samples to test the prediction performance of the SFLA-RBF neural network model.

The parameters of the RBF neural network: initial learning rate of 0.015, number of iterations epochs of 1000, selection target of 0.0001. Parameters of the SFLA algorithm:

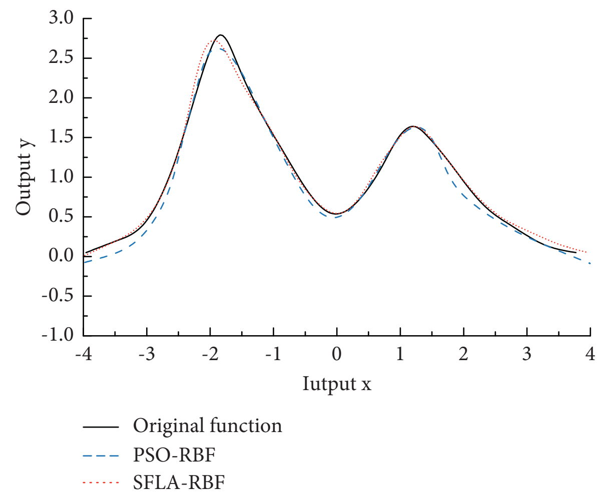

Figure 3: Simulation results at 200 iterations.

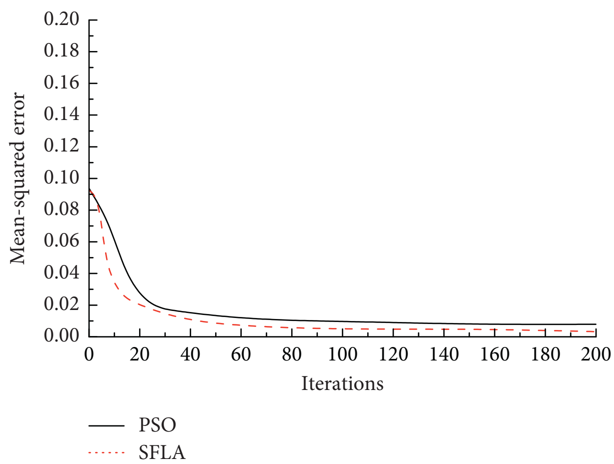

Figure 4: Convergence curve of the objective function values.

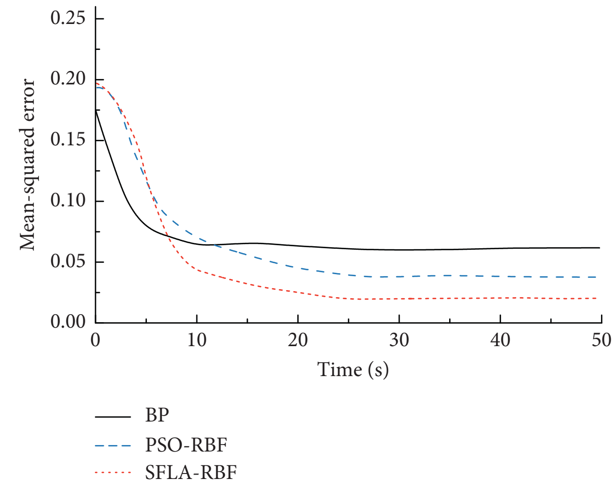

Figure 5: Variation of error over time.

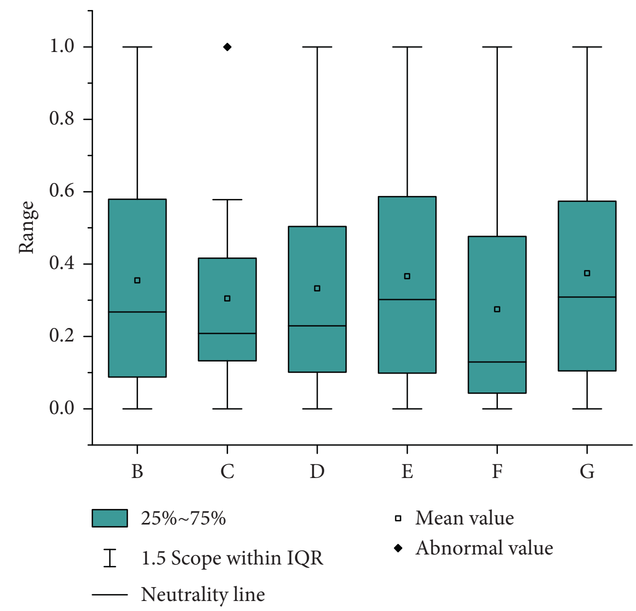

Figure 6: Box plot of GDP data series.

population size of 64, number of population selections of 40, initial weight of 0.9, step size factor of 2. In the experiment, the model was first trained with 14 sets of data, and 4 sets of data were input into the model after the training was completed to obtain the prediction output of the model The predicted output of the model was obtained.

5.2. Simulation Example of SFLA-RBF Neural Network Model. First, the same RBF neural network is optimized by using the PSO algorithm [34] and the SFLA algorithm to optimize the weight parameters for the approximation of the Hermit polynomials, respectively.

$$f(x) = 1.1\left(1 - x + 2x^2\right)\exp\left(-\frac{x^2}{2}\right). \quad (20)$$

The RBF network structure is 1-5-1. The simulation results at 200 iterations are shown in Figure 3. The convergence curves of the objective function values are shown in Figure 4. It can be seen that compared to the PSO-RBF algorithm, the SFLA-RBF approximation is better and almost coincides with the original function.

The simulation experiments were then programmed in MATLAB to classify the Iris problem using a three-layer RBF network. The RBF network structure was 4-6-3. The RBF neural network was trained using the PSO algorithm, the BP algorithm and the SFLA algorithm respectively. The trained neural network was then tested with samples from the test set, and the results are shown in Figure 5. It can be seen that SFLA-RBF has the fastest convergence speed and the smallest error, which is significantly better than the other two models.

5.3. Comparison of GDP Forecast Results. First, we confirmed the non-smoothness of the normalized GDP data series (Table 2) by examining the autocorrelogram, as shown in Figures 6 and 7.

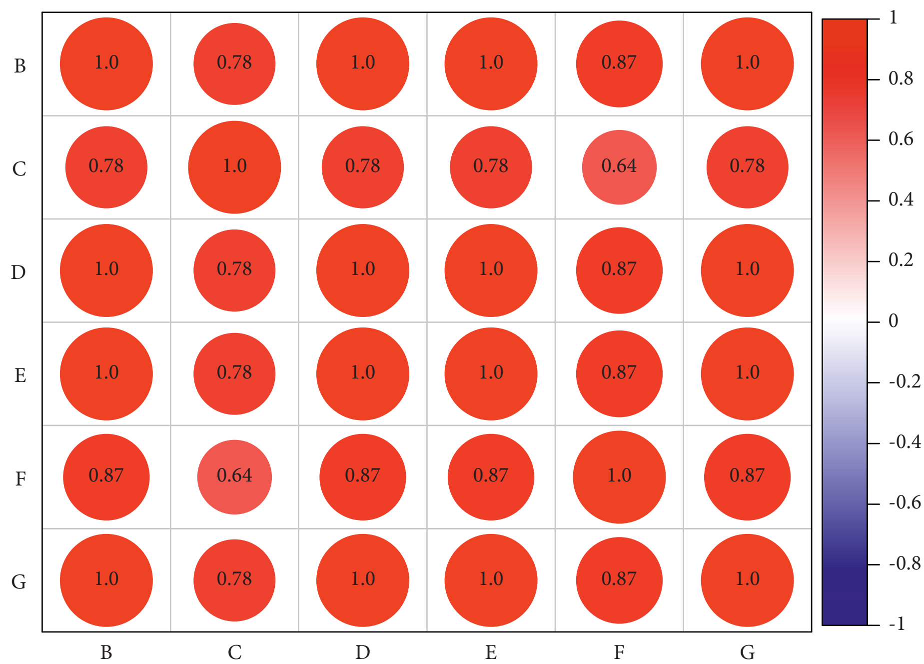

Figure 7: Autocorrelation coefficient for GDP data series.

Table 3: Accuracy of GDP forecasts for different models.

Year	Number of hidden layer neurons	RMSE			
		Stochastic time series forecasting	Regression model prediction	RBF	SFLA-RBF
2011	5	0.0874	0.0802	0.0771	0.0703
	10	0.0821	0.0721	0.0634	0.0535
	20	0.0751	0.0749	0.0674	0.0598
	30	0.0733	0.0678	0.0662	0.0572
2012	5	0.0892	0.0801	0.0762	0.0711
	10	0.0674	0.0660	0.0644	0.0578
	20	0.0848	0.0797	0.0707	0.0604
	30	0.0736	0.0676	0.0668	0.0612
2013	5	0.0928	0.0871	0.0792	0.0751
	10	0.0759	0.0743	0.0653	0.0577
	20	0.0771	0.0725	0.0691	0.0614
	30	0.0691	0.0691	0.0688	0.0607
2014	5	0.0920	0.0855	0.0817	0.0773
	10	0.0760	0.0705	0.0672	0.0549
	20	0.0869	0.0776	0.073	0.0618
	30	0.0847	0.0784	0.0691	0.0592

It can be seen that the normalized GDP data series is non-stationary. Stochastic time series forecasting, regression model forecasting, RBF neural network, and SFLA-RBF neural network were used for GDP forecasting respectively. The RMSE was chosen as the criterion for the accuracy of the network predictions. In the simulation process, the RBF neural network structure was set differentially to verify its performance in order to fully validate the impact of SFLA-RBF on the prediction accuracy, and the simulation comparison results are shown in Table 3.

It can be seen that the RMSE of GDP prediction based on SFLA-RBF is lower for the same neural network size, indicating a higher prediction accuracy. In particular, when the number of hidden layers is 10, the prediction results of SFLA-RBF all exhibit lower RMSE, which can obtain more satisfactory prediction results. Therefore, in practice, a suitable neural network size can be chosen to accomplish GDP economic forecasting.

5.4. Effect of SFLA Parameters on GDP Forecasting Performance. In order to further validate the optimization performance of SFLA on RBF neural networks, the main parameters of SFLA were set differently. The number of groups, move steps, and number of iterations within groups were mainly simulated to verify the effect of different parameters on the prediction accuracy. The number of hidden layer neurons of the RBF neural network was set to 10 and

Table 4: RMSE for different groupings and step sizes.

Grouping	Step length	RMSE		
		Maximum value	Minimum value	Average
10	1	0.0611	0.0579	0.0591
	3	0.0591	0.0572	0.0588
	5	0.0620	0.0601	0.0612
20	1	0.0594	0.0569	0.0577
	3	0.0553	0.0534	0.0542
	5	0.0617	0.0577	0.0593
30	1	0.0532	0.0502	0.0513
	3	0.0507	0.0483	0.0499
	5	0.0569	0.0529	0.0537
40	1	0.0604	0.0571	0.0582
	3	0.0591	0.0559	0.0573
	5	0.0642	0.0616	0.0627
50	1	0.0607	0.0581	0.0593
	3	0.0588	0.0564	0.0579
	5	0.0651	0.0617	0.0632

Table 5: RMSE for different number of iterations within the group.

Number of iterations within a group	RMSE		
	Maximum value	Minimum value	Average
10	0.0578	0.0561	0.0573
20	0.0557	0.0531	0.0539
30	0.0541	0.0527	0.0513
40	0.0509	0.0482	0.0501
50	0.0508	0.0482	0.0501

after 10 predictions. The maximum, mean, and minimum values of its predicted RMSE were solved as shown in Table 4.

It can be seen that when the number of groups belongs to [10, 20, 30, 40, 50] and the step size [1, 3, 5], the RMSE does not exceed 0.7, and the maximum and minimum values do not deviate much from the mean value, so the algorithm is relatively stable. In practice, the SFLA parameters can be fine-tuned by changing the main parameters several times in order to achieve better prediction results.

The number of groups and step size were fixed at 30 and 3, and the number of different iterations was adjusted to verify their effect on prediction accuracy as shown in Table 5.

It can be concluded that as the number of iterations in the group increases, the maximum, minimum and mean values of RMSE slowly decrease. However, when the number of iterations is 40 and 50, the minimum and average values of RMSE for both do not change. In addition, the maximum value also remained almost unchanged and reached stability, and did not keep decreasing as the number of iterations increased. Therefore, the number of iterations should be set reasonably. If the number of iterations is increased, the prediction time will definitely increase. The number of iterations in a group should be set at a reasonable level according to the actual situation.

6. Conclusion

In order to solve the problem of optimal forecasting of high-complexity nonlinear dynamic macroeconomic systems, a GDP economic forecasting model based on an improved RBF neural network is proposed in this paper. In this paper, a GDP forecasting model is developed using an SFLA-optimised RBF neural network. When training the network, a normalization process is used to pre-process the input and output data of the neural network to ensure that the data are of the same order of magnitude, and the prediction results are compared with the traditional prediction model. The experimental results show that the improved RBF neural network has better application value in GDP prediction. When the number of hidden layers is 10, the prediction results of SFLA-RBF all exhibit lower RMSE, which leads to more desirable prediction results. Follow-up studies will further adjust the SFLA parameters to improve the time efficiency of GDP prediction.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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Research Article

Analysis of Modern Public Art Design Integrating Traditional Elements under Interactive Technology

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In order to give full play to the carrier role of modern public art design and inherit the traditional elements whose vitality is gradually losing, this paper analyzes the modern public art design integrating the traditional elements under the interactive technology. Firstly, it analyzes the origin of modern public art design, which is manifested in the rational product of science and technology and the materialized form of cultural aesthetics. Then, it analyzes the current development situation of blindly seeking internationalization, over-reliance on modern tools, and insufficient design education level, and discusses the classification of modern public art integrating traditional elements and the inheritance problems it faces; under the interactive technology, the traditional elements and features are transmitted imperceptibly through a variety of carrier forms to realize the modern public art design integrating the traditional elements. The experimental results show that the resource utilization and benefit of modern public art are increasing exponentially year by year. With the increase of government investment in modern public art design activities, the complete contour map can be obtained by extracting the marked points.

1. Introduction

In the thousands of years of civilization construction of the Chinese nation, many valuable material and intangible cultures have been developed and inherited [1, 2]. Modern public art with traditional elements is a material culture created and shared by groups in a long life. It is not only a modern public art culture with high comprehensive value, but also a traditional folk culture with many ideologies [3]. Under the interactive technology, modern public art, as the mother of art, should not only conform to the application of modern reality, but also convey the aesthetic spirit and moral concept of the traditional nation [4]. The change of times and national cultural construction are witnessed by modern public art, and the integration of contemporary characteristics and traditional elements of The Times is reflected by art design. Modern public art design and traditional elements are closely related and complement each other in the process of promoting social development [5].

There has been a lot of research on this; Zhou [6] proposed the fusion of Chinese traditional elements and modern architectural design; This sentence should be revised to read: As China has a long history and many kinds of traditional culture, modern architectural decoration design needs to comprehensively analyze various traditional cultural elements, enhance the artistic expression of the whole design, and give architectural decoration a vitality. Zhang et al. [7] put forward regional culture elements in the urban public art design, the application of through elaborated the importance of regional culture in city public art design, analysis of urban public art design, and the main reasons for the lack of regional cultural features and discuss the regional culture elements in the urban public art design in the practical application. Wang and Wan [8] put forward the research on the correlation, measures between enterprise capital intervention and public art operation based on computer correlation analysis, expounds the advantages of computer science correlation, and discusses the current situation and optimization of enterprise capital intervention and public art operation for readers' reference. Reference [9] describes socialism and proposes public art design in East Germany. Writing art history in East Germany usually needs to deal with the influence of West Germany and the West during the Cold War, as well as the influence of the Soviet Union and countries within its sphere of influence.

Although the above research has made some progress, the research on interaction is not sufficient. Therefore, the analysis of modern public art design integrating traditional elements under the interaction technology is proposed. It analyzes the origin of modern public art design, which is manifested as the rational product of science and technology and the materialized form of cultural aesthetics. Then, it analyzes the development status of blind pursuit of internationalization, excessive reliance on modern tools, and inadequate design education level. It classifies modern public art with traditional elements and discusses the inheritance problems. Under the interactive technology, traditional elements and features are imperceptibly transmitted through various carrier forms. The research content of the innovation is based on the analysis of contemporary public art design in the process of interactive technology which is put forward; at the same time, fusion of traditional elements, resource utilization and efficiency of modern public art index rising trend year by year, the government of modern public art design activities into increased year by year, extracting markers can get complete profile.

2. Tracing Back to the Origin and Development of Modern Public Art Design

2.1. Tracing the Origin of Modern Public Art Design. Modern public art is inseparable from culture. It can be said that culture is a necessary condition for the existence of modern public art. Considering the development and origin of modern public art from the perspective of culture is a clear and necessary research angle. When thinking about the existing form of an art, tracing the source can better highlight the significance of the art. Modern public art, as a cultural concept of contemporary art, appeared in the USA in the 1960s. It is different from the general traditional concept of environmental art and has a close relationship with the development of cities [10, 11]. The social division of labor, the intensive living environment, and the evolution of commodity exchange make the city develop continuously. The development of the city has prepared a solid foundation for the emergence of modern public art.

The formation and development of modern public art are the historical product of Western social culture. Traceability is represented by the following:

(1) The product of scientific and technological rationality: the top manifestation of creation is art design, which evolves creative thinking into concrete forms. The development of science and technology is synchronized with art design. Whether macro or micro, the emergence of new forms has a strong stimulating effect on designers' creative inspiration [12, 13].

(2) Materialized form of cultural aesthetics: modern public art design is a key component of social material production, and the materialized form must also be aesthetic and practical [14]. For example, the modern public art design of packaging should not only reflect the gift value, but also promote consumption on the premise of maintaining economic order, so that the cultural aesthetic psychology can be displayed through materialized art design.

2.2. Development Status of Modern Public Art Design. The main structure of the development status of modern public art design is shown in Figure 1.

(1) Blindly seeking internationalization: economic globalization gradually assimilates art design forms. With the development of economy, a large number of Western modern industrial design concepts and related works have poured in and penetrated into every corner of social life. The parts they reach are gradually westernized, and the national cultural connotation and charm are increasingly lost [15].

(2) Over-reliance on modern tools: information technology constantly updates design software. Most designers often use the existing materials and programming design methods of the Internet to complete art design through patchwork. Excessive reliance on modern design tools not only makes the works lack of cultural heritage, but also leads to monotonous design results.

(3) Insufficient level of design education: under the influence of Western modern design thoughts and education, China's modern public art design education is more mechanical imitation and one-sided copying, and the regional characteristics and national historical charm have disappeared. Due to the lack of local connection, the national characteristics are no longer [16]. The rapid development of design education and the increasing number of design students year by year have also led to disorderly competition among colleges and universities, resulting in the obvious backwardness of the education level.

2.3. Classification of Modern Public Art with Traditional Elements and its Inheritance

2.3.1. Modern Public Art Category Integrating Traditional Elements. Modern public art under interactive technology, which integrates traditional elements and accounts for a high proportion, has many types and a wide range. Its main categories are divided into 10 categories, and its specific forms are shown in Table 1.

It can be seen from Table 1 that the heritage of modern public art integrating traditional elements is extremely rich and brilliant. Traditional music, traditional calligraphy, and traditional painting have accumulated for thousands of years, have made great innovations, and are imbued with the profound cultural heritage of a 5000 –year-old civilization. It is not only the precious wealth of the Chinese nation, but also the precious wealth of all mankind. With its strong local

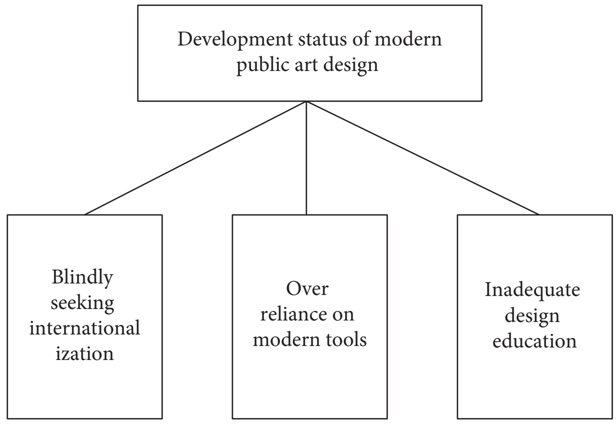

Figure 1: Structure diagram of current development of modern public art design.

Table 1: Categories and specific forms of modern public art integrating traditional elements.

Serial number	Category	Form
1	Music	National music, new music, Chinese music, Chinese traditional music, etc.
2	Calligraphy	Seal script, official script, running script, regular script, cursive script, etc.
3	Painting	New Year pictures, lantern paintings, fan paintings, prints, murals, etc.
4	Traditional opera	Kunqu opera, Hunan opera, Qin opera, Sichuan opera, Henan opera, Jin opera, Han opera, etc.
5	Clothes	Silk flower, wedding dress, insole, jewelry, flannel, etc.
6	Sculpture	Wood carving, dough sculpture, stone carving, color sculpture, bamboo carving, etc.
7	Embroidery, dyeing, and weaving	Tie dyeing, batik, pad dyeing, brocade, printed cloth, etc.
8	Food	Candy modeling, cake model, pastry modeling, etc.
9	Paper-cut	Embroidery patterns, window decorations, etc.
10	Weave	Bamboo, straw, paper, wicker, etc.

flavor, mellow artistic connotation, and vivid historical traces, Chinese traditional art is more and more loved and appreciated by people all over the world, and has become the common cultural “feast” of mankind. It is a long cultural scroll that reflects the social and historical life of China through the understanding of humanities, society, and environment.

2.3.2. The Existing Inheritance of Modern Public Art. Like other intangible cultural heritages that integrate traditional elements, modern public art forms are unable to truly implement the protection concept of folk art to all relevant personnel in terms of inheritance. In particular, the internationalization process has deepened in recent years. Although the attention of intangible cultural heritage has gradually increased, there are still many little-known cultural heritage in the forgotten stage, among which the most representative is modern public art [17, 18]. Based on the influence of the current world background and values, the inheritance problems faced by modern public art include the following factors:

(1) Insufficient support from relevant local departments. Relevant departments have a great impact on the vitality of modern public art, and their support directly determines the development trend of modern public art [19, 20]. With the increasing attention, although China has carried out legislative treatment, it still fails to work for the modern public art, which needs someone to inherit and continue, integrating traditional elements.

(2) Insufficient market acceptance. The mismatch between the modern public art form integrating traditional elements and the current market demand is also a reason for its gradual desolation. In particular, the market environment pursuing economic benefits has also prompted more people to abandon the intangible cultural heritage integrating traditional elements [21, 22]. For the inheriting group, it has been unable to weigh the dispute between the original ecology and marketization of modern public art.

(3) Insufficient public promotion. Only under the joint protection of the departments and the public, modern public art can fundamentally guarantee the inheritance of such intangible cultural heritage. Some private art groups are scattered and cannot well promote modern public art forms, while the popular art groups have poor ways to make profits and are difficult to continue to inherit [23]. Most of the relevant departments are researchers of modern public art. Inheritors who really understand modern

public art skills have limited ideas and have less contact with official institutions, which is not conducive to improving the popularity of the culture and is increasingly submerged in the modern art trend.

(4) The impact of foreign culture is too strong. The greatest impact on modern public art is due to foreign cultural factors. In recent years, the rapid development of information technology has led to Earth shaking changes in national culture and thought. Many intangible cultural heritage cultures have fallen into the embarrassing situation of no successor, such as Shaanxi shadow play, Yunnan batik, and Naxi ancient music which are disappearing day by day, and some typical objects of folk art and culture have been lost overseas. Some art colleges also take Western sketch and oil painting as the main art teaching content and form of expression, but rarely mention the information of Chinese modern public art, which blocks the cognitive channel of contemporary young people to traditional elements and weakens their sense of national identity.

3. Modern Public Art Design under Interactive Technology

Before the traditional elements were integrated into modern public art, the way of transmitting information was release-transmission-reception. This way spread the information of the creator of the work one way. The audience can only passively accept the established information. At the same time, the creator cannot get any feedback from the audience. However, under the interactive technology, the modern public art design integrating traditional elements has realized the two-way information transmission. The design concept of interactive technology has become the mainstream of modern public art.

3.1. Interactive Technology. The translation of “interaction” involves interaction, exchange, communication, cooperation, mutual influence, and interaction. In short, interaction means two-way interaction. Interaction is mutual action, performing actions opposite to each other [24]. For example, chatting, playing table tennis, playing chess, symposiums, etc., all belong to the category of interaction. The advantage of interactive technology is about creating a new user experience. Its purpose is to enhance and expand the way people work, communicate, and interact. Interaction design is described as the design of human communication and interaction space; interaction design supports people’s behavior, which is another embodiment of human nature.

Interaction is also a sociological concept, which refers to the interaction, promotion, and causality between various factors. “Interaction” in the digital era is more widely used in the Internet, digital television, and other related fields based on digital platforms [25]. It has become a way of communication between people and things, through which the purpose of information exchange can be achieved; at the same time, “interaction,” as a medium, links art and technology, art and audience, works and authors, and authors and audiences, and produces the relationship of interaction and interaction. The “interaction” referred to in this article is a kind of two-way communication, a process of participation, and the interaction and interaction in participating in modern public art design activities or works, including thinking interaction, behavior interaction, five sense language interaction, and psychological interaction [26]. It emphasizes the two-way communication between information input and output, so as to achieve the purpose of information docking between the author and the audience. The interactive technology structure is shown in Figure 2.

According to Figure 2, interaction technology changes people’s way of designing modern public art and also changes people’s emotional cognition and thinking mode, thus making interactive thinking come into being. The concept of interaction design is a kind of thinking concept that takes “interaction” as the ultimate ideal of design. As the core of this concept, “interaction” determines the way of thinking and methods of technicians and artists at the beginning and during design. Interactive thinking has changed the way of thinking and process of artistic creation in the past. It is a transformation of thinking from one-way to two-way and one-dimensional to multi-dimensional, and “interaction” runs through the whole process of artistic creation and display.

3.2. Modern Public Art Design Integrating Traditional Elements under Interactive Technology. The premise of modern public art design is based on the integration of traditional elements. As a historical successor, we should deeply understand that modern public art is the main body, and traditional elements are the starting point for doing anything. The calculation of correlation coefficient of modern public art design under interactive technology is shown in

$$G(t) = \frac{L_{\min} + k \times L_{\max}}{L_{ij} + Z_O + K_P}. \tag{1}$$

In formula (1), $G(t)$ represents the correlation coefficient of modern public art design under interactive technology at t time, L_{ij} represents the random vector of modern public art design, $L_{\max}$ and $L_{\min}$ represent the maximum and minimum values of vector weight given by modern public art design, respectively, Z_O and K_P, respectively, represent the standardized value of modern public art design, k represents the resolution coefficient of coupling degree, and generally, k is between 0.5 and 1.

Because modern public art design has too many and scattered correlation coefficients under the interactive technology, in order to facilitate calculation, the correlation coefficients of modern public art design at each time are concentrated near one value, and the average value calculation formula is used to process the correlation coefficient. The formula is

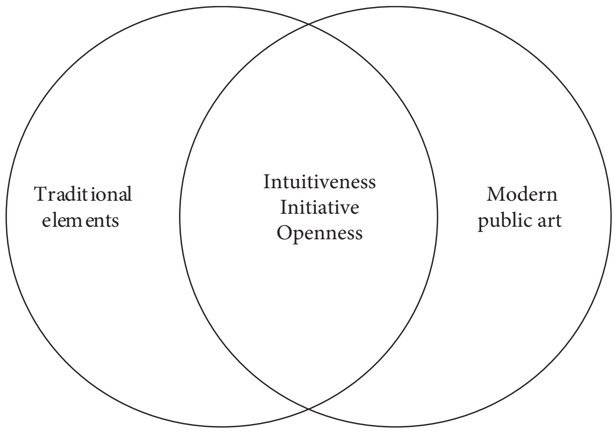

Figure 2: Interactive technology structure.

$$M_{ij} = \frac{1}{n}\sum_{i=1}^{n} G(t). \tag{2}$$

In formula (2), M_{ij} represents the degree of correlation between modern public art design planning and traditional elements. By comparing the size of M_{ij}, we can quickly screen out the factors that have a great impact on modern public art design planning by traditional elements.

Modern public art, as a carrier of artistic image, subtly spreads traditional elements and characteristics through a variety of carrier forms when it spreads traditional culture. In the process of rapid construction and development, modern public art, as a carrier and medium, has thrown away the reflection of the spirit and consciousness of the essence of art form, integrated traditional elements into it, and sublimated it, making it functional in expression, and conveying the deep-rooted elements in culture, history, society, and other countries through structured media. The form of modern public art makes the traditional elements concentrated and representative, improves the cultural quality, artistic accomplishments, and self-feelings of art, and thus realizes the modern public art design integrating the traditional elements under the interactive technology.

4. Experimental Analysis

In order to verify the performance and feasibility of modern public art design analysis integrating traditional elements under interactive technology, experiments are designed. Under the interactive technology, different indicators of modern public art design planning are graded to obtain different levels of value ranges and assignment standards. The basis for assigning values to different indicators is the actual scores of different indicators. Select five items from the 10 categories in Table 1, and divide the different indicators into three levels, represented by A, B, and C, respectively, as shown in Table 2. The assignment criteria for different levels are 1.0 for level A, 0.5 for level B, and 0.01 for level C.

Let t represent a set of indicators of different states of modern public art, then the expected value and entropy of t accurate values to measure one indicator of modern public art are, respectively, expressed by formulae (3) and (4):

Table 2: Classification and weight of different indicators.

Evaluating indicator	Hierarchy	Weight
Music	A: >0.29%; B: 0.29%–0.09%; C: <0.09%	0.124
Calligraphy	A: >0.19%; B: 0.19%–0.09%; C: <0.09%	0.135
Painting	A: <29%; B: 29%–59%; C: >59%	0.116
Traditional opera	A: >0.10; B: 0.10–0.066; C: <0.066	0.086
Clothes and accessories	A: >490; B: 490–135; C: <135	0.046

$$Qx = \frac{Qx_1 + Qx_2 + Qx_3 + \cdots + Qx_t}{t}, \tag{3}$$

$$Qn = \frac{\max\left(Qx_1, Qx_2, Qx_3, \ldots, Qx_t\right) - \min\left(Qx_1, Qx_2, Qx_3, \ldots, Qx_t\right)}{U}. \tag{4}$$

In formulae (3) and (4), Qx_t represents the index coefficient of modern public art, and U represents the total number of modern public art data.

Let $V = \{A, B, C, D, E\}$ represent the comment set of modern public art, and its value range is 0–1, where A, B, C, D, E represent poor, average, good, good, and excellent, respectively. The change range of comment value is shown in Table 3.

In the middle section of the modern public art index data, there are bilateral constraints, which are represented by $[F_{\inf}, F_{\sup}]$, so the expectation and entropy of the left and right sides take the 1/2 of the overall expectation and entropy, and then use the expectation and entropy of the cloud theory model to build a qualitative comment set. The expression formula is as follows:

$$\begin{cases} Qx_i = \dfrac{F_{\inf}}{2} + \dfrac{F_{\sup}}{2}, \\ \\ Qn_i = \dfrac{F_{\inf}}{2} - \dfrac{F_{\sup}}{2}. \end{cases} \tag{5}$$

In formula (5), Qx_i and Qn_i, respectively, represent the expected value and entropy of the evaluation value of a modern public art index.

After calculating the expected value and entropy of the evaluation value of modern public art indicators, a directional evaluation cloud generator is generated. According to the corresponding change interval between the cloud generator and the evaluation value of modern public art indicators, the change of cloud center of gravity can be obtained. Repeat the above operations until the value of modern public art indicators is obtained, which is the result of modern public art design.

Taking the annual data of the project-based learning mode of modern public art design in a province from 2012

Table 3: Change range of comment value.

Comment set	Variation interval
Poor grade	0.00–0.29
General grade	0.30–0.49
Better grade	0.50–0.69
Good grade	0.70–0.89
Excellent grade	0.90–1.0

to 2021 as the empirical analysis object, in order to ensure the authority and effectiveness of the obtained data of modern public art design, we fully visited the relevant modern art design project planning and management departments in the province, and sorted out the fund injection and management of modern public art in the province. Take the sorted annual data of modern public art services as input, and output the evaluation results of modern public art in the province. By analyzing the correlation coefficient of modern public art in the province, the results are shown in Figure 3.

According to the analysis of Figure 3, the resource utilization and benefit of modern public art in the province are increasing exponentially year by year. However, before 2016, the performance of modern public art services in the province increased slightly. Since 2017, the performance of modern public art services in the province has increased significantly. It shows that since 2017, the province has gradually strengthened the initiation and management of modern public art projects, which has greatly improved the service performance of modern public art projects in the province. Take the number of public sports planned by the government as the measurement index to further analyze the performance of modern public art design in the province. The results are shown in Figure 4.

According to the analysis of Figure 4, the number of modern public art design projects planned by the provincial government has increased year by year in different years. In 2020, the number of public sports activities planned by the provincial government reached 14, which has exceeded the average of once a month, indicating that the province has invested a lot of manpower and material resources in its modern public art design projects. With the increase of government investment in modern public art design activities, it also promotes the increase in the number of social organizations and improves the performance of modern public art design services.

In order to further verify the feasibility of this method, the pixel coordinates on the 3D point projection image reconstructed by modern public art and the corresponding pixel coordinates of the original image are determined. This experiment uses the image taken from the front of the digital camera, as shown in Figure 5.

According to Figure 5, mark points on the original image of modern public art, with box marks on the main line and circular box marks on the branch line. Through the automatic extraction of spatial marker points, the coordinates of the center, the matching of spatial image points, and the center coordinates can reach the pixel level. The design

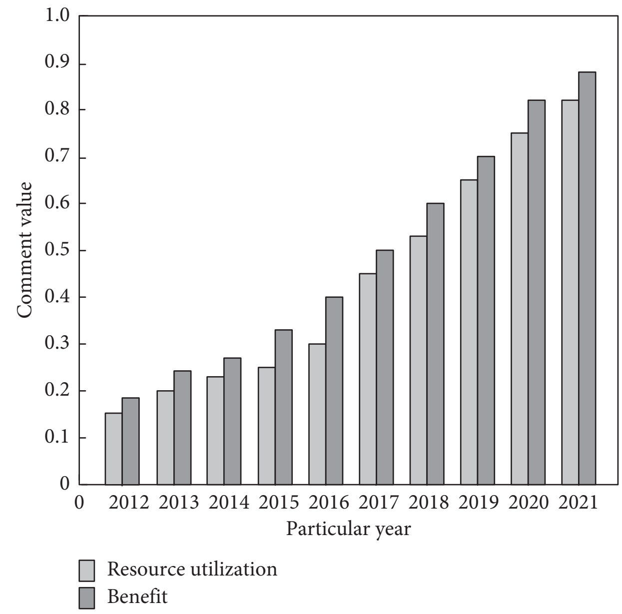

Figure 3: Evaluation results of primary indicators of modern public art service performance.

results of spatial reconstruction image of modern public art space are shown in Figure 6.

It can be seen from Figure 6 that a complete outline can be obtained by manually extracting the marked points in the modern public art space. Using this method can obviously reduce the projection error and then rationalize the three-dimensional vision of modern public art interior space design. The reason is that the method in this paper integrates traditional elements under interactive technology and increases interactive thinking, which can change the thinking mode and creative process of previous art creation, from one-way to two-way, one-dimensional to multi-dimensional thinking, and make “interaction” run through the whole process of art creation and display.

To sum up, the significance and functions of modern public art design integrating traditional elements are as follows:

Significance: China’s 5000 years of cultural and historical deposits contain strong artistic emotions. Modern public art, which integrates traditional elements, as an art form that can fully demonstrate the national inclusiveness and sensibility, exposes the charm of the national spirit and cultural atmosphere. Therefore, modern public art design integrates the charm and elements of traditional elements, which not only helps to increase the connotation of modern design, but also helps modern public art to be inherited and carried forward imperceptibly. China’s long history is surging, and the traditional culture is accumulating continuously. From the contention of various schools of thought to the profound modern tempering, this colorful modern public art feast is finally formed.

Modern public art forms are diverse, and their skills are also different. It has profound cultural connotations and profound cultural implications. In recent years, China has

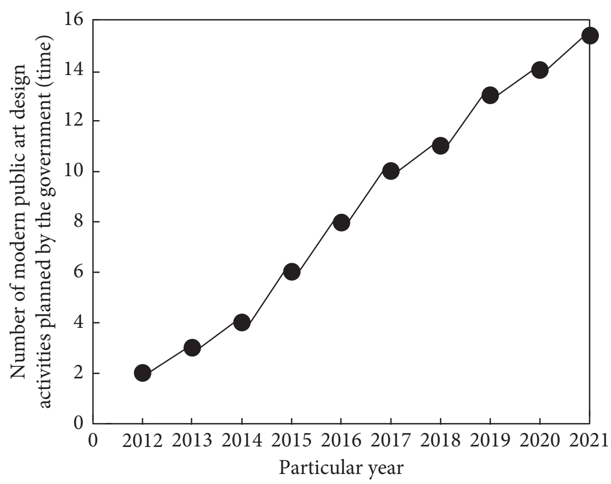

Figure 4: Times of modern public art design projects planned by the government in different years.

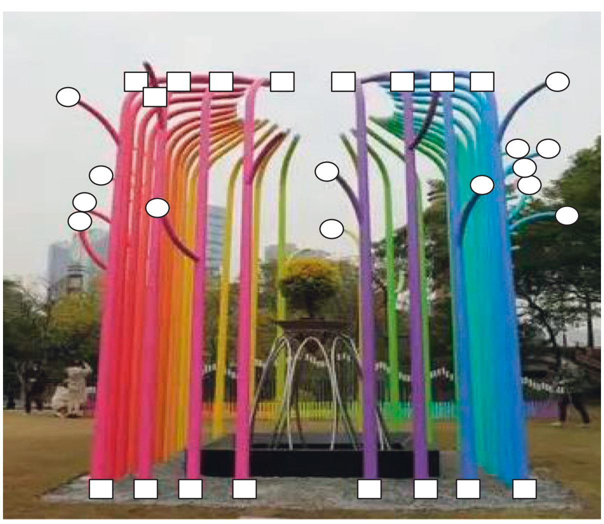

Figure 5: Original image of modern public art.

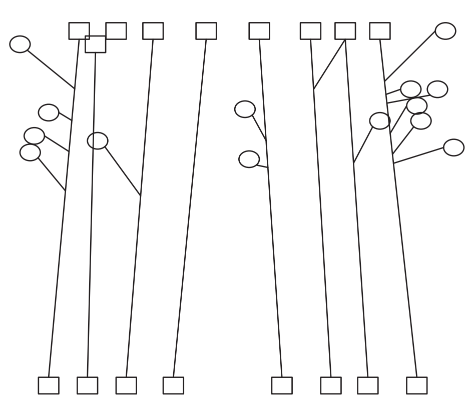

Figure 6: Reconstruction image design results of modern public art space.

become more and more influential in the world. Modern public art, which integrates traditional elements under interactive technology, has a great artistic shock and influence on Chinese people. At the same time, it also has a strong attraction to people with similar aspirations all over the world who yearn for art and pursue art. Based on the background of today's modern economic globalization, the world culture has aroused the global concern of the traditional culture of the Chinese nation through the exchange of what is needed, which makes the field of modern public art design also begin to pay attention to the rational use of traditional elements. It is hoped that the gaps and obstacles in modern public art design can be filled and broken with the help of the form of traditional elements. Traditional elements not only bring more developmental thinking and infinite creative inspiration to the field of modern public art design, but also make the design work more unique in the case of mutual penetration and inclusion, carrying forward and inheriting the artistic heritage and value of traditional elements.

Functions: Traditional elements are conducive to promoting the development of modern public art design. On the contrary, modern public art design is conducive to the inheritance and development of traditional elements. In other words, the integration of traditional elements in modern public art design can not only scientifically promote traditional elements, establish the concept of protection and promotion of intangible cultural heritage, inherit national culture and humanistic spirit, but also highlight the artistry and applicability of modern public art design. Traditional elements endow modern public art design with brand-new implication and charm, which greatly improves the level of aesthetic value and massiness of design. The effective integration of the two has been highly praised by artists, which has expanded the scope of influence from regional to international, and the influence has gradually developed in a globalized trend. With the integration of traditional elements, modern public art design has increasingly evolved into a carrier of traditional elements by virtue of its strong attraction.

To sum up, traditional elements are a relatively effective means of boosting the diversification and enrichment of modern public art design forms, and have an important practical significance in promoting the development of modern public art design. Modern public art design also provides a three-dimensional display platform for the development and inheritance of folk art and plays a subtle role in expanding the influence of traditional elements.

5. Conclusion and Prospect

5.1. Conclusion

(1) The resource utilization and benefit of modern public art in the province are increasing exponentially year by year. Gradually strengthening the project approval and management of modern public art projects can greatly improve the service performance of modern public art projects.

(2) With the increase of government investment in modern public art design activities, it also promotes the increase in the number of social organizations and improves the performance of modern public art design services.

(3) By manually extracting the marked points in the modern public art space, a complete outline can be obtained. Using this method can obviously reduce the projection error and then rationalize the three-dimensional vision of modern public art interior space design.

5.2. Prospect

(1) Up to now, many scholars have realized the necessity to protect the integration of traditional elements. At present, various cities have carried out activities from top to bottom to highlight the regional cultural characteristics by repeating the local historical context, such as emphasizing the "historical meaning" of the environment through the creation of public art works such as urban sculpture and murals, in order to improve the quality of the urban environment and enhance urban recognition. However, this surface modification did not bring about rich cultural transmission, but led to people's aesthetic numbness, reduced regional recognition, and even the dislocation of context and other follow-up problems.

(2) The in-depth study of public art design from the perspective of urban context protection is an in-depth excavation of how to improve the quality of urban environment. At present, the material input of construction and the quantity and scale of works are no longer the effective standards to judge the quality of urban environment. People are more concerned about whether the profound historical context and vivid collective memory have been perfectly interpreted, whether there is an appropriate field and integrated into it. Therefore, it is more necessary for researchers to determine relevant laws and regulations, formulate standardized management systems, and actively and positively publicize and enable more and more public to actively participate in the creation of urban public art.

(3) With the continuous advancement of the urban process, people will eventually deepen their understanding of modern public art, and the focus of the urban public environment will gradually develop from the involvement of the representation material to the construction of urban connotation, such as paying attention to the promotion of the cultural spirit of the urban field. Modern public art creation also needs to create more works that reflect urban life, ideas, and spirit through systematic planning and research. Only in this way can we carry out reasonable planning and layout of urban public space environmental resources and endow them with social significance that depends on context, so as to create high-quality and pleasant urban public space and improve the quality of urban public environment.

Data Availability

The raw data supporting the conclusions of this article can be obtained from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding this work.

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Research Article

Exploration of the Problems and Solutions Based on the Translation of Computer Software into Japanese Language

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At present, the research on machine translation mainly focuses on English-Chinese translation, while the research on Japanese college students using Japanese Chinese machine translation software is relatively few. In order to solve the above problems in Chinese Japanese bilingual translation, this paper proposes a phrase translation method based on sequence intersection. This method regards sentences as word sequences and aligns the sequence intersection of all source sentences corresponding to the target sentence in the corpus with Chinese and Japanese sentences containing the phrases to be translated. By fully mining the information of sentence alignment bilingual corpus without word alignment resources, we can obtain high-quality phrase translation, syntactic analysis, and dictionary. Then, we focus on the automatic construction of sentence level aligned bilingual corpus and explore the automatic sentence alignment technology of Chinese and Japanese bilinguals. A ten-year alignment model based on combination cues and core extended square matching is proposed. The preprocessing of the computer corpus and the basic construction of the corpus are completed. This paper also puts forward corresponding countermeasures and approaches to the problems encountered in the construction of computer translation.

1. Introduction

Computer software translation (machine translation) is an important area of natural language understanding. In the early 1930s, the French scientist Altruinhad the idea of "machine translation" [1]. China began to study machine translation in 1956, and with the rapid development of the Internet and the expansion and deepening of cross-cultural communication, machine translation is gradually becoming an important means for people to overcome the language barriers they face in accessing information, and the increasing demand for translation makes translation software enter a new period of development.

With the expanding and deepening economic and cultural exchanges between China and Japan, the demand for rapid and accurate access to Japanese information in China is increasingly urgent. In machine translation, Chinese-Japanese translation has attracted much attention. Although the number of Japanese learners in China is increasing, and China has now surpassed Korea as the country with the largest number of Japanese learners, it is still far from meeting this demand [2]. The emergence of Japanese-to-Japanese machine translation software provides an efficient means to break through the Chinese-Japanese information barrier. The translation quality of today's Chinese-Chinese translation software has come a long way compared with that of the previous, but it is undeniable that there is still a huge gap between the translation quality of Chinese-Japanese translation software and that of professional translators. Especially in the field of literary translation, machine translation is still difficult to be involved due to the lack of human feelings, the lack of delicate human deduction efforts, and the lack of human "encyclopedic knowledge" and linguistic and cultural knowledge. In addition, in the field of legal documents and contracts, which requires very precise language where language errors can have serious consequences, machine translation should be used with caution. The advantage of machine translation lies in "quantity," in its unreachable human speed, and the advantage of human translators lies in "quality." In order to translate quickly and well, we should combine the two organically and combine their outstanding advantages, such as arranging human translators to carefully review and reprocess the preliminary processed text translated by machines rapidly, so as to achieve complementary advantages [3]. However, the current research has not been able to find a solution for the Japanese and Chinese machine translation. However, the current research is relatively rare in terms of analysis and countermeasure research on the shortcomings and solutions of Japanese-Chinese machine translation software in translation.

The innovative contribution of this paper is to propose a phrase translation method based on sequence intersection. This method does not need auxiliary word alignment, syntactic analysis, and dictionary to obtain candidate translations. Sentences containing phrases to be translated can be intersected in a sentence level aligned bilingual corpus. Then, the translation of phrases is obtained after postprocessing. The phrase translation acquisition method based on sequence intersection gets rid of the dependence on word alignment, syntax analysis, and dictionary. It makes full use of the information of bilingual sentence alignment corpus and has a high accuracy. This will help build a Chinese Japanese machine translation corpus and solve the current problem of computer software corpus for Chinese Japanese translation.

2. State of the Art

Today's society is in the information age, with the rapid development of the Internet, and there is an urgent need to remove the textual barriers between people of different nationalities through machine translation. But natural language translation is one of the advanced levels of human intelligence activities, and artificial intelligence research has not yet reached the level of fully understanding natural language, so machine translation research is an important element of computational linguistics research with a significantly socioeconomic value [4]. According to the different knowledge representation and processing methods, there are two main translation methods: rule-based machine translation method and corpus-based machine translation method [5].

2.1. Rule-Based Machine Translation Methods. Until the 1990s, rule-based approaches dominated machine translation. Rule-based machine translation started with Chomsky's formal linguistics and the rise of artificial intelligence. The traditional rule-based machine translation process includes steps such as lexical analysis, syntactic analysis, semantic analysis, pragmatic analysis, intermediate language generation, and target language generation [6]. The rule-based machine translation system is to analyze, judge, and take the lexical, syntactic, semantic, and syntactic aspects of language utterances and then rearrange and combine them to generate equivalent target languages. Rule-based machine translation system can be divided into three kinds from the architecture: direct translation method, conversion generation method, and intermediate language translation method [7]. In the direct translation method, some electronic dictionary resources are mainly used, and these resources are mainly constructed by experts manually, and the translation method is also mainly based on dictionary-to-translation. As can be imagined, the quality of such translation results is not high, and the readability is poor. There are three basic steps in the conversion-based approach: analysis, conversion, and generation [8]. Analysis means transforming the source language into a predefined intrinsic abstract representation through word form processing, word division and lexical annotation, syntactic analysis, semantic analysis, etc.; conversion means transforming this intrinsic structure of the source language lexically and structurally into the corresponding target language or the abstract intrinsic structure of the target language; and generation means observing the necessary syntactic, semantic, and pragmatic constraints to produce the target language from its intrinsic structure out of the target language. The intermediate language-based approach is to analyze the source language to produce a representation that becomes an intermediate language and then to generate the target language directly from this intermediate language representation. An intermediate language is a systematic computer representation of a natural language, which attempts to create an artificial language that is independent of, and at the same time capable of representing, a variety of natural languages.

The rule-based machine translation approach can express the linguist's knowledge more intuitively and facilitate the handling of complex structures and deep understanding, which can effectively solve the long-distance dependency problem [9]. However, the rule-based approach also has its inherent drawbacks. Firstly, because the rules are handwritten by experts, they are inevitably highly subjective, and there is often a gap when these highly subjective rules are used to describe objectively existing linguistic phenomena. Secondly, the coverage of the rules is poor, as it is often difficult to summarize the rules comprehensively because these limited rules written manually are used to describe all the phenomena of a language. Although this problem can be remedied by continuously increasing the number of rules, after the rule base reaches a certain size, researchers find that the phenomenon of rule conflicts tends to be serious, making it difficult to effectively expand the existing rule base. Moreover, it is difficult to deal with real texts with rule bases constructed manually by experts, so the resulting translation systems tend to achieve better results only in some small areas [10]. Moreover, because the rule base must be constructed manually by experts with profound linguistic knowledge, it results in a high development cost of the system. The high cost of manual rule writing, the difficulty of guaranteeing rule consistency, and the difficulty of building and maintaining the relevant knowledge base make the method unable to adapt to the needs of large-scale data development and eventually escape the fate of being replaced.

2.2. A Corpus-Based Approach to Machine Translation. By the mid-to-late 1980s, the corpus-based machine translation approach gained significant development and gradually took a dominant position. This approach is based on a large-scale collection of bilingual corpora that are translated into each other. The method is further divided into two types: the statistical-based translation method (SBMT) and the instance-based translation method (EBMT) [11]. The statistical-based translation method (SBMT) was first proposed by Weaver in 1949, but statistical machine translation did not form a systematic theoretical framework in the following decades. Moreover, due to the limitations of computer computing power and corpus size at that time, researchers were not in a position to experiment with such an over-the-top theory.

The value of the IBM model is that, on the one hand, it describes machine translation in terms of a formal mathematical model for the first time and gives an effective method for estimating the model parameters; on the other hand, it provides a word-based alignment model that can automatically obtain word alignment information through training [12]. The IBM model, as the earliest proposed statistical machine translation model, has been influencing the later research on statistical machine translation. The straight IBM model as an early statistical machine translation model brought a new vision to the field of machine translation when it was first proposed, but researchers soon discovered its shortcomings. The most representative one is the limitation of the IBM model on word alignment, which does not allow one-to-many alignment cases from the source to the target language. This also limits the translation capabilities of the IBM model. In traditional machine translation systems, translation knowledge is expressed in the form of rules, which are written manually by linguists. This method requires a lot of money and manpower to develop dictionaries and rule systems. From the perspective of research, the experiment relies too much on the knowledge and experience of language rule developers, the research cycle is too long, and there is a lack of comparability between different research works. From the experimental point of view, when dealing with large-scale real data, the effect is always very unsatisfactory. With the development of machine translation research, people gradually realize that this manual method of obtaining translation rules has become a bottleneck restricting the development of machine translation research. Nowadays, phrase-based statistical machine translation has become a widely used approach in statistical machine translation, and phrase-based statistical machine translation systems have achieved good results in many reviews [13]. However, phrase-based statistical machine translation suffers from poor generalization ability, inability to represent translations of discontinuous phrase collocations, and inability to perform long-range discourse order adjustment. The best way to solve these problems is to introduce syntactic structure and build a statistical translation model based on syntactic structure, that is, syntax-based statistical translation model. And syntax-based machine translation is the current research hotspot in the field of statistical machine translation. There are numerous syntax-based statistical machine translation models, which can be broadly divided into formal syntax-based models and linguistic syntax-based models. The method used in the formal syntax-based model is the syntactic structure obtained from the corpus by automatic learning methods. The syntax used in linguistic syntax-based models is what linguists call syntactic structure and usually requires either learning the syntactic analysis of the sentence patterns in question from a manually constructed corpus or using artificially constructed linguistic rules for syntactic analysis [14].

The advantage of statistical machine translation over other machine translation methods is that it does not require the support of linguistic knowledge. The entire translation process is simulated by a mathematical model and can be done automatically by a computer. In addition, statistical machine translation requires only a certain size of bilingual aligned corpus as training data and does not rely on expensive human word-aligned corpus [15].

The instance-based translation approach obtains the target translation mainly by finding the most similar translation instances in a bilingual corpus. In instance-based machine translation systems, translation knowledge is represented as a lexicon of instances and sense classes and is easy for addition or removal, the system is simple and easy to be maintained and has the potential to produce high-quality translations if a larger library of translation instances is utilized and accurately compared, and it avoids the difficulties of deep linguistic analysis that those traditional rule-based machine translation methods must perform, which is very strategic in translation attractive [16]. In order for us to be able to accurately find the corresponding target language example sentence from the source language example sentence in the instance base, the concrete implementation of an instance-based machine translation system requires the ability to perform automatic bilingual alignment correctly, and not only at the sentence level, but also at the lexical level and even at the phrase level.

2.3. Analysis of Machine Translation Problems in Chinese and Japanese Languages. Japanese-Chinese/Chinese-Japanese machine translation is more difficult compared with Japanese-English/English-Japanese machine translation. The reason is that Chinese is an isolated language with a different grammatical structure, no active forms and tenses, and sentences cannot be divided by words, but by a string of consecutive Chinese characters, which are completely different from European and American languages and Japanese. Therefore, it is difficult to segment Chinese sentences by words, and the analysis of Chinese syntactic structure is not simple [17].

In order to continue the development of Japanese-Chinese and Chinese-Japanese machine translation, there is an urgent need to integrate machine translation research results, various accurate dictionaries, aligned parallel text data, etc. from China and Japan to build a practical Chinese-Japanese and Japanese-Chinese machine translation system. Such a high-quality and robust machine translation system will not only enhance the development of machine translation research itself, but also apply it to cross-lingual information services between libraries, or to practical scenarios in economic and cultural exchanges, which will be a great contribution to all aspects of information exchange and resource sharing between China and Japan [18]. The translation systems developed so far are mostly computer software translation systems. Most of the currently developed computer software translation systems are based on the framework of example-based machine translation, which absorbs the complex variations of linguistic representations through the effective use of dependency structure analysis to produce high-quality translations. Future work will focus on improving the accuracy of the dependency structure analysis for Chinese and expanding the instance dictionary to several times the number of dictionaries in the existing system with a view to achieving a diversity of representations in response to language. To this end, a large collection of aligned parallel texts is required.

3. Methodology

At present, corpus-based machine translation is still the dominant approach to machine translation, and this translation method based on large-scale real text processing is still the general feature of current machine translation. Phrase translation acquisition, as the main method for constructing the unmatched part of the translation unit, is one of the indispensable core aspects of machine translation [1]. Establishing sentence-level correspondence for bilingual texts means determining which sentence or sentences in the source language text and which sentence or sentences in the target language are mutually translated. The purpose of sentence alignment is to identify the sequence of sentence beads in a bilingual text that are composed of sentences that are mutually translatable.

3.1. Phrase Translation Acquisition Method Based on Sequence Intersection. The phrase translation acquisition method based on sequence intersection consists of a basic model, a high-frequency interference word restriction module, and a support degree restriction module. The basic model extracts high-quality phrase translation pair candidates from the sentence-level aligned bilingual corpus and ranks them; the high-frequency word restriction module solves the high-frequency word interference problem in the output results of the translations; the support restriction module controls the number of output results [19].

The corpus used in the sequence intersection-based phrase translation acquisition method is the sentence-level aligned bilingual corpus BC, which contains several Chinese-Japanese aligned sentence pairs. A sentence pair S is denoted as

$$S = CS \leftrightarrow JS, \tag{1}$$

where CS and JS are mutually translated Chinese sentences and Japanese sentences. In this method, the sentences are represented in the form of word sequences.

$$\begin{aligned} CS &= \ < c_1, c_2, \ldots, c_m >, \\ JS &= \ < j_1, j_2, \ldots, j_n >. \end{aligned} \tag{2}$$

Thus, the sentence pair S can be expressed in the form of a word sequence.

$$S = \ < c_1, c_2, \ldots, c_m > \leftrightarrow < j_1, j_2, \ldots, j_n >. \tag{3}$$

Let P be the Chinese phrase to be translated, expressed in the form of a sequence of words.

$$P = \ < P_1, P_2, \ldots, P_n >. \tag{4}$$

Let the double statement pair $S_k, S_h \in BC$,

$$\begin{aligned} S_k &= CS_k \leftrightarrow JS_k = \ < c_{k+1}, c_{k+2}, \ldots, c_{k+m} > \leftrightarrow < j_{k+1}, j_{k+2}, \ldots, j_{k+m} >, \\ S_h &= CS_h \leftrightarrow JS_h = \ < c_{h+1}, c_{h+2}, \ldots, c_{h+m} > \leftrightarrow < j_{h+1}, j_{h+2}, \ldots, j_{h+m} >. \end{aligned} \tag{5}$$

S_k intersection with S_h is defined as

$$S_k \cap S_h = CS_h \cap CS_k \leftrightarrow JS_h \cap JS_k, \tag{6}$$

where $CS_h \cap CS_k$ is defined as

$$\begin{aligned} &CS_h \cap CS_k \\ &= \arg\max_{\langle c_{h+h1}, c_{h+h2}, \ldots, c_{h+hq} \rangle} \left| \langle c_{h+h1}, c_{h+h2}, \ldots, c_{h+hq} \rangle \right|, \end{aligned} \tag{7}$$

$$0 \le h_1 < h_2 < \ldots h_q \le m_h, \tag{8}$$

$$0 \le k_1 < k_2 < \cdots k_r \le m_k. \tag{9}$$

Equation (7) indicates that the result of $CS_h \cap CS_k$ is a new word sequence, and each word in this sequence corresponds to each word in CS_h, CS_k , and the subscripts $h1$, $h2, \ldots, hq$ and $k1, k2, \ldots, kr$ of the two sequences should fall within the subscripts of CS_h, CS_k and be monotonically increasing, respectively; that is, they should satisfy (8) and (9).

If the intersection of S_k and S_h is

$$S_k \cap S_h = P \leftrightarrow T = P \leftrightarrow < j_{g1}, j_{g2}, \ldots, j_{gn} >, \tag{10}$$

P is the Chinese phrase to be translated and T is the intersection of the Japanese parts of S_k and S_h. Then, say that S_k and S_h support $P \leftrightarrow T$, and call T a candidate translation for P. If there are x sentence pairs in the corpus supporting $P \leftrightarrow T$, then the support of T as a candidate translation of i is said to be x, denoted as

$$SV\,(P \leftrightarrow T) = x. \tag{11}$$

The candidate translation with the highest support was selected as the translation result for P.

$$\text{Translation}\,(P) = \arg\max SV\,(P \leftrightarrow T). \tag{12}$$

In general, the translation of phrases results in a certain tendency of continuity in the translated sentences. And this tendency is not reflected in the basic model. If $g1, g2, \ldots, gn$ is continuous, it is a strong candidate translation of P; otherwise, it is an if candidate translation. In the continuity-constrained model, the strong candidate translation with the greatest support is chosen as the translation result of *P*; if there is no strong candidate translation, the weak candidate translation with the greatest support is chosen as the translation result of *P*.

3.2. Length-Based Sentence Alignment Methods. By alignment, we mean the creation of a mapping of intertranslational fragments or units between two languages in a parallel corpus. In simple terms, the sentence alignment problem is the process of corresponding a set of sentences in the source language to a set of sentences in the target language in terms of sentence content. As a special kind of corpus, parallel corpus is important for research on corpus-based machine translation, human-machine interactive translation, machine translation evaluation tools, cross-lingual information retrieval, bilingual phrase dictionary compilation, and word sense disambiguation [20].

If one wants to obtain a larger bilingual knowledge base, one must first establish the sentence-level pairwise translation relations of the obtained bilingual texts. And the correspondence relations between bilingual sentences include complex forms of one-to-many and many-to-many, in addition to a large number of one-to-one cases, and are thus quite technically challenging. BMT uses the mechanism of analogy for natural language understanding, which does not require understanding of the source language but requires keeping a large library of instances in which a large number of bilingual contrastive sentences or phrases are kept. When a sentence needs to be translated, the system goes to the instance library to find one or more source language instances that are similar or partially similar to it, identifies its corresponding target language instances, represents the sentence as some combination or transformation of these source language instances, and then applies the same combination or transformation to the target language corresponding to these instances to obtain a target language translation of the sentence [21].

This paper presents a bilingual sentence alignment method using sentence length and position information. This is a sentence alignment method for bilingual texts, wherein a plurality of alignment anchor points is calibrated in the bilingual text before automatic alignment. The alignment anchor divides the bilingual text into several alignment intervals, and automatic alignment is carried out within the several alignment intervals, respectively. The sentence alignment method of bilingual text according to claim 1: the alignment anchor points are uniformly distributed and calibrated in the bilingual text. The sentence alignment method of bilingual text according to claim 1 or 2: after the automatic alignment is performed, the sentence alignment results in the alignment interval are checked, and the alignment anchor points incorrectly calibrated in the automatic alignment process are modified and calibrated. In length-based alignment methods, some use the number of words in a sentence as a measure of sentence length units, while others use the number of characters in a sentence as a measure of sentence length. Such alignment algorithms require no linguistic knowledge and utilize a very simple statistical model based mainly on the fact that long sentences in one language are still longer when translated into the other language; conversely, short sentences are still shorter when translated into the other language; that is, the two mutually translated sentences are considered to be highly correlated in length. Another premise of this alignment algorithm is that the order of the mutually translated sentences does not change drastically in their respective texts. The length-based approach treats sentence alignment as a function of sentence length, does not require additional lexical information, and is more efficient, but is prone to error spreading.

The number of characters C corresponding to each character in language $L1$ in language $L2$ is a random variable and that random variable is normally distributed $N(c, s2)$, defined as

$$\delta = \frac{(l_2 - l_1 c)}{\sqrt{l_1 s^2}}. \tag{13}$$

For the probability $p(\text{match}|\delta)$, this is transformed into $p(\delta|\text{match})p(\text{match})$ using the Bayesian formula, where P(match) is a constant and can be statistically derived from the tagged corpus, and $p(\delta|\text{match})$ can be estimated by the following equation:

$$p(\delta|\text{match}) = 2(1 - p(\delta)), \tag{14}$$

of which

$$p(\delta) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} e^{-z^2/2} dz. \tag{15}$$

Based on the above distance metric, the distance values are calculated for various alignment cases, and then, the dynamic programming algorithm is used to determine the sentence alignment of the two texts by calculating the minimum distance between the two texts.

3.3. Implementation of Segmentation and Alignment Tools for Chinese and Japanese Language Corpora. Bilingual corpus is a kind of corpus containing information of mutual translation between two languages. It can provide rich matching information between two languages and has important applications in the fields of translation knowledge acquisition, bilingual dictionary building, instance-based machine translation, word sense disambiguation, etc. In computer language compilation, alignment mostly adopts a stepwise sequential alignment method based on the length of the original translation. It is assumed that the two languages correspond in a sequential and equal proportion, and for each alignment of a language unit referring to a chapter, paragraph, or sentence, the remaining language units are then aligned according to the new proportion. In the collection of corpora, the practical needs of language research and natural language processing research and application are considered. While paying attention to the scale and the quality of the original text and the translation, the balance of various genres and chronological data should also be fully considered. In order to meet the needs of knowledge extraction in natural language research, the corpus collected in the translation corpus is processed in three aspects: original translation alignment, part of speech tagging, and syntactic tagging.

This software tool has two main functional modules: the segmentation module and the alignment module. The segmentation module is responsible for segmenting the Chinese and Japanese English source files in sentence units, where the Chinese and Japanese corpora are separated by the Chinese period ("。") as the separator. After segmentation, each natural sentence is a natural segment, and the segmentation result is saved as a corresponding document with the following file name: original file name-after segmentation. extension. The alignment module realizes the function of aligning the translation of Chinese and Japanese, Chinese, and English files by sentence and saves each group of alignment results to an excel file with the file name: original file name-alignment. During the processing of the two modules, the similarity between the generated file name and the original file name is maintained to improve the user's experience. The processing flow of each module is shown in Figures 1 and 2.

4. Result Analysis and Discussion

In order to verify the effectiveness of the basic model of phrase translation acquisition based on sequence intersection proposed in this paper, and the improvement of the basic model by the high-frequency interfering word restriction module and support restriction module, the sentence-aligned bilingual corpus *BC* used in this experiment is a 1000-sentence Chinese-Japanese bilingual sentence-aligned corpus in the sports domain. We randomly selected 40,000 Chinese phrases from *BC* for testing. Also, to test the effectiveness of our designed parallel corpus-based Chinese and Japanese language computer software translation, we experimentally compared the machine translation results with the human translation results.

In order to ensure the accuracy of the experiment, the order of the various categories of corpus selected from the corpus was disordered and not sorted according to categories, nor was the content to be translated informed. The test data used in the experiment was provided by Fuji Xerox, and we randomly selected eight chapter-level alignments in different domains and manually marked the standard sentence alignment answers. A total of 512 alignments were included in the standard answers of the test set.

4.1. Sample Validity Analysis. In order to verify whether the hypothesis of this experiment is valid, we need to test the sample. First of all, the samples of this experiment are two independent samples of machine translated translations and human translated translations, and the sample size is less than 30; if it meets the normal distribution, then it meets the t-test criteria; then, first of all, we judge whether the samples meet the normal distribution. We use the software SPSS to do the normal analysis for the human translation sample and the machine translation sample, respectively, and the results are shown in Figures 3 and 4.

According to the normality test criteria, it is known that the normal distribution is met when the significance value in Kolmogorov–Smirnov is greater than 0.05, and from the experimental data, we find that the significance value of both human translation and machine translation is 0.200, and 0.200 is greater than 0.05, which means that the normal distribution is met, and from the Q-Q plot, we can see that most of the experimental data are near the straight line, so the human translation and machine translation samples both conform to the normal distribution characteristics. Therefore, this experiment meets the requirements of independent sample t-test, and independent sample t-test can be conducted.

4.2. Comparison and Analysis of Experimental Results. To measure the translation results of translation software for different sentence types, we used Gale's sentence alignment system, which is very influential in the field of sentence alignment, as the Baseline system. Eight types of chapter-level alignment subaccounts were also selected from the corpus, and the results of the length comparison of different sentences in the article for the Chinese and Japanese languages are given in Figure 5.

In order to measure the translation results of the translation software for different sentence types, three sentences were selected for each sentence in this experiment, and the average scores of each of the three sentences were used to represent each score of such sentences (e.g., if the fidelity score of all three sentences is 5, then the score of such sentences in terms of fidelity is $(5 + 5 + 5)/3 = 5$, collectively referred to as the fidelity score).

From Figure 6, it can be seen that the mean scores of fidelity, natural mean, and total mean scores for human translation are 4.57, 4.14, and 4.40, respectively, and the mean scores of each item for machine translation are 3.33, 3.00, and 3.20, respectively. It can be seen from the figure that the computer software translation designed in this paper is close to the level of professionals in terms of scores.

A comparison of the number of correct alignments between these two systems on multiple alignment types is given in Figure 7, from which it can be seen that the advantage of the sentence alignment system is more obvious on multiple alignment types. This further validates that the use of the combined cue-based similarity calculation method makes full use of the connection between the two and explores the connection between Chinese and Japanese bilinguals more comprehensively and fully than the length-based method alone. Some rely on syntactic analysis or word alignment technology, which requires high resources. In this paper, a phrase translation acquisition method based on sequence intersection is proposed. Without the help of word alignment, syntactic analysis, and dictionary, this method can find the intersection of sentence pairs containing phrases to be translated in the sentence level aligned bilingual corpus. The candidate translation is obtained, and then the translated translation of the phrase is obtained through

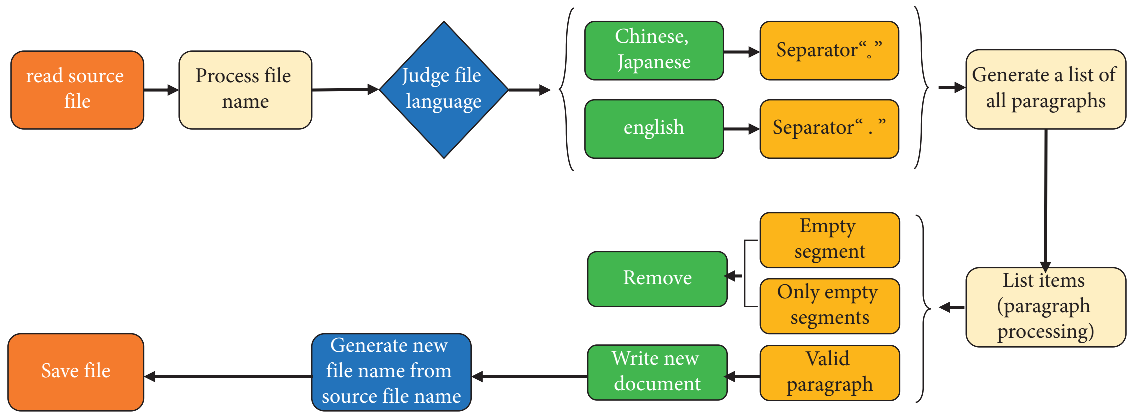

Figure 1: Flow chart of segmentation function module.

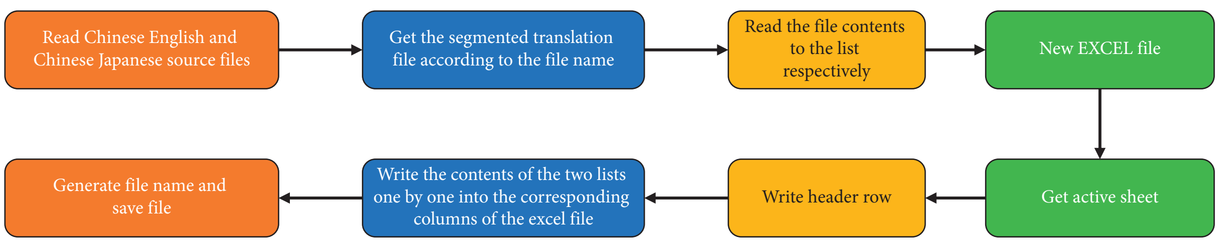

Figure 2: Flow chart of the alignment function module.

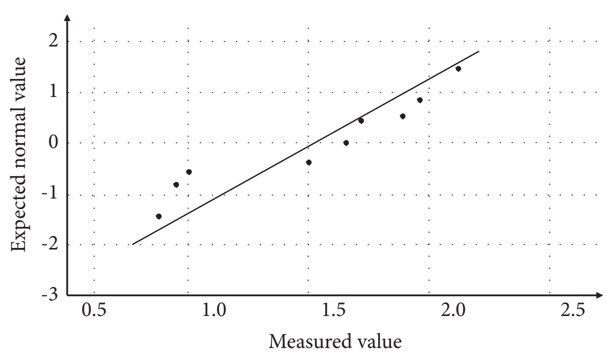

Figure 3: Analysis of human translation normality test.

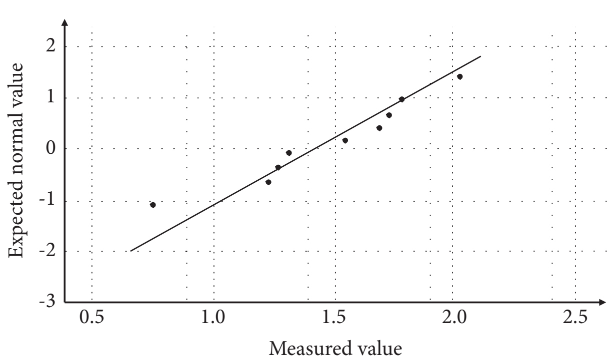

Figure 4: Analysis of machine translation normality test.

postprocessing. The phrase translation acquisition method based on sequence intersection gets rid of the dependence on word alignment, syntax analysis, and dictionary. It can be used as a module of multistrategy phrase translation acquisition.

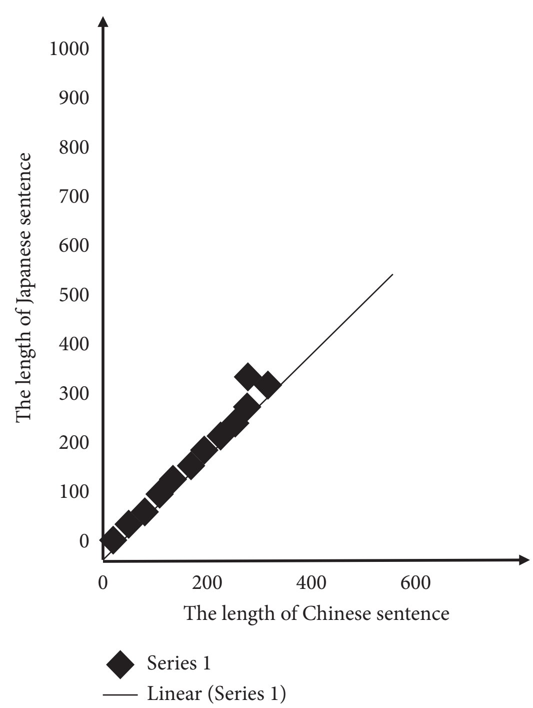

Figure 5: Ratio of sentence length between China and Japan.

The translation quality of today's Chinese-Chinese translation software has made great progress compared with that before, but it is undeniable that there is still a huge gap between the translation quality of Chinese-Japanese

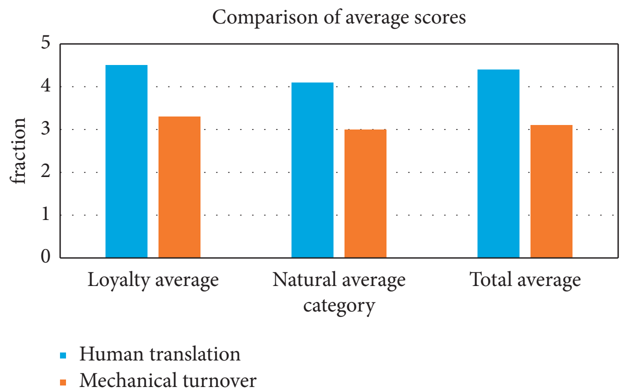

Figure 6: Score results of human translation vs. machine translation.

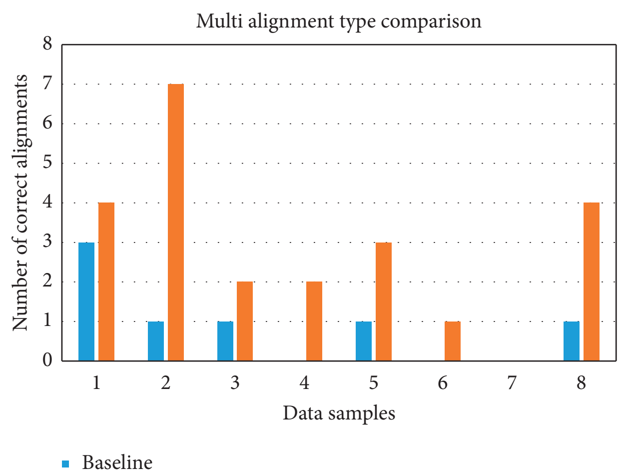

Figure 7: Results of sentence alignment on different test data.

translation software and that of professional translators. By building a large-capacity parallel corpus, it helps improve the quality and effectiveness of computer software translation.

5. Conclusion

This paper explores the automatic sentence alignment technology of Chinese and Japanese bilinguals and proposes a ten-year alignment model based on combination cues and core extended square matching. In this model, the similarity between bilingual sentences is calculated by using dictionary, word form, length, and special character combination clues to construct a ten-year aligned similarity matrix. This method does not need auxiliary word alignment, syntactic analysis, and dictionary to obtain candidate translations. Sentences containing phrases to be translated can intersect in a sentence level aligned bilingual corpus. And then, the phrase translation is obtained through postprocessing. The phrase translation acquisition method based on sequence intersection gets rid of the dependence on word alignment, grammar analysis, and dictionary. It is further verified that the combination similarity calculation method based on clues makes full use of the relationship between the two and explores the relationship between Chinese and Japanese bilinguals more comprehensively and comprehensively than the length-based method alone. However, the research has certain limitations. The research also needs to collect a large number of aligned parallel text comparisons, and future work needs to focus on improving the accuracy of Chinese dependency structure analysis. And expand the example dictionary to several times the number of dictionaries in the existing system to realize the representation of language diversity.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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Retraction

Retracted: The Basic Principles of Marxism with the Internet as a Carrier

Mathematical Problems in Engineering

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

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

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

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

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Research Article

The Basic Principles of Marxism with the Internet as a Carrier

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We live in a real society today with the Internet as the carrier. Marxist philosophy is of great significance to the study of computer science and technology majors, such as the standardization of learning methods and the improvement of learning horizons. In order to study the ideology of the current Internet carrier, this study first introduces the ideology in the Internet scenario and again describes the basic principles of Marxism. Web text data were collected from both static and dynamic websites, and the data were initially preprocessed using the ICTCLAS word separation tool. After that, a text lexicon set related to Marxism was built and combined with the surplus value calculation formula. Analysis of the text data shows that the expectation error of the Internet population approximately obeys a positive-term distribution, and the online text data are feasible in the estimation of the influence of Marxism. The statistical results show that the percentage of serious philosophical discussions from 2017 to 2021 in which Marxism is mentioned has steadily increased from 62% to 78%, indicating that Marxism still has great influence to this day. For these three different attitudes toward Marxism, the number of comments agreeing and disagreeing differed significantly, indicating that different groups of people show very different attitudes toward Marxism.

1. Introduction

The Internet has not only provided unprecedented convenience for human society but also brought great changes. The Internet is a huge carrier of information, and along with the steady forward development of the global economy, its tentacles have extended to every corner of the Earth [1]. And the websites, news media, social software, and entertainment information built on its technology are profoundly changing human behavior and thinking patterns with astonishing influence [2]. And multiple philosophical schools of thought have lent themselves to the dissemination of articles, social comments, and videos, either long or short, in a different way than before and ideologies are being transmitted from person to person in a whole new way.

The existence of society determines the social consciousness, and different social forms are supposed to have different social consciousness. However, influenced by the rapid dissemination of information through the Internet, multiple social consciousnesses have begun to spread in societies where they do not exist [3]. Diverse cultural communication brings opportunities for the survival of relatively small and disadvantaged groups, providing them with more tolerance and care. And in some ideologically homogeneous and narrow-minded societies, the spread of pluralistic ideas is like a seed that takes root in the soil of a group of people's minds. After some years, it is bound to bring about changes and evolution [4]. And ideology needs to be matched with economic development; matching ideology and economic level can promote national cohesion and lead people to greater victory. And mismatched ideology and economic level can be counterproductive to social development, negatively impacting economic development and people's working life, and hindering social progress and development [5]. Diversity of thought is not beneficial across the board, and there is a great deal of backwardness and dross in philosophical thought, while the rapid but shallow communication characteristics of the Internet make a large part of the population lose the ability to think deeply. This has facilitated the spread of some extreme contents, and people no longer look into the reasons and meanings behind the events, but simply vent their emotions [6]. Moreover, in the last decade or so, all events that should be taken seriously have been entertained by the dissemination of texts of no more than one hundred words, the insertion of a large number of emoticons, and the prevalence of short videos [7]. The creation of this universal pan-entertainment is inevitably detrimental to the improvement of people's state of mind and the rise of national economic level.

Marxism was proposed by Karl Marx and Friedrich Engels in the mid-to-late 19th century, and it is the basis of the socialist ideological system. Marxism has a rich connotation and profound ideas, and it mainly includes three major parts: materialistic dialectics, Marxian political economy, and scientific socialism [8]. It is an all-encompassing system of thought, and the richness of its principles is astonishing. It not only exposes that the world is material and has its specific laws of development but also puts forward the guiding method of discovering and understanding the laws of development of things in which practice is the only criterion for testing the truth. It also elaborates the development of human society, in which it reveals the essence of capitalism and the laws of development, depicts the emergence and development of socialism, and predicts that the final form of society is communism [9–15]. In the context of network globalization, are the basic principles of Marxism still applicable, have they been more widely disseminated, and have they correctly predicted the development of society? The study of these questions cannot be done without the support of data, and the development of computer technology out of data mining algorithms provides tools for research. In terms of the Internet realm, which reaches into every aspect of life, humanity has entered the era of big data. The scale of big data is so huge that it is impossible to directly obtain the desired information from it, and it needs to be processed and analyzed, collectively known as data mining [16]. Internet articles, social media text messages, and long and short videos are very important components of big data, and for the development of Marxist influence, the massive amount of Internet data that have accumulated over decades has considerable mining value [17]. To mine these data requires more knowledge about big data, which can be classified according to the distribution form of the data: structured big data, semi-structured big data, and unstructured big data. In the field of philosophical thought dissemination, unstructured big data have the highest percentage, which can reach 83.9%, and this percentage will continue to increase with the continuous improvement of data collection and storage [18–20]. This study, based on the understanding and recognition of the characteristics of big data, also requires technology as a means to bring the value of big data into play with the various algorithms that are popular and common today, and most of these algorithms are already relatively well developed and mature. The use of computer algorithmic techniques to mine data on philosophical ideas in the web and the ideologies developed from them is the only way to demonstrate the true value of big data in terms of the field of Marxist studies [21].

To sum up, there are many shortcomings in the current research on the basic principles of Marxism in the context of big data. The first is the lack of concretization of philosophical ideas, which still remains at the stage of perceptual description, without clear assessment indicators to enable it to be defined at the rational level. Second, the research intensity and practice of it is not deep enough, and more scholars are needed to cut into it from different perspectives. Finally, it is the backwardness of research tools and objects. In the era of big data, data with a lot of noise that were neglected in the past and could not be mined because of insufficient technical power can be better utilized. The exploration and development of the basic principles of Marxism in modern times using the new tool of computer algorithms and the web as a vehicle is the way and method that this study focuses on. According to the characteristics and requirements of the big data era, this paper carries out Marxist theory education and realizes the thinking reform of Marxist theory education. In the era of big data, cloud computing technology, computer technology, and network technology are developing rapidly. It provides technical support for collection, computer and other information collection, and storage devices. It enables people to upload a large amount of data to the Internet, providing a digital platform for sharing educational information and educational resources. Second, the digital platform has a certain virtuality so that people can be more active in revealing their ideas. And big data technology can also analyze people's thoughts. In this way, the education of Marx's main theory can be spread according to people's ideas. In the data age, there are not only a large number of data audiences but also a wide range of applications of big data technology, which has changed our lives. Make them the disseminators and receivers of information, which can expand the audience of Marxist theory education and make more people accept Marxist theory.

2. Identification and Preparation of Research Methods

2.1. Web Text Data Mining. First proposed by two scientists in the United States in 1995, text mining probability is a comprehensive technique that encompasses information retrieval and statistics, big data mining, machine black-box learning, and computer algorithms across many disciplines. Internet text mining converts unstructured data into structured and easy-to-read data and then discovers keywords, mines hidden information, acquires new knowledge, and finds connections between words and phrases from the structured data. With the development of statistical learning methods, especially after the 1990s, the number of online texts on the Internet has increased and the rise of machine learning disciplines. We gradually formed a set of classic methods to solve the problem of large-scale text classification. The main routine at this stage is artificial feature engineering + shallow classification model. Text mining will first preprocess the text dataset, then represent the unstructured data using text, and finally mine the structured text to finally get the required information.

For Chinese text data within web-based articles, news, microblogs, comments and videos, and data cleaning needs to be performed first. Chinese text data cleaning includes removing deactivated words, restoring pinyin abbreviations, and eliminating meaningless phrases. Because computer algorithms cannot directly recognize and process Chinese utterances, the raw social media comment text data need to be formalized first. Aiming at the problem of visual clutter in large-scale geographic data visualization, a variety of visualization methods are proposed, mainly including filtering, aggregation and sampling. In the filtering scheme, attribute values are always considered to simplify the visualization of geographical data. In this method, data items with attribute values outside the scope of interest will be filtered out in the visualization of results. Three models are usually used to represent the Chinese text processing domain, namely dynamic vector space model, discrete probability model, and fuzzy concept model. In this experiment, the dynamic vector space model, which is relatively more stable and mature, is chosen to represent the social media comment data. In the dynamic vector space model each text is a collection of phrases, which are called features, and then the Chinese text can be represented in the form of vectors. It can be expressed by the following equation:

$$D = \begin{bmatrix} d_1 \\ d_2 \\ \vdots \\ d_m \end{bmatrix} = \begin{bmatrix} w_{11} & \cdots & w_{1n} \\ \vdots & \ddots & \vdots \\ w_{m1} & \cdots & w_{mn} \end{bmatrix}, \tag{1}$$

where d is a text and m is the number of texts in this dynamic vector space model and then w is the weight of the text that is the same as each corner marker. The specific weights can be calculated by the following formul:

$$\begin{aligned} w_{td} &= tf(t,d) \times idf(t) \\ &= tf(t,d) \times \log\left[\frac{m}{df(t)} + 0.01\right]. \end{aligned} \tag{2}$$

2.2. Web Text Data Collection. Currently, the main content expressions on the Internet are web version and mobile version, and the mobile version is divided into two kinds of Android APP and iOS APP. Because of the closed nature of iOS system, it is difficult to capture the text data of its intrinsic APP, while Android system is relatively open, but it also needs many permissions to get the required text data completely. Therefore, the text data on Marxism in this study are mainly collected from the web side, which can be divided into static web pages and dynamic web pages according to the form of data. Static web pages are also known as HTML (HyperText Markup Language) format web pages, which are characterized by the fact that the content is already determined during the process of web page writing and does not change with changes in the background and user interaction. It is only necessary to use Python programming technology to crawl static web pages, compress and save all the content on these pages into txt text format, then remove the web tags, and store them in the database for use.

In contrast to static web pages, dynamic web pages are much more complicated to collect data than static web pages because their contents change with background operations. Once the web content is published to the website server, whether or not users visit, the content of each static web page is saved on the website server. In other words, a static web page is a file actually saved on the server, and each web page is an independent file. The content of static web pages is relatively stable, so it is easy to be retrieved by search engines; dynamic web design usually includes some animation effects and dynamic special effects in the production, so as to make the website more dynamic and cause stronger visual impact to visitors. Reasonable application of dynamic effects can give the website a better experience and make visitors more clearly understand the content of the website. Figure 1 shows the flow chart of dynamic web text data mining.

From the flowchart of dynamic web page processing in Figure 1, it can be seen that the dynamic content of the web page is first crawled in time by using the web text-crawling tool GooSeeker and then saved in xml text format that can be used by the Python algorithm and then the text is initially preprocessed using the Python algorithm. Unlike static web pages, dynamic web pages have a lot of scrolling information, so it is necessary to remove this part of text that is not meaningful to the study. In this study, ICTCLAS, a good word-splitting tool for Chinese, was chosen for processing. ICTCLAS can split the whole sentence into phrases and can recognize the semantics, actively removing, for example, advertisements and other content, leaving only city-related comments. The segmentation mainly divides phrases into three broad categories: nouns, verbs, and adjectival adverbs, as prepositions and pronouns have no real meaning. The selection of features for the phrases can be further optimized for the weight values of the text feature vector and then equation (2) can be rewritten as

$$w(t,d) = \frac{tf(t,d) \times \log\left(N/N_t + 0.01\right)}{\sqrt{\sum_{t\in d}\left[tf(t,d) \times \log\left(N/N_t + 0.01\right)\right]^2}}, \tag{3}$$

$tf(t,d)$ in Equation (3) is the probability that a noun, verb, or adjectival adverb t appears in the text, and d and N are the total number of Marxist-related texts in the text database. Together, these texts form a feature space, and a text data set on its space is first defined as

$$\begin{gathered} T = \{(x_1,y_1),(x_2,y_2),\cdots,(x_N,y_N)\}, \\ x_i \in R^n, y_i \in \{+1,-1\}, \quad i = 1,2,\cdots,N, \end{gathered} \tag{4}$$

where x_i refers to the first i feature vector and y_i refers to the dynamic class marker, which takes the value of +1 for positive cases and −1 for negative cases. Then, with the set text data set and hyperplane formula, the sample point (x_i, y_i) is taken and its several intervals can be found by the following formula:

$$\gamma_i = y_i\left(\frac{w}{\|w\|}\cdot x_i + \frac{b}{\|w\|}\right). \tag{5}$$

The maximum γ can be found and then the newly constructed objective function can be obtained by using the Lagrange multiplier method on it as follows:

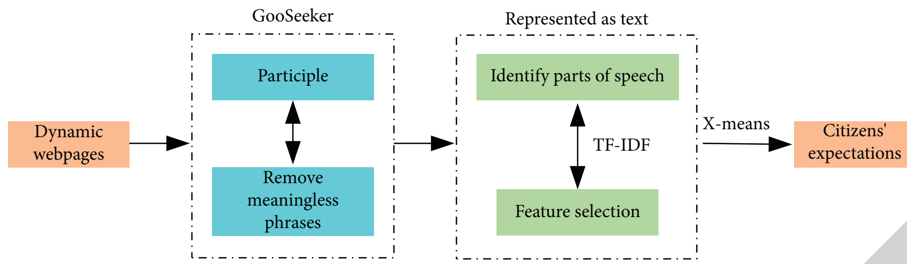

Figure 1: Converting Marxism-related content in dynamic web pages to text data flow chart.

$$L(w,b,\alpha) = \frac{1}{2}\|w\|^2 - \sum_{i=1}^{N} \alpha_i \left(y_i \left(w \cdot x_i + b\right) - 1\right). \tag{6}$$

The value of α_i is a Lagrange multiplier, which is greater than or equal to 0. When the sample point is in the feasible region, x, α_i is set to infinity, and the constraint is satisfied. When the sample point x is in the infeasible region, the value can be expressed by the following equation:

$$\theta(w) = \begin{cases} \frac{1}{2}\|w\|^2, \\ \\ +\infty. \end{cases} \tag{7}$$

After obtaining this new objective function, the original text-capture problem is equivalent to

$$\min_{w,b} \theta(w) = \min_{w,b} \max_{\alpha_i \geq 0} L(w,b,\alpha) = p^*. \tag{8}$$

It would be quite complicated to find the maximum value and then the minimum value for the above equation, so using Lagrangian duality, the positions of the maximum and minimum values are swapped to facilitate solving for both, and the transformed equation is

$$\max_{\alpha_i \geq 0} \min_{w,b} L(w,b,\alpha) = d^*. \tag{9}$$

To make $d^* = p^*$, it is necessary that this text-crawling problem is a convex optimization problem and satisfies the KKT condition, which satisfies the following set of inequality equations:

$$\begin{cases} \alpha_i \geq 0, \\ y_i \left(w_i \cdot x_i + b\right) - 1 \geq 0, \\ \alpha_i \left(y_i \left(x_i \cdot x_i + b\right) - 1\right) = 0. \end{cases} \tag{10}$$

The separation yields a maximum hyperplane of

$$w^* \cdot x + b^* = 0. \tag{11}$$

The final classification decision function for the data set of crawled text can be obtained as

$$f(x) = \operatorname{sign}\left(w^* \cdot x + b^*\right). \tag{12}$$

It is well known that Marxism specifies the formula for calculating surplus value in capitalism, which can be expressed as

$$\frac{m}{v} = \frac{m}{L} = \frac{s}{n}. \tag{13}$$

In the previous equation, m represents the surplus value in a factory under capitalism, v represents variable capital, L is the value of labor, s refers to surplus labor, and n represents the necessary labor of workers.

This derived formula actually indicates in what proportion the working day or its valuable product is distributed between the capitalist and the worker. Thus, if one considers these formulas as direct expressions of capital's own multiplication, one arrives at a false law: surplus labor or surplus value can never reach 100%. This introduces the variable of whether labor is remunerated or not, and the above equation is equivalent to

$$\frac{m}{v} = \frac{m}{L} = \frac{\text{non}}{h}, \tag{14}$$

nonrepresents unpaid labor, while h represents paid labor.

The Marxist formula for calculating capitalist surplus value can be applied to some of its counterparts in the textual crawl, making some texts that elaborate on surplus value more intuitive and easier to analyze. The law of surplus value refers to the law of surplus value production and capital proliferation. It reflects the essence of capitalist production and is the basic economic law of capitalism. In capitalist society, capitalists possess the means of production, and although workers have personal freedom, they are deprived of the means of production. Only when workers sell their labor as commodities and are purchased by capitalists can labor and means of production be combined for capitalist production. The basic economic laws of capitalism. It shows that the purpose of capitalist production is to produce and occupy surplus value.

3. Web Lexicon Building and Text Data Analysis

This study analyzes the relationship between the texts presented by the Internet as a vehicle and the understanding of Marxism by the population, which is reflected by the type of influence of Marxism and the impact on the population. From the results of the analysis of Internet text data, it can be obtained that the three interaction terms, the percentage of mentions, the percentage of applications, and the percentage of elaborations of Marxism are statistically strongly correlated with its influence. In order to verify the feasibility of the analysis and use of the Internet lexicon, this experiment draws the relationship between the expected cumulative probability and the observed cumulative probability of the model, as shown in Figure 2.

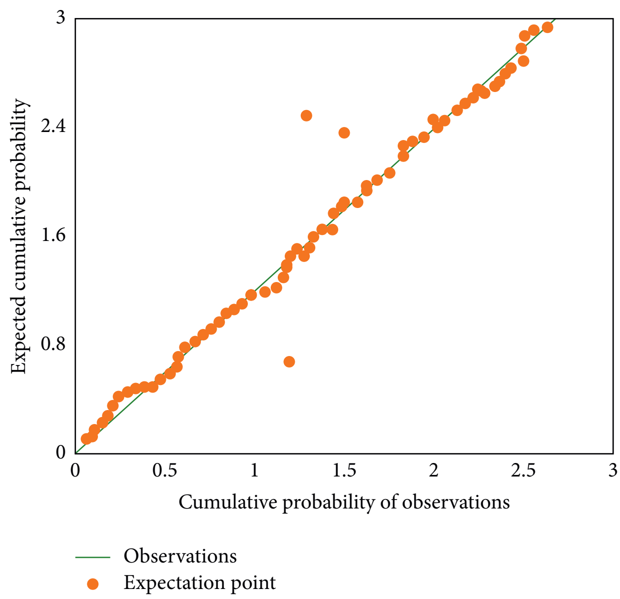

FIGURE 2: Relationship between expected cumulative probabilities of web texts and observed cumulative probabilities.

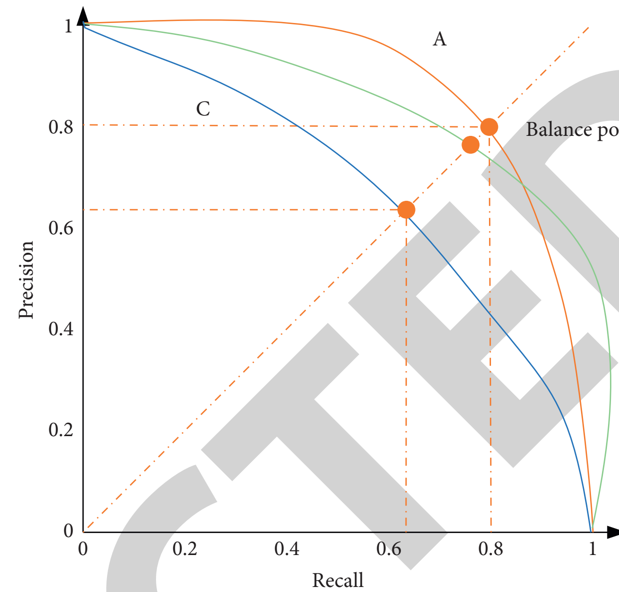

FIGURE 3: Schematic diagram of P-R curve and equilibrium point obtained by hybrid algorithm analysis data.

It is obvious from Figure 2 that most of the expected points are randomly distributed near the observation standard line. The two and one deviated points distributed on both sides of the baseline line, respectively, are analyzed in this study and learned to be invalid data, which can be ignored.

Then the analysis of the texts crawled in the network was continued to obtain a subset of texts strongly correlated with the description of Marxist principles, and the results are represented by the P-R curve in Figure 3.

The P-R graph visually shows the search completion rate and accuracy rate of Marxist-related texts on the Internet. The three balance points in the graph are a measure of the prediction accuracy of each sample subset, and the larger the value taken indicates the greater the relevance of this subset to Marxist principles.

The number of texts about Marxist discussions in the Internet in the past years can visually reflect its influence and has certain reference significance for the exploration of its principles. Therefore, this study has conducted an analysis of the proportion of Marxist discussion texts to the texts of serious philosophical discussions in the Internet using the established Internet thesaurus, and the results of recent years are shown in Figure 4.

From 2017 to 2021 the percentage of mentions of Marxism in serious philosophical discussions has steadily increased from 62% to 78%, indicating that Marxism still has great influence and its value today. In a contemporary era where the division of human labor is becoming more and more fragmented and the hours of work are becoming longer, the ideas proposed and articulated by Engels and Marx are still applicable to a society with a highly developed Internet.

The understanding and elaboration of Marxist principles show obvious differences between the proletariat and the bourgeoisie, and the establishment of a social class role lexicon is necessary to improve the accuracy of the experimental findings. The establishment of a role lexicon can further improve the efficiency of the analysis by eliminating phrases with small role differences and thus effectively reducing the capacity of the database. At the same time, it can filter out the phrases with social role characteristics and improve the accuracy of the analysis of basic Marxist principles. In this paper, 12,000 proletarian texts and 12,000 bourgeois texts related to Marxism were selected from the Internet text data to form the experimental objects. For the textual texts first, we use ICTCLAS word-splitting tool for word splitting, and then calculate the interaction information value of the two classes separately, and the result is that the maximum difference of interaction information value between the real classes is 6.28, so this experiment selects 0%, 10%, 20%, 30%, 40%, and 50% of the

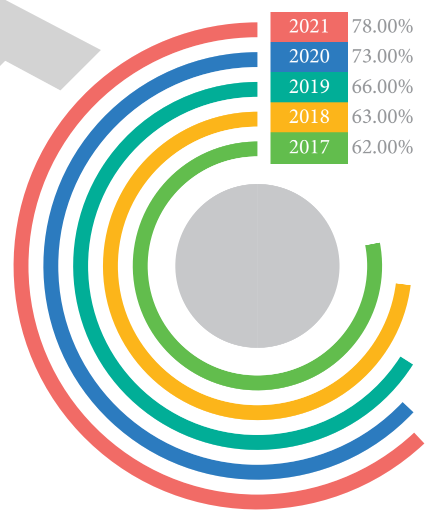

FIGURE 4: Proportion of Marxist discussion texts to serious philosophical discussion texts on the Internet.

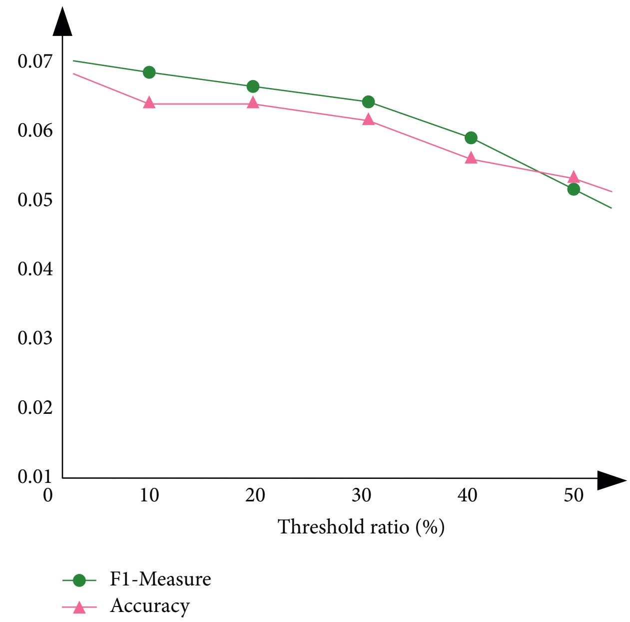

Figure 5: Experimental results of optimal threshold selection for bourgeois and proletarian thesaurus in Internet Marxism-related texts.

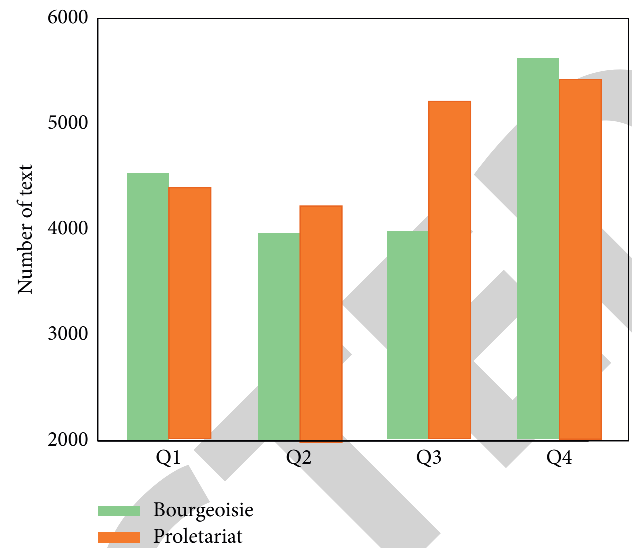

Figure 6: Changes in the number of male and female social media comments by quarter.

maximum value of interaction information value difference in the texts as the threshold value. Because phrases exceeding 50% of the maximum value are categorized into differential tremendous phrases, which have no reference significance for the study of basic Marxist principles, they are not considered. Six lexicons were created according to different proportions, the lexicons were vectorized using the dynamic vector space model above, and the classification results for 50 cross-validations of this data object are shown in Figure 5.

The results of the above Figure 5 show that as the maximum percentage of the difference increases, both the interaction information value and the accuracy rate show decreasing results. The accuracy rate is higher at the threshold percentage of 20%, and the difference between the interaction information values of the two orders is smaller, so the optimal threshold percentage is selected as 20%, and this ratio applied to the ranking of the Marxist principle study can improve the accuracy and scientificity of the results of gender classification pairs.

Based on the results of the above analysis, this paper divides the texts published by proletarian and bourgeois societies in online platforms into different groups of people's interpretation and application of Marxist principles according to the characteristic words in the understanding content that contains their expressions. Marxist class theory believes that the class of people is determined by relationship rather than by rank. The central axis of the class lies in the social organization of production rather than in the market. The analysis of class relations is rooted in the examination of the process of exploitation rather than the division of labor and technology or authority relations. For the bourgeoisie and the proletariat, for which there is a clear distinction, this study separately counts the number of texts produced by each of their groups in each quarter, and the results are shown in Figure 6.

The results of the above graph show that the proletariat went to talk and pay attention to Marxism more in the second, third, and fourth quarters and in total and more frequently than the bourgeoisie. This is the same as the expectation of this experiment, Marxism is the guiding light for the proletariat, it finds the way to victory for the proletariat, and it is the comfort as well as the action program for the toiling masses exploited by capital.

The ICTCLAS word-sorting tool can also determine the emotional color of adjectives in the text, which can translate the online text into a more intuitive rating of the acceptance of Marxism. The comments of this experiment are divided into one to three stars. The one-star comments mainly consider that Marxism is outdated, and its theory and connotation have shown fatigue due to the development of the Internet and technology. The three-star comments represent the authenticity of Marxism, and the people concerned are very satisfied with its principles. Figure 7 shows the relationship between the number of emotionally expressed texts and the corresponding scores.

The results of the above graph show a significant difference in the number of texts between the three scoring levels of the dynamic ANOVA. For these three different attitudes toward Marxism, the number of comments agreeing and disagreeing differs significantly, thus it can be known that different groups of people show very different attitudes on Marxism. It can be seen that the amount of textual data considering Marxism in the Internet context remains stable, and none of the ratings 1, 2, and 3 deny its philosophical achievements and practical guidance. And those who think it is still practical generally rate it at 3. The crowd that considers Marxism obsolete is as expected, with the majority giving it a score of 1. Marx has exerted an important influence on the development of the Internet in three aspects: broadening the research field, improving the analysis method, and innovating the basic theory. There are some commonalities between Marx's theory and Internet

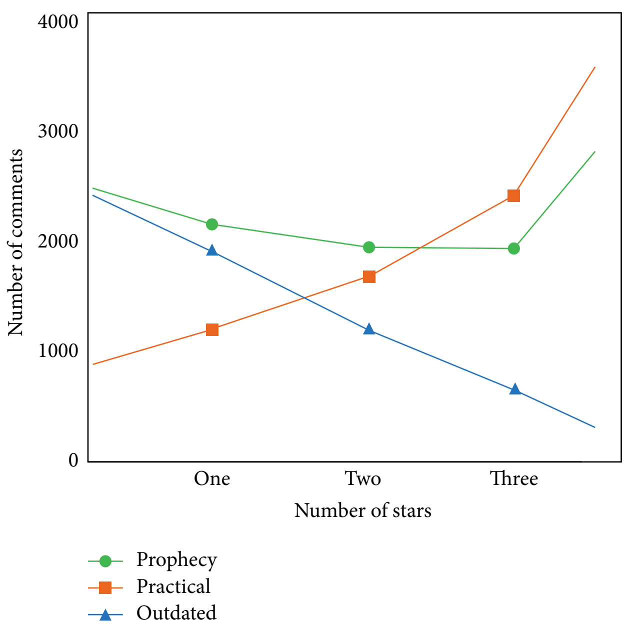

Figure 7: Graph of online text volume and rating scales for different attitudes toward Marxism.

culture in terms of research objects and research methods. It is the prerequisite for Marx to have an impact on social development. Marx studied social development from a higher angle than all sociologists. This is the fundamental reason why Marx can still have a great impact on the whole society.

4. Conclusion

This study establishes a set of text dictionaries related to Marxism and combines it with the residual value calculation formula to get a more intuitive and easier to use formula. From the results of network text data analysis, we can see that the three interactive terms of Marxism, namely, the percentage of mention, the percentage of application, and the percentage of elaboration, are statistically closely related to their impact. The expected error of Internet population approximately obeys the positive land distribution, and Internet text data are feasible in impact calculation. The statistical results show that from 2017 to 2021, the proportion of Marxism mentioned in serious philosophical discussions has steadily increased from 62% to 78%, indicating that Marxism still has great influence and value today. The continuous analysis of text data shows that when the threshold percentage is 20%, the accuracy rate is higher, while the difference between the interactive information values of the proletariat and the bourgeoisie is small. Therefore, the optimal threshold percentage is selected as 20%. Applying this proportion to the ranking of Marxist principle research can improve the accuracy and scientificity of gender classification results. Dynamic variance analysis shows that there is a significant difference in the number of texts between the three scoring levels of Marxism. For these three different attitudes toward Marxism, there are significant differences in the number of comments in favor of and against Marxism, which let us know that different people have very different attitudes toward Marxism. However, Marxism is a huge and profound system. This study only captures several aspects of the Internet for related research. I hope to further reveal the basic principles of Marxism in future research.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest regarding this work.

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Research Article

Studies of Chordal Ring Networks via Double Metric Dimensions

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Locating the sources of information spreading in networks including tracking down the origins of epidemics, rumors in social networks, and online computer viruses, has a wide range of applications. In many situations, identifying where an epidemic started, or which node in a network served as the source, is crucial. But it can be difficult to determine the root of an outbreak, especially when data are scarce and noisy. The goal is to find the source of the infection by analysing data provided by only a limited number of observers, such as nodes that can indicate when and where they are infected. Our goal is to investigate where the least number of observers should be placed, which is similar to how to figure out the minimal doubly resolving sets in the network. In this paper, we calculate the double metric dimension of chordal ring networks $CR_n(1,3,5)$ by describing their minimal doubly resolving sets.

1. Introduction and Preliminaries

Suppose that Γ is a connected, finite, and undirected graph. Its vertex set is V_Γ and its edge set is E_Γ. The distance $d(f,g)$ between two vertices $f,g \in V_\Gamma$ in a connected graph is the shortest path connecting those two vertices. If $e \in V_\Gamma$ is a vertex such as $d(e,f) \neq d(e,g)$, then we say e resolves the vertices f and g. The representation $r(h,J_\Gamma)$ of a vertex h with respect to an ordered set $J_\Gamma = \{j_v | 1 \leq v \leq \rho\} \subseteq V_\Gamma$ is defined as a ρ-vector $(d(h,j_1),\ldots,d(h,j_\rho))$, also called the distance vector. If each vertex of the graph Γ has a unique distance vector with respect to the set J_Γ, then J_Γ is called the resolving set (or sometimes called locating set) for graph Γ. The minimum possible cardinality of a resolving set in Γ is called the metric dimension (MD), represented as $\dim(\Gamma)$. A resolving set of cardinality $\dim(\Gamma)$ is said to be the metric basis of Γ.

The notion of MD was first proposed by Slater in [1] and investigated independently by Harary and Melter in [2] because of the problem of locating an intruder in a network. Later, Chartrend and Zang [3] demonstrated various applications in biology, robotics, and chemistry. From a two-dimensional real plane, the MD of graphs can extend the concept of trilateration. For instance, distances are used by the Global Positioning System (GPS) to identify an object's location on Earth. In the context of MD, Hamming graphs are closely related to the difficulties in weighing of coins discussed in [4, 5], and the comprehensive study of the Mastermind game given in [6].

Resolvability of graphs has become a significant parameter in graph theory as a result of its widespread applicabilities in different areas of mathematics, including facility location problems, network discovery and verification [7], applications in molecular chemistry [8], the positioning of robots in a network [9], routing protocols geographically [10], the problems of sonar or LORAN stations [1], and the optimization problem in combinatorics [11]. After that, we will have a look at some research work on the mathematical significance of this distance-based parameter.

The MD has been used to study a variety of mathematically interesting graph families. We will highlight some of the significant work in this section: Similar to many other graph-theoretic parameters, finding the MD of arbitrary graphs is a computationally tough task [9, 12]. For example, the bounds for the MD of the Petersen graph family was studied by Shao et al. [13]. On various distance-regular graphs (such as kayak paddle graphs and chorded cycles), Ahmad et al. investigated the MD [14]. Bailey et al. [15] investigated the MD of Kneser graphs. For wheel graphs, Buczkowski et al. in [16] investigated the MD, whereas Baca et al. in [17] examined the MD of regular bipartite graphs. Chartrand et al. [8] categorized n-vertex graphs with MD 1, $n-2$ and $n-1$. From the perspective of MD, graphs of relevance in group theory, such as Cayley digraphs [18] and Cayley graphs formed by certain finite groups [19], have also been investigated. [20] provides a response to the question of whether the MD is a finite number or an infinite quantity. The minimum ordered resolving sets of Jahangir graphs (resp. necklace graphs) were investigated by Tomescu et al. in [21] (resp. in [22]). Investigations have also been carried out into the MD and the resolving sets of product graphs, such as the categorical product of graphs [23] and the cartesian products [24].

MD has also been generalised and extended by offering more mathematically rigorous general ideas, such as the double metric dimension (DMD). Caceres et al. [24] proposed and defined the notion of doubly resolving sets (DRSs) of graph Γ as follows: a pair of vertices g and h of graph Γ is said to double resolve vertices g' and h' if the following equation holds: $d(g',g)-d(g',h)\neq d(h',g)-d(h',h)$. A DRS of Γ is a subset $N_\Gamma=\{k_1,k_2,\ldots,k_n\}$ of V_Γ, where every two different vertices of Γ are resolved by some two vertices of N_Γ. The minimal doubly resolving set (MDRS) problem is to find a DRS of Γ with the smallest cardinality, which is called the DMD of Γ indicated by $\psi(\Gamma)$. If the vertices g' and h' can be doubly resolved by the vertices g and h then either $d(g',g)-d(h',g)\neq 0$ or $d(g',h)-d(h',h)\neq 0$ which follows that either g or h resolve the vertices g' and h'.

Because a DRS is also a resolving set, we have $\psi(\Gamma)\geq \dim(\Gamma)$, so we can use the MDRSs to get an upper bound on the MD of the graph under discussion. The idea of establishing upper boundaries in the cartesian product encouraged us to explore on DRSs of different graph classes. In general graphs, the MDRS problem has been shown to be NP-hard [25]. Many families of graphs, such as cocktail graphs, prisms, and jellyfish graphs, have been studied for the problem of finding the MDRSs (for details see: [26, 27]). The MDRSs for convex polytope structures and Hamming graphs have been derived and may be found in [28], and [29], respectively. The DMD and minimal order resolving sets of Harary and circulant graphs were studied in [30, 31]. It was Chen et al. that provided the first approximated upper bounds for the MDRS problem [32]. The authors in [33, 34] demonstrated that the DMD of some convex polytope structures is finite and constant. The line graphs of chorded cycles [35], kayak paddle graphs [36], n-Sunlet, and prism graphs [37] were discovered to have the MD and DRSs. In [38], layersun graphs and associated line graphs were studied for the MDRSs. Liu et al. gave the results for the minimum order resolving sets and DMD of the line graph of the Necklace graph in [39].

Using resolving sets is a natural way to find the origins of a network spread. For example, determining where a disease originated as it spreads through a population might be helpful in a variety of scenarios. A direct solution can be found if the time at which the spread began and the internode distances are reliable and known. Resolvability, however, needs to be expanded to account for things like an unknown start time and irregular transmission delays among nodes. The former problem can be solved by employing DRSs. The variation involved with arbitrary internode distances is critical in successfully determining the source of a spread [40].

Detecting virus sources in starlike networks are more complicated than in pathlike networks. While the DMD is $n-1$ for a star-type structure with n nodes, and for a path-type structure with the same number of nodes it is 2 (see [40]). In addition, this demonstrates that the DMD is always reliant on the topology of the network being used.

The purpose of this research is to find the MDRSs and DMD for a class of chordal ring networks, which are helpful in the designing of local area networks. The following result regarding the MD of chordal ring networks $CR_n(1,3,5)$ is helpful in determining its DMD:

Theorem 1. *[41] Let $CR_n(1,3,5)$ be the chordal ring network. Then, for any even integer $n\geq 6$, we have*
$$dim(CR_n(1,3,5))=\begin{cases}3, & if\ n\equiv 0(mod4)\\ 4, & if\ n\equiv 2(mod4)\end{cases}$$

The rest of the article is arranged in this following way:

(i) In Section 2, we discussed the construction of chordal ring networks and investigated the MDRSs of $CR_n(1,3,5)$

(ii) Finally, in Section 3, we summarize the findings of the article

2. Double Metric Dimension of Chordal Ring Networks $CR_n(1,3,5)$

In this section, we calculated the MDRSs and DMD for chordal ring network $CR_n(1,3,5)$.

If every closed path of length 4 or more in an undirected network contains a chord, it is referred to as chordal. Arden and Lee [42] first proposed chordal ring networks of degree 3. An undirected cycle of even order can be used to form a chordal ring network, in which all newly added chords connect an even labelled node to an oddly labelled node.

Let $\alpha,\beta,\gamma\in\{1,2,\ldots,n-1\}$ be three distinct odd integers and $n\geq 3$ be an even natural number. A chordal ring network having order n with chords α,β, and γ represented by $CR_n(\alpha,\beta,\gamma)$, has the nodes set Z_n, and links are given by $\delta\sim\delta+\alpha,\delta\sim\delta+\beta$ and $\delta\sim\delta+\gamma$ for every even node $\delta\in Z_n$. By definition, every chordal ring network $CR_n(\alpha,\beta,\gamma)$ is bipartite and 3-regular. Further, every odd node $\theta\in Z_n$ forms a link with $\theta-\alpha,\theta-\beta,\theta-\gamma$ in $CR_n(\alpha,\beta,\gamma)$. There are no specific rules for selecting three different odd integers α,β, and γ from the set $\{1,2,\ldots,n-1\}$. Actually, we can choose any three different odd integers and, as a result, we obtain different chordal ring networks each time, with the possibility that few of them are isomorphic. To make a $CR_n(\alpha,\beta,\gamma)$, select 3 different even integers from the set $\{1,2,\ldots,n-1\}$ and connect odd numbered nodes to them, as explained earlier. In addition,

α, β, and γ are stated to be chords because they help to connect nodes in the $CR_n(\alpha, \beta, \gamma)$, and each obtained link represents a chord for at least one path in $CR_n(\alpha, \beta, \gamma)$ as demonstrated in Figure 1.

Here, the DMD. $\psi(CR_n(1,3,5)) \geq \begin{cases} 3, & \text{if } n \equiv 0 (\text{mod}4) \\ 4, & \text{if } n \equiv 2 (\text{mod}4) \end{cases}$ for any even integer $n \geq 6$ by applying Theorem 1. Also, we are going to prove the DMD $\psi(CR_n(1,3,5)) = 4$, for any even integer $n \geq 6$.

Define $S_v(h_0) = \{h \in V_{CR_n(1,3,5)}: d(h_0, h) = v\}$ be a vertex set in $V_{CR_n(1,3,5)}$ at distance v from h_0. Table 1 is simply constructed for $S_v(h_0)$ and employed to compute the distance between any pair of vertices in $V_{CR_n(1,3,5)}$.

The symmetry of $CR_n(1,3,5)$ for any even integer $n \geq 6$, shows the following fact that: $d(h_v, h_\tau) = d(h_0, h_{|\tau - v|})$ if $0 \leq |\tau - v| \leq n-1$.

As a conclusion, by knowing the distance $d(h_0, h)$ for all $h \in V_{CR_n(1,3,5)}$, we can reconstruct the distances between every two vertices in $V_{CR_n(1,3,5)}$.

Lemma 1. *For $n \geq 8$ and $n \equiv 0 (\text{mod}4)$, we have $\psi(CR_n(1,3,5)) > 3$.*

Proof. We know that $\psi(CR_n(1,3,5)) \geq 3$. Therefore, we need to explain that every set $D_{CR_n(1,3,5)} \subseteq V_{CR_n(1,3,5)}$ of order 2 is not a DRS for $CR_n(1,3,5)$. There are some different types of set $D_{CR_n(1,3,5)}$, as well as their nondoubly resolved pair of vertices from $V_{CR_n(1,3,5)}$, listed in Table 2. Let us show that the vertices h_0, h_{n-3} are not doubly resolved by any two vertices of the set $\{h_0, h_v, h_\tau; 1 \leq v \leq 2l-2 \text{and} \tau = n-1\}$. Now, for $1 \leq v \leq 2l-2$ and $\tau = n-1$:

$$d(h_0, h_0) = 0, \tag{1}$$

$$d(h_0, h_{n-3}) = 1, \tag{2}$$

$$d(h_0, h_v) = v, \tag{3}$$

$$d(h_v, h_{n-3}) = d(h_0, h_{|n-3-v|}) = v + 1, \tag{4}$$

$$d(h_0, h_\tau) = 1, \tag{5}$$

$$d(h_\tau, h_{n-3}) = d(h_0, h_{|n-3-\tau|}) = 2. \tag{6}$$

From equations (1) to (6), we have $d(h_0,h_0) - d(h_0,h_{n-3}) = d(h_0,h_v) - d(h_v,h_{n-3}) = d(h_0,h_\tau) - d(h_\tau,h_{n-3}) = -1$, that is, the set $\{h_0, h_v, h_\tau; 1 \leq v \leq 2l-2 \text{and} \tau = n-1\}$ is not a DRS of $CR_n(1,3,5)$. All other forms of the set $D_{CR_n(1,3,5)}$ in Table 2 can be examined and confirmed to have nondoubly resolved vertices, as well. □

Lemma 2. *Let $n \equiv 0 (\text{mod}4)$ for $n \geq 8$, we have $\psi(CR_n(1,3,5)) = 4$.*

Proof. Consider the case where $n \equiv 0 (\text{mod}4)$ for $n \geq 8$. To demonstrate that $\psi(CR_n(1,3,5)) = 4$, a DRS of order 4 is all that is required. Now, by using the sets $S_v(h_0)$ from Table 1, Tables 3 and 4 demonstrate the metric coordinate vectors for

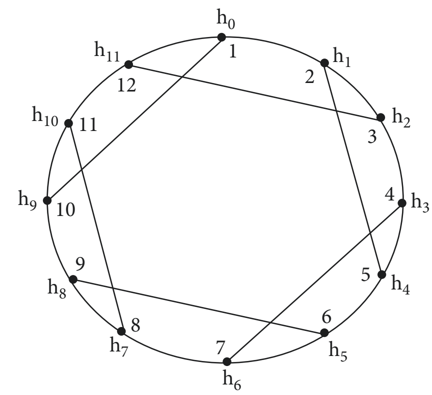

Figure 1: Chordal ring network $CR_{12}(1,3,5)$.

each vertex of $CR_n(1,3,5)$ in relation to the set $D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l-1}\}$, where $n = 4l$ and $l \geq 2$ be an integer.

Using Tables 3 and 4, it is possible to verify directly that, for any given integer $v \in \{1, 2, \ldots, l+1\}$ if two vertices $a_1, a_2 \in S_v(h_0)$, then the difference between their first coordinates is zero, but the difference between their overall coordinates is not zero that is the representation $r(a_1, D_{CR_n(1,3,5)}) - r(a_2, D_{CR_n(1,3,5)}) \neq 0$. In the same way, for the vertices $a_1 \in S_v(h_0)$ and $a_2 \in S_\tau(h_0)$ for any $v \neq \tau \in \{1, 2, \ldots, l+1\}$, the difference between their first coordinates is $v - \tau$ but the difference between all coordinates is not $v - \tau$ at the same time, that is the representation $r(a_1, D_{CR_n(1,3,5)}) - r(a_2, D_{CR_n(1,3,5)}) \neq v - \tau$. Therefore, the set $D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l-1}\}$ is the MDRSs. Thus, Lemma 2 holds. □

Lemma 3. *Let $n \equiv 2 (\text{mod}4)$ for $n \geq 6$, we have $\psi(CR_n(1,3,5)) = 4$.*

Proof. Consider the case where $n \equiv 2 (\text{mod}4)$ for $n \geq 6$. To demonstrate that $\psi(CR_n(1,3,5)) = 4$, a DRS of order 4 is all that is required. Now, by using the sets $S_v(h_0)$ from Table 1, Tables 5 and 6 demonstrate the metric coordinate vectors for each vertex of $CR_n(1,3,5)$ in relation to the sets $D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l+1}\}$ and $D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l+2}\}$ respectively, where $n = 4l + 2$ and $l \geq 1$ be an integer.

Using Tables 5 and 6, it is possible to verify directly that, for any given integer $v \in \{1, 2, \ldots, l+1\}$ if two vertices $b_1, b_2 \in S_v(h_0)$, then the difference between their first coordinates is zero, but the difference between their overall coordinates is not zero, that is the representation $r(b_1, D_{CR_n(1,3,5)}) - r(b_2, D_{CR_n(1,3,5)}) \neq 0$. In the same way, for the vertices $b_1 \in S_v(h_0)$ and $b_2 \in S_\tau(h_0)$ for any $v \neq \tau \in \{1, 2, \ldots, l+1\}$, the difference between their first coordinates is $v - \tau$ but the difference between all coordinates is not $v - \tau$ at the same time, that is the representation $r(b_1, D_{CR_n(1,3,5)}) - r(b_2, D_{CR_n(1,3,5)}) \neq v - \tau$. Therefore, the sets $D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l+1}\}$ and $D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l+2}\}$ are the MDRSs. Thus, Lemma 3 holds.

Using Lemmas 2 and 3, the main theorem is stated below: □

TABLE 1: $S_v(h_0)$ for $CR_n(1,3,5)$.

n	v	$S_v(h_0)$
	1	$\{h_1, h_{n-3}, h_{n-1}\}$
$4l$, $(l \geq 2)$	$2 \leq v \leq l$	$= \begin{cases} \{h_{2v-2}, h_{2v}, h_{n-2v}, h_{n-2v+2}\}, & \text{if } v \text{ is even} \\ \{h_{2v-3}, h_{2v-1}, h_{n-2v-1}, h_{n-2v+1}\}, & \text{if } v \text{ is odd} \end{cases}$
	$l+1$	$= \begin{cases} \{h_{2v-2}\}, & \text{if } v \text{ is even} \\ \{h_{2v-3}\}, & \text{if } v \text{ is odd} \end{cases}$
$4l+2$, $(l \geq 1)$	$2 \leq v \leq l+1$	$= \begin{cases} \{h_{2v-2}, h_{2v}, h_{n-2v}, h_{n-2v+2}\}, & \text{if } v \text{ is even} \\ \{h_{2v-3}, h_{2v-1}, h_{n-2v-1}, h_{n-2v+1}\}, & \text{if } v \text{ is odd} \end{cases}$

TABLE 2: Nondoubly resolved pairs of vertices for $CR_n(1,3,5)$, for $n \geq 8$ and $n \equiv 0 \pmod 4$

$D_{CR_n(1,3,5)}$	Nondoubly resolved pairs
$\{h_0, h_v, h_\tau\}$, $v = 1, n-4 \leq \tau \leq n-3$	$\{h_0, h_{n-1}\}$
$\{h_0, h_v, h_\tau\}$, $2 \leq v \leq 3, n-4 \leq l \leq n-3$	$\{h_1, h_{n-1}\}$
$\{h_0, h_v, h_\tau\}$, $4 \leq v \leq 5, n-4 \leq l \leq n-3$	$\{h_0, h_{n-1}\}$
$\{h_0, h_v, h_\tau\}$, $1 \leq v < \tau \leq 2l-2$	$\{h_0, h_{n-3}\}$
$\{h_0, h_v, h_\tau\}$, $2l+1 \leq v < \tau \leq n-1$	$\{h_0, h_1\}$
$\{h_0, h_v, h_\tau\}$, $1 \leq v \leq 2l-2, \tau = n-1$	$\{h_0, h_{n-3}\}$
$\{h_0, h_v, h_\tau\}$, $2l-1 \leq v \leq 2l, \tau = n-1$	$\{h_1, h_{n-3}\}$

TABLE 3: Metric coordinate vectors for $CR_n(1,3,5)$, where $n = 4l$, $l \geq 2$ is even.

v	$S_v(h_0)$	$D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l-1}\}$
0	h_0	$(0, 1, 2, l+1)$
	h_1	$(1, 0, 1, l)$
1	h_{n-3}	$(1, 2, 3, l)$
	h_{n-1}	$(1, 2, 1, l)$
$2 \leq v \leq l$,		
	h_{2v-2}	$(v, v-1, v-2, l-v+1)$
	h_{2v}	$(v, v-1, v, l-v+1)$
when v is even	h_{n-2v}	$= \begin{cases} (v, v+1, v+2, l-v+1), & \text{if } v < l \\ (v, v-1, v, 1), & \text{if } v = l \end{cases}$
	h_{n-2v+2}	$(v, v+1, v, l-v+1)$
	h_{2v-3}	$(v, v-1, v-2, l-v+1)$
when v is odd	h_{2v-1}	$(v, v-1, v, l-v+1)$
	h_{n-2v-1}	$(v, v+1, v+2, l-v+1)$
	h_{n-2v+1}	$(v, v+1, v, l-v+1)$
$v = l+1$, when v is odd	h_{2v-3}	$(v, v-1, v-2, 0)$

TABLE 4: Metric coordinate vectors for $CR_n(1,3,5)$, where $n = 4l$, $l \geq 2$ is odd.

v	$S_v(h_0)$	$D_{CR_n(1,3,5)} = \{h_0, h_1, h_2, h_{2l-1}\}$
0	h_0	$(0, 1, 2, l)$
	h_1	$(1, 0, 1, l-1)$
1	h_{n-3}	$(1, 2, 3, l-1)$
	h_{n-1}	$(1, 2, 1, l+1)$
$2 \leq v \leq l$,		
	h_{2v-2}	$(v, v-1, v-2, l-v+2)$
	h_{2v}	$(v, v-1, v, l-v)$
when v is even	h_{n-2v}	$= \begin{cases} (v, v+1, v+2, l-v), & \text{if } v < l-1 \\ (v, v+1, v+2, 1), & \text{if } v = l-1 \end{cases}$
	h_{n-2v+2}	$(v, v+1, v, l-v+2)$
	h_{2v-3}	$(v, v-1, v-2, l-v+2)$
when v is odd	h_{2v-1}	$(v, v-1, v, l-v)$
	h_{n-2v-1}	$= \begin{cases} (v, v+1, v+2, l-v), & \text{if } v < l \\ (v, v-1, v, 0), & \text{if } v = l \end{cases}$
	h_{n-2v+1}	$(v, v+1, v, l-v+2)$
$v = l+1$, when v is even	h_{2v-2}	$(v, v-1, v-2, 1)$

TABLE 5: Metric coordinate vectors for $CR_n(1,3,5)$, where $n=4l+2$, $l\geq 1$ is odd.

v	$S_v(h_0)$	$D_{CR_n(1,3,5)}=\{h_0,h_1,h_2,h_{2l+1}\}$
0	h_0	$(0,1,2,l)$
1	h_1	$(1,0,1,l+1)$
	h_{n-3}	$=\begin{cases}(1,2,1,0), & \text{if } n=6\\ (1,2,3,l-1), & \text{if } n\neq 6\end{cases}$
	h_{n-1}	$(1,2,1,l+1)$
$2\leq v\leq l+1$,		
	h_{2v-2}	$(v,v-1,v-2,l-v+2)$
	h_{2v}	$(v,v-1,v,l-v+2)$
when v is even	h_{n-2v}	$=\begin{cases}(v,v+1,v+2,l-v), & \text{if } v<l+1\\ (v,v-1,v-2,1), & \text{if } v=l+1\end{cases}$
	h_{n-2v+2}	$=\begin{cases}(v,v+1,v,l-v+2), & \text{if } v<l+1\\ (v,v-1,v,1), & \text{if } v=l+1\end{cases}$
	h_{2v-3}	$(v,v-1,v-2,l-v+2)$
when v is odd	h_{2v-1}	$(v,v-1,v,l-v+2)$
	h_{n-2v-1}	$=\begin{cases}(v,v+1,v+2,l-v), & \text{if } v<l\\ (v,v+1,v,0), & \text{if } v=l\end{cases}$
	h_{n-2v+1}	$(v,v+1,v,l-v+2)$

TABLE 6: Metric coordinate vectors for $CR_n(1,3,5)$, where $n=4l+2$, $l\geq 1$ is even.

v	$S_v(h_0)$	$D_{CR_n(1,3,5)}=\{h_0,h_1,h_2,h_{2l+2}\}$
0	h_0	$(0,1,2,l)$
	h_1	$(1,0,1,l+1)$
1	h_{n-3}	$(1,2,3,l-1)$
	h_{n-1}	$(1,2,1,l+1)$
$2\leq v\leq l+1$,		
	h_{2v-2}	$(v,v-1,v-2,l-v+2)$
	h_{2v}	$(v,v-1,v,l-v+2)$
when v is even	h_{n-2v}	$=\begin{cases}(v,v+1,v+2,l-v), & \text{if } v<l\\ (v,v+1,v,0), & \text{if } v=l\end{cases}$
	h_{n-2v+2}	$(v,v+1,v,l-v+2)$
	h_{2v-3}	$(v,v-1,v-2,l-v+2)$
	h_{2v-1}	$(v,v-1,v,l-v+2)$
when v is odd	h_{n-2v-1}	$=\begin{cases}(v,v+1,v+2,l-v), & \text{if } v<l+1\\ (v,v-1,v-2,1), & \text{if } v=l+1\end{cases}$
	h_{n-2v+1}	$=\begin{cases}(v,v+1,v,l-v+2), & \text{if } v<l+1\\ (v,v-1,v,1), & \text{if } v=l+1\end{cases}$

Theorem 2. *Let $CR_n(1,3,5)$ be the chordal ring network. Then for any even integer $n\geq 6$, $\psi(CR_n(1,3,5))=4$.*

3. Conclusion

This study is concerned with the concept of calculating MDRSs of graphs that has been proposed earlier in the literature. The DMD of chordal ring networks $CR_n(1,3,5)$ is computed by describing their MDRSs. In this study, we found that the number of vertices in the chordal ring networks does not affect its DMD.

Data Availability

The whole data are included within this article. However, the reader may contact the corresponding author for more details on the data.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Feature Extraction of Color Symbol Elements in Interior Design Based on Extension Data Mining

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In order to improve the indoor color symbol elements in the design of visual communication ability, the interior design color symbol element feature extraction process is needed. We need to put forward a kind of extension data mining based on the interior design color symbol element feature extraction methods, build the visualization visual expression and big data characteristics of the distribution of the interior design of texture color symbol elements in intelligent information collection model, indoor color symbol elements in the design of the texture image and character segmentation, and extraction of texture and color symbol element in interior design edge feature point, based on the texture and edge profile characteristics of the distribution in the design of indoor color symbol elements of texture segmentation and matching, and extract the edge of the color symbol elements in interior design outline feature points. The extracted edge contour feature points of color image in interior design are used as the extended data feature components for texture matching, and the color symbol element feature extraction is realized according to the prior data distribution and extension data mining results. Simulation results show that this method has good adaptive performance in texture matching and feature extraction of color symbol elements in interior design and has a strong texture discrimination ability, which improves the visual communication ability of color symbol elements in interior design.

1. Introduction

With the development of modern interior decoration design technology, the color symbol element design in interior design is carried out under the computer vision environment [1, 2], and the creative idea of color symbol element design in modern interior design is adopted to design the composition and color of interior decoration design, so as to improve the color expression ability of interior decoration design and promote the balance and harmony of interior decoration design [3]. Through visual communication, interior decoration design can be more in line with human visual experience and improve the aesthetic value of interior decoration design. Research on visual communication optimization design technology of interior decoration design is based on the texture intelligent matching of color symbol elements in interior design, which adopts visual communication design method to optimize interior decoration design and pattern texture intelligent matching to achieve the perfect combination of pattern texture and interior decoration design [4]. Research on feature extraction method of color symbol elements in interior design is of great significance in optimizing color image design in interior design. As a new concept of space design, humanized design generally follows the following main basic principles: First, adhere to the concept of environmental protection and prevention. In interior design, harmony with the natural environment is the main body of today's social development. Protecting the environment and avoiding waste of resources has become an important task of the society, and interior design must also abide by it. Second, take into account the principle of comfort. The most basic goal of interior design is to meet the needs of people's lives, maintain the comfort of the environment, and create a satisfactory living environment, which is also the basic principle of humanized space design. Third, ensure safety. As a place where people live in daily life, the safety demand should not be underestimated, which is also the foundation of space design. Without safety, the design products cannot meet the requirements of humanized design [5, 6]. The safety here not only includes the safety of raw materials and products used in the design but also covers the safety of the living environment itself. Both of them are very important and play a complementary role.

In the study of interior design, it is necessary to adopt an optimized color symbol element feature extraction algorithm according to the feature distribution of color symbol elements in interior design to improve the expression ability of color symbols in interior design. Zhang and He [7] proposed a feature extraction method of color symbol elements in interior design based on block region contour detection, established a mesoscale spatial information clustering model of color symbol elements in interior design, and, combined with the spatial information fusion method, realized the feature extraction and recognition of color symbol elements in interior design. However, the time cost of color symbol element feature extraction in interior design is high, and the quality of feature extraction is not good. Reference [8] is proposed based on multiscale color symbol elements in interior design features of information fusion feature extraction methods, combined with the feature of multidimensional sampling method, in the design of indoor color symbol element feature extraction model design, combined with the feature of multidimensional registration method, and in the design of indoor color symbol element feature extraction and feature extraction. The feature extraction and recognition of color symbol elements in interior design is realized, but the process complexity of color symbol element feature extraction in interior design is large, and the intelligence of image feature extraction is not good. Reference [9] is proposed based on subspace division of color in interior design symbol element feature extraction method, and fuzzy information fusion method was adopted to realize the scale of the interior design color symbol elements in spatial information fusion and feature extraction and improve the adaptability of image feature extraction, but the method that is a 3D image feature extraction output of the fuzzy degree is bigger.

Aiming at the disadvantages of traditional methods, this paper proposes a color symbol element feature extraction method in interior design based on extension data mining, constructs an intelligent information collection model of color symbol element texture in interior design under visual expression and big data expansion feature distribution, adopts extension data mining and multidistribution information fusion method to enhance and optimize the detection of color symbol element texture information in interior design, extracts the edge contour feature points of color symbol elements in interior design, and realizes the adaptive matching of color symbol element texture in interior design. Finally, the simulation experiment is analyzed, and the validity conclusion is obtained.

2. Image Acquisition and Preprocessing of Color Symbol Elements in Interior Design

2.1. Image Acquisition of Color Symbol Elements in Interior Design. In order to realize the feature extraction of color symbol elements in interior design based on extension data mining, firstly, a three-dimensional image reconstruction method is used to collect the visual information of color symbol elements in interior design, multimedia digital information reconstruction method is used to extract and sample the features of color symbol elements in interior design [10], image texture distribution area is used to extract the features of color symbol elements in interior design, and image feature reconstruction space technology is adopted. It is used to read three-dimensional data feature quantity of color symbol element texture in interior design to form raw file of color symbol element texture in interior design, establish PBO (OpengGl pixel cache object) of color symbol element texture in interior design according to spatial feature sampling technology, store the image in device memory, and read texture information of color symbol element in interior design; according to that data information of color symbol elements in interior design in device memory, the texture match of color symbol elements in interior design is carried out. The specific operation process is shown in Figure 1.

According to the above design idea, assume that the pixel set distribution of color symbol elements in interior design is n, and the output label category information feature quantity of color symbol elements in interior design is $P(1) = [1 - L^{-1}]^{m-1}$. According to the size and texture complexity of color symbol elements in interior design, the texture point pairs of interior decoration design are matched to obtain the texture distribution of color symbol elements in interior design:

$$E_m^{ij} = \sum_{k=0}^{255} e_{mk}^{ij}. \quad (1)$$

In formula (1), E_m^{ij} represents the color information of the ith row and the J-column in the data sampling sequence of color symbol elements in three-dimensional interior design, $e_{mk}^{ij} = \begin{cases} -p_k \log(p_k) & p_k \neq 0 \\ 0 & p_k = 0 \end{cases}$ represents the edge information of color symbol elements in 2×2 interior design, and texture registration is carried out in combination with pixel frame distribution. For pixels on each scale $\sigma_I^{(n)}$ (1, 2, . . ., n), K-order moment feature statistics are adopted to fuse the color symbol elements in interior design, and one sampling point is taken in each subinterval. The gray histogram of color symbol elements in interior design is obtained. For N color symbol element labels in interior design, the information fusion expression of color, texture, shape, and other characteristics of color symbol elements in interior design is as follows:

$$c(x, y) = [\Delta x \;\; \Delta y] \left[\sum_W I_x^2 \sum_W I_x I_y \sum_W I_x I_y \sum_W I_y^2 \right] \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix}. \quad (2)$$

In formula (2), Δx and Δy are gradient features of color symbol elements in interior design, and I_x and I_y are edge pixel values of color symbol elements in interior design. An intelligent information collection model of color symbol elements in interior design based on visual expression and big data expansion feature distribution is constructed. The

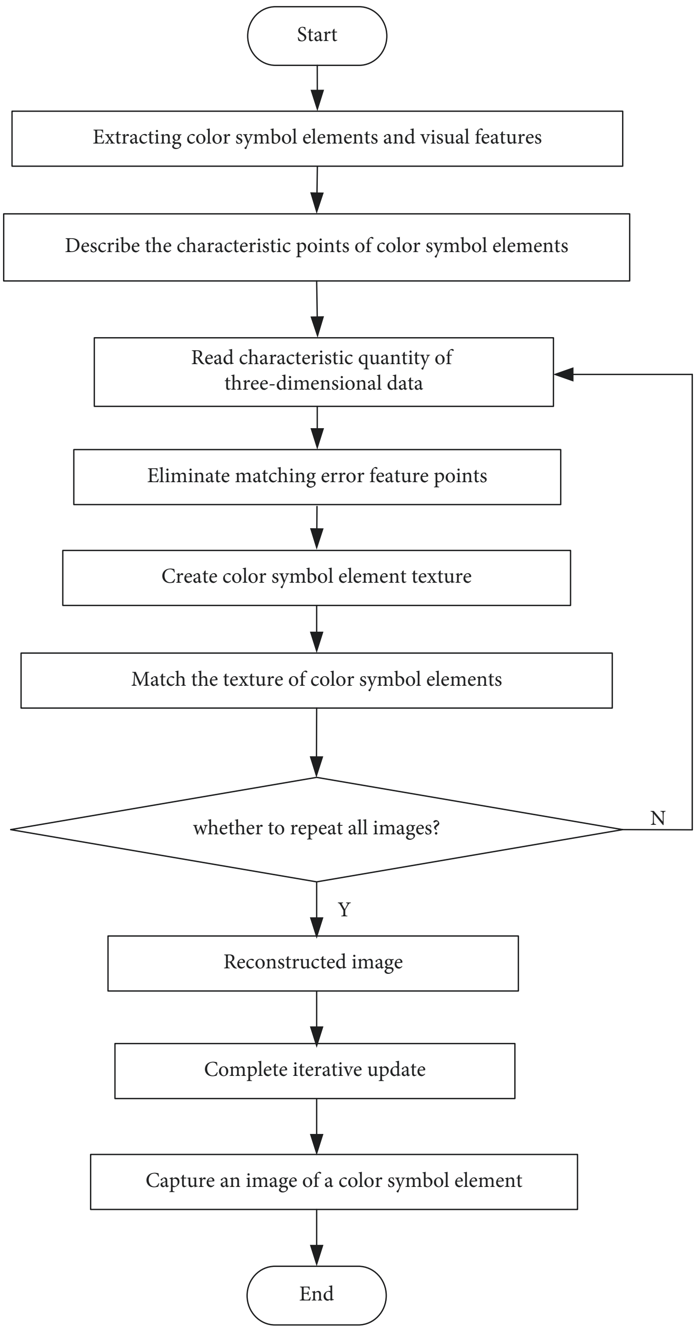


Figure 1: Color symbol element texture matching process.

extension data mining and color symbol enhancement technology are used to image and segment the color symbol elements in interior design, and the average energy of the window is investigated. In interior design, the texture space scale of color symbol elements is (x, y, σ):

$$H = \begin{bmatrix} L_{xx}(x,\sigma) & L_{xy}(x,\sigma) \\ L_{xy}(x,\sigma) & L_{yy}(x,\sigma) \end{bmatrix}. \tag{3}$$

In formula (3), $Lxx(x,\sigma)$ is the texture convolution of color symbol elements in interior design, and Lxy and Lyy have similar meanings. According to the fusion results of edge pixel sets of color symbol elements in interior design, the multidimensional feature space reconstruction method is realized. The information of color symbol elements in interior design is collected, and the edge energy value of regional distribution pixels $P(i, j)$ of color symbol elements in interior design is obtained. Based on this data input, the feature extraction and feature extraction of color symbol elements in interior design are carried out.

2.2. Feature Segmentation of Color Symbol Elements in Interior Design. The collection model of color symbol elements in interior design is established. The collected color symbol elements in interior design are processed by feature extraction and information fusion. The artificial intelligence feature extraction of three-dimensional images is combined with multidimensional segmentation and gray histogram reconstruction. Image enhancement, as a basic image processing technology, aims to make the image more suitable for specific applications than the original image by processing it; that is, image gray enhancement is purposefully carried out according to specific needs [11]. Through image enhancement, the visual quality of the image is improved so that the observer can see more direct, clear, and suitable information for analysis. Traditional image gray enhancement methods can be divided into two categories: spatial domain method and frequency domain method [12–14]. The spatial domain image gray enhancement method directly processes the gray values of pixels in the image, such as linear gray transformation, nonlinear gray transformation, and histogram equalization. The frequency domain image gray enhancement method firstly transforms the image in the frequency domain, then performs corresponding operations on each spectrum component, and finally obtains the required results through inverse frequency domain transformation. Any image grayscale enhancement algorithm can achieve a satisfactory enhancement effect only in specific situations. In image processing, one of the simplest and most practical tools is the gray histogram of the image. The quality of an image can be roughly judged by the distribution of its gray histogram. If the gray histogram of an image is squeezed in a small gray range, the dynamic range of the grayscale of the image will be small, the contrast of the image will be poor, and the quality of the image will be poor [15]. On the contrary, if the dynamic range of the grayscale of the image is large, the contrast of the image will be good. To improve the small dynamic range of grayscale of images, an intuitive idea is to modify the histogram of images. The commonly used methods to modify the histogram are grayscale transformation and histogram enhancement. Grayscale transformation, also known as contrast expansion and adjustment, is an enhancement method that transforms an image pixel by pixel. Generally, the grayscale of an image is modified point by point by linear or nonlinear functions to achieve image enhancement. Histogram enhancement technology is a technology of image enhancement by changing all or part of image contrast, and one of its typical processing methods is histogram equalization. The idea of histogram equalization is to make some mapping transformation of the pixel grayscale in the original image so that the probability density of the transformed image grayscale is uniformly distributed; that is, the transformed image grayscale is uniform, which means that the dynamic range of the image grayscale is increased and the contrast of the image is improved. The texture imaging and feature segmentation of color symbol elements in interior design are carried out by extension data mining and color symbol enhancement technology, and the texture and edge feature points of color symbol elements in interior design are extracted [16]. According to the known pixel points of color symbol elements in interior design, the maximum intensity of texture distribution of color symbol elements in interior design is obtained, and the matching value of the regional template of interior decoration design image is determined as follows:

$$J^{\text{dark}}(x) = \min_{c\in\{r,g,b\}}\left(\min_{y\in\Omega(x)}\left(J^c(y)\right)\right). \tag{4}$$

In formula (4), J^c is the similarity characteristic quantity of color symbol elements in interior design, $J^c(y)$ is the similarity characteristic component of characteristic component Y, and $\Omega(x)$ is the neighborhood size. The self-adaptive block feature matching method is adopted to determine the priority coefficient of color symbol elements output in interior design, and the relationship of color symbol elements output to epipolar geometry in interior design is described as follows:

$$P = \sum_{i=1}^{M}\left(\lambda_i\cdot\frac{\sum_{m=1}^{|S_{SR}|} p_{im}T_{\text{SRm}}}{\sum_{m=1}^{|S_{SR}|}\lambda_{\text{SRm}}}\right). \tag{5}$$

In formula (5), p_{im} is the gray information of color symbol elements in interior design, T_{SRm} is the nearest neighbor sampling feature of color symbol elements in interior design, λ_{SRm} is the nearest neighbor sampling width, and λ_i is the multiscale feature component of color symbol elements. The template registration of color symbol elements in interior design is carried out by the texture intelligent matching method, and the template registration function is constructed as follows:

$$\text{STFT}(t,f) = \int_{-\infty}^{\infty} x(\tau)h^*(\tau-t)e^{-j2\pi f\tau}\mathrm{d}\tau. \tag{6}$$

In formula (6), $x(\tau)$ is the dynamic component of color symbols in interior design, $h^*(\tau-t)$ is the color distribution delay, f is the frequency domain component of pixel distribution, and t is the edge of the maximum gray value of the image. Using the pixel difference and spatial distribution pixel level of color symbol elements in two interior designs, the texture matching window of interior decoration design is

$$\text{SPEC}(t,f) = |\text{STFT}(t,f)|^2. \tag{7}$$

In formula (7), $|\text{STFT}(t,f)|$ represents the absolute average value of $\text{STFT}(t,f)$, which represents the associated characteristic components of color symbol elements in interior design. By adopting the adaptive block technology, a matching window of color symbol elements texture template in interior design is established, and the texture distribution function of color symbol elements in interior design is described as

$$U(x) = 1-\tilde{t}'(x) = \omega\tilde{U}(x) = \omega\min_{c\in\{r,g,b\}}\left(\min_{y\in\Omega(x)}\left(\frac{I^c(y)}{A}\right)\right). \tag{8}$$

In formula (8), $\tilde{t}'(x)$ is the difference feature, ω is the adaptive distribution weight, $\tilde{U}(x)$ is the dynamic component of color symbol element texture in interior design, $I^c(y)$ is the spatial distribution intensity of Lab, and A is the sampling amplitude of texture color. Through two-dimensional function expression, color symbol element texture segmentation in interior design is carried out. The schematic diagram of the implementation process is shown in Figure 2.

3. Optimization of Feature Extraction of Color Symbol Elements in Interior Design

3.1. Extraction of Texture and Edge Feature Points of Color Symbol Elements in Interior Design. On the basis of constructing the intelligent information collection model of color symbol element texture in interior design based on visual expression and big data extended feature distribution, the feature extraction of color symbol element in interior design is carried out, and a feature extraction method of color symbol element in interior design based on extension data mining is proposed. The edge of an image is an important feature of an image [17]. It is a collection of pixels whose distribution of grayscale and texture is discontinuous and whose surrounding characteristics have a step change or a roof-like change. The edge part of an image concentrates most of the information of the image, and the edge structure and characteristics of an image are often an important part to determine the characteristics of the image [18, 19]. Another definition of the edge of an image refers to the set of pixels whose surrounding pixels have discontinuous gray changes. Edge exists widely between objects and background and between objects, so it is an important feature of image segmentation, image understanding, and image recognition. Image edge detection is mainly used to enhance the contour edge, details, and gray jump in the image and form a complete object boundary so as to separate the object from the image or detect the area representing the same object surface. So far, the most common method is to detect the discontinuity of brightness value, which is detected by the first derivative and the second derivative [20]. Taking the characteristic points of edge texture distribution as the center, the fuzzy characteristic distribution function W_{mE}^{ij} of color symbol elements in interior design is calculated in the triangle area of irregular texture distribution. The initial pixel set of color symbol elements in interior design is described by $L(a, b_m) = \sum_{V_m} \in P^{\text{res}} \sum_{V_n \in P^{\text{true}}} |V_m \cap V_n| / |V| \log (|V||V_m \cap V_n| / |V_m||V_n|)$, and the distribution scale function of characteristic points of color symbol elements in interior design is expressed as follows:

$$W_{mE}^{ij} = \frac{E_m^{ij}}{\sum_{m=1}^{N} E_m^{ij}}. \tag{9}$$

In formula (9), E_m^{ij} is the statistical characteristic quantity of color symbol element significance detection, and N is the element point dimension. In the gray neighborhood of color symbol element in interior design, the length of spatial distribution cluster center of texture matching is as follows:

$$d_{mn}^{ij}(x, y) = \begin{cases} \dfrac{\sum_{k=-s}^{+s} \left| \theta_m^{ij}(x+k, y+k) - \theta_n^{ij}(x+k, y+k) \right|}{(2s+1)^2}, & m \neq n, \\ 0, & m = n. \end{cases} \tag{10}$$

In formula (10), m and n are three-dimensional image projection numbers of color symbol elements in interior design, i and j are feature matching points of color symbol elements in interior design, and θ is the regional rotation angle of color symbol elements in interior design. Taubin smoothing operator is used for three-dimensional reconstruction of color symbol elements in interior design [21], and the main direction feature components of edge contour of color symbol elements in interior design are recorded as follows:

$$D_{mn}^{ij}(x, y) = \begin{cases} 1, & d_{mn}^{ij}(x, y) \geq \operatorname{median}\left(d_{mn}^{ij}(x, y)\right), \\ 0, & \text{else}. \end{cases} \tag{11}$$

In formula (11), median(.) is the expression of median operation, and $d_{mn}^{ij}(x, y)$ is the distribution distance of boundary points of medium color symbol elements. According to the sparsity of boundary pixels of color symbol elements in interior design, the texture matching value W_{mD}^{ij} is as follows:

$$W_{m\,D}^{ij} = \begin{cases} 1, & n_{m\,d}^{ij} < \alpha, \\ 0, & \text{else}. \end{cases} \tag{12}$$

In formula (12), n_{md}^{ij} represents the edge pixel set of color symbol elements in interior design, and α is the ratio of the number of all pixels, which is set to 5%. The extension data mining and color symbol enhancement technology are used to image and segment the color symbol elements in interior design, and the texture and edge feature points of color symbol elements in interior design are extracted [22]. According to the texture distribution and edge contour feature distribution, texture segmentation and automatic matching are carried out under visual expression and big data expansion feature distribution.

3.2. Visual Communication of Color Symbol Elements in Interior Design. Extract texture and edge feature points of color symbol elements in interior design, perform texture segmentation and automatic matching of color symbol elements in interior design under visual expression and big data expansion

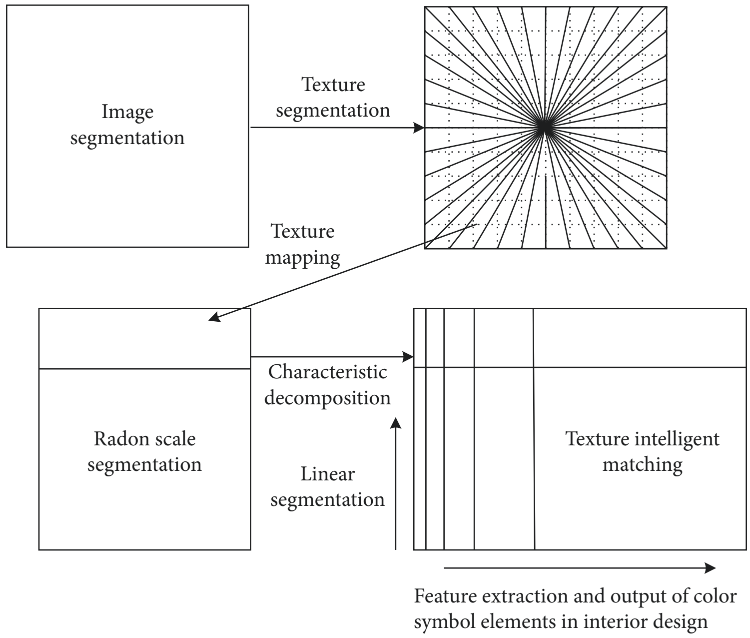


Figure 2: Schematic diagram of the realization process of color symbol element texture segmentation in interior design.

feature distribution according to texture distribution and edge contour feature distribution, construct texture active contour components of color symbol elements in interior design in a 4 × 4 subgrid area, and set SF as edge pixel set of color symbol elements in interior design. The adaptive block feature matching method is used to match the window template. Shape is a kind of existence or expression of things or substances, such as rectangle and square. In an image, a shape is a way to describe an edge or an area [23]. HALCON shape-based matching is a pattern recognition algorithm that identifies and locates the measured object through the edge of the image. This algorithm has good robustness to the change of illumination and fast processing speed, so it is a common positioning method in industrial vision solutions [24]. HALCON uses a hysteresis threshold algorithm to extract edges and adjusts the integrity of edges by modifying "contrast (low)" and "contrast (high)." In the process of edge extraction, pixels whose contrast exceeds "contrast (high)" will be selected as edge points by the algorithm, pixels whose contrast is lower than "contrast (low)" will be regarded as background by the algorithm, and the points between them will be selected as candidate points. If these points are connected with the selected edge points, they will also be selected. Adjust "contrast (high)" to make most edges visible, then adjust "contrast (low)" to remove noise with low contrast, and finally adjust "minimum component size" to remove smaller noise edges [25]. In $N \times N$ window, w_i is used as the weighting vector, and the center pixel set and edge pixel set of color symbol elements in interior design are, respectively, expressed as follows:

$$I_{if}(x, y) = I * G(x, y, \sigma_i), \tag{13}$$

$$I_{iv}(x, y) = I * \text{stdfilt}(x, y, w_i), \tag{14}$$

$$S_{\text{gif}}(x, y) = -\log\left(P_{if}(x, y)\right). \tag{15}$$

In formula (13) to (15), $G(x, y, \sigma_i)$ represents the multicolor set of color symbol elements in interior design, I is the segmented texture of color symbol elements, $\text{stdfilt}(x, y, w_i)$ is the standard color component, and $P_{\text{if}}(x, y)$ is the reconstructed spatial distribution domain of images. On each scale $\sigma_I^{(n)}$ (1, 2, ..., n) of color symbol elements in interior design, the texture matching hierarchical function of color symbol elements in interior design is calculated, and the feature distribution of color images in interior design is obtained by feature segmentation according to the edge contour feature points of images:

$$\begin{aligned} f_R(z) &= \begin{pmatrix} f_x(z) \\ f_y(z) \end{pmatrix} \\ &= \begin{pmatrix} h_x * f(z) \\ h_y * f(z) \end{pmatrix}. \end{aligned} \tag{16}$$

In formula (16), $f(z)$ is the texture feature component of color symbol elements in interior design, $*$ is convolution operation, $f_x(z)$ is the significant graph of color symbol elements in interior design, and $f_y(z)$ is the significant Y component of color symbol elements in interior design. Calculate the edge information feature quantity of color symbol elements in interior design, and let I_x be the block feature matching set of color symbol elements in interior design, where $x = P, N$, and the active contour of color symbol elements in interior design is as follows:

$$S_c = \left[S_0, \ldots, S_{Q-1}\right]_{binary} = \left[\sum_{i}^{Q-1} S_i \times 2^i\right]_{Dec}, \tag{17}$$

$$S_i = \sum_{j}^{W\times W} I_x^j. \tag{18}$$

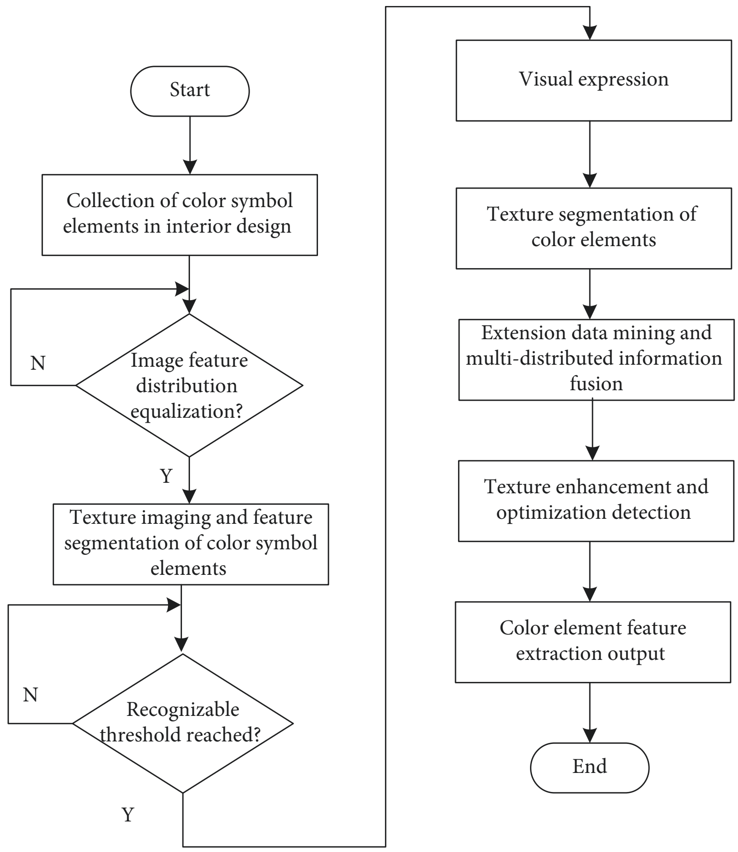


Figure 3: Algorithm optimization implementation process.

In formulas (17) and (18), Q is the edge scale of color symbol elements in interior design, W is the weak edge feature quantity, and I_x^j is the texture detection component of color symbol elements. The extension data mining and multidistribution information fusion method are used to enhance and optimize the texture information detection of color symbol elements in interior design [26], and the output texture intelligent matching map is as follows:

$$w(i,j) = \frac{1}{Z(i)} \exp\left(-\frac{d(i,j)}{h^2}\right). \tag{19}$$

In formula (19), $Z(i) = \sum_{j\in\Omega} \exp(-d(i,j)/h^2)$ represents the symbol distance function of color symbol element feature extraction in interior design, h is the displacement characteristic of color symbol element, and $d(i,j)$ is the fusion characteristic value of edge pixels, so that H_x, H_y are the wavelet characteristic solution of color symbol element in multiresolution interior design. To sum up, the edge contour characteristic points of color symbol element in interior design are extracted, and the extracted edge contour characteristic points of color image in interior design are used as extended data feature components for texture matching. According to prior data distribution and extension data mining results, color symbol element feature extraction is realized. The implementation flow is shown in Figure 3.

3.3. Simulation and Result Analysis. In order to test the application performance of the improved method in color symbol element feature extraction and feature extraction in interior design, a simulation experiment was carried out in Matlab. The frame scanning frequency of color symbol element collection in interior design was 3400 kHz, the pixel error range of texture feature distribution was 0.35~0.85, the feature block scale of color symbol element in interior design was $a = 0.43$, the iteration step of texture matching was 12, and the simulation times were 2000. See Table 1 for other parameter settings.

According to the above simulation environment and parameter settings, the color symbol elements in interior design are extracted and simulated, and the color symbol elements in interior design are obtained as shown in Figure 4.

Taking the color symbol element image in the interior design of Figure 3 as the research object, the feature extraction of color symbol elements in interior design is carried out. The visual feature detection results are shown in Figure 5, and the output of the original feature extraction results of color symbols is shown in Figure 6.

According to the analysis of Figures 5 and 6, this method can effectively realize the feature extraction of color symbol elements in interior design under visual expression and big data expansion feature distribution, and the effect of texture matching is good. The accuracy of color symbol element

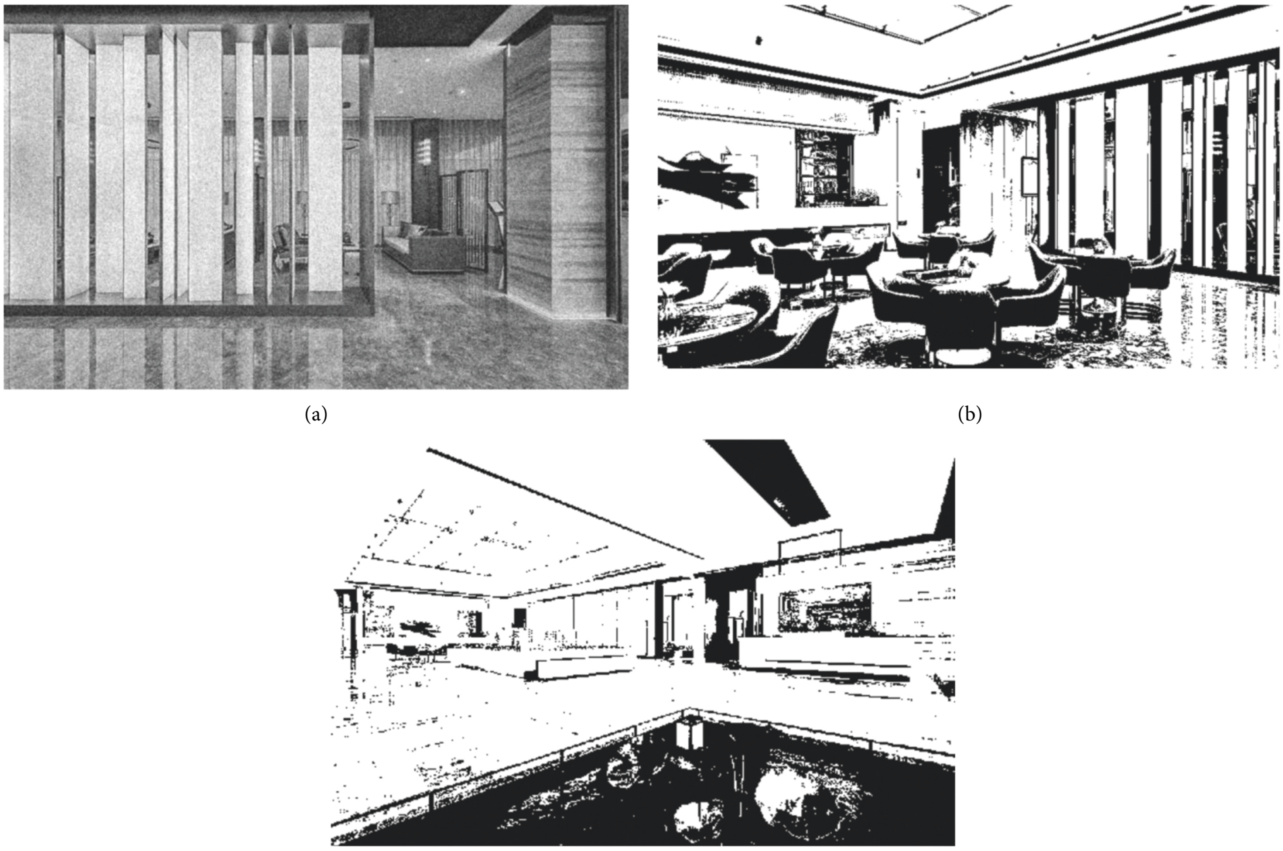
Table 1: Parameter setting.

Sample	Pixel value	Texture segmentation threshold	Edge pixel fusion coefficient
1	0.931	1.375	0.899
2	0.391	4.846	0.876
3	1.144	1.247	0.833
4	0.382	5.796	0.893
5	1.998	1.628	0.834
6	0.469	2.311	0.888
7	1.243	4.819	0.848
8	1.736	5.583	0.895
9	1.988	6.010	0.862
10	2.777	1.785	0.858
11	0.772	6.818	0.850
12	1.400	3.039	0.825

(a) (b)

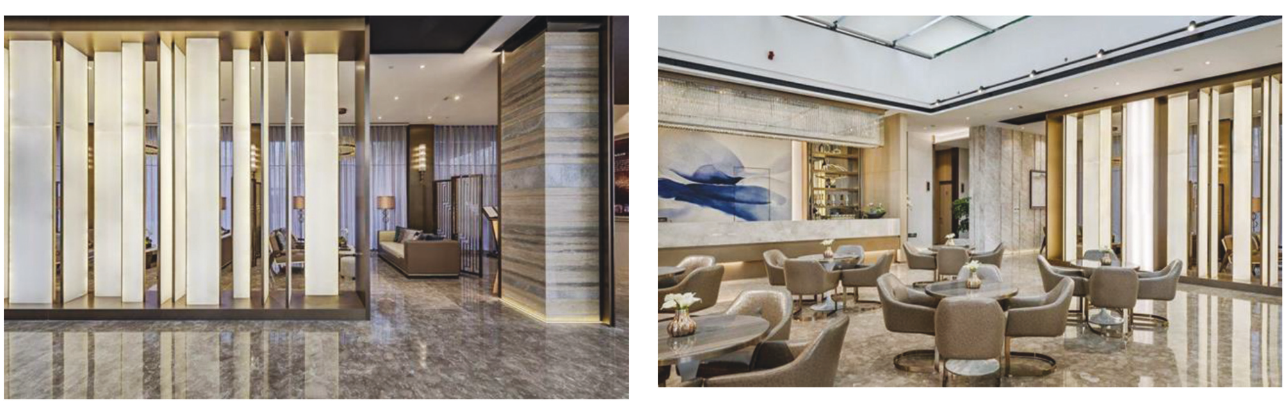
(c)

Figure 4: Color symbol elements in the original interior design. (a) Sample 1. (b) Sample 2. (c) Sample 3.



(a) (b) (c)

Figure 5: Results of feature extraction of color symbol elements in interior design. (a) Sample 1. (b) Sample 2. (c) Sample 3.



(a) (b)

Figure 6: Continued.

(c)

Figure 6: Extraction results of original features of color symbols. (a) Sample 1. (b) Sample 2. (c) Sample 3.

Table 2: Comparison of matching accuracy.

Iterations	Improve one's method	PCA	PSO
100	0.945	0.846	0.814
200	0.959	0.861	0.844
300	0.977	0.916	0.917
400	0.996	0.926	0.925

feature extraction in interior design is tested, and the comparison results are shown in Table 2.

The analysis shows that the proposed method has higher accuracy in color symbol element feature extraction in interior design.

4. Conclusions

Interior decoration design is carried out through visual communication so that the form of interior decoration design is more in line with human visual experience and the aesthetic value of interior decoration design is improved. A method of color symbol element feature extraction in interior design based on extension data mining is proposed. The research shows that this method can effectively realize the feature extraction of color symbol elements in interior design under visual expression and feature distribution of big data expansion, the texture matching effect is better, and the accuracy is higher.

Future research can increase the creativity of human beings reflected in the design of interior spaces and use this as a basis to produce a better living environment. Looking at the development situation at home and abroad, interior design reflects the most basic demands of human life. In the premise of a substantial increase in material life level, human requirements constantly improve, also produce a large number of excellent interior humanized space-related designs, and increase the color symbol in the interior design of visual communication ability research, and seepage affects the living environment of people's life, foreshadowing for the field application.

Data Availability

The raw data supporting the conclusions of this paper can be obtained from the author without undue reservation.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding this work.

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Retraction

Retracted: Analysis of Realistic Problems and Practical Paths of "Three-Wide Education" in Higher Education Based on Text Analysis and Mining

Mathematical Problems in Engineering

Received 26 September 2023; Accepted 26 September 2023; Published 27 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

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

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

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

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[1] Y. Yin and L. Guo, "Analysis of Realistic Problems and Practical Paths of "Three-Wide Education" in Higher Education Based on Text Analysis and Mining," *Mathematical Problems in Engineering*, vol. 2022, Article ID 2192712, 10 pages, 2022.

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Research Article

Analysis of Realistic Problems and Practical Paths of "Three-Wide Education" in Higher Education Based on Text Analysis and Mining

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As the basic concept of higher education, the three comprehensive education is a reliable guarantee for strengthening and improving moral work in higher education, which is a complex of talents meeting the requirements of the times, and "universal education" is a comprehensive training for students to improve their cultural and spiritual moral level to meet the requirements of future social consumption. In order to study the comprehensive reform and development of moral education in universities, this paper reviews and standardizes the formation and development of comprehensive reform in universities, which is closely related to the development of comprehensive reform: strengthening the interconnection of systems in the process of training all employees, strengthening the effective interaction between cultures in the whole process, and ensuring the complete organic integration of cultures. The authors propose a solution for the comprehensive reform of "three-completion education" in universities. The authors offer some reasonable suggestions for the development of moral education in colleges and universities.

1. Introduction

The impact of multiple ideologies in the international society on the moral education of universities needs to be addressed urgently [1–3]. The continuous development of China's economic globalization, cultural pluralism, network informatization, and big data application has made college students suffer from the impact of various western cultural trends in the context of globalization. In the stormy international environment, if we want to guide college students to continue to carry forward positive ideology and discard negative and backward corrupted ideas, we must establish a full-range and all-round work mechanism of moral education [4].

The state places high hopes on students. The younger generation is the future of the motherland, the central force of society, and an important force for the future progress of the country. The vast number of young people have proved by their actions that in the new century, Chinese youth are excellent and should shoulder heavy responsibilities and extend my cordial greetings to you and to the vast number of young people fighting on all fronts of the antiepidemic war [5]. If the young generation has dreams, skills, and responsibilities, the country has a future and the people have a future. She is to make the party and the state attach importance to young students in real life, and all teachers should attach importance to youth work and work together for good moral education [6].

As the basic concept of higher education, "three comprehensives" is a reliable guarantee to strengthen and improve the moral work of higher education [7]. With the rapid dissemination of information on the Internet, some selfish hedonism thoughts have penetrated into students' consciousness, changed their values and behaviors, made moral education difficult, and made the traditional moral education model difficult to adapt to the changing environment

[8]. The "Trinity" education mode determines the position of teachers in the process of education, enables them to actively participate.

In the traditional higher education system, students' learning mainly depends on universities. In universities, teaching, management and logistics are carried out separately, which leads to the separation of students' study, life, practice, and employment and hinders their all-round development [9, 10]. The "education for all" model can effectively connect and integrate the educational resources of different sectors of higher education. In addition, educational subjects, including family and social forces, will actively participate in the development of students' comprehensive education.

2. Related Work

The three whole education includes: (1) The whole staff education. The "four-in-one" nurturing mechanism is composed of college staff, family members, social forces, and students themselves [11]. First of all, as the primary position of teaching and educating, students, teachers, and staff should cooperate with each other to implement teaching, management, and service education [12]. Secondly, families have an irreplaceable role in cultivating and shaping students' correct three views and developing good habits and character [13]. Finally, all sectors of society, including the government, enterprises and institutions, and outstanding individuals, also need to take responsibility for the cultivation of students [14]. (2) Whole process nurturing. The whole process of nurturing people means that the nurturing work should accompany the whole process of students' study and life in the four years of university until they reach lifelong education. In a long time, the focus should be on the adaptation of education, so that students can adapt to college life as soon as possible. The second task is to prevent ideological and behavioral deviations. The focus of work in the past three years should be to cultivate students' professional skills and accumulate more professional theory, practical experience, and technical skills. In the fourth year period, attention should be paid to students' internship career selection education to enhance employment awareness, improve employability, and career competitiveness, so as to ideally select a career [15]. (3) All-round education. All-round education means that the educational work should stand at a global and strategic level and be expanded and extended continuously [16, 17]. In addition, nurturing work should penetrate into all aspects of college students' life, study, and work, and cultivate students from multiple perspectives and levels so as to finally make them talented, thus realizing the goals pursued by higher education [18, 19].

There are many research studies on the three holistic education. In [20], it is pointed out that under the concept of "adult-achieving" education, the "Three Associations and Two Guides" education mode and "Adult-achieving Integration" education mode should be explored. In the article, it was pointed out that under the concept of "adult-achieving" education, the "Three Whole Education" system was constructed on the basis of the "integrated adult-achieving" education system. In [21], they propose "Building a 'three-wide education' system with the foundation of moral education," it is proposed that in the construction of the three-wide education model, "first of all, we should implement the spirit of the National Education Conference," take the foundation of moral education as the foundation, integrate moral theory courses with general education courses through the means of information technology, and integrate students' education with the general education courses. The "Three Whole Nurturing Model" is proposed to "firstly, implement the spirit of the National Education Conference," and to build a whole person, full-range, and all-round nurturing mechanism by integrating moral courses with general courses, combining students' moral work with campus culture, and combining classroom teaching with extracurricular quality development platform through information technology [22].

In [23], it listed how universities should build a working pattern of "three-wide cultivation" in the cultivation stage of graduate students, and she believed that we should build a pattern of "three-wide cultivation" by integrating resources from three aspects: teaching, management, and service. She thinks that we should integrate resources from teaching, management, and service to build a comprehensive education pattern, build a comprehensive education pattern from the main channel of two courses, academic activities of professional courses, "three self" education of postgraduates and social practice, build an ideal and belief education before enrollment, education of world view, life view and value after enrollment, and education of professional ethics before graduation. The whole-range education mechanism in [24], it is pointed out in "Theoretical Implications, Realistic Problems, and Practical Paths of 'Three-Wide Education' in Higher Education" that in order to promote "Three-Wide Education" in higher education, the first thing is to lead the "Three-Wide Education" with collaborative linkage. In the article, it is pointed out that in order for higher education to advance the "three whole education," firstly, we should lead the "three whole education" practice innovation by synergistic linkage, integrate educational resources, strengthen collaborative research, form a system, and open the "last mile" of "three whole education." Secondly, the system construction should guarantee the "three comprehensive education" to take root. Universities should promote the construction of the five-in-one thinking pattern of discipline thinking, curriculum thinking, network thinking, cultural thinking, and daily thinking. Thirdly, to create a good atmosphere of "three-wide education" with cultural influence, it is necessary to create a multidimensional and inclusive education culture to promote "three-wide education," so as to convince people with reason, educate people with culture, nurture people with learning, and educate people with beauty.

3. Methodology

Text analysis and mining is a process of obtaining information from text data, which is usually not structured. Researchers obtain information according to needs or values. It is generally believed that text mining is a process of extracting unknown and available knowledge from a large number of texts, which can interpret information and provide help and reference for research.

The principle of text mining is similar to that of digital mining, but it is different from traditional data mining in some aspects. The object of data mining is mainly composed of structured data in the database, and some data mining methods are not applicable in text mining. The characteristic of text mining is that the text it studies is semistructured or unstructured, and there is no certain form, so it is difficult for machine tools to understand the content contained therein. In short, we need to extract features from the text, analyze meaningful information, and establish useful models. Chinese text search includes the following steps as shown in Figure 1.

The first step is input of the data source text; the second step is text preprocessing subword semantic analysis; the third step is intermediate data set stored in Database Excel; the fourth step is analysis; and then visualization analysis.

This study adopts a standardized qualitative research methodology to develop qualitative coding in the context of China's education informatization 2.0 era, conducts cluster analysis and multidimensional scale analysis based on the research method of text co-word analysis, and follows the logic of thinking from theory to practice and from the particular to the general.

Representing text is an important part of the task. Computer encoding of natural language solves problems such as transferring and storing natural language, but the encoding itself does not contain semantic information. If the natural language encoding is used directly for processing tasks, it will result in a lack of semantic information. This is where a language model is needed to transform the text into a specific input containing semantic feature information. One of the common language models is the statistical language model, which is essentially a probabilistic model for computing sentence probabilities, and the construction of such a model also needs to rely on a corpus. Suppose $W(w_1, w_2, \ldots, w_T)$ denotes a corpus of T words $w_1, w_2, \ldots, w_T$ a sentence text composed in order. Then $w_1, w_2, \ldots, w_T$ have the joint probability of

$$p(W) = p\left(w_1^T\right) = p(w_1, w_2, ..., w_T). \quad (1)$$

This is the probability of the text W. Using the Bayesian formula, the above equation can be decomposed as

$$p\left(w_1^T\right) = p(w_1) \cdot p(w_2|w_1) \cdot p\left(w_3|w_1^2\right) \cdots p\left(w_3|w_1^{T-1}\right). \quad (2)$$

The implementation idea of the above measurement method is simple, but there are two such problems in practical application.

(1) The number of model parameters tends to increase exponentially with the growth of the text length. For example, equation (2) calculates the probability of a text of length T, which requires T parameters. Now suppose there is a corpus corresponding to a dictionary D, and consider any text of length T. Theoretically, there are N^T possibilities, each of which requires the calculation of T parameters. In total, TN^T parameters need to be computed without considering duplicate parameters. This results in huge computational and storage overheads when dealing with larger text sizes.

(2) The data sparsity is more serious. This will lead to a probability result of 0 for most of the sentences we finally compute. The N-gram model is a typical statistical language model, currently more commonly used are the binary Bigram model and the ternary Trigram model, which provide feasible methods to calculate the model parameters and solve both problems. First, considering the approximate calculation of $p(w_k|w_1^{k-1})\,(k > 1)$ using the Bayesian formula yields.

$$p\left(w_k|w_1^{k-1}\right) = \frac{p\left(w_1^k\right)}{p\left(w_1^{k-1}\right)}. \quad (3)$$

According to the large number theorem, when the corpus size is large enough, $p(w_k|w_1^{k-1})$ can be approximated as

$$p\left(w_k|w_1^{k-1}\right) \approx \frac{c\left(w_1^k\right)}{c\left(w_1^{k-1}\right)}, \quad (4)$$

where $c(w_1^k), c(w_1^{k-1})$ indicate the number of occurrences of word strings w_1^k, w_1^{k-1} in the corpus, respectively. When k is large, the time overhead of counting the number of these two strings is also large.

$$p\left(w_k|w_1^{k-1}\right) \approx p\left(w_k|w_{k-n+1}^{k-1}\right) \approx \frac{c\left(w_{k-n+1}^k\right)}{c\left(w_{k-n+1}^{k-1}\right)}. \quad (5)$$

When $n = 2$, equation (5) becomes

$$p\left(w_k|w_1^{k-1}\right) \approx p(w_k|w_{k-1}) \approx \frac{c\left(w_{k-1}^k\right)}{c(w_{k-1})} = \frac{c(w_{k-1}, w_k)}{c(w_{k-1})}. \quad (6)$$

Such simplification makes the matched word strings shorter for statistics and shortens the statistical time. It also makes the total number of model parameters smaller, which solves the first problem mentioned above. The second problem is solved by smoothing the data.

The Neural Network Language Model (NNLM), which solves the problems of traditional statistical language models, but has difficulties in obtaining context-dependent long time and lacks sufficient generalization ability, the model captures contextual information and obtains similarities between words by training distributed word vectors. Figure 2 shows the network structure of the model.

The above parts constitute the overall word vector training model. The word vector parameters during training are shared by these three parts, and the overall training process is completed by the joint training of these three

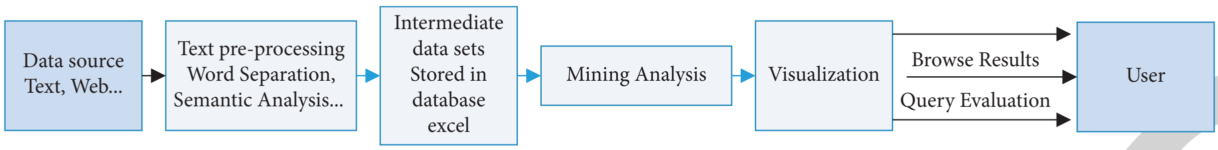

Figure 1: Flow chart of text analysis and mining.

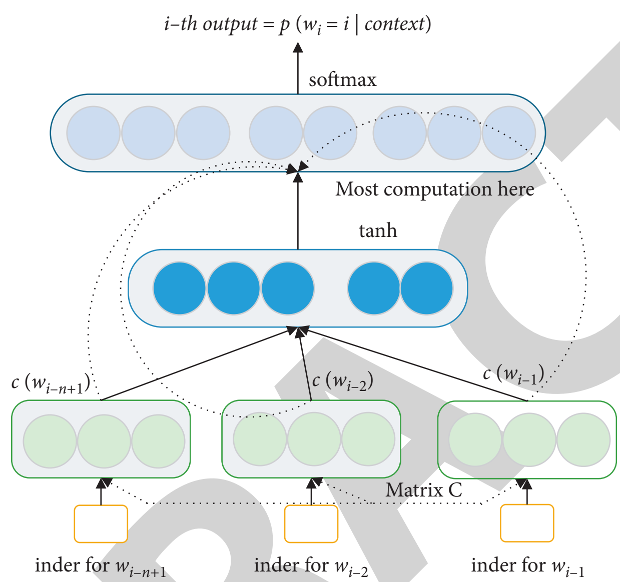

Figure 2: Text language model.

Algorithm: word vector update
Input: the i th sentence in the dataset s_i and the central word w containing m characters
Output: word vector matrix
Begin
(1) Obtain the vector representation e_w of the word w in the word vector matrix and the vector representation of each character that makes up w. The vector representation of the k th character is c_k.
(2) Calculate the vector representation of word w at training time using equation (12) x_w.
(3) Select the context word $\{v\}$ of w according to the set window size, and obtain its negative sampling result NEG(v), and then merge the two sets to form a new set $T = \{v\} \cup \mathrm{NEG}(v)$.
(4) Initially define the update intermediate quantity p such that $p = 0$.
(5) Sequentially traverse the set T and select word $u \in T$.
(6) Combining u auxiliary vector θ^u, indicator function $L^v_{(u)}$, learning rate η, and activation function σ, compute the intermediate quantities $q = \sigma(x_w^T * \theta^u)$, $g = \eta(L^v_{(u)} - q)$.
(7) Compute $p = p + g\theta^u$ and then $\theta^u = \theta^u + gx_w$ based on the intermediate quantity g.
(8) If the set T has not been traversed, then turn 5.
(9) Update word vector e_w of w, make $e_w = p + e_w$, then update all character vectors of word w, update character vector c_k of the k th character to $c_k = p + c_k$, end of one update of word vector.
End

Algorithm 1: Word vector training algorithm incorporating contextual information.

parts. In the specific implementation, the stochastic gradient ascent method is used for training, and the negative sampling method is used to optimize the three parts. Therefore, the core algorithms of the three parts have the same idea. Taking the first part as an example, the word vector update algorithm incorporating contextual information as the following Algorithm 1.

In summary, the overall training steps of the exacting word vector pretraining model can be described as follows:

(1) Preprocessing the training set with the text preprocessing method described in 3.1.2 and constructing the seed sentiment lexicon.

(2) Initialize the training parameters of the model, such as the window size of the interception context, the dimensionality of the training vector, the auxiliary vectors of each part, and the learning rate.

(3) Input the training set data into the model for training.

(4) After the training of the model is completed, the completed word vectors are obtained to complete the exact word vector pretraining process.

The co-word analysis method can visualize the network formed by the keywords and the sparsity characteristics, which can grasp the structure and characteristics of the research object more completely and accurately in the study. The preliminary keyword word frequencies were obtained by counting the class keywords derived from the rooting theory, and the keyword word frequencies were imported into Excel for data processing to obtain the keyword co-word matrix (the number of occurrences of every two keywords in the same policy). Then SPSS is used to further process it into a similarity matrix, and the high-frequency keywords are clustered and analyzed through the similarity matrix. The keywords are grouped into large and small clusters by the clustering algorithm, so as to obtain a clustering dendrogram, and the structural model of the policy is constructed again according to its development, and the optimal one is selected in comparison with the model obtained from the zapping theory.

The clustering analysis of keywords can only reflect the structural information of the policy structure system, and the relationship between various types of structures cannot be accurately judged; further analysis of the relationship between structures can provide a deeper understanding of the characteristics of the policy structure. In order to understand the structural characteristics and interrelationships of China's education informatization policy, a multidimensional scale analysis is further conducted on the basis of cluster analysis using the research method on keywords in bibliometrics to analyze the interrelationships among the structures in addition to the structural components of the policy and to grasp the structural characteristics of the policy more comprehensively.

The process required constant sampling, repeated reading of the data, and revision and comparison of the codes until no new concepts or classes were found. In the process of coding the 73 policy texts, starting from the 57th text, the 58th to the 73rd text, the coding process did not extract any new concepts or genera, and the codes were all able to be grouped into the previously coded genera, indicating that the current codes were saturated.

After the axial coding is completed, the word frequency of keywords can be counted according to the coding. 27 keywords of policy texts are obtained here (e.g., the word frequency of "education equity" is 12, which means that the keyword appears in 10 policy texts, and only once is counted when it appears in the same policy several times), and the keywords are counted and organized. Table 1 shows the keywords.

Based on the word frequency of the policy source material and keywords, the number of times every two

Table 1: Frequency of keywords in the texts of the three comprehensive education policies.

Keywords	Frequency
Regulatory coordination	42
Resource development and sharing	38
Three communication project	37
Teachers training	33
Education management and government	29
Policy environment	29
Campus network construction	24
Teacher education informatization	22
Platform construction	23
Information technology education applications	22
Informatization support services	21
Public service system	21
Investment and financing support	15
Information security	16
Rural education	16
Pilot demonstration	13
Education reform	13
Dedicated funds	11
Cross-border integration	12
Educational equity	12
National network construction	12
Information capacity	6
Talent development	5
Cultural development	4
Distance education	4
Smart education	4
Teaching materials construction	4

Table 2: Keyword co-word matrix of the texts of the three whole education policies (partial).

	PSS	NNC	TC	TEI	TT	ER
Public service system (PSS)	1	6	0	11	10	7
National network construction (NNC)	6	1	0	7	4	4
Textbook construction (TC)	0	0	1	1	2	0
Teacher education informatization (TEI)	11	5	2	0	14	4
Teacher training (TT)	10	6	0	12	1	6
Education reform (ER)	5	4	0	6	5	1

Table 3: Similarity matrix of keywords in the text of Sankyo Education Policy (partial).

	Public service system	National network construction	Textbook construction	Teacher education informatization	Teacher training	Education reform
Public service system	1.000	0.861	0.786	0.853	0.872	0.818
National network construction	0.863	1.000	0.618	0.905	0.871	0.826
Textbook construction	0.788	0.615	1.000	0.598	0.692	0.495
Teacher education informatization	0.853	0.904	0.596	1.000	0.780	0.737
Teacher training	0.870	0.872	0.692	1.782	1.000	0.781
Education reform	0.817	0.828	0.495	0.737	0.782	1.000

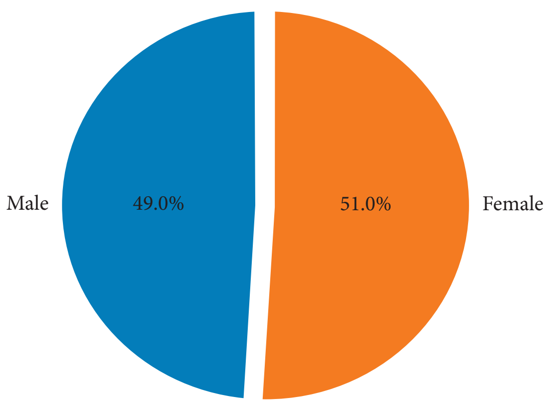

Figure 3: Gender of survey respondents (students).

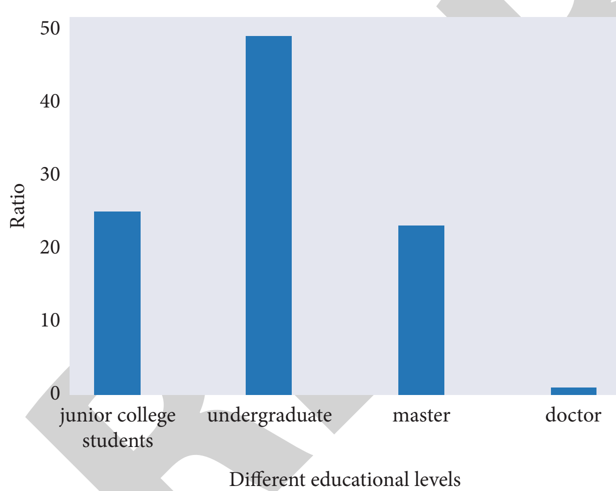

Figure 4: Survey respondents' education status (students).

keywords appeared in the same text was counted, and the pivot table function of Excel was used to draw the co-word matrix (e.g., the data in row 2 and column 3 of the matrix represent the number of times two keywords with serial number 2 and serial number 3 appear together in the same policy). The more times a pair of words appears together in the same policy, the more closely connected the topics represented by the pair are. The keywords obtained from Table 1 were organized and the co-word matrix generated is shown in Table 2.

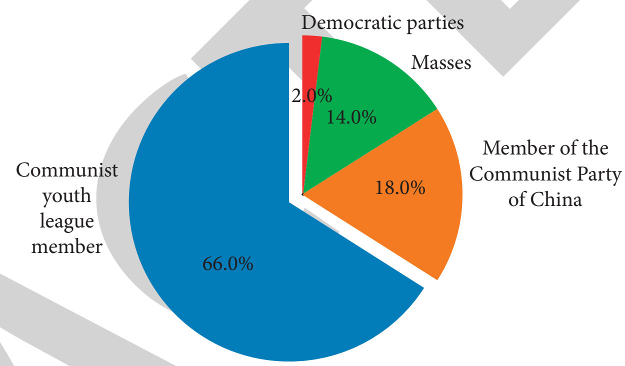

Figure 5: Political outlook of the respondents (students).

The prerequisite for performing clustering analysis is the need to convert the co-word matrix into a similarity matrix that represents the correlation between word pairs. In this paper, we use cosine similarity, and in text mining each keyword is also given dimensions, and each dimension can be represented by a vector, and the frequency of the keyword in each dimension is also its frequency in the document. Therefore, the similarity between keywords can also be derived using cosine similarity. Some of the results of the similarity matrix obtained by cosine similarity in this paper are shown in Table 3.

4. Case Study

4.1. The Current Situation. The investigation is carried out from three perspectives: the overall development of personality, the development of the whole process, and the overall development on which the moral education work is based. The content of the questionnaire is also designed around these three aspects. By asking a series of questions, we can obtain real information from students and staff about the overall composition of the university, the entire process, and the entire scope of education.

Respondents to this survey included students and teachers from multiple institutions, including 585 students and 173 teachers from China, whose institutions covered finance, politics and law, teacher training, science and technology, medicine, and vocational education. The subjects of the respondents include science and technology, literature and history, and art, and the academic level includes undergraduates, masters, and doctoral students.

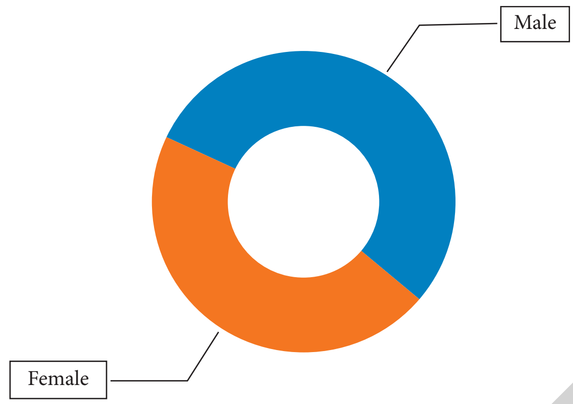

Figure 6: Gender of survey respondents (teachers).

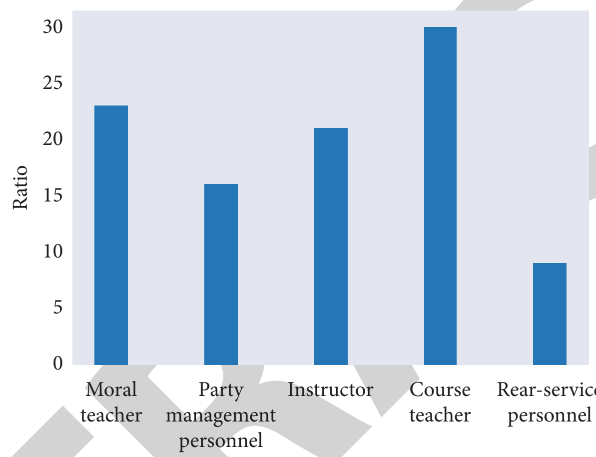

Figure 7: Job categories of interviewed teachers.

As shown in Figure 3, this chart reflects the gender situation of the survey respondents. From the data, the proportion of men and women is relatively balanced, with 287 male respondents and 298 female respondents, accounting for 49% and 51%, respectively. From Figure 4, we can see that among all the respondents, there are 150 specialists, accounting for 25.64%; 292 undergraduates, accounting for 49.91%, the largest number and the highest percentage; 137 master students and 6 doctoral students, accounting for 23.42% and 1.03%, respectively.

From Figure 5 that this study focuses on the work of moral education of college students, so the political outlook of the respondents is also crucial. Among the 585 students surveyed, 387 were members of the Communist Youth League, accounting for 66.32%, followed by 105 members of the Communist Party of China, accounting for 17.88%, and including 14.51% of the masses and 1.29% of the democratic parties, with 85 and 8 members, respectively.

Among the surveyed teachers, the distribution of men and women is roughly balanced, with 92 male teachers and 81 female teachers, accounting for 53.18% and 46.82% respectively, and the gender distribution of the survey is reasonable, see Figure 6.

Among these 173 faculty members, they come from three categories of posts, teaching and research posts, administrative posts, and logistic service posts, including 55 teachers of general and specialized courses in terms of categories, accounting for 31.87%. In terms of categories of teachers interviewed the most, including full-time teachers of various majors and teachers of general courses, the number of teachers of moral theory courses interviewed 40 people, accounting for 23.15%. The number of interviewed teachers of moral theory courses is 40, accounting for 23.15%, and also includes 28 party and administrative managers, accounting for 16.32%, as well as 15 logisticians, accounting for 8.62%. In terms of political orientation, all teachers in universities are basically CPC members, with the proportion of party members reaching 82.78%, and some democratic parties and masses, which account for less than 20% in total; see Figure 7.

4.2. Analysis of the Implementation Results of the "Three Comprehensive Education" Strategy in the New Environment, Taking a University as an Example. In the past two years, the "multidimensional" thinking and government work

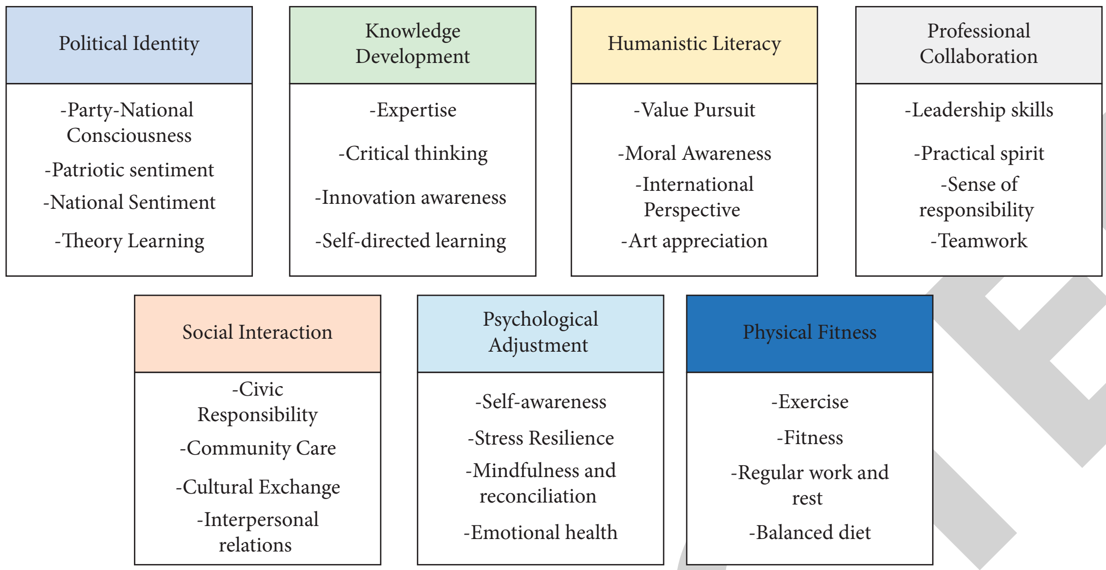

Figure 8: Assessment dimensions and indicators.

Table 4: Social interactions.

Serial number	Assessment indicators
1	I like and enjoy cross-cultural communication
2	I participate in social activities and integrate quickly into new groups
3	I take an active interest in my community and can contribute to its development
4	I am interested in social issues and am willing to participate
5	I take the initiative to volunteer
6	I am good at maintaining interpersonal relationships
7	I have a harmonious relationship with my family members

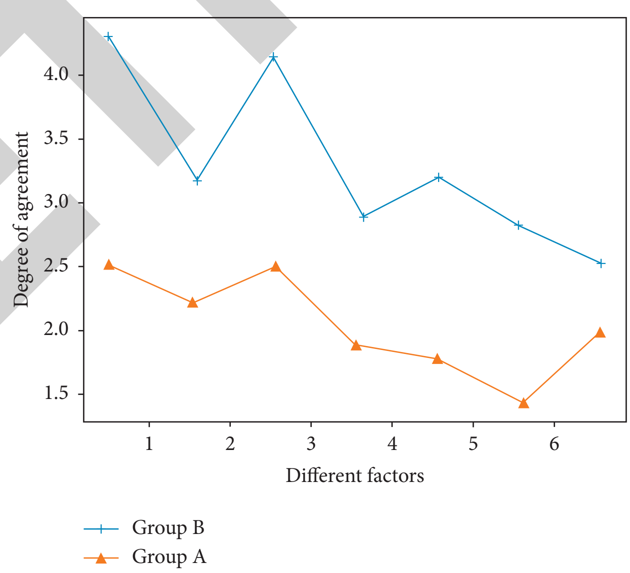

Figure 9: Comparison of parenting effectiveness.

system have strongly promoted the development of a university into "a research university with interdisciplinary characteristics and integrated development of arts, science, medicine, and engineering," which has greatly expanded the university's schooling pattern and made its contribution to "four leading positions." At the same time, the school has also driven the rapid development of various educational work through the "multi-dimensional" thinking and government work system, and achieved remarkable results.

4.2.1. Evaluation of the Effectiveness of Education. A university actively explores the mode of improving the mechanism of thinking and government work, and deepens the system of coordinated education through the "multi-dimensional" thinking and government work system, and has achieved remarkable results. For example, the Whole Person Development Inventory (WPDI) of Hong Kong Baptist University and the Self-Assessment of Whole Person Development Inventory of Nanjing University of Aeronautics and Astronautics. Based on the years of implementation of the "Three dimensions" Civic and Political Work System, the survey respondents were divided into two groups: former students of 2014 and 2015 who had graduated, hereinafter referred to as Group A; and current students of 2016 and 2017 who were in their senior year, hereinafter referred to as Group B. The questions of this questionnaire mainly involved the following 7 dimensions and indicators (see Figure 8) and were randomly distributed to the target group by using the 6-point Likert scale questions. In this study, students' self-ratings of the assessment indicators under each dimension will be counted according to their groups, and the mean value of the total score of each dimension will be taken for group comparison as in Table 4.

4.2.2. Comparison of the Effectiveness of Education. In this study, 400 questionnaires were randomly distributed to each of the two groups of students, A and B. A total of 800 questionnaires were returned. There were 687 questionnaires returned. Among them, 326 valid questionnaires were returned from group A, with a recovery rate of 81.50%; 361 valid questionnaires were returned from group B, with a recovery rate of 90.25%. The overall comparison results of the survey on the effectiveness of human education were obtained (see Figure 9).

The comparison results in Figure 9 show that, except for the physical health dimension, the scores of the two groups were similar in the four dimensions of political identity, humanistic qualities, social interaction, and psychological adjustment.

On the basis of actively exploring the "three-party co-construction" of a high-level university and building the "multi-dimensional" thinking and government work system around the main line of "three-wide education," a university has integrated. Based on the international standard full credit system that has been successfully implemented for many years, we have explored the management system and education model that meet the international standard and innovated the mechanism of cultivating multidisciplinary cross-composite talents, built a mature integrated talent cultivation system with Outcome-Based Education (OBE), and formed a unique Shantou University characteristic. The "three comprehensive education" model is unique to Shantou University. On the premise of actively exploring the "three-wide education" model and education path that is suitable for China and its own reality, a university's "multi-dimensional" political work system is designed, to cultivate students with international vision, independent personality, inquisitiveness, and innovation.

5. Conclusion

In recent years, moral education in universities has been paid more and more attention. As the basic concept of moral education in universities, the "three-wide education" emphasizes the importance of establishing a new national, whole process cultivating the all-round and continuous development of socialist construction. The comprehensive reform of "triple education" is an increasingly profound and gradual process. In practice, universities should, according to their own conditions and students' characteristics, strengthen the cooperation of the education system for all, strengthen the effective interaction of the whole process of education, ensure the organic connection of high-quality education, and establish a long-term education mechanism. It has its own characteristics. Establish an effective mechanism for long-term education characterized by self-development.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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Research Article

Analysis of Factors Influencing the Development of mHealth Innovation Based on Data Mining Algorithms

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Data mining algorithms combine expertise in machine algorithm learning, software modeling pattern recognition, statistical analysis principles, database construction, and artificial intelligence. With the rapid development of Internet technology and the common application of cell phones, mobile medical, a new medical method based on this technology, has been spawned, which greatly facilitates multiple aspects of medical services such as doctor diagnosis, patient treatment, disease care, and health management of critically ill patients and also alleviates the imbalance of medical resources. This paper firstly starts from the background of rapid development of information technology and mobile technology, combines the theoretical knowledge of data mining algorithm and mobile medical, as well as previous research reviews, and presents the main research content of this paper: analysis of factors influencing the development of mobile medical innovation based on data mining algorithm. Based on the *K*-means algorithm in the data mining algorithm and the Apriori algorithm in the association algorithm, this paper analyzes the current situation and problems of mobile medical development in China based on the algorithm model, analyzes the influencing factors of mobile medical innovation development in China based on the algorithm model, and summarizes and concludes the influencing factors of mobile medical innovation development and concludes that there are four categories of mHealth innovation development influencing factors: demand influence, policy orientation, technological innovation, and capital injection.

1. Introduction

With the advent of the information age various kinds of data are rapidly expanding and diverse. In the face of the huge amount of complex storable information data, how to analyze and find the key information data resources or information-related knowledge resources that can be used in a practical way is another very complex, difficult, and urgent task for human beings. The theory of data and information resources mining has been increasingly and rapidly developed to meet the basic theoretical needs of data and information utilization. Data information resource mining should actually be the study of how human beings can extract all the data information resources and other related information resources from the massive information data resources containing a large amount of information and not quite complete, with a certain amount of noise, fuzzy information, and various random changes in nature, which are temporarily hidden and of unknown significance but still have the possibility and are still useful or meaningful in practice. The research process of scientific knowledge resource information: Data resource visualization and its mining method is a kind of research based on modern computing machine meta-learning, pattern feature recognition, statistics, database analysis and modeling algorithms and large-scale data visualization and mining, and artificial intelligence as the core discipline and is an in-depth research on the development of the key technologies of today's world database architecture and large distributed complex information intelligent collection, analysis, decision-making, and application and other system technology issues. The research content of frontier technologies and fundamental theories of major disciplines has attracted the attention of domestic and international researchers. At the same time, a variety of new mining algorithms based on visualization of big data and visualization of deep mining are also emerging. In this paper, we mainly introduce the K-means algorithm, the classical Apriori algorithm of the clustering analysis algorithm, and the SPSS tool software to conduct the main analysis of the algorithm based on data deep mining.

At present, almost all countries in the world have been faced with a series of health management problems plagued by the imbalance between supply and demand of medical resources in each country and the imminent reform of medical institutions. The rapid and healthy development of Internet information technology has brought many traditional industries a lot of new eras of business development innovation model problems and business opportunities. The rate of aging of our society and the continued rise in the incidence of chronic diseases among the elderly have basically become irreversible social trends in the future, along with a sharp increase in demand for healthcare resources from year to year; the large-scale construction and application of mobile network medical system will not only rapidly expand the coverage of primary care and improve the level of social medical quality, but also provide timely personalized and customized quality medical technology services to meet the health needs of various different population user groups, improve the utilization of resources of technical experience and knowledge, and effectively alleviate the current tension in the supply of medical resources. China's mobile hospital Internet products and value-added services have begun to form a preliminary scale after the rapid Internet development speed in recent years, but the current technical development of the domestic mobile online medical field is still in a relatively less mature and stable start-up stage. For service providers, some services are still superficial; for users, mobile medical habits have not yet been formed, and the awareness and use of mobile medical care is not high. Therefore the development of mHealth has a very important impact on our country and even on the world. However, the development of mobile medical innovation is still constrained and influenced by many factors.

This article is based on the K-means algorithm in the data algorithm of the cluster analysis algorithm, the classical Apriori algorithm in the association algorithm, to analyze the multiple constraints and factors affecting the development of mobile medical innovation.

2. Research Background

With the development of smartphones, the popularity of wireless signals, and the decrease in charges and increase in speed of 4G and 5G cell phone data networks, data mining algorithms and mobile medical services have been rapidly developed. This section summarizes the research on the development of data mining algorithms and mHealth at home and abroad to provide a basis for subsequent research.

2.1. Overview of Data Mining Algorithm Research

2.1.1. Review of Foreign Research. The analysis of foreign big data and its mining methods involved in the field of big database related research scope and content have been very mature and extensive, and many significant and representative technical results have been achieved [1]. So far, the research problems of knowledge systems and data value mining in the fields related to relational database models and associated transactional database models have basically made a lot of significant technical progress and have some important representative values. The academic results can be summarized as follows: methods such as induction and analysis oriented to data relational attribute features are used to find relational attribute differentiation rules and feature rules of data attributes in relational database models [2]. In order to be able to go deeper into solving the most complex uncertainty problems in the computational analysis of Duri databases, rough set theory, evidence-theoretic models, and fuzzy set theory have also been applied and carried out, respectively, forming databases with increasingly high breadth and depth of research, related problems research methods practice models, and related technical applications [3]. In addition, neural networks, decision trees, visualization analysis methods, and optimization models of genetic algorithms and other artificial intelligence technologies that combine with a variety of massive data deep information mining and its related theoretical methods models of research experimental work research and results development and application demonstrations have also, respectively, achieved new series of domestic and international breakthrough progress with great impact. Among them, the most representative data mining algorithms with global influence mainly include Harvard University's IBM professor by Agrawal and another forty people in cooperation with the research proposed association rule algorithm, Princeton University's Canada Simon Fraser University professor by Han Jiawei cooperation in the development of the proposed concept tree improvement algorithm, and Columbia University by Professor Quinlan proposed algorithm classification algorithm. The genetic algorithm proposed by Professor Goodman of the Department of Computer Science at Michigan State University is the Bayesian approach to probabilistic concept learning [4].

2.1.2. Review of Domestic Research. Compared with other similar research and practice field projects jointly conducted abroad, some of the technical research results obtained by the domestic Chinese group members in terms of cultivating the ability of rapid analysis and mining analysis of network data and the ability to continuously discover and acquire the value of network knowledge have been transformed and scientific practice and application work are carried out at a later stage and are still mostly in the early stage of development or the beginning of the fumbling stage. It has not been further developed to form a more complete and mature force of such a technical system [5]. At present, most of the research and data mining projects in academia are mainly funded by the government or organizations, and most of the professionals or researchers involved in the research or data mining process are still concentrated and residing in universities, research institutions, or companies. The main recent research results are reviewed as follows: (1) the in-depth research of the National Natural Science Foundation of China, Beijing Institute of Systems Engineering Fund, demonstrates the fuzzy methods and the practical application research in the field of knowledge system discovery; (2) the in-depth theoretical research of data cubic algebra; (3) the research of East China University of Science and Technology, Beijing University, Fudan University, Zhejiang University, China University of Technology, Institute of Mathematics, Chinese Academy of Sciences, and Jilin University optimized and modified the mining algorithm of association rules; (4) Nanjing University, Sichuan University, and based Shanghai Jiaotong University, etc. carried out empirical research on knowledge resource discovery mechanism and data mining problems for unstructured data networks, etc.; (5) Institute of Computing Technology, Chinese Academy of Sciences, Tsinghua University, Chinese Academy of Sciences' group of professors, using Zhongzhi and other multiperson data mining tool designs, developed a knowledge discovery and analysis platform with multihuman strategy, which can detect various kinds of abnormal situation information in local tax systems such as Guangdong providing services to taxpayers using decision tree algorithm [6].

2.2. Review of Mobile Medical Development Research

2.2.1. Review of Foreign Research. This paper mainly comes to describe the development of Internet mobile medical technology and other situations in foreign countries such as the United States [7]. Since the late 1990s of the last century, the US government has facilitated the rapid development of our entire mobile Internet medical industry in China through the establishment of special government approval departments, the promulgation of corresponding industry technology laws and regulations, and the formulation of mobile medical technology development policies and plans. The United States attaches great importance to the protection of user data privacy and has enacted the Health Insurance Portability and Accountability Act, the Economic and Clinical Health Information Technology Act, and the Health Information Technology Improvement Act, which define in detail the scope of the content of data privacy disclosure information disclosure and elaborate and clarify the content of the general operating procedures rules and supervision methods for the release of electronic medical information, other rights protected by the owner of the content of information privacy disclosure, and false information disclosure cases, as well as the requirements and timely corrective disposition measures for handling penalty mechanisms for cases of illegal disclosure of false information [8]. In addition, the FDA has issued mobile Internet devices and cell phone applications that involve users' privacy and product quality specification information, and all medical device applications that pose a risk to users' life safety require certification.

To date, mHealth has largely penetrated all aspects of healthcare delivery in the US, such as health management systems based on physician and patient communication, Blue Star based on chronic disease management, adapters based on health management, remote monitoring based on patient discharge, and popular literature based on physician and patient communication. Diabetes, hypertension, and mental illness are the most common disease-specific applications. In the market, the most famous software developer in the United States—Google Inc.—integrates devices and big data platforms into a closed loop of big data, where users can choose products or service providers according to their condition [9]. Ninety percent of apps can be downloaded for free from the app store, but for autism apps, the price exceeds \$150, and more than 30% of apps require the purchase of an assistive device to use. Apple, on the other hand, usually collaborates with other medical institutions through medical device manufacturers to create their personal health records based on these user behavioral and medical data and usually establishes a link with their doctors by triggering system alerts when there are some abnormalities in the behavioral health record data of some users and family members and synchronizing medical data and disease associated with other doctors' risk assessment with other physicians to further facilitate better treatment for other users [10].

Istepanian and lacal argued that good compatibility and connectivity between mobile medical device products are the most critical factors affecting the sustainability of mobile web-based healthcare. Liang et al. successfully developed a mobile telemedicine product with emergency medical call service function, which will actively trigger the emergency medical call service when a patient suddenly encounters an emergency distress situation, and all emergency search and rescue team personnel around will instantly obtain the latest basic medical patient information transmitted by the system in real time, shortening the response time to rescue the scene in medical emergency situations. This will shorten the response time to medical emergencies and improve the efficiency of treatment. Liu et al. summarized and predicted the future development of mobile applications and future trends of the industry from the perspective of the needs of the application developer community. Kim argued that the disclosure of and access to user data should be made more secure through appropriate security mechanisms and protocols. Bricker et al. also used apps with mobile smart opt-out as an experimental group based on the synchronized treatment that patients received with the real world and tried to use some apps based on our clinical application practices and guidelines as a control group and found that the smart opt-out rate of users was higher in apps that used mobile smart opt-out [11].

2.2.2. Review of Domestic Studies. More than a dozen domestic scholars, such as Yumeng, have used model design techniques and analytical methods for goal-oriented services to significantly improve clients' goal-decision adherence to a service model for managing patients with hypertension chronic diseases. A software model for the management of hypertensive chronic disease patients was developed for the Chinese hypertensive population, and a comprehensive statistical analysis of user data was conducted. The results of the study also revealed that patients with diabetes at different developmental stages differ in their subjective understanding of their own characteristics and disease characteristics, as well as in their ability to manage objective and self-information cognition and regulatory processing and that the degree of familiarity with the use of differentiated diabetes mHealth monitoring and software development needs and the degree of decision support power vary accordingly. The study further identified three core dimensions of cognitive management, motivation, and decision support power as required for software designers of differentiated diabetes product frameworks [12]. Yang's development team provided such a mobile telediagnosis medical system on an android-based mobile device platform. The mobile telemedicine platform can provide test and diagnosis medical guidance to multiple health patients remotely by entering multiple diagnostic medical parameters at the same time, and the patients themselves can also directly query the test and diagnosis reports remotely for online diagnosis and treatment. The patient can also access the test and diagnostic reports, perform online diagnosis and treatment, and receive health advice on the platform. Han et al. also conducted the basic structure combination and key function application analysis of the mobile remote monitoring product system and explained the application design method and function interaction integration logic of the core part of the mobile healthcare product. Among them, Xing elaborated the mobile intelligent medical system of Xuanwu Hospital of Capital Medical University in detail, including its system architecture, the scope of application research areas, and related product functions, covering the hospital big data interaction integration cloud platform system and mobile doctor assistant [13].

2.3. Research Methods and Materials. This chapter mainly describes the theories related to data mining algorithms and theories related to mobile medical care. The main overview of the research theories and research methods used in this paper is given.

2.4. Data Mining Algorithms

2.4.1. Meaning of Data Mining Algorithms. Data information mining research is also often translated and understood as big data knowledge exploration research and information data information mining, which is firstly required to start research from the research activities of knowledge system discovery carried out in information database research and is an important working step of scientific research one [14]. Data mining is usually considered as a process of how to automatically search for a large amount of valuable information hidden in a large number of information data systems with certain special relationships. Data information mining systems are usually also related to other computer science systems, using data statistics and analysis, automatic information retrieval, machine learning, expert systems, pattern recognition, online information analysis models, and information processing technology methods to assist in achieving the above system goals. A data mining algorithm system is a methodological and computational technology approach to data mining that provides a set of methodological and computational techniques that can be used to create a system of algorithmic models for data information mining based on existing data [15]. In order to achieve the creation of data mining models, algorithms have to first analyze what kind of data the system needs to provide and look for specific types of patterns and trends. Data mining algorithms combine expertise in modern machine deep learning, pattern recognition, statistics, database principles, and computer artificial intelligence systems to obtain knowledge in large amounts of information and provide references for decision-making [16].

2.4.2. Types of Data Mining Algorithms. Data mining algorithms are divided into two categories in the general direction: supervised learning and unsupervised learning, and supervised learning and unsupervised learning are further divided into several major categories. As shown in Figure 1.

Supervised learning data mining is a top-down approach that is usually performed in the form of predictive models where the users already know what they are looking for; that is, the users already know what to predict [17]. The goal of data mining with supervised learning is to use existing data to build a model to describe a specific variable.

The unsupervised learning data mining method refers to a bottom-up learning data mining method, a mining method that uses a method that acquires learned data patterns on behalf of the users own methods to discover learning patterns throughout the process of performing data pattern mining work and then allows these users themselves to judge the importance of the data that they decide to learn using these data patterns. The ultimate goal of the unsupervised learning pattern data pattern mining method is also to find out the correlation that exists between all the learning variable data of the data. Berry divides data information mining tasks into six main categories: classification, estimation, prediction, association, clustering, and information visualization. The combination of more than two or at least two or more types of information data with mining technology methods is usually used in the practical solution of various practical business problems [18]. Several important data mining algorithms are described and analyzed below.

2.4.3. Theory of Clustering Analysis. Data clustering is a multivariate statistical analysis method that uses the idea of "similarity clustering" to find useful information by classifying samples or indicators. The objects discussed in data clustering are usually a large number of samples that can be reasonably classified according to their characteristics, without any existing pattern to follow or reference and without prior knowledge. Data clustering evolved from taxonomy, where in ancient taxonomy, people generally used historical experience to make qualitative classifications and rarely used mathematical tools to make quantitative

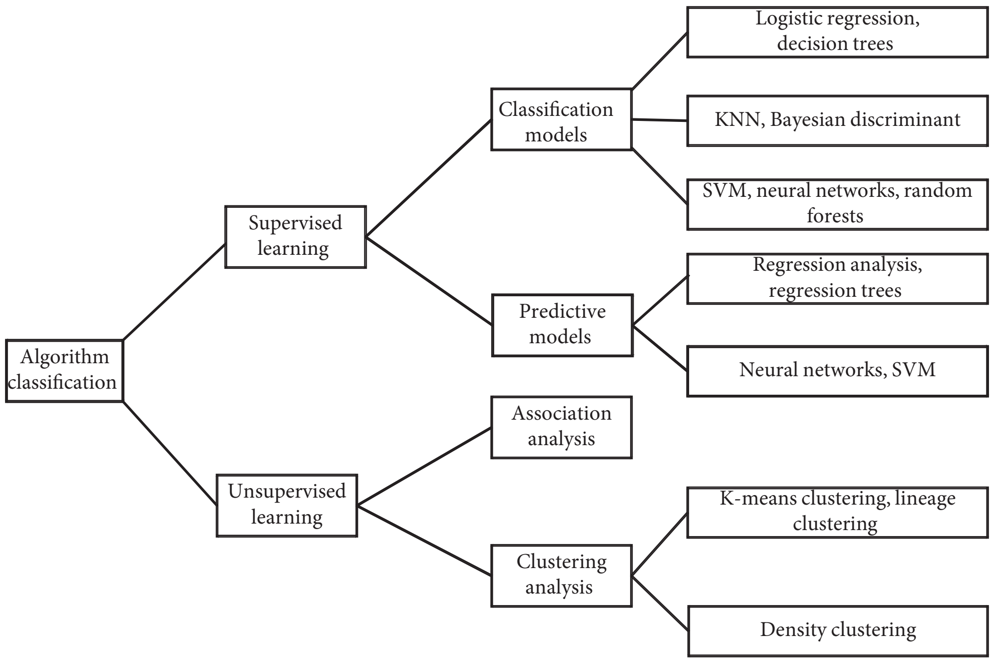

Figure 1: Classification of data mining algorithms.

classifications. With the development of modern science and technology, the requirements for classification are getting higher and higher. It has been difficult for the original classification methods based on experience and professional knowledge to meet the requirements. Digital classification was created when mathematical tools were introduced into taxonomy, and data clustering in the modern sense was created after multivariate analysis was introduced into digital classification. Clustering is the process of classifying data into different classes or clusters according to the characteristics of the data. Objects in the same class or cluster have strong similarities, while objects in different classes or clusters have strong dissimilarities. Data clustering comes from many fields, including mathematics, computer science, statistics, economics, and so on. Data clustering is also widely used in many fields, and clustering techniques have been developed in different application areas [19].

2.4.4. Theory of Association Analysis. Association rules are used to analyze and discover the degree of association between different variables or individuals in a database and to model customer purchase behavior using association rules, such as the effect of purchasing a desktop computer on the purchase of computer peripherals. Association rule is a simple and practical data mining rule first proposed by Agrawal et al. in 1993. Association rules can discover valuable correlations between sets of items from a large number of business transaction records. The process of mining association rules in transaction databases can be described as for a given transaction database, the problem of mining association rules is to eliminate the minimum support and minimum confidence to find the appropriate association rule.

2.4.5. The Process of Data Mining Algorithm. The process of data mining algorithm to mine data is as follows: first, the external data is organized, followed by the preprocessing work on the data, then the data information is formed, and finally, after the main algorithm procedures and formulas of data mining, the analysis is processed, and finally the calculation results of data mining are formed and given to display, as shown in Figure 2.

2.5. Mobile Medical

2.5.1. The Meaning of Mobile Healthcare. Mobile healthcare, translated from the English word "mobile" and the Chinese word "health," is referred to as mobile healthcare and is one of the parts of the national health management information system. This concept of mobile healthcare system was first proposed by Istvanian Robert, a professor at Imperial College London, Stanford University, as a new-age mobile communication device and network technology for mobile medical and healthcare services. The International Health Organization defines mHealth services as primarily the provision of mHealth-related service functions and demand information through the use of modern mobile communication technologies such as personal digital assistants, cell phone networks, and in-vehicle satellite positioning communication services. It can be seen that the value of mobile intelligent medical equipment is mainly through mobile intelligent computing, medical sensor technology, and other modern communication technologies; the carrier can be wireless PDA, cell phone switch, and other wireless terminal equipment; the output product's greatest value can be to provide medical technology service needs and application information. These high-quality information sharing services, including teleconsultation, body mass index

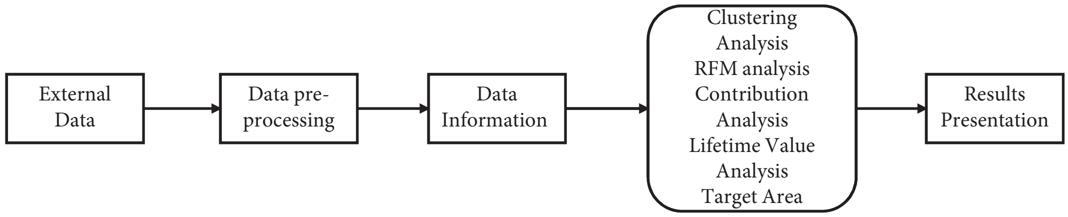

Figure 2: Data mining algorithm flowchart.

monitoring, electronic registration for appointment, and palm teleconsultation platform, will show to play its own great unique service value in actively promoting the rational and coordinated use of various high-quality medical resources in different places, improving the level of urban and rural medical environment and sharing medical experience [20].

2.5.2. Development Trend of Mobile Medical Care. China's mobile medical has gone through four main growth stages: exploration period, start-up period, high growth period, and maturity period. The initial formation of medical informatization began in the 1980s; with the support of national policies and the investment of medical insurance, mobile medical became a key industry to be fostered. From the initial formation to 2011, with the development of network technology coupled with a large number of intelligent devices, mobile medical technology began to start the development, coupled with a variety of investors, capital forces involved, and mobile medical into the rapid growth of the golden period; until today, the application of mobile medical has gradually tended to mature and stable period, as shown in Figure 3 below.

2.6. Research Methods and Tools. The main research methods used in this paper are as follows.

(1) K-means algorithm. The K-means algorithm was used to analyze the dynamics of mobile medical development and technological innovation and to find out the dynamics of mobile medical technological innovation and the factors influencing technological innovation.

(2) Apriori algorithm. Using the Apriori algorithm, we analyzed the internal connection between the dynamics of mobile medical development and technological innovation and the region where they are located and found out the association rules between them.

(3) SPSS is the main research tool used in this paper. SPSS is the modeling tool software for data mining algorithms.

3. Results and Discussion

3.1. Construction of the Algorithm Model

3.1.1. K-Means Algorithm Model. The K-means algorithm (K-means algorithm), first proposed by Macqueen in about 1967, is the most influential and famous mean division method in today's academic world and has the widest application. K-means algorithm is a kind of algorithm division method. The similarity calculation is mainly used to find the minimum spatial distance between a data object and the center of this cluster, and all the data objects near the center of a cluster are divided into several clusters, so that the "central object" (center of gravity) value obtained from the weighted average of the distance of all the objects in each cluster can be used to quantitatively calculate the similarity of each cluster.

The work and analysis process of K-means algorithm can be described as follows: first, data objects are randomly selected from the list, and for the objects that do not have the remaining initial data, the center of their clustering with the initial data of these data is found according to the calculation. After finding a maximum similarity value (distance) between them and the center of the initial data cluster, the K-means algorithm is used to solve the problem analytically by reassigning all of them to the centroid of an initial new cluster object (represented by the center of the cluster) at the most likely similar position to its center and then calculating the center of each original new cluster object that is in it during the calculation. The whole measurement process is repeated until a standard measurement function starts to converge. The standard measure function mean squared deviation is by far the most usually, not actually, used in the calculation. One of the three most important features of K-cluster theory is that the cluster model itself must be as compact as possible, with clusters as independent as possible. The specific steps of the K-means algorithm are as follows.

(4–1) Input $k, \text{data}(n)$

Selecting K points as cluster $c(0) = \text{data}(0), \ldots, c(k-1) = \text{data}(k-1)$ centers. (4–2)

will $\text{data}(0), \ldots \text{data}(n)$ be $c(0) \ldots c(n-1)$ compared $c(j)$ with i respectively, assuming the least difference with, then mark as (4–3)

For all points i labeled as $c(i)$ points, recalculate (4–4)

Repeat the (4–2) calculation, (4–3) until all the $c(i)$ change values are less than the given threshold.

3.1.2. Apriori Algorithm Model. The Apriori algorithm model finds all database items and item sets that occur frequently in the database by performing multiple scans of

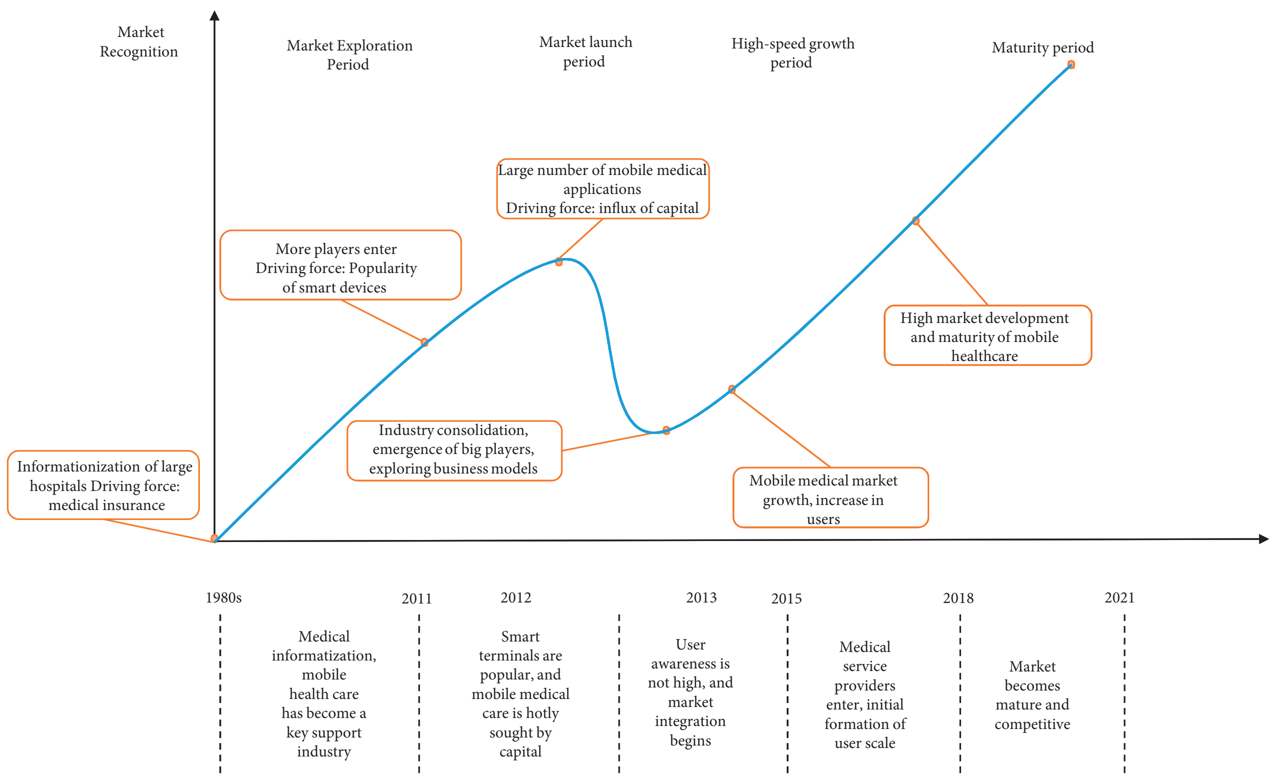

FIGURE 3: Stages of development of mobile medical.

the database items to calculate the support of the item set. The frequency of these items must be at least as frequent as the predefined minimum support frequency. The frequent itemsets then generate a series of strongly associated rules, which in turn must satisfy their minimum reliability and minimum support, respectively. The Apriori algorithm requires multiple scanning cycles of the database. KThe value of the first scan requires first using $k(k-1)$ the results of the first scan to generate a k set Ck of candidate items, then determine the support Ck of the scanning process, at the end of each scan to calculate the K set $k1$ of frequent items, k and the Ck algorithm ends when the set of candidate items is empty.

The Apriori algorithm model can be divided into two steps.

Step 1: Linking.

To find, lk a $l(k-1)$ candidate set is generated by k linking CK with itself. Assume that l_1 with l_2 is l_{k-1} the set of items in. $l_i(j)$ is l_i the items of j the itemset. For $(l_1(1) = l_2(1)) \cap \ldots \cap (l_1(k-1) = l_2(k-1))$ example, l_1 can l_2 be linked with. (4–5)

Step 2: Pruning. K All subsets of items, which must be sequent sets.

The process is as follows

Input: database D minimum support $\min - \sup$ threshold (4)–(6)

$$\begin{aligned} &\text{begin},\\ &L1 = 1,\\ &\text{for}\,(k = 2; lk - 1 \neq \varnothing)\text{do},\\ &CK = \text{Apriori} - \text{gen}\,(lk - 1),\\ &CT = \text{subset}\,(ck, t),\\ &lk\,(ck, c.\text{count}),\\ &\text{Return}LI \cup L2 \ldots \cup Lm. \end{aligned} \tag{1}$$

3.1.3. Model Implementation Tool Construction. The above two models are mainly implemented by SPSS tools, which are described below.

SPSS software is the world's first ever computing system software for statistical data processing and economic analysis, which is currently the world's first computer version of economic statistical data management and economic analysis application computer software known to mankind, hosted and developed and designed successfully by three master's degree graduate doctoral students from Stanford University class of Harvard University in the United States since 1968. It has created the modern SPSS computer application software series as another major development and technical direction of the new software and greatly enriched the actual social and

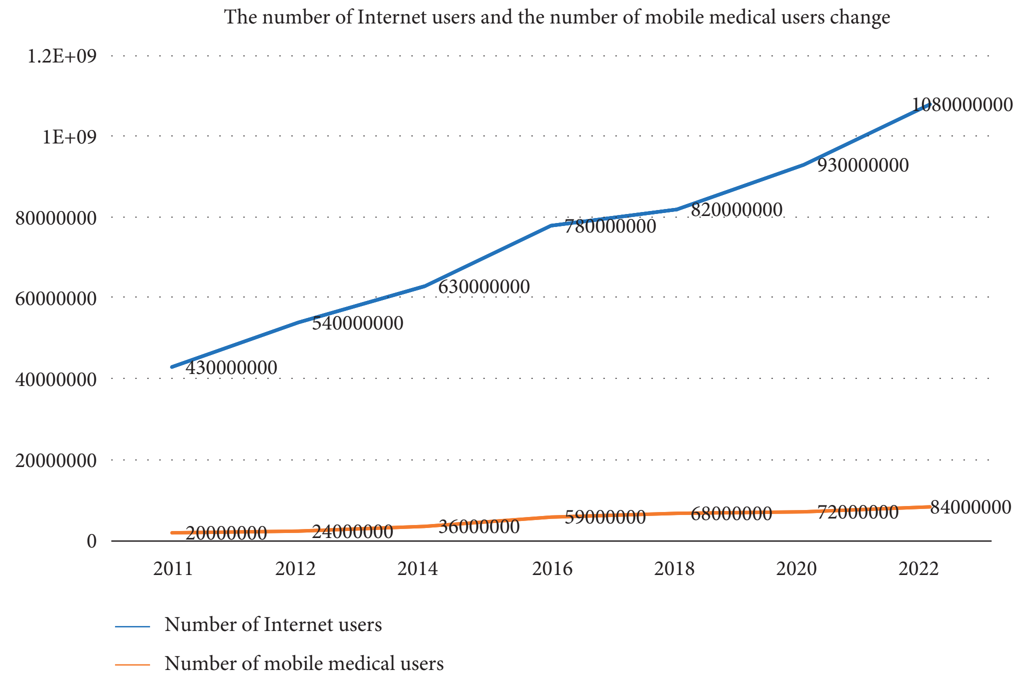

Figure 4: The number of Internet users and the number of mobile medical users change graph.

practical application scenarios and research scope of the modern SPSS computer technology application, so that its products can be rapidly and widely used in the natural science, technical science, social science basic research, and related fields in the world today. The SPSS modeler is based on a comprehensive application platform of big data analysis and mining with many leading technologies in the industry, which has been greatly improved and upgraded. Its powerful data mining analysis capabilities will be a variety of complex statistical modeling methods and various machine learning techniques applied to transaction data to effectively help customers; powerful analysis of data and mining information capabilities are applied to a variety of complex statistical modeling methods and various machine learning techniques in the analysis of data to effectively help transaction customers quickly discover the hidden in the transaction system or enterprise resource planning, the structured databases, and public documents, enabling trading clients to achieve significant growth in ROI. The system's features can be summarized as follows.

(1) The system has a user-friendly interface and is simple to operate.

(2) The system has the special features of this fourth-generation programming language.

SPSS software modeling is used to classify the types of research objects as follows: Type I hospitals: including well-known domestic hospitals and hospitals in economically developed areas; Type II: hospitals in economically underdeveloped areas; Type III: hospitals in economically deprived areas.

3.2. Algorithm Model Analysis

3.2.1. Analysis of Mobile Medical Development. According to the above algorithm plus SPSS software modeling for mobile medical development for analysis, we have the following.

The application of mobile medical care in China started to appear in 2011 and started late, but the application of mobile medical care in China has developed rapidly. Currently, there are more than 2,000 mobile applications based on various smartphone development systems in China. The emergence of cell phones has increased the number of Internet users in China, and with the increase in the number of Internet users the number of mobile medical users in China has also shown a rising trend. In 2011, the number of Internet users was 430 million and the number of mobile medical users was 20 million. From 2011 to 2022, both the number of Internet users and the number of mobile medical users are gradually increasing, and by 2022, the number of Internet users will reach 1.08 billion and the number of mobile medical users will reach 84 million, as shown in Figure 4.

In 2011, the number of mobile payment transactions such as Alipay and WeChat is 11,000, and the number of

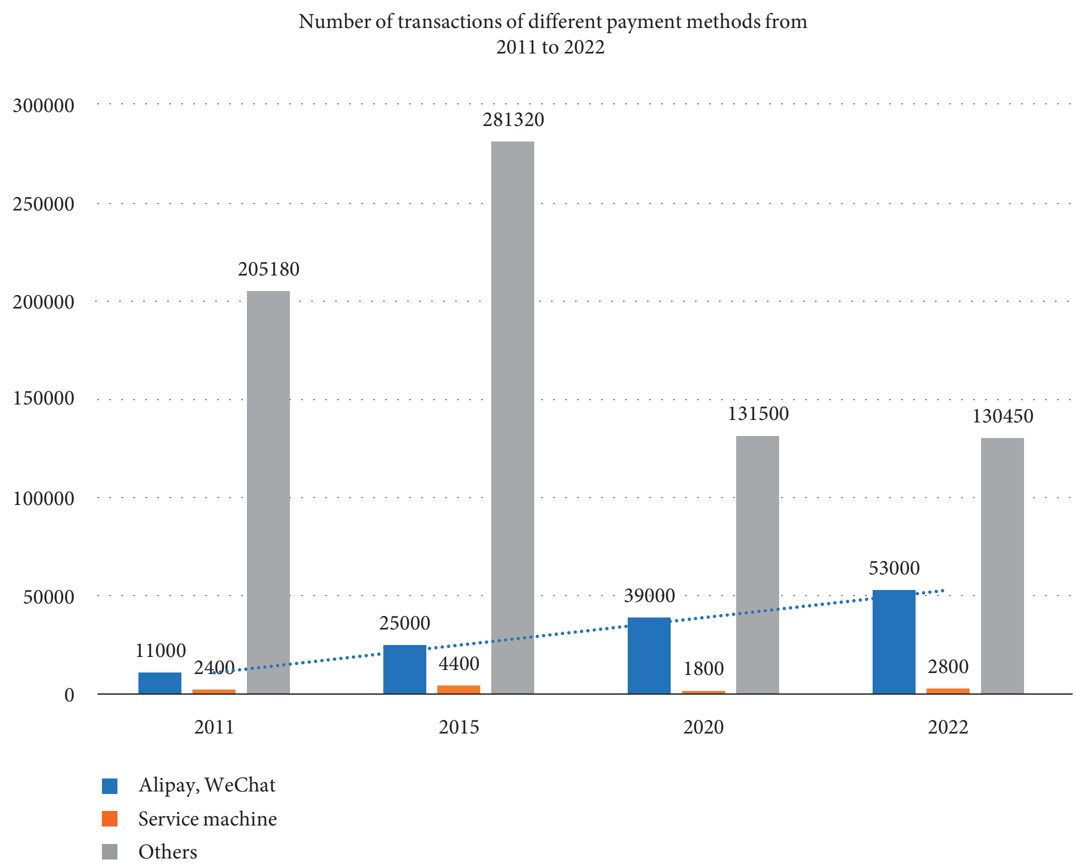

Figure 5: Comparison of the number of transactions of each payment method from 2011 to 2022.

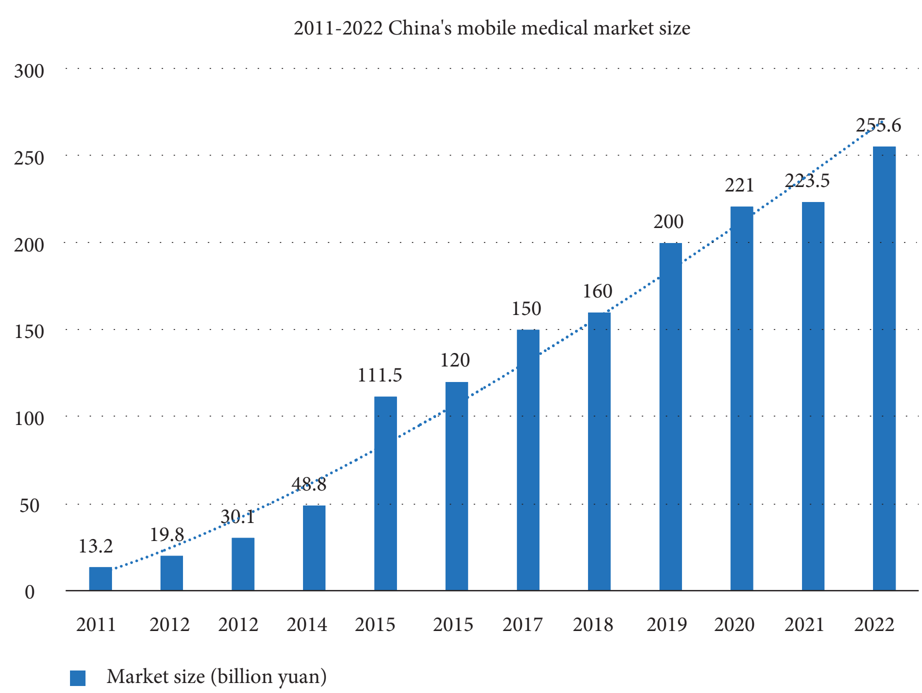

Figure 6: Mobile medical market size, 2011–2022.

mobile payment transactions in 2022 is 53,000 rising year by year; the number of other transaction methods transactions declines year by year. The convenience and low cost of mobile medical services make them more effective in solving common problems in medical information services. Overall, the future of mobile medical services in China is very

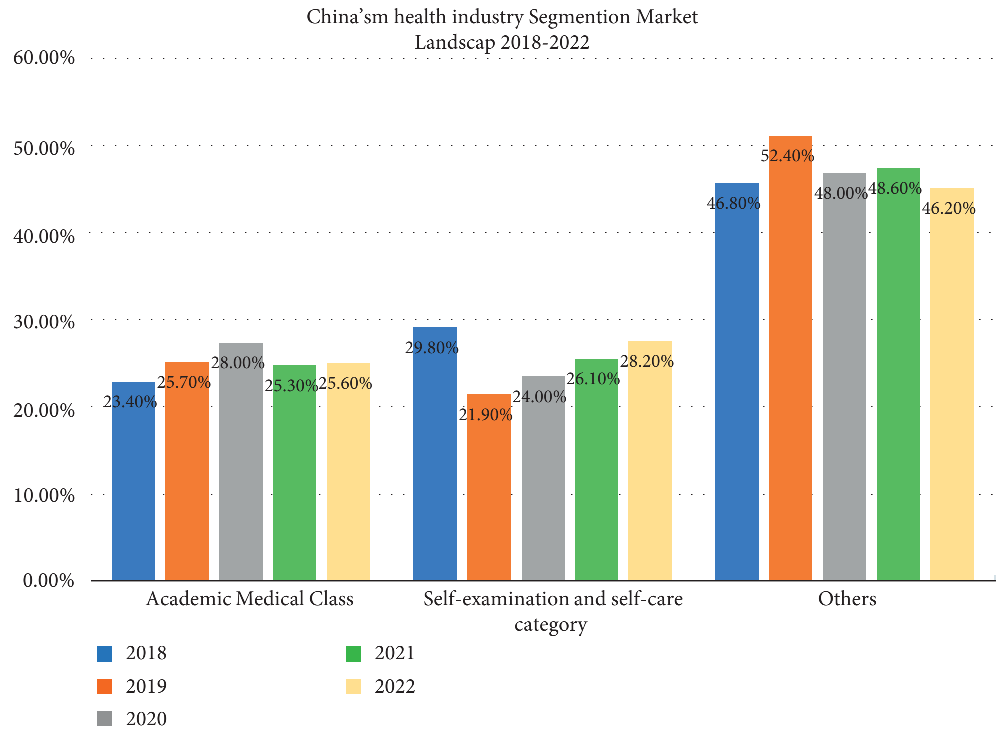

Figure 7: Market segmentation pattern of mobile medical industry from 2018 to 2022.

promising, but its profit model is not yet clear. In the field of mobile payment, China has taken the lead in recent years, and this convenient payment method has also penetrated into the mobile medical field, as shown in Figure 5.

The market size of mobile healthcare in China has gradually expanded from 2011 to 2022, from 1.32 billion yuan in 2011 to 25.56 billion yuan in 2022, which reflects the increase in the share of mobile healthcare in China's market, the increase in the proportion of related investment, and the better development of mobile healthcare in China, as shown in Figure 6.

China's mobile medical industry segmentation market pattern from 2018 to 2022: academic medical category accounted for 23.4% in 2018, 25.7% in 2019, 29% in 2020, 25.3% in 2021, and 25.6% in 2022, which shows that academic medical category, with a stable share, occupies roughly a quarter of the share. It can also be seen from the figure that self-examination accounted for 29.8% in 2018, 21.9% in 2019, 24% in 2020, 26.1% in 2021, and 28.2% in 2022. Therefore, self-examination also accounted for a quarter of the market share. Other models accounted for about 50 percent in 2018–2022. According to the statistics, academic medical treatment and self-examination accounted for a large proportion, as shown in Figure 7.

3.2.2. *Analysis of Existing Problems in Mobile Medical Development*

(1) The shortage of scientific research funds will still be the biggest bottleneck restricting the research and development of mobile telemedicine technology, technological innovation process, and the application and transformation ability of medical scientific and technological achievements in China in the future. The innovative research, pilot development and promotion, and application of mobile Internet medical technology innovation results are always inseparable from the effective investment of a large amount of capital and manpower. However, in terms of the overall situation in China, on the one hand, with the gradual deepening and implementation of the strategy of scientific and cultural construction of public hospitals, the proportion of scientific research tasks undertaken by hospitals and the proportion of contributions to scientific research activities may increase correspondingly. However, in the short term, the overall proportion of national social investment in medical technology innovation and the average proportion of domestic hospital investment in medical and health technology innovation may still be relatively limited.

(2) According to the characteristics of the overall level of economic development in our country at present and all the people to bear ability, basic urban and rural medical and health resources allocation system in China should be a pyramid. Providing health care services to more people should be a priority for the country to develop and build in the future. It is the dominant position and social foundation of grassroots medical and health service. However, in the great development of China's current medical and health reform, we have really embarked on another road of high level and low coverage. Healthcare system structure has been formed on an inverted

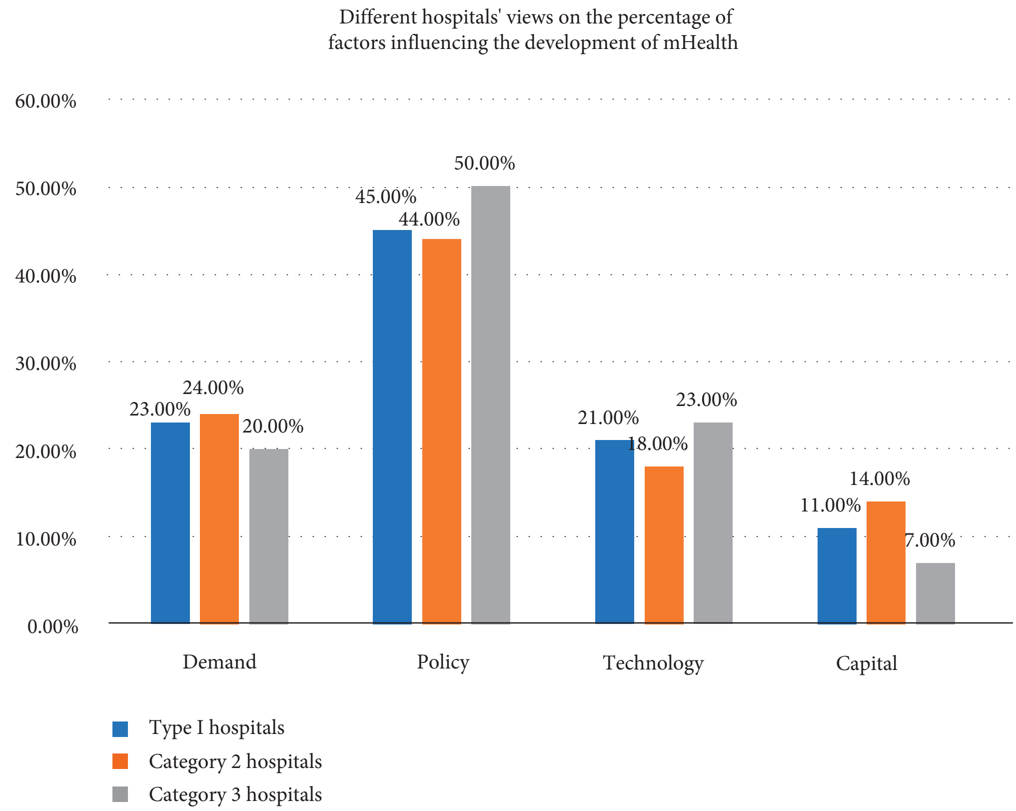

Figure 8: Proportion of influencing factors of different types of hospitals on the development of mHealth.

pyramid structure; high technology, outstanding, more professional high-level medical health senior professional talents are all concentrated and dispersed in many large and medium small cities in the area of rural kindergarten and the general public or large hospital and rural school small urban communities. At present, there is no way to effectively reverse the extreme supply shortage and imbalance between supply and demand of urban and rural medical treatment from the real fundamental structure level. Currently there are many common diseases that cannot be admitted free of charge by the state, a measure that would waste the city's resources. At present, the allocation of social resources in the field of public health in China is still extremely limited and unreasonable.

3.2.3. Analysis of Influencing Factors of Mobile Medical Development. Through the above analysis of the development status and problems of mobile medical care, the influencing factors of the development of mobile medical care are further studied. A number of domestic hospitals were selected as research objects, including hospitals in economically developed areas, economically underdeveloped areas, and economically poor areas, as well as representatives of domestic advanced hospitals, third-class hospitals, and other general hospitals as data sources. According to K-means algorithm model, Apriori algorithm model, and SPSS software, the influencing factors of mobile medical development are analyzed:

The first type of hospital: including domestic well-known hospitals, hospitals in economically developed areas; Type II: economically underdeveloped hospitals; Type III: hospitals in economically poor areas. Visibly, all think that no matter what kind of hospital, policy influences the mobile medical development accounting for about 40%, demand and technology influence each accounts for about twenty percent, capital and accounts for about 10%, thus, national policy is the most important factor influencing the mobile medical development; hospital departments and patients demand mobile medical treatment only. The development of electronic information technology and the development of Internet plus technology and the needs of all parties are keeping pace, occupying the same important proportion. Finally, private capital only accounts for a small part of the investment, as shown in Figure 8 below.

4. Conclusion

As a new analysis technology, data mining is the most advanced research direction in the field of database and information decision and has been promoted in various fields. At present, this technology has not been deeply applied in the field of medicine and health. With the popularization of medical and health information, the application of data mining technology to data analysis in the field of medical and health will have a huge market prospect and provide effective data support for the innovative development of mobile health. Based on the K-means algorithm in the clustering analysis algorithm of data mining algorithm and the Apriori algorithm in the association algorithm, assisted by the SPSS software modeling, this paper analyzes the development status and existing problems of China's mobile medical treatment and analyzes the influencing factors of China's mobile medical innovation development according to the algorithm model. The factors influencing the development of mobile medical innovation are summarized, and the conclusions are as follows:

(1) Demand impact: with unreasonable allocation of medical resources, lack of experience of patients, overwork or underpayment of doctors, and hospital managers hoping to make hospital management more efficient and time-saving, all three hope to use new Internet thinking to improve the pain points of the medical industry.

(2) Policy orientation: driven by policy, the state vigorously advocates reform of the medical industry, and the State Council's No. 1 document calls for the active development of rural teleconsultation systems conducive to rural "Made in China 2025." The State Council also calls for improving the innovation capability and industrialization of medical devices, focusing on the development of high-performance diagnostic and treatment equipment such as imaging devices and medical robots, high-value medical supplies such as fully biodegradable vascular stents, and mobile medical products such as wearable and remote diagnosis and treatment.

(3) Technological innovation: driven by technology, products such as wearable medical devices, as well as the combination of 4G networks and smartphones, have given a huge impetus to the mature development of mobile medical care as a whole.

(4) Capital injection: capital-oriented and market-based companies are looking to merge with other traditional industries to earn more profits, including the healthcare industry, which is also looking to leverage the advanced technologies of Internet companies, such as big data, cloud computing, and the Internet of Things, to facilitate the integration of the healthcare and Internet industries.

Data Availability

The dataset is available upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

Image Classification Learning Method Incorporating Zero-Sample Learning and Small-Sample Learning

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At present, artificial intelligence algorithms based on deep learning have achieved good results in image classification, biometric recognition, medical diagnosis, and other fields. However, in practice, many times researchers are unable to obtain a large number of samples due to many limitations or high sampling costs. Therefore, image sorting zero-sampling order research algorithms have become the central engine of intelligent processing and a hot spot for current research. Because of the need for the development of deep learning prediction capability, coupled with the emergence of time and technical-level drawbacks, the advantages of zero-sample and small-sample are gradually emerging, so this paper chooses to fuse the learning methods of both for image recognition research. This paper mainly introduces the current situation of zero-sample and small-sample learning and summarizes the learning of zero-sample and small-sample. And the meaning of zero-sample learning and small-sample learning and the classification of the main learning methods are introduced and compared and outlined, respectively. Finally, the methods of zero-sample and small-sample learning are fused, the design is introduced and analyzed, and the future research directions are prospected according to the current research problems.

1. Introduction

With the rapid development of big data and computer devices, deep learning has entered a phase of rapid development. Although great progress has been made in recent years in terms of in-depth research, especially in image recognition, and in the field of computer vision speech recognition, deep learning based on deep learning models and the powerful potential of large-scale learning data sets have made great progress and shown vigor, and the accuracy of image classification of large data sets has been improving, but it relies heavily on the collected labeled data. Coupled with the exponential growth in time and manpower required as the number of image data and classifications grows rapidly, this has severely hampered the development of the ability to study predictions in depth. In this context, zero-sample learning models and small-sample learning have attracted increasing attention from scholars [1].

Most of the existing methods for image classification are part of the teaching of control methods. Such models require a large amount of explanatory data. In addition, some training units for certain class facilities are difficult to obtain. In the case of endangered species, it is very valuable that image data are difficult to obtain due to extinction. Considering the importance of image data, identifying and promoting wild endangered species that do not rely on large-scale training samples would have significant commercial and environmental value. In addition, as the number of object types increases, new data from detection systems need to be added in the real world to restart training. Zero-sample learning methods and small-sample sampling methods are among the most important directions if target classification techniques are to be more widely developed. On the one hand, machine learning is improving, and HRI growth data are becoming less and less realistic. On the other hand, computer technology has made significant progress in recent years, with unprecedented breakthroughs in the field of learning appropriate for development in areas such as migration, adaptation to local conditions, and also in the field of image recognition. Such based on two development scenarios, zero-sample and small-sample learning aims to identify certain classes of unspecified targets from labeled raw data. Zero-trial learning to study small samples is very important and represents an important new stage in the development of artificial intelligence. As humans learn, we define categories we have never seen before by understanding the images of the categories and the semantics of the relationships between visible and invisible classes. Zero-sample learning and small-sample learning are identical in their basic ideas. The labeling of visible and invisible classes allows to divide the semantic space between the same classes and to achieve the recognition of invisible classes. Both zero-sample and small-sample have improved considerably, but are still in a rapid development stage. Zero-sample and small-sample detection have a wide range of applications not only in the field of image recognition but also in computer vision perception-related fields and even in natural language processing. Such extended generalized zero-sample and small-sample classification methods are also called generalized sample learning, while the earliest methods for sample learning in the direction of image classification are called narrow-sample learning. This paper focuses on narrow-sample learning, which represents a sample learning method for image recognition classification. This phenomenon is known as over-simulation because if the depth model is very complex, it is easy to consider the noise in a small-sample training data set as a sign of the whole sample and therefore the training model on the test data set performs poorly [2].

In summary, because of the need for the development of deep learning predictive capabilities, coupled with the emergence of time and technical-level drawbacks, the advantages of zero and small samples are gradually emerging, so this paper chooses to fuse the two learning approaches for image recognition research.

2. Research Background

2.1. Review of Zero-Sample Learning Research. In the early development stage of zero-sample learning, the classification of target categories is usually achieved using a two-stage approach. In order to infer the category of the input attributes, the attributes of the image are first entered and then searched among a set of category attributes [3]. For example, the direct attribute prediction proposed by Lampert et al. is a great improvement to category inference. The main approach to direct attribute prediction is to learn a classifier on attributes, which achieves prediction of classes by computing the posterior probabilities of attributes of input samples. Again, most attribute-based methods require a complete description of the properties of each invisible class. Making this connection takes a long time and usually requires domain-specific expertise [4]. Norouzi et al. proposed a method for learning coupling relationships between classes and their corresponding attributes. Automatic prediction of class properties is performed using a learned relationship model given only invisible class names [5]. Matthew et al. proposed a simple method to create an embedded image system that consists of any existing N directional classification mechanism and any existing semantics. Its basic idea is to label categories in the semantic space. In recent years, many zero-sample teaching models have emerged, basically it allows to classify images in the semantic space [6]. The concept of semantic output code classifier was defined by Palaucci et al. The semantic output code classifier uses the knowledge base of semantic properties of invisible classes to create new classes, giving a view of the classifier, validating its theoretical properties, and providing it with the conditions for accurate prediction of new categories. It combines multitask learning and multidisciplinary learning, interpreting classical and modern multitask and multidisciplinary learning algorithms as different structured semantic description methods, and proposes a semantic deep visual embedding model that uses labeled image data and semantic information instead of text to identify visual objects [7]. Alexande et al. show a recent performance of the model in a 1000-level image web object recognition challenge, and he also shows that the model can use semantic information to predict images not seen in tens of seconds of training, using state-of-the-art image features, where we monitor different control attributes and embedded outputs without involvement, as well as hierarchical structures and untagged text storage. The results show that pure unsupervised output embedding has emerged convincing results even beyond previous control on state-of-the-art techniques [8]. A two-layer network based on the relationship between features and categories was developed by Romera et al. Converting these methods to a regional adaptive approach shifts the limits of error generalization and further considers an important factor to re-examine the problem of text representation. There are also some studies of zero-sample learning through nonlinear cross-modal embedding, which uses a class-compatible model that extends a bilinear network model with latent variables. Instead of studying individual maps, it uses two independent recognition models to identify and classify invisible classes using differences in the semantic space [9]. Zhang et al. argue that if any source or target is considered as a mixture of visible proportions, assuming that both instances belong to the same invisible category, then the mixture models should be similar. Specifically, the functional source or target data fields of the embedded source and target that are available to any user will be learned to be distributed in the same semantic space. Then measure the similarity in the semantic space. Establishing a learning framework based on the maximum limit of similarity function, the problem of zero-sample study from the perspective of multiangle learning is proposed by station manager Ping-Yu et al. The core idea is the alignment of semantic space and visual feature space. It introduces two rooms. In both cases, there is a set of "phantom categories" that serve as the basis for query dictionaries. These "mirage" categories can be optimized by using data from a single source field to obtain better results [10].

2.2. Review of Small-Sample Learning Studies. Wang et al. argue that small-sample learning algorithms are the key to the intelligent transformation of traditional industries, and they have a wide range of technical and theoretical implications. At present, microsample research algorithms have been widely used in image recognition, spectroscopy, industrial production, text classification, radar detection, agricultural disease detection, and physical examination. From the perspective of error segmentation, a small sample of key learning problems in machine learning theory is conducted, and a small sample is summarized on the basis of theoretical analysis to study the motivation of designing algorithms, and existing algorithms are classified into learning strategies, data extensions, and learning strategies according to the design motivation. A comparative analysis of the basic ideas and representative algorithms of various approaches is also presented. The advantages and disadvantages of the various methods and the future directions of development are reviewed in the combination of experimental results. Based on the analysis and prospective analysis of existing research methods, the research idea proposed in this paper is presented [11]. Lazebnik et al., based on the word packet model, calculate the attributes of each block using multiscale blocks. Finally, by connecting all features and using hierarchical pyramids, it is possible to correct the error in the precise positioning of points in the packet matrix and get good results in small-sample image classification based on the packet model. The dictionary model-based ACO model must make full use of expert knowledge to represent complex image structures, similar to the deep sea model approach based on large-scale data images. The dictionary model-based scheme is still not universal, and as the deep study is becoming more accurate in a wider range of image classification, many researchers have tried to apply the deep study approach to classify small image samples. Many sources point out that small samples can be used to classify images using a wide range of data sets, such as ImageNet, which has been trained in convolutional neural networks [12]. Salakhutdinov et al. introduced the HDPDM model, which better supports vector algorithms in databases such as CIFAR, handwritten fonts, and human motion detection. Fan Hu et al. introduced a preprepared deep learning model that also generalizes well to the classification of small data and high-resolution remote sensing images after refining the parameters [13]. Hu et al. proposed the same classification method as Fan and performed experimental validation with better results in most cases, but also some poor results. Many researchers in China have tried to apply deep analysis to small-sample data in order to classify images. These methods are based on the prepreparation of deep learning and then transformed into small-sample data sets, which have achieved good results in related fields. No training depth model is prepared using small data samples and then the pretrained methods are classified using an auxiliary vector machine. Although the classification results are better than those of the “word packet” based model, the classification accuracy is still significantly lower than when the model is prefabricated. Therefore, the most common method for classifying images into small samples is to prefabricate the deep learning model using large-scale data and then convert it into small samples [14].

3. Research Methods and Materials

3.1. Zero-Sample Learning

3.1.1. Concept. Zero samples obtained through knowledge transfer are transferred from the material class to the immaterial class to establish appropriate relationships between the material and immaterial classes and classify the immaterial classes. Zero sampling enables knowledge transfer between visible and invisible classes, and knowledge transfer relies on spatial embedding. During the training process, using the data and semantic space of the visible classes with labels, the model can fully understand the visible features and semantic space of the classes, as well as the correlations between the relevant class attributes. After studying these relationships, the classification of invisible classes can be obtained by extracting the visual features of invisible classes and then by searching the corresponding attribute combinations in the semantic space [15]. The specific operation process is shown in Figure 1.

3.1.2. Algorithm Flow. A set of training modules is given, in which the first graphical image, class labels, and training package are arranged. The task of zero-sample training is to identify the samples and classify them into new classes, that is, to classify the samples into new classes. Other matters identify the samples and classify them. As for the other matters, the test categories differ from the textbook categories. In addition, the empty sample analysis contains additional textual information of all categories as feature descriptions. Using the generic vector of class descriptions, we can learn zero samples and transfer the knowledge from the learned sample classes to the new test classes. As zero samples in the training process of knowledge transfer bridge, class description vectors usually consist of attribute vectors such as shape, color, size, and material for training sets and tests. Some studies have used text interpretation regions as vectors of function descriptions [16].

3.1.3. Method Classification. A series of methods have been proposed to solve the problem of zero-sample learning, which can be classified into quantitative learning methods, similar learning methods, multistructure methods, and model methods [17], as shown in Figure 2.

(1) Quantitative learning methods: quantitative teaching methods aim to determine the space, i.e., the minimum distance between other matter image features and the corresponding semantic vector. The simplest method is to use the semantic vector space as the metric space with features distributed in the semantic vector space and its nearest neighbor classification. The Euclidean or cosine distance is used directly as a measurement function. Several studies have shown that using the image feature space as a

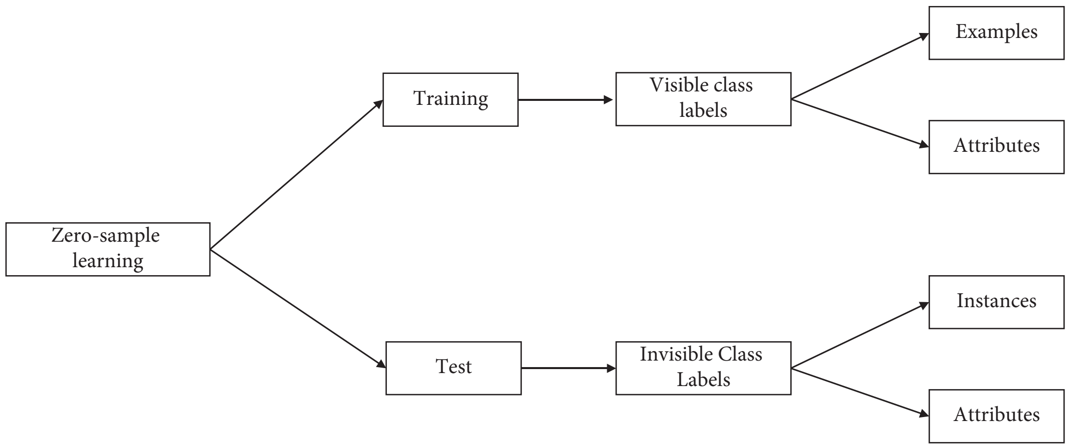

Figure 1: Zero-sample learning flowchart.

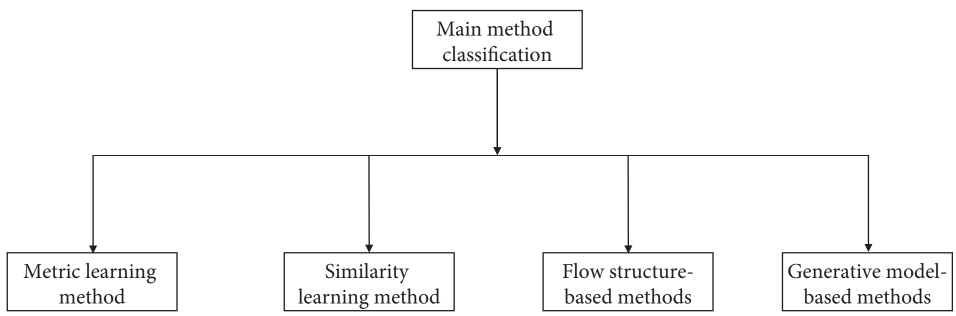

Figure 2: . Classification of zero-sample learning methods.

metric space can effectively reduce the field and axis complexity problems inherent to the zero energy level. Based on this, a spatial depth model based on image features is developed. The original image is encoded by CNN into the eigenspace, and the semantic vectors are mapped to the same eigenspace by multilayer sensors. The method classifies the nearest neighboring multilayer sensors based on the specificity of the image and the semantic features of the space itself and considers the spatial search as an implicit method of spatial measurement. These methods change the functions of the metric sphere and the spatial distribution between the metric spheres. It includes linear and nonlinear transformations, such as support vector returns. The most important issue in measurement is the design of the objective (loss function), which is related to the overall characteristics of the model. The measurement-based approach allows for the classification of features in space using the latest neighborhood rules. The model is clear and easy to understand, but its performance varies considerably due to the choice of measurement chamber [18].

(2) Similarity learning methods: in contrast to the study of spatial mapping functions, compatibility learning methods are directly related to the study of image space and semantic space vectors. The basic approach is a bilinear form that converts spatial and semantic vectors into similar scalar vectors. This belongs to a deep visual semantic design model with structured joint embedding. Taking advantage of the nonlinear function transformation, the proposed method is simple and computationally small, but requires more training data.

(3) Structural diversity approach: some studies have explored the diversity of semantic and graphical spaces from the perspective of diversity studies and tried to explore the structure of diversity to a new test category. The model learns the different structures of each vector in the semantic space and transforms it into a model space for multielement learning concepts. Zero-sampling methods based on multiple structures can consider the relationship between categories; however, the different structures in different feature spaces are different and difficult to move.

(4) Model-building-based approach: some recent studies are based on the idea of samples that can be used to generate new feature types or even original 2D images by constructing sets of network teaching materials. The classification problem is solved by shifting from on-the-job training to supervised training. This approach usually consists of two parts: sampling training and classification training. In the sample generation phase, new image types are generated based on the training samples and the

corresponding text descriptions when describing the new category vectors. In classifier training, the classifier is trained for sample generation and test sample online recognition. The model-based approach is incremental and easy to apply, but it has some problems such as low sample presentation rate and difficulty in production.

3.1.4. Properties

(1) Portability. Attributes can only describe one aspect of a given situation and usually attributes cross between classes. It is due to the difference or similarity of attributes between classes that the description of each attribute of a class is characterized and creates a bridge between visible and invisible classes. The zero-sample learning approach learns the visual features of the visible category and the corresponding properties of the various visual attributes by learning the visual features of the visible category. Then from the visual features of the invisible category, the corresponding set of attributes is found and the corresponding classes are found in the semantic space. This transposition of semantic attributes ends with knowledge transfer between the visible and invisible classes.

(2) Flexibility. Semantic properties can be configured very flexibly. By eliminating specific situations and different detection tasks, the most appropriate type of attribute can be more efficiently determined to distinguish between tangible and invisible categories.

(3) Interpretability. The interpretability of semantic attributes is a unique and superior condition for their existence. Semantic attributes are usually matched with certain visual features. By studying the semantic attributes, we can understand the differences between categories accurately.

3.2. Small-Sample Learning

3.2.1. Concept. Similar to zero-sample training, small samples solve the problem of manually labeling invisible images, thus avoiding consuming too much time and effort. Unlike zero-sample learning, small samples do not use the common semantic knowledge between the source and target domains, but for the test categories, each category is given one or more labeled instances, and the test categories can be identified by using very small-sample learning [19].

3.2.2. Algorithm Flow. In this section, a small sample is studied as an active subject. It is motivated to classify it into an image representation phase, a data expansion phase, and a learning phase, and the schematic diagram of the small-sample learning algorithm is shown in Figure 3 [20].

The motivation of representation learning is to transform the raw data into feature domains through representation learning. The feature domain has very little measurement and semantic information, which greatly reduces the learning difficulties, and the simplest idea is to extract one or more features from a large number of basic categories so that they can be adapted to the limited differences between the basic categories and the new categories and then to recognize them by category. Although this initial approach to adjustment is intuitive and simple, it is difficult to study general features in small instances and achieve good results. In recent years, representative learning has made great strides with the development of automatic tuning techniques, facilitating further development of small-scale studies. The goal of learning self-monitoring is to reliably represent one's own learning data. There are no signs of classes, and only their own information and data structures are used. The main problem is to construct complex tasks, extracting instances from large amounts of unmaintained data, and then completing downstream tasks based on a more compact semantic view. In a small example, the representation of levels is very important, as constructing a reasonable concept of self-controlled learning is a hot topic of research.

Based on data extension for small sampling algorithms, data extension is motivated by the desire to generate as many anomalous samples as possible to increase the sample size, reduce the upper limit of cumulative error, and improve the reliability of empirical risk. Data expansion can be divided into two parts: source domain expansion and semantic space expansion. Expanding the semantic space means creating samples based on tables and feature vectors.

It uses knowledge transfer experience to reduce the learning cost of the model and achieve the purpose of neural network adaptation to small-sample data. Their concept suggests some similarity between similar tasks. The essence is to classify new classes of data based on the common features, connections, and parameters shared by the models. If sufficiently similar tasks exist, an off-the-shelf model can be used as a good initialization. In big data preprocessing, a fast response to the task at hand can be made by fixing feature extraction, differentiation, and other methods. If the preparation is not sufficient to complete the task, additional parameters can be input and the learning process can be initiated. The specific migration methods can be divided into feature migration, model migration, and dependency migration, as shown in Figure 4.

4. Results and Discussion

4.1. Fusion of Zero-Sample Learning and Small-Sample Learning. The current research on image classification methods is mainly focused on zero-sample and small-sample, while the research on zero-sample and small-sample is relatively weak. Zero-sample learning and small-sample integrated learning not only contains multiple support instances but also textual information, which has the unique advantage of learning different patterns. Compared with zero and little learning, from the perspective of human perception, human perception of a new category or concept is summarized by a small number of samples and also combined with different cognitive modes for overall understanding, which is the result

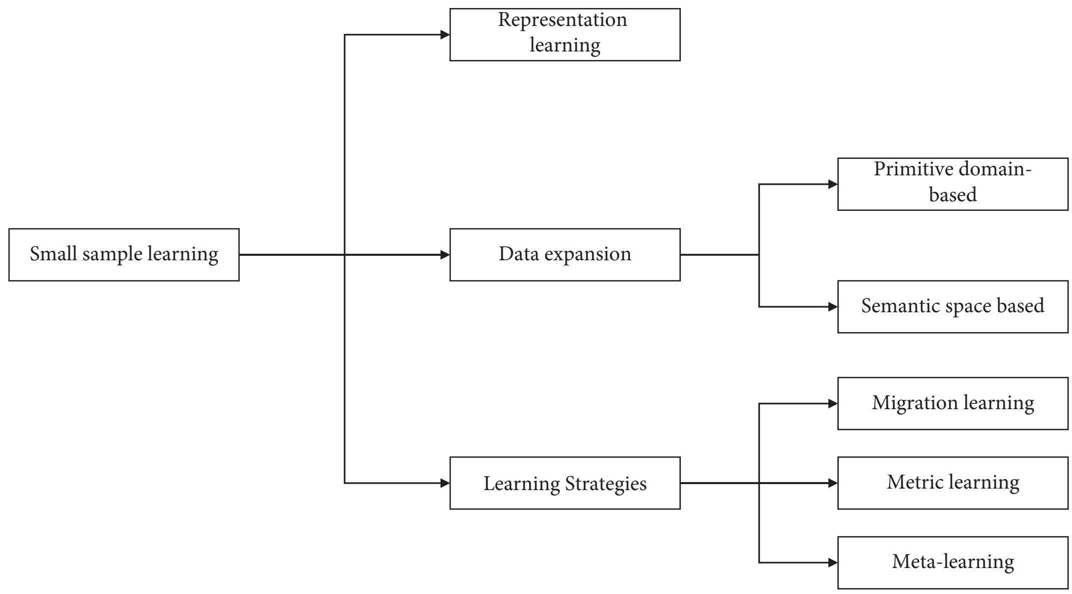

Figure 3: Schematic diagram of the small-sample learning algorithm.

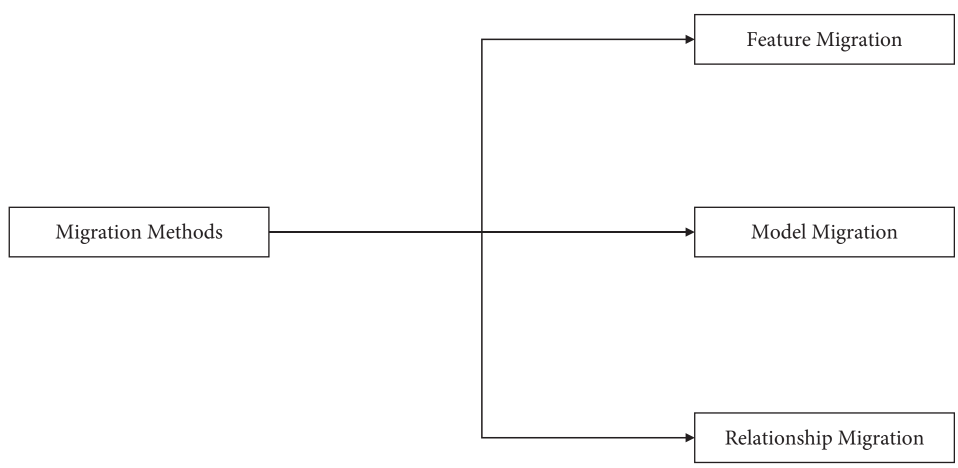

Figure 4: Classification of specific migration methods.

of the interaction of different cognitive modes. Combining zero-sample and microsample instruction with practical needs and scientific research, this would be a way to study image classification and people's perception. In addition, zero-sample learning can be combined with active learning to improve the effectiveness of active learning. Zero-sample learning can be integrated into lifelong learning systems which only provide relevant information, and continuous learning and enhancement of new missions is rapidly developing. Coupled with poor control, an improved training system will be better able to cope with new challenges, new developments, and even new fields.

4.1.1. Design Theory. Zero-sample studies are the result of combining small-sample studies with zero-sample studies. A small sample is based on a general description of a category. To define new categories or concepts, if the sample supports a small number of samples, first clarify the explicitly stated problem and introduce the experimental design and the results of some basic tests.

To further identify new categories that do not appear during the learning process, a small instance-based category description vector is added to explore the problem of learning based on textual information. In other words, a combined learning sample of zero and small learning samples is given in this paper. For the first time, the combination of zero and small samples is an effective way to improve machine intelligence. Since then, the integration of zero and small samples for teaching gradually involves preparation. A multiobjective network has been designed to investigate small samples supported by semantic information using semantic descriptions of image features and local features. The model-based idea envisages the creation of a bitriangular network based on the semantic information category to create new sample features with a multimodal cross-fitting loss function in the encoder model. To obtain new samples in the new implicit feature space, a cross-modular multimodal and distributed monolithic encoder is proposed where zero-to-data expansion is performed under small-sample conditions. Although it has been around for a long time, there are still a few learning instances that have not been fully investigated. In some specific domains, limited labeled data make prior learning difficult.

There are two approaches: image streams and text streams. The image stream is displayed at the top and the text stream at the bottom. The model is an adaptive exploitation mechanism for multimodal information, allowing the adaptation of weight factors in text and image attributes. Different information modalities are utilized to improve the learning of small samples.

The data set and test equipment are still in the initial stages of small-sample formation. Zero- and small-sample integration requires some new examples to support the categories and additional semantic features to describe the vectors as additional information. In the training phase, the instances, categories, and descriptions of known training images are used to describe the parameters of the vector training model. In the testing phase, a large number of test samples are categorized and identified, a series of auxiliary samples and their new categories are used to describe the vector information, and the correct test coefficients are calculated as the final metrics for model evaluation. Currently, the conventional experimental set-up is classified as a subspace.

4.1.2. Experimental Validation. Currently, most of the studies related to image classification research are conducted with uniform data sets, and the training set is continuously analyzed even when testing is performed. For example, most zero-sample studies use a fixed 40-level training and pooled data to determine a 10-level test with relatively reliable experimental data. In this data set, the validity of the model against other data, i.e., the validity of the model, should be studied. Other matters we can use traditional training methods for large data sets, such as 5x cross-validation, zero-sample and small-sample training integrated experimental validation, and comprehensive testing of the model under various data conditions.

At the same time, the experimental set-up should be more suitable for practical applications, such as the current small and zero samples, which mostly only test the classification performance of new categories that have not been discovered so far. In practice, however, the tests are usually conducted according to the new curriculum, which focuses on vocational training. Improving the efficiency of such broad classifications is also an important area of research.

On the other hand, although the amount of training data required for zero- and small-sample training is very small, the pretraining of the model directly affects the final performance of the model. How to minimize the model complexity is also a problem that needs to be investigated. The current research mainly consists of heuristic studies and experimental certifications and lacks sufficient theoretical foundation. Theoretical analysis is needed on how to select more zero-sample information from the training set to the unknown sample, which data and knowledge are more effective, and how to suppress external information in training to avoid negative transfer. Scientific theoretical analysis and sufficient experimental data will help to include zero and small samples in the investigation.

4.1.3. Formulation. According to the expression of the computational function used to fuse zero-sample learning and small-sample machine learning methods and their description in the claim satisfaction design theory text, the expression of the feature centers of class images is

$$X_k = \frac{1}{n}\sum_{i=1}^{n} X_{ki}. \tag{1}$$

The above X_k formula indicates the feature n centroids, the number i of samples, and the image feature class.

$$V_k = \frac{1}{2}\left(X_{k+}M_k\right). \tag{2}$$

The above equation V_k denotes the feature representation vector and M_k denotes the mapping feature vector.

4.2. Analysis of Results. In this section, the application of fused zero-sample learning and small-sample machine learning methods in image classification learning is analyzed using the comparative analysis method. The three modes described below are zero-sample learning, small-sample learning, and fused zero-small-sample learning.

4.2.1. Comparative Analysis of Image Classification Speed under the Three Modes. When the number of samples is 100, the speed of image classification processing with zero-sample learning is 4.3 minutes, the speed of image classification processing with small-sample learning is 2.4 minutes, and the speed of data processing with fusion method is 2 minutes; when the number of samples is 150, the speed of image classification processing with zero-sample learning is 4.5 minutes, 3.4 minutes with small-sample learning, and 2.1 minutes with fusion; when the number of samples is 200, the speed of image classification processing with zero-sample learning is 4.7 minutes, 4.4 minutes with small-sample learning, and 3 minutes with fusion. When the number of samples is 200, the speed of image classification processing with zero-sample learning is 4.9 minutes, the speed of image classification processing with small-sample learning is 4.4 minutes, and the speed of data processing with the fusion method is 3.37 minutes. From the data analysis, it can be seen that the three modes of image classification speed from fast to slow are: fused zero small-sample learning, small-sample learning, and zero-sample learning, thus it can be proved that fused zero small-sample learning has an advantage in image classification processing speed, so the study of fused zero small-sample learning mode is very useful and has a high value as the advantages are very obvious as shown in Figure 5.

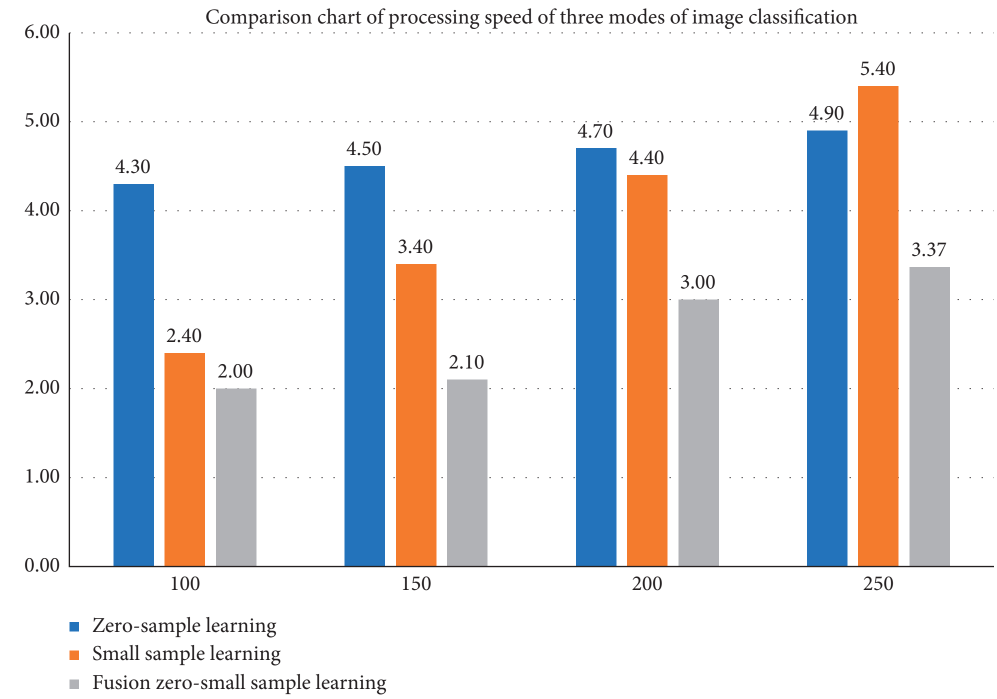

Figure 5: Comparative analysis of image classification speed under three modes.

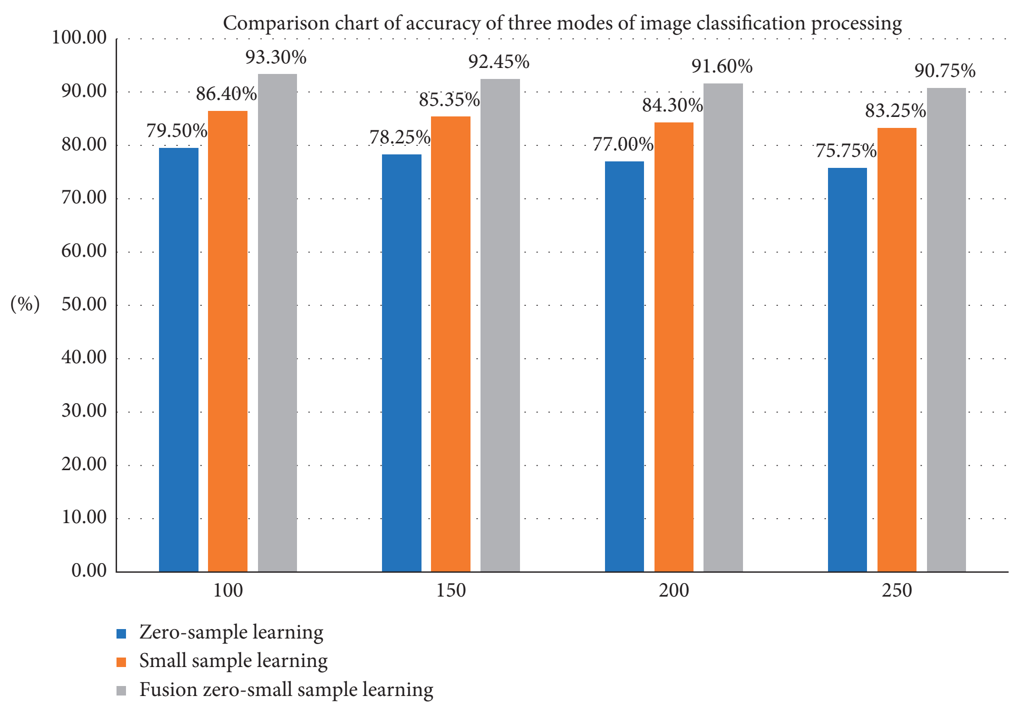

Figure 6: Comparative analysis of image classification processing accuracy in three modes.

4.2.2. Comparative Analysis of Image Classification Processing Accuracy under the Three Modes. When the number of samples is 100, the accuracy of image classification processing with zero-sample learning is 79.5%, the accuracy of image classification processing with small-sample learning is 86.4%, and the accuracy of data processing with fusion method is 93.3%; when the number of samples is 150, the accuracy of image classification processing with zero-sample learning is 78.25%, the accuracy of image classification processing with small-sample learning is 85.35%, and the accuracy of data processing with fusion method is 92.45%; when the number of samples is 200, the accuracy of image classification processing with zero-sample learning is 77%, the accuracy of image classification processing with small-sample

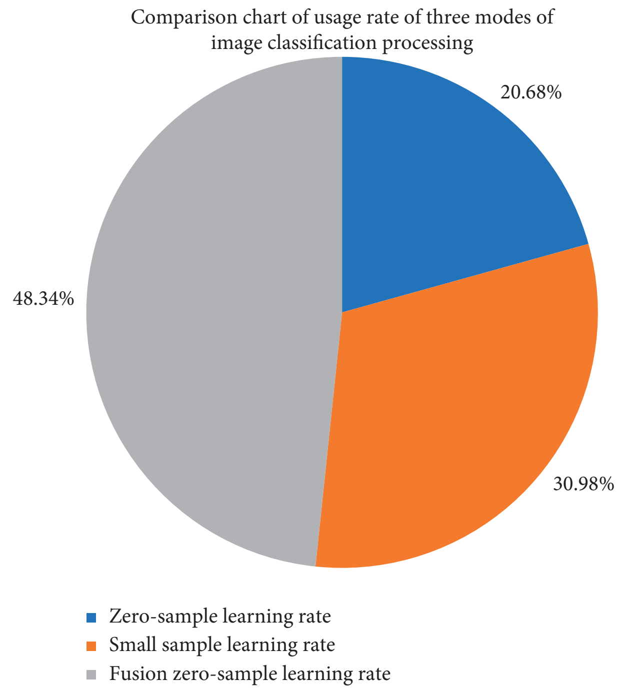

Figure 7: Comparative analysis of the usage rate of image processing in the three modes.

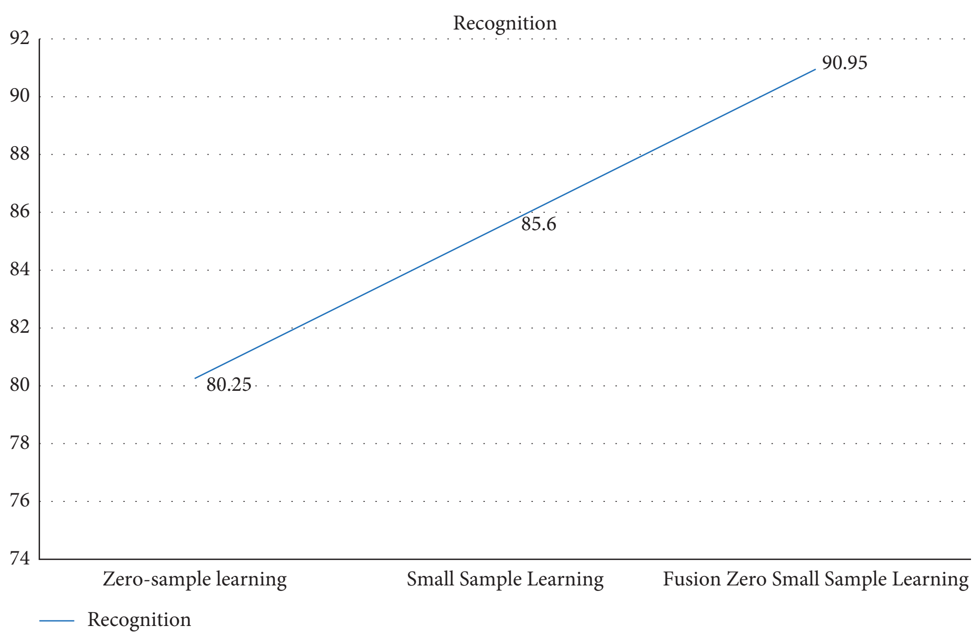

Figure 8: Comparative analysis of image processing recognition in three modes.

learning is 84.3%, and the accuracy of data processing by fusion method is 91.6%; when the number of samples is 250, the accuracy of image classification processing by zero-sample learning is 75.75%, the accuracy of image classification processing by small-sample learning is 83.25%, and the accuracy of data processing by fusion method is 90.75%. From the data analysis, it can be seen that the accuracy of the three modes of image classification processing is from high to low: fused zero small-sample learning, small-sample learning, and zero-sample learning, thus it can be proved that fused zero small-sample learning has an advantage in image classification processing accuracy, and the accuracy rate is high, and the data processing ability is strong, so it has a high value for research, as shown in Figure 6.

4.2.3. Comparative Analysis of the Usage Rate of Three Modes of Image Processing. 20.68% are zero-sample learning; 30.98% are small-sample learning; and 48.34% are fused zero-small-sample learning. This shows that fused zero-small-sample learning has a high usage rate in image classification processing and a strong data processing capability, as shown in Figure 7.

4.2.4. Comparative Analysis of the Recognition of Image Processing in the Three Modes. Assuming that the recognition score is 100, the zero-sample learning score is 80.25; the small-sample learning score is 85.6; the fused zero-sample learning score is 90.95. From the data analysis, it can be seen that the higher score of fused zero-sample learning represents the highest recognition of its image processing, so the fused zero-sample learning method in image sample processing has more obvious advantages, as shown in Figure 8.

5. Conclusion

With the rapid development of big data and computer equipment, deep learning has entered a stage of rapid development. In recent years, in the field of computer vision speech recognition, especially in the field of image classification, deep learning based on deep learning models and the powerful potential of large-scale learning data sets have made great progress and shown vigor, and the accuracy of image classification of large data sets has been improving. The task of image classification in computer vision is to classify images of interest by mechanical learning and other methods, and other matters image classification techniques are gradually being introduced into people's lives and work, greatly facilitating people's lives and changing their lifestyles. Although great progress has been made in recent years in terms of in-depth research, especially in image recognition, it relies heavily on the collected labeled data. As the number of image data and classifications grow rapidly, the time and manpower required grow exponentially, severely hindering the development of deep learning predictive capabilities. In this context, zero-sample learning and small-sample learning have attracted increasing attention from scholars. Because of the need for the development of deep learning prediction capability, coupled with the emergence of time and technical-level drawbacks, the advantages of zero-sample and small-sample are gradually emerging, so this paper chooses to fuse the learning methods of both for image recognition research. In this paper, we describe the current status of research on zero-sample learning and small-sample learning, summarize and outline the research on zero-sample learning and small-sample learning, and introduce the meaning of zero-sample learning and small-sample learning and the classification of the main learning methods and compare them, respectively. Finally, the integration of zero-sample and small-sample learning methods is presented and analyzed in terms of design, and future research directions are envisioned based on the current research problems as follows:

(1) Consider how to improve image rendering through self-control without supervision. Based on learning, the mapping space can be optimized by using simpler assumptions. Also, the number of samples required is lower due to the lower difficulty of spatial reception, which facilitates sample propagation.

(2) Given the higher level of reliability and control, the development of more general, efficient, and appropriately scaled data expansion algorithms should be considered.

(3) Consider more flexible and effective use of meta-learning to integrate zero-sample learning and small-sample learning.

(4) Consider how to design an effective algorithm for integrating zero-sample learning and small-sample learning.

Data Availability

The dataset is available upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Pattern Recognition of Wushu Routine Action Decomposition Process Based on Kinect

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Human action recognition is a hotspot in the fields of computer vision and pattern recognition. Human action recognition technology has created huge social value and considerable economic value for the society. Meeting people's needs and understanding people's expressions are the current research focus. Aiming at the problem that the movement cannot be continuously identified and due to a lack of detailed features in the action decomposition pattern recognition in the traditional Wushu routine decomposition process, it is proposed to use Kinect technology to identify the Wushu routine movement decomposition process in the Wushu routine movement decomposition process. This paper analyzes the principle of skeleton tracking and skeleton extraction performed by the Kinect human sensor and uses the Kinect sensor with the Visual Studio 2015 development platform to collect and process the skeleton data of limb movements and defines eight static limb motion samples and four dynamic limbs. The study uses a deep learning neural network algorithm to train and identify the established database of static body movements and uses the same template matching algorithm and K-NN. The recognition effects of the algorithms were compared and analyzed, and it was concluded that the static body motion recognition rates of the three algorithms were all above 90%. In this paper, recognition experiments are carried out on the MSR action 3D database. The influence of different integrated decision-making methods on the recognition results is further discussed and analyzed, and the average method integrated decision-making, which is most suitable for the algorithm model in this paper, is proposed. The results show that the recognition accuracy of the algorithm reaches 98.1%, which proves the feasibility of the preprocessing algorithm.

1. Introduction

Machines can accurately identify and respond to human body movements, which is a new way of communication between robots and humans [1]. In some relatively harsh environments, the data information and expression effects brought by action recognition are much higher than speech recognition [2]. Using machines to recognize images can be used in various aspects. Figure 1 also shows the development process of image recognition technology. The Kinect camera launched by Microsoft can not only extract human skeleton point data but is also not affected by the lighting environment, which promotes the process of human action recognition [3].

Limb motion recognition refers to the process in which the robot can read and analyze the current body motion of the human body and respond correctly. There are many disciplines related to body recognition [4]. What is a body movement? A body movement is the displacement sequence formed by the position of the same body part of the human body changing with time in space [5]. A well-known psychologist once conducted a survey and researched on "the way of human information communication and expression" and found that only 7% of the information is communicated directly through language, and 38% of it is communicated through the difference in intonation and speed of speech [6]. Convey information, and the proportion of people who convey information through human facial expressions and

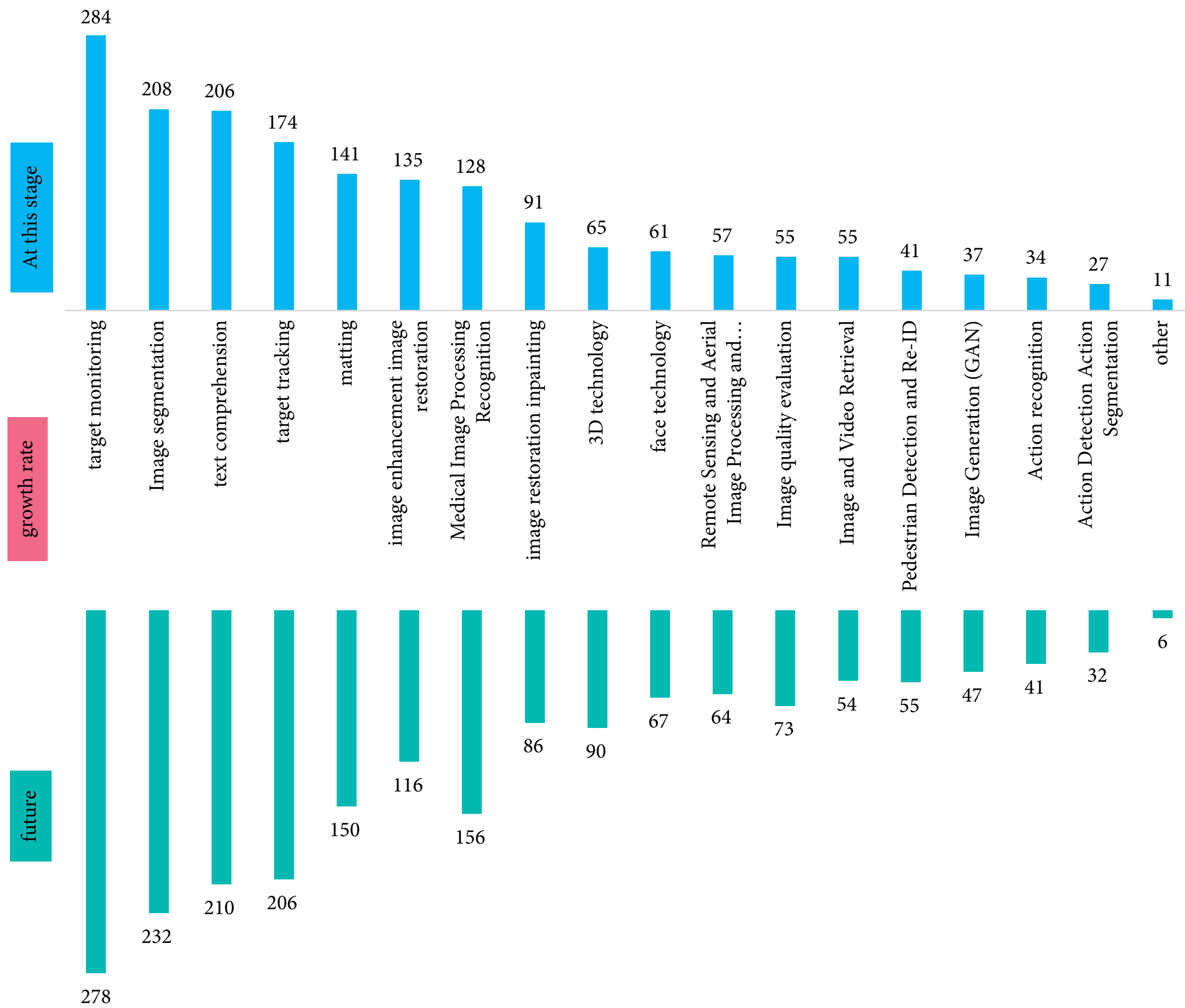

Figure 1: The development history of image recognition technology.

body movements is as high as 55% [7]. It can be seen that in life, the communication of information is more conveyed through human body language. In many cases, although people can disguise themselves through words, it is difficult to disguise their subconscious body movements. Therefore, it is very necessary to study the recognition of human body movements [8]. At present, body motion recognition technology has high research value and application value in this field [9].

In the process of decomposing martial arts routines, traditional action pattern recognition methods use the form of RGB images to identify, and the identification content includes action information and martial arts routines, but traditional methods are very sensitive to changes in light, viewing angle, frequency of actions, and other factors [10]. When the chain structure is used, the movement characteristics of Wushu routines are often manifested in the change of joint positions. Due to the limitation of the recognition method, the continuous movement cannot be recognized to a large extent [11]. The traditional recognition method is very difficult to recognize the human action in the low-dimensional motion space; the effectiveness of pattern recognition is less than 45%. Although complex dynamic data are required to describe human motion in low-dimensional motion space, martial arts routines are limited by the influence of kinematic mechanics [12]. This paper proposes a decomposition process of martial arts routines. It can effectively solve the limitations of angle, light perception, and other factors in traditional pattern recognition methods. Using the Kinect technology as the expression method of human body details features, it can effectively change the details of changes in the human body [13]. Maintain a high sensitivity and reoptimize the embedding method to achieve the continuity of low-dimensional motion space mapping, so as to solve the problem that the traditional method cannot continuously identify [14]. Therefore, this paper uses the human body sensor Kinect with the Visual Studio 2015 development platform for limbs. The collection and processing of action data, the use of deep learning neural network algorithms to train and recognize body movements, the design of a remote-control system for robots based on martial arts action recognition, the combination of martial arts action recognition and mobile robots, and finally the realization of the real-time control of remote robots [15].

2. Methodology

2.1. Introduction of the Kinect Device. Human action recognition is generally based on pictures or videos to carry out related research, aiming to classify various actions that occur in them [16]. With the successive advent of depth sensors represented by Kinect, classification through bone data and depth image database has become an important means of human behavior recognition research. The current into three processes: feature extraction, feature fusion, and behavior classification [17]. Liu et al. systematically studied the modeling and online updating methods of two-dimensional principal component analysis. The two-dimensional principal component analysis algorithm is applied to the foreground segmentation of overlapping blocks. Then, using the research methods of background difference, optical flow, and frame difference, the research model of the adaptive recognition method of martial arts decomposition VR image based on feature extraction is established [18]. As a successful image classification technology, deep learning has significant advantages in feature extraction. It can automatically extract features from preprocessed image data and has better robustness than artificially constructed feature vectors [19]. Therefore, deep learning-related technologies have been concerned by some scholars and gradually applied to human behavior recognition [20].

Kinect is a game somatosensory peripheral launched by Microsoft. It can enable players to get rid of interface devices such as mouse and keyboards and control the application by the player's body to achieve a natural human-computer interaction experience. This experience is due to Kinect. The principle of depth imaging and bone tracking technology. Kinect has its own development tools, which can not only obtain image and audio data but also develop related programs. Based on its powerful functions, Kinect has also been innovatively used in medicine, scientific research, monitoring, and other fields. There have been two generations of Kinect since its release: Kinect V1 and Kinect V2, which were released in 2012 and 2014, respectively. Compared with the Kinect V1, the properties of the Kinect V2 have been further improved, and some configuration functions have been enhanced.

The first camera on the left is an infrared emitting device, which is used to emit infrared light; the second camera in the middle is an RGB camera, which is used to capture color images; the third camera on the right is an infrared depth camera, which is used to receive infrared light reflection signals, and for depth imaging; the microphone array at the bottom is a plurality of microphone holes, which are used to collect sound signals within a specific distance and perform noise reduction processing. Therefore, the Kinect device can obtain three raw data streams, namely, color RGB image, depth data, and audio data. The establishment of a human behavior database promotes the research of behavior recognition algorithm, which can provide a common platform for many scholars to verify the recognition rate of different algorithms, which will undoubtedly become an important basis for comparing the performance of each algorithm. Kinect devices have established four common human behavior databases, including the MSR Action 3D database, MSR Daily Activity 3D database, UTD-MHAD database, and NTU RGB-D database. Among them, the UTD-MHAD database contains four-modal data: inertial sensor data, depth image sequence, RGB video, and skeletal motion sequence. These advantages of depth image and bone data enable researchers and developers of recognition system to pay more attention to the research of pattern recognition algorithm. There is no need to put too much energy into some front-end tasks such as image preprocessing. This greatly reduces the development time and difficulty of human motion recognition system. All these advantages make depth data have more application space in motion recognition than RGB images. Because the actions in this database have different execution speeds and large intraclass differences, there is a great deal of recognition difficulty. The four-modal data on the UTD-MHAD database are shown in Figure 2.

For the replacement of Kinect, the appearance of the two generations of products has not changed much, but the hardware performance has been improved. For example, the resolution of the RGB camera increased from $640 * 480$ to $1920 * 1080$, the resolution of the infrared depth camera increased from $320 * 240$ to $512 * 424$, and the transmission capacity of the USB connector increased from 60 MB/s to 500 MB/s; at the same time, the KinectV2, the skeletal tracking ability of the system, has been further enhanced. The number of skeletal nodes recognized by KinectVl has been increased from 20 skeletal nodes per person to 25 skeletal nodes per person. The system structure of Kinect is shown in Figure 3.

2.2. Obtaining Human Behavior Data Based on Kinect

2.2.1. Kinect Obtains Depth Image. Kinect obtains depth images according to its infrared emission device and infrared depth camera, and its specific imaging principle is shown in Figure 4. When Kinect's infrared emitting device emits infrared light onto the surface of the scene, the rough surface or transparent diffuser will scatter the light into randomly distributed light and dark spots, that is, the phenomenon of light interference. Because these light spots are independent of each other, and scattered points at different distances in the same scene will form different light spot patterns, this feature can be used to encode the location information of the scene. Then, through the CMOS sensor included in the Kinect infrared depth camera, the light spot pattern of each scattering point is collected, and then the depth image can be obtained through the relevant decoding operation. If the scene in the field of view moves, it will not affect the acquisition of position information, but correspondingly, the depth video will be generated at a rated frequency of 30 frames/s. The above is actually the depth imaging principle of KinectVl, and the depth imaging principle of Kinect V2 is different. Although KinectV2 still transmits and receives infrared light through the infrared emission devices and infrared depth cameras on both sides, it is based on the reflection principle of light and uses the built-in

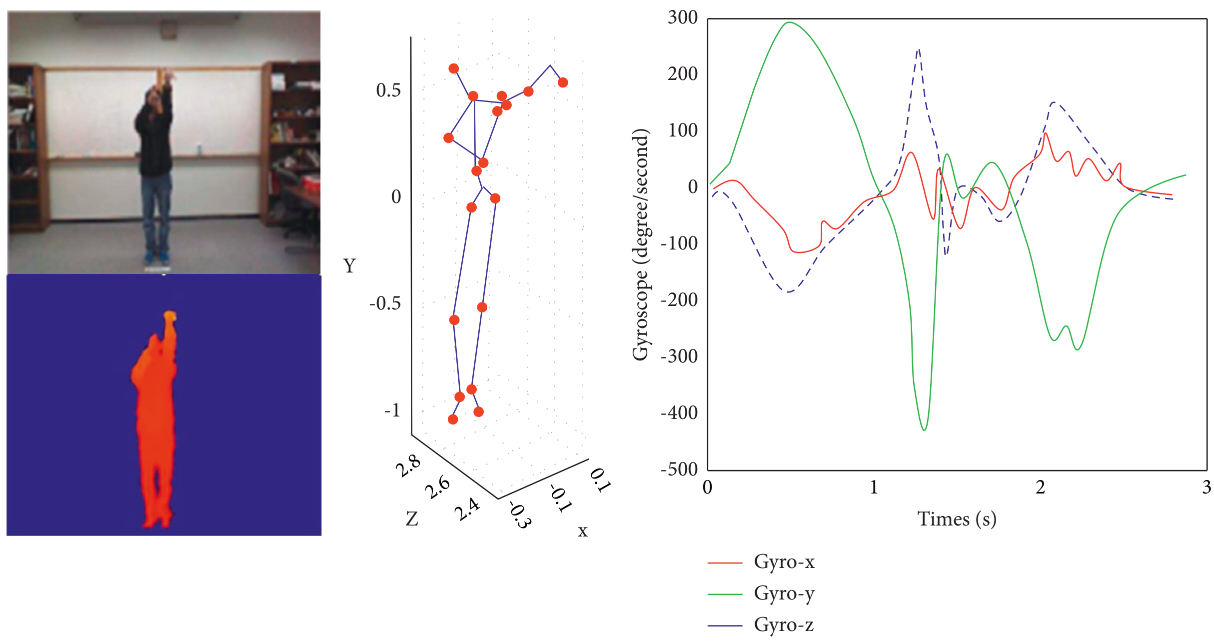

FIGURE 2: Four-modal data of UTD-MHAD database.

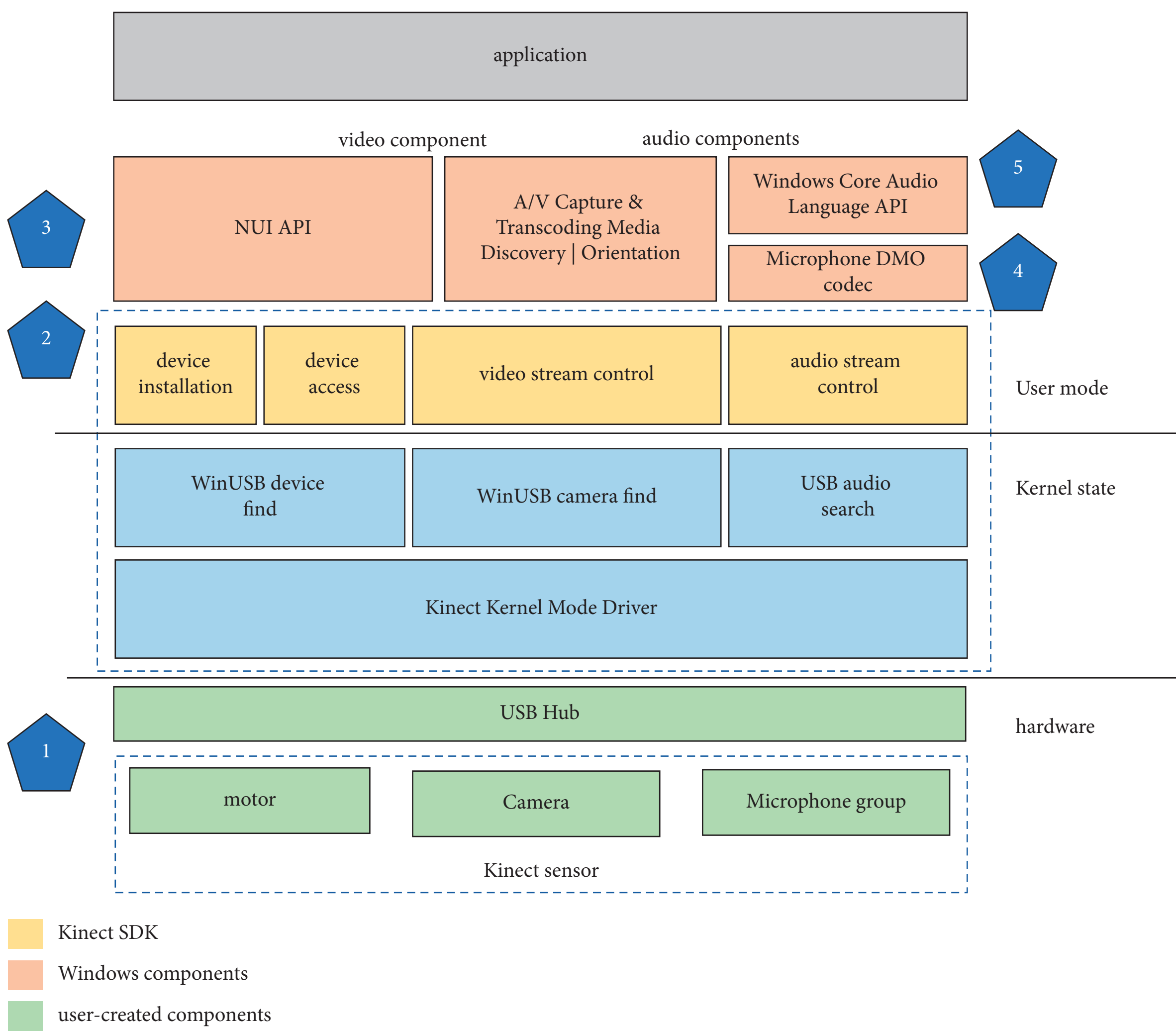

FIGURE 3: Kinect system structure.

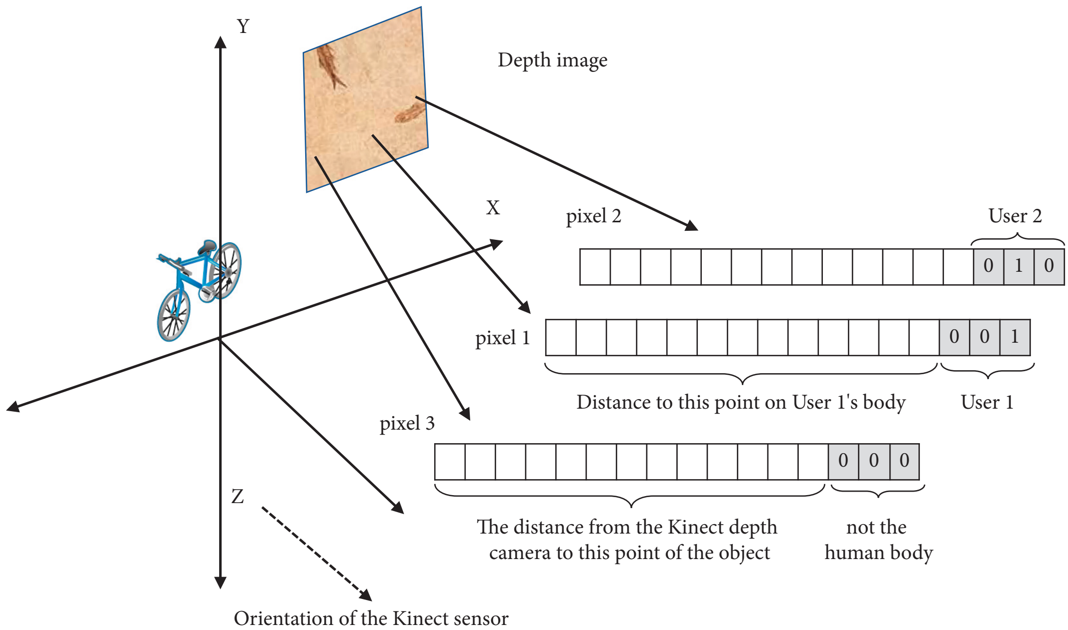

Figure 4: Kinect depth imaging principle.

photosensitive device to record the round-trip time difference of light so as to calculate the position information of the scene and obtain the depth image.

2.2.2. Kinect Obtains Bone Data. Bone positioning based on the depth image of human behavior can obtain human bone data, which should be attributed to the Kinect bone tracking technology. Bone tracking systems usually use depth cameras to obtain the most reliable real-time results, but at the same time, 2D cameras with open-source software can be used to track bones at a lower frame rate. In short, bone tracking algorithms can recognize the presence of one or more people, as well as the location of their heads, bodies, and limbs. Some systems can track hands or specific gestures at the same time but not all bone tracking systems. The principle of bone tracking technology is based on the method of computer vision, and its specific implementation is as follows: firstly, the obtained depth image of human behavior is image processed, and the distance information is used to detect the edge of human behavior; then, the detected target human body is imaged for the purpose of the behavior contour, which is extracted from the image background; secondly, the key parts of the human body and main skeletal nodes, such as head, limbs, and body are identified by machine learning methods; finally, the human skeleton model is established based on the Kinect coordinate system, and the three-dimensional coordinates of the skeletal nodes are generated. Figure 5 shows the human skeleton extracted by Kinect.

2.3. Deep Learning Technology. This method can be used to analyze the characteristic patterns of target objects. Compared with traditional machine learning, deep learning can avoid the trouble of manually designing features. The robustness of deep learning is that its performance is very stable, with more data. The more stable it is, the less reliable it will be. Secondly, versatility is also surprising. Many of the same business processes will do it, especially in the medical field. Many scholars have begun to refer to its algorithm to do some tumor analysis. Finally, scalability, because when doing data analysis, each data sample is independent of each other. These independent data can be used for training, and distributed clusters can also be used for parallelization of models and data. So as to quickly help model training and get a better accuracy. It adopts an end-to-end method to convert data input into target output. The intermediate process automatically collects low-level features of data to represent high-level features of the target. Deep learning corresponds to the deep-level structure in machine learning. Compared with the shallow-level structure, deep learning can better extract the high-dimensional features of the target, and is more suitable for processing data such as images and videos. Since the development of deep learning, many learning models have emerged, but they can be roughly divided into three types: discriminative models, generative models, and hybrid models. Among them, the discriminant model directly models the conditional probability $p(y|x)$, that is, it first learns the experience from the sample, and then extracts the corresponding features of the target to predict the label. Common discriminant models are: CNN and conditional random field (CRF) wait. The generative model models $p(x,y)$ then uses the Bayesian formula to find $p(y \mid x)$, and finally selects the one that maximizes $p(y \mid x)$. The calculation process is expressed as follows:

$$y = \text{argmax}_y p(y \mid x) = \text{argmax}_y \frac{p(x \mid y)p(y)}{p(x)} = \text{argmax}_y p(x, y). \tag{1}$$

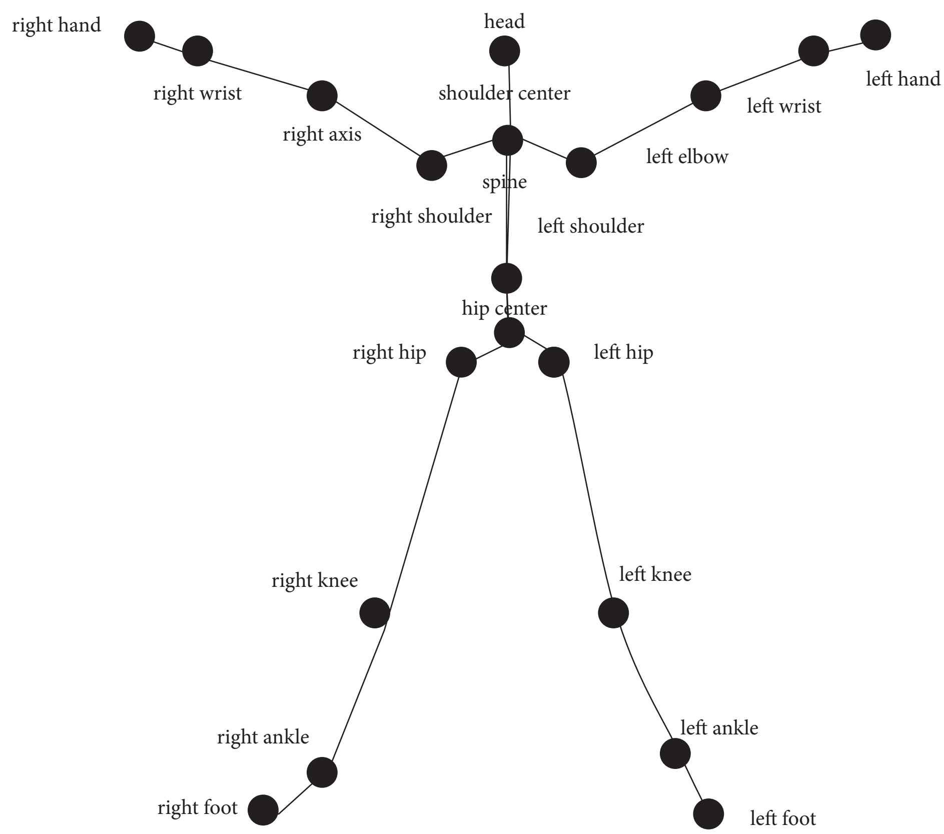

Figure 5: Kinect extracts skeleton diagram.

That is, first learn multiple experiences based on the characteristics of multiple samples, and then select the maximum value of the probability that the corresponding features of the target belong to each sample to predict the label. Regarding the comparison between the two, as shown in Figure 6, the hybrid model is the combination of the discriminative model and the generative model.

3. Methodology

3.1. Wushu Action Feature Extraction Based on Neural Network. Different neural network technologies have different accuracy in extracting martial arts movements. Figure 7 shows the accuracy results of neural network technologies including MLP and SVM in image feature extraction.

3.1.1. Preprocessing of Martial Arts Action Images. The depth image sequence is the depth image arranged in time sequence, which contains rich spatial structure and temporal information. The depth image at a certain moment is called the frame or the i-th frame of the depth image sequence. In order to construct each frame into a two-dimensional structure similar to a slice, this paper adopts a projection algorithm to obtain the three-dimensional information of the behavioral depth image. Specifically, each frame of the depth image Mapi (i represents the *i*-th frame) of the depth image sequence map is projected onto three orthogonal Cartesian plane coordinate systems to obtain the front view Map_f^i, side view Map_s^i and the top view Map_t^i is $\mathrm{Map}_v^i\,(v \in (f, s, t))$. The main steps to obtain Map_v^i in this article are as follows:

(1) Calculate the maximum pixel value of each frame of the depth image sequence:

$$\mathrm{Max} = \max\left(\mathrm{Map}_{a*b*n}\right), \tag{2}$$

where $a * b$ is the size of the frame and n is the total number of frames in the sequence;

(2) Determine the dimensions of the three projection views as

$$\begin{aligned}\mathrm{Size}\left(Map_f^i\right) &= a * b,\\ \mathrm{Size}\left(\mathrm{Map}_s^i\right) &= a * \mathrm{Max}.\end{aligned} \tag{3}$$

(3) If $\mathrm{Map}_f^i\ (x,y)$ represents the pixel in the xth row and the yth column of Map_f^i, when $\mathrm{Map}_f^i\ (x,y) \neq 0$, the projection formula of this pixel on Map_s^i is

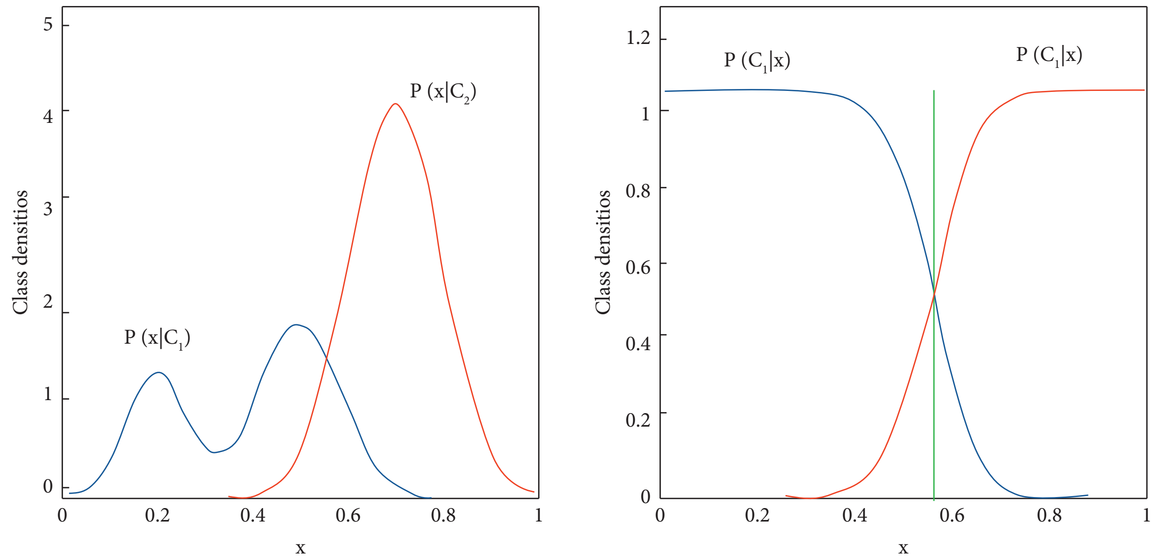

FIGURE 6: Comparison of generative models and discriminative models.

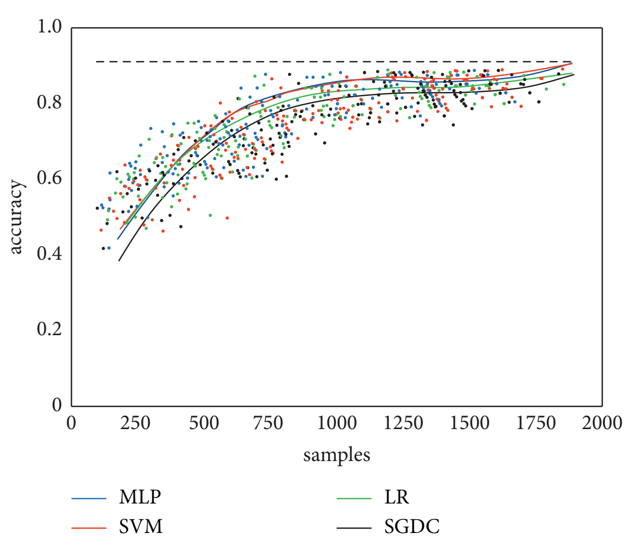

FIGURE 7: Accuracy of different neural network techniques for extracting martial arts action features.

$$\mathrm{JMap}_s^i\left(x, \mathrm{Map}_f^i(x, y)\right) = y. \tag{4}$$

The projection formula on Map_t^i is as follows:

$$\mathrm{Map}_t^i\left(\mathrm{Map}_f(x, y), y\right) = x. \tag{5}$$

After the above algorithm steps, the projected view Map_v^i of each frame of Map^i in each map can be obtained. Map_v^i contains the three-dimensional structure of the depth image sequence and extracts the spatial characteristics of the behavior, but lacks the temporal information of the behavior, so the acquired Map_v^i needs to be further processed.

The combined morphological operation formula can be expressed as follows:

$$G(x, y) = F(x, y).B(x, y) - F(x, y). \tag{6}$$

$G(x, y)$ represents the image processed by the combined operation; $F(x, y)$ represents a frame of image; $B(x, y)$ represents the structural element; and ● represents the closing operation. Complete target extraction. A frame of the video images cannot fully describe an action. Due to differences in motion rates, the number of frames per video image may be different even for the same motion. In order to deal with the changes of these two rates, the grayscale features of it on this into the image, and this are from the established images.

The operation process of the accumulated edge image is as follows: a frame of image processed by it in the video image is by $G(x, y)$; the edge of it by using this on $G(x, y)$. $E(x, y)$ indicates that this image; it by multiplying $G(x, y)$ and $E(x, y)$ on it is $I(x, y)$, and the grayscale information is on the edge point. If the pixel point is this, the grayscale value is 0; the accumulated edge image is by $H(x, y, t)$. The scale is of $G(x, y)$, and $H(x, y, t)$ is obtained to the $I(x, y)$ in a certain time window in the video image to one image.

Initialize $H(x, y, t)$, set all pixels to 0, and set the time condition to $t = 0$; based on edge detection, the first frame is the $G(x, y)$ of it can be obtained. The grayscale image $I(x, y)$ is the $G(x, y)$ and the $E(x, y)$; compare $I(x$ on all pixels, y) and the accumulated $H(x, y, t-1)$ obtained in the previous frame, the gray value of it with a larger gray value will be used of $H(x, y, t)$; repeat Edge detection step until all image operations are completed. The information content in this is huge, and the formula for it at point (x, y) at time t is

$$\begin{aligned} I(x, y) &= G(x, y)E(x, y), \\ H(x, y, t) &= \max(H(x, y, t-1), I(x, y)). \end{aligned} \tag{7}$$

Image into it, not accumulating each frame of binary image into one image. 0 and 1 are the only two values o fit of the $E(x, y)$, if this in the $E(x, y)$ and the $I(x, y)$ is 1. If it is accumulated for it, it contains this of more frame images, the directional gradient can be directly solved these.

If this is accumulated for it, the information center already contains it, and the directional gradient histogram can be directly solved all problems.

4. Result Analysis and Discussion

4.1. Experimental Data Setup. Simple descriptive statistics can only make a superficial description and a display of statistical data. In order to explore the regularity, we need to infer the statistical method. Inferential statistics is to infer the relevant population on the basis of collecting and sorting out the data of observation samples. According to the random observation sample data and the conditions and assumptions of the problem, an inference in the form of a probability is made for the unknown. That is the content of probability theory and mathematical statistics. To use descriptive data, it is necessary to set the data standard. In this paper, the human body is decomposed and set. The experimental data are shown in Table 1.

4.2. Human Wushu Action Recognition Based on Dynamic Time Regularization. The continuity, that is, an action can be a collection of it. The human body can reflect the change trend of it of this, and the angle change curve of it can be called it. The human motion features are joint angle time series. If the duration of a martial arts action is set to T, the motion features can be defined as follows:

$$\text{action feature} = \{A_1, A_2, \ldots, A_M T\}. \tag{8}$$

Here, vector A is the row; M is the number of motions, and the range is $1 \le M \le 16$.

The comparison of the focus of this, which will lead to it of the data, so the following formula is

$$x_i = \frac{x_1 + x_2 + \cdots + x_n + x_{n+1}}{n}. \tag{9}$$

X_i is the joint angle value at the i-th time; x_n, x_n+1 are the values of n and n+1 orders, respectively; n is an integer greater than 0.

The theory is based on the idea of it to find the distance between two test samples. The time is set to $R = \{r_1, r_2, \ldots, r_i, \ldots, r_{L_1}\}$, and the test sample is set to $T = \{t_1, t_2, \ldots, t_j, \ldots, t_{L_2}\}$.

The values at time i and j are r_i and t_j; L_1 and L_2 represent the lengths. The distance matrix $D(i, j)$ can be described as follows:

$$D(i, j) = \min \left\{ \begin{array}{c} D(i, j-1) \\ D(i-1, j) \\ D(i-1, j-1) \end{array} \right\} + \mathrm{d}(r_i, t_j), \quad i = 1, 2, \ldots, L_1;\ j = 1, 2, \ldots, L_2. \tag{10}$$

Here, $d(r_i,t_j)$ represents the distance function of r_i and t_j; $D(i,j-1)$, $D(i-1,j)$, $D(i-1,j-1)$ are the distance elements.

To make points r and t on the different angle Y-axis values, it is necessary to construct a three-dimensional vector based on points r_i and t_j to redefine $d(r_i, t_j)$ to replace the distance, that is, $r_i = [r_i, \dot{r}_i, \ddot{r}_i]$ and $t_j = [t_j, \dot{t}_j, \ddot{t}_j]$, the first derivative $\dot{r}_i$ of it and the $\ddot{r}_i$ of the reference sequence are described in turn as follows:

$$\begin{aligned} \dot{r}_i &= \frac{(r_i - r_{i-1}) + ((r_{i+1} - r_{i-1})/2)}{2}, \\ \ddot{r}_i &= r_{i+1} + r_{i-1} - 2r_i, \end{aligned} \tag{11}$$

where r_i−1 is value at the i−1th time; r_i+1 is the value in i+1th time point. Since the vector is beneficial to the accuracy of the mapping, $d(r_i, t_j)$ can be defined as follows:

$$\mathrm{d}(\ddot{r}_i - \ddot{t}_j) = w_1(\ddot{r}_i - \ddot{t}_j)^2 + w_2(\ddot{r}_i - \ddot{t}_j)^2 + w_3(\ddot{r}_i - \ddot{t}_j)^2. \tag{12}$$

Here, $\dot{t}_j$ represents the first-order derivative value of it of this; $\ddot{t}_j$ is the second-order value of it of this; w_1, w_2, and w_2 represent, respectively. Adjust the weight of it of the value, and adjust the first-order value of angle. The shortest distance weight and the shortest distance weight of the second derivative of the adjustment it.

Its extraction of this in the image is carried out by the Kinect technology, and then the time sequence of it is calculated by it. Martial arts action decomposition and identification process.

4.3. Analysis of Experimental Results

4.3.1. Analysis of Experimental Results Based on NReJ3D Technology. During the experiment, two pieces of muscle pattern recognition data and two pieces of joint transition recognition data were selected, respectively. The experimental recognition results are shown in Figure 8. The basic idea of action recognition is to use the sample data in the action data set. Nrej3d technology is used to match the angle features extracted from the sample training set with the angle features in the test set. It can be seen that, at the beginning, the traditional method is slightly better than the recognition method. But in the subsequent experiments, it is not higher than this method. Therefore, the recognition method proposed in this paper has stronger recognition ability. Therefore, the angle between bones can be used to replace the changes of bones, that is, the changes of actions, so as to recognize actions. Not all the joint points in the action data set can be used, so unnecessary joint points can be filtered out to realize the dimension reduction processing of the data, making the data more reliable and universal.

4.3.2. Method Comparison Based on MSR Action 3D Database. After discussing and analyzing the influence of different ensemble decision methods on the behavior recognition results, the average value method ensemble decision that is most suitable for the algorithm model in this paper is proposed. The experimental results show that the average of the algorithm on the MSR Action 3D database

Table 1: Experimental parameter settings.

Superficial muscle movement	Large joint movement
Vastus rectus, VR	Flexion, leg lift, and kick
Tibialis anterior, TA	Dorsiflexion, inversion, and adduction
Peroneus longus, PL	Use group eversion and plantar flexion to flex the forearm, lift the heel, and fix the joint
Gastrocnemius, Gs	Upper body leaning forward (similar to the movement of the lateral gastrocnemius muscle on the inside)
So leus musc, SM	Fixed joints, back support, and half body rotation
Tuorp lrgsiing, TL	Stabilize the half body and rotate the lower body ankle joints

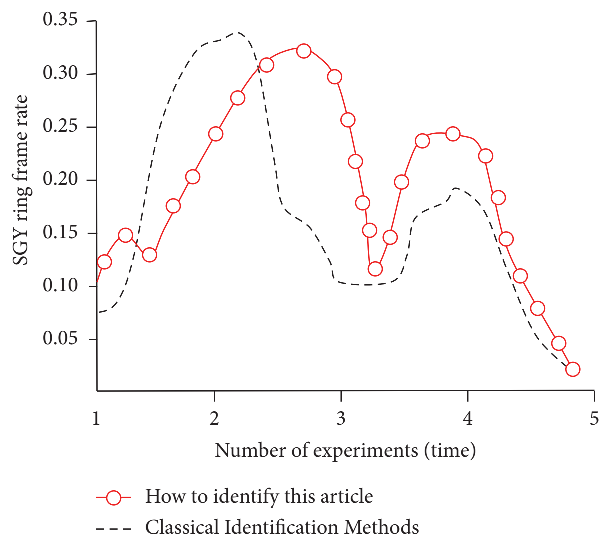

Figure 8: Comparison of experimental results.

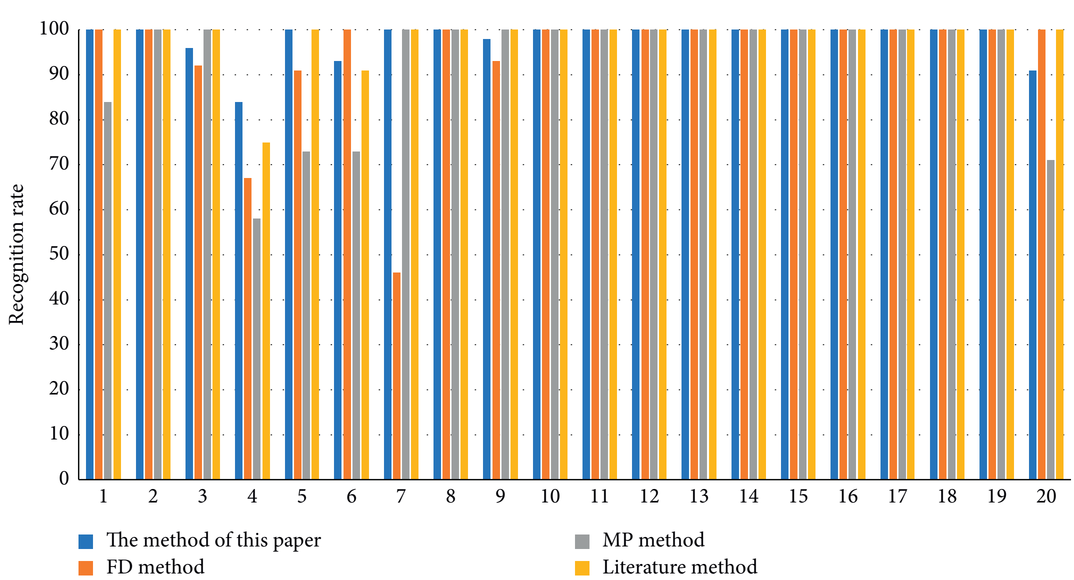

Figure 9: Classification and recognition performance of this paper and the other three methods.

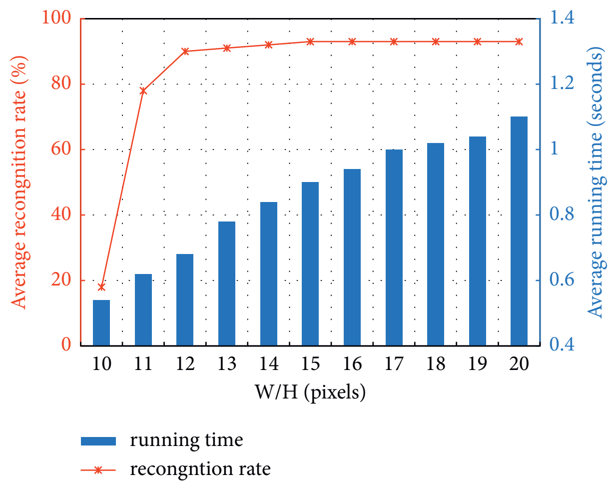

Figure 10: Accuracy and speed of the recognition algorithm in this paper.

reaches 98.1%, which verifies the effectiveness of the 5C–CNN model construction, which was further analyzed through the confusion matrix, and the recognition performance of the 5C–CNN model based on the mean value method ensemble decision on the MSR Action 3D database test set was further analyzed. This paper will compare other literature algorithms using the same experimental settings on the same database. The experimental results are compared in Figures 9 and 10.

5. Conclusion

As a research hotspot at this stage, human behavior recognition has been successfully applied to various fields of life and technology. With the emergence of Kinect devices, the research object of human behavior recognition has gradually changed from traditional RGB images to depth data that is not easily disturbed by noise. Based on the research status at home and abroad, depth image-based, bone data-based, and deep learning-based have become the three major directions of human behavior recognition in recent years, but the above studies still have their own problems: human behavior recognition based on depth images. Higher actions lead to misjudgment, and this based on skeleton data has serious self-occlusion problems. Human behavior recognition based on deep learning requires the model to make corresponding structural adjustments to different data. We propose a deep learning algorithm for human action recognition based on Kinect multiview features. Behavior recognition combined with depth images and skeleton data can better make up for the lack of single data and enrich the details of behavior to a greater extent. In this paper, the recognition experiment is carried out on the MSR action 3D database, the influence of different ensemble decision methods on the recognition results is further discussed and analyzed, and the average value method ensemble decision that is most suitable for the algorithm model of this paper is proposed. The results show that the recognition accuracy of the algorithm reaches 98.1%, proving the feasibility of the preprocessing algorithm.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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Research Article

Analysis of the Operation and Management of Higher Education by Using the Media Platform

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Universities are considered the main place for university students to study and live and also shoulder the important task of training talents for the future of our country. As a manager of university education and the relevant supervisor of education and teaching, it must constantly seek more efficient teaching mode and use the new communication platform in order to solve the current problems in the management of higher education. Since the media platform plays an important role in the social and political and economic life, it affects the way of education and the way of thinking in universities. Self-media technology promotes the communication between teachers and students in the teaching process. Educators can carry out a variety of teaching through the media, which innovates the educational methods of the University. This fully reflects the advantages of we media teaching in the media era. As a new means of information dissemination, the self-media platform not only has the traditional media communication functions but also gradually affects the way of thinking and lifestyles of university students to promote their correct world outlook, outlook on life, and formation of values. In this paper, self-media platform is used for university education and operation management process to conduct a systematic analysis and research. The Delphi method is used to screen out five major dimensions of hardware platform, content construction, communication mode, the quality of teachers and students in universities, and the environment of media network dissemination and interpret the positive effects of self-media platform in improving university teaching and operation management efficiency. Based on particle swarm optimization (PSO) algorithm, the importance distribution of the five dimensions is identified and an optimal path of university education operation and management is constructed to improve the overall efficiency of university education operation and management.

1. Introduction

The actual effect of university education operation and management will directly affect the improvement of university teaching quality and the quality of university graduates, so how to improve the operation and management of higher education has become a hot social issue [1]. In recent years, with China's economic and social development and progress, the specific teaching mode and training mode have been optimized, but in specific ways on the dissemination of knowledge, it is too single, and the management philosophy and philosophy of education are relatively backward, which is bound to affect the efficiency of education management and the actual effect [2]. In the actual education and management work, many universities have stressed the need to strengthen the teaching management of university students but lacked specific management methods and management channels [3]. At present, the actual operation and management methods of universities are based on traditional conference mode, classroom mode, and group mode, and the supervision of the specific implementation process is not enough, so the real-time management is less effective [4]. The education management work in universities needs to make student management as the center [5]. At present, many university classroom teaching does not start from the perspective of students, nor does it always adhere to the student-oriented education concept [6].

With the development of computer science and technology and Internet media, the development of we media platform has gradually entered public life. The mode of culture and knowledge transmission is gradually changing from the traditional one-way transmission to the two-way cross individual flow mode [7]. As a young group with a certain knowledge reserve, university students should be the core audience in the era of self-media, and their ideological consciousness, behavior style, and values have been deeply affected [8]. In today's diversified environment, the teaching of professional knowledge, the cultivation of core values, and the communication between teachers and students need to rely on the self-media platform to improve their competitiveness [9]. How to make rational use of self-media as a new media means is an important issue that needs to be paid attention to in the ideological and political education of higher education in China. The positive results of the cultivation of College Students' core values can improve the negative effects caused by the poor management of the media environment [10]. Based on the investigation and analysis of related data, this paper explores how to use self-media platform to improve the operation and management efficiency of universities [11–13]. The algorithm in this paper is simple and easy to implement without adjustment of many parameters [14]. At present, it has been widely used in function optimization, neural network training, fuzzy system control, and other application fields of genetic algorithm [15]. Five elements that are closely related to the self-media platform are selected. Based on particle swarm optimization algorithm, an optimal element distribution path is found [16]. This paper aims to solve the problems in the operation and management of the current we media platform in Colleges and universities. The current management problems include poor information communication, low efficiency of operation and management, and the management mode cannot be implemented. Therefore, it is necessary to further improve the management efficiency of colleges and universities [17, 18].

2. Research Status

2.1. The Status of Domestic Research. The group of campus we media is mainly students, and a few are graduates, teachers, and parents. The content theme is mainly related to students, and the content is mainly professional learning, campus life, etc. At present, the vast majority of we media are public welfare, especially the official media. Only a few are for-profit [19]. Campus media is the epitome of social media, and many changes have taken place. With the development of the Internet, the information dissemination and communication methods of self-media platform are widely used in all kinds of universities. The interaction between communication media and traditional media is very different [20]. Its outstanding spread characteristic is the mutual dissemination between the media and the audience, and in the process of mutual communication, there are also broad, fast, fair, and other characteristics between the two. Through the analysis of the communication form and characteristics of the self-media, Wang Li found some invalid phenomena in the dissemination of the media from the modern society. At the same time, the author also proposes to strengthen the sense of social responsibility operation of network operators to regulate the phenomenon of self-media failure. From the characteristics of the media itself, its development is accompanied by certain vulnerabilities and drawbacks. Through the research and comparison of these problems, many scholars have given corresponding solutions, which provide new ideas for the development and improvement of the media itself. But the analysis of the literature in this area is more focused on the practical problems and the reasons, not closely integrated with the training contents of the socialist core values to provide guidance for the cultivation of university students' work. The media has strengthened the propaganda of socialist core values. The media has a positive impact on the cultivation of socialist core values, and there are three main aspects. First, the rich content of the media can make the cultivation of socialist core values more vivid. Secondly, due to the media interaction and timeliness, teacher-student interaction has been strengthened. The timeliness of Cultivating College Students' socialist core values has been enhanced. Finally, through the media platform, management efficiency and results can be improved in higher education. The new "new media era" requires colleges and universities to do a good job in the management and construction of various new media platforms. There are not only the external requirements of the superior departments to improve the level of government information and patient service but also the internal needs of the school to serve teachers, students, and staff.

3. Foreign Research Status

Foreign research on self-media platform mostly focuses on social influence. A media report from the American Journalism Institute gives a detailed explanation of the concepts, characteristics, modes of transmission, and dissemination effects of the media from the angle of the media, arousing worldwide sensational effects. Online blogs are the earliest forms of media that originated in the media. The whole trajectory of self-media development has followed the path of old media-new media-self-media. In his article, William, a well-known British mediaman, discusses how self-media spreads information through traditional media, and at the same time, the author points out that there are many potential advantages compared with traditional media. Gilmer once pointed out the following. Since the advent of media communicators, the traditional way of social hot news dissemination has been radically changed, and social media is no longer one to many. But is determined according to the way in which the information disseminator and the receiver communicate with each other.

4. Methods

Teaching operation management refers to the management of teaching process and other work according to the teaching plan. The content of teaching operation management includes organizing teaching activities, formulating syllabus, formulating teaching courses, dividing teaching venues, and arranging teachers to attend classes, as well as organizing examinations, marking papers, and other work. Therefore, it is necessary to fully understand the current situation of the operation and management of colleges and universities, analyze the problems existing in the management process, and take corresponding measures to solve them, so as to improve the management level of teaching in colleges and universities. There are many indicators of operational management efficiency in universities related to the self-media platform. The Delphi method is applied to select the five most important index dimensions from a large number of indicators. An expert set $E = \{E_1, E_1, \ldots\ldots, E_m\}$ is defined, where E_i is the ith expert and the evaluation set is defined as $A = \{(a_1, r_1), (a_2, r_2), \ldots, (a_n, r_n)\}$, where (a_i, r_i) is the original evaluation set given by the ith expert, a_i is the specific evaluation value, and r_i is the fluctuation range of the evaluation value.

The best evaluation index set is an optimized evaluation set based on the original evaluation to meet the requirements of diversity, reliability, and convergence of indicators. The best evaluation index set can be expressed as:

$$x_i = \{x_1, x_2, \ldots, x_n\}. \tag{1}$$

In the knowledge integration results of expert group, weighted mean $U(x)$ and standard deviation $\sigma(x_i)$ can be expressed as

$$\begin{cases} U(x_i) = \sum_{i=1}^{n} x_i \times w_i, \\ \sigma(x_i) = \sqrt{\sum_{i=1}^{n} \left[x_j - (U(x))^2\right] \times w_i}. \end{cases} \tag{2}$$

In formula (2), w_i is the weight coefficient; based on the expert evaluation knowledge set, the normal distribution of the importance distribution of the index is obtained. The importance of using particle swarm algorithm to extract the index is optimized to find the best way to improve the efficiency of operation management by using the self-media platform. In the d dimensional space, let any factor a be z_i that has an important impact on university management, then the population composed of these particles is $S = \{\overrightarrow{z_1}, \overrightarrow{z_2}, \ldots, \overrightarrow{z_m}\}$, where any one of $\overrightarrow{z_i}$ is $\{z_{i1}, z_{i2}, \ldots, z_{\text{id}}\}$, representing the vector point of i-th particles in the d dimensional space. $\overrightarrow{P_i} = \{p_{i1}, p_{i2}, \ldots, p_{\text{id}}\}$ is used as the optimal location in the process of particle optimization, and $\overrightarrow{V_i} = \{v_{i1}, v_{i2}, \ldots, v_{\text{id}}\}$ is the optimal speed; then, in d dimension space, the path optimization process of the influence factors in the self-media platform can be described as

$$\begin{cases} \overrightarrow{V_i^{k+1}} = \overrightarrow{V_i^k} + \varsigma_1 \times \kappa_1 \times \left(\overrightarrow{p_i^k} - \overrightarrow{z_i^k}\right) + \varsigma_2 \times \kappa_2 \times \left(\overrightarrow{p_j^k} - \overrightarrow{z_i^k}\right), \\ \overrightarrow{z_i^{k+1}} = \overrightarrow{z_i^k} + \overrightarrow{V_i^{k+1}}. \end{cases} \tag{3}$$

The particle movement diagram affecting the efficiency of operation and management of higher education is shown in Figure 1.

Through the optimization of the path of particles with different influence factors, it can identify the distribution of factors affecting the efficiency of operation and management of higher education and achieve the purpose of strengthening the operation and management of higher education by using the self-media platform.

5. Results

The construction of educational informatization generally includes infrastructure, information resources, various applications, standards and norms, talent training, support and gap protection, and so on. In order to facilitate statistics, the statistical indicators of educational informatization mainly select indicators that are easy to quantify and closely related to the degree of development, and the meaning of each indicator is relatively simple. The form filling person is easy to understand, but all indicators can well predict the development of school informatization. In the process of selecting the relevant indicators of the university education media platform, 10 experts are invited to mark the importance of the index, and the statistical information obtained is shown in Table 1.

Based on the knowledge aggregation statistics of the expert team, five major dimension indicators of hardware platform, content construction, communication mode, college teachers and students' literacy, and network communication environment are selected. Then, based on the PSO algorithm, the distribution of the importance of factors is recognized to find out an optimal path to improve the efficiency of university education and operation management. Genetic algorithms, ant colony algorithm distribution, and particle swarm optimization algorithm for path optimization results are compared, and the results are shown in Figures 2 and 3.

From Figures 2 and 3**,** we can recognize that the particle swarm optimization algorithm has the shortest optimal path and the highest efficiency. Due to the shortcomings of precocious maturity, genetic algorithm has larger deviation in the later stage of the path selection. However, the ant colony algorithm has large deviation in the initial stage of path finding and can correct the deviation in the later stage, but the overall path finding effect is not as good as the particle swarm optimization algorithm (Figure 4).

From the path optimization error comparison of higher education operation and management, it can be clearly analyzed that the result of particle swarm algorithm is closest to the theoretical value, and the errors of other two path optimization algorithms are greater.

6. Discussion

Since the type of self-media platform has a variety of characteristics, in the specific application process, we should highlight the interactive mode of self-media, and through the self-media platform, the information interaction and dissemination in the management of universities are achieved. In the self-media age, the ways of interacting with university management information have surpassed the

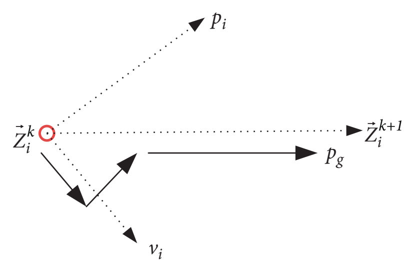

Figure 1: Principle of particle movement.

Table 1: Statistics of expert knowledge sets.

Expert	Weight w_i	Evaluation value a_i	$(a_i - E)^2$	$w_i a_i$
1	0.15	80	5.69	12.58
2	0.05	90	55.41	5.47
3	0.20	75	12.87	2.25
4	0.04	86	131.46	17.54
5	0.08	69	94.36	9.87
6	0.16	75	254.58	4.56
7	0.11	68	9.87	8.77
8	0.04	95	154.7	7.76
9	0.10	88	0.08	7.64
10	0.07	79	17.87	9.36

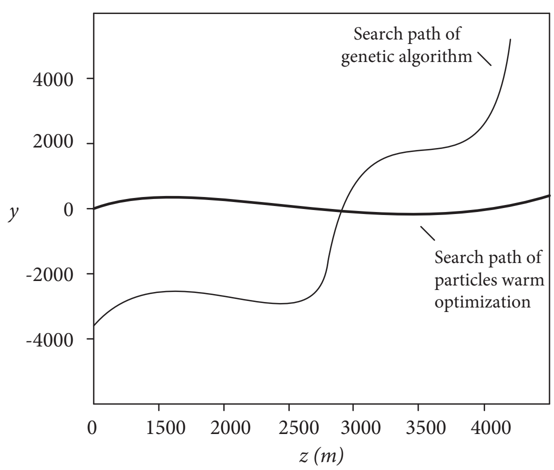

Figure 2: Result comparison 1 of operation and management path optimization algorithm.

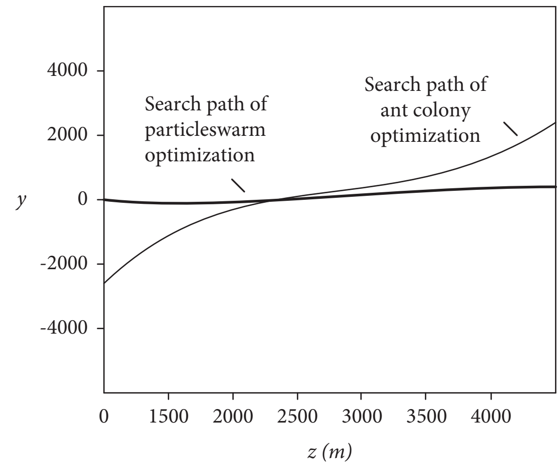

Figure 3: Result comparison 2 of operation and management path optimization algorithm.

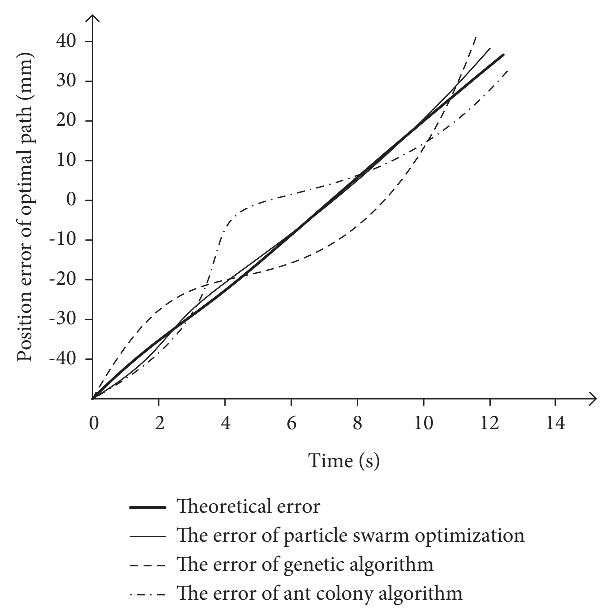

Figure 4: Comparison of path optimization error of university education operation and management.

existing ways of interaction. The new self-media platform of universities needs to be more humane, in order to meet the needs of university operation and management.

(1) There are many self-media platforms that affect the operation and management of universities. Excessive interference factors are not conducive to finding an optimal management path. This not only wastes too much college resources, but also is not conducive to the improvement of teaching management efficiency. From the analysis of actual operational results of the Delphi method, the relevant experts are consulted to identify and classify the affected factors to find out five key factors related to the operation and management of universities as well as the hardware construction, content construction, communication mode, quality of teachers and students in universities, and network communication environment related to the media platform.

(2) The five factors screened out are still different in the degree of importance distribution. Based on the particle optimization algorithm, this paper determines the importance distribution of the five factors, that is, to improve the quality of teachers and students in universities $\longrightarrow$ to optimize the environment of network communication $\longrightarrow$ to enhance the hardware construction of platform $\longrightarrow$ to optimize the content $\longrightarrow$ to optimize communication mode. Compared with genetic algorithm and ant colony algorithm, particle swarm optimization has obvious advantages in speed optimization and position optimization and performs well in error control.

7. Conclusions

Since the type of self-media platform has a variety of characteristics, in the specific application process, we should highlight the interactive mode of self-media. Through the self-media platform, information interaction and dissemination in the management of universities can be achieved. In the self-media age, the ways of interacting with university management information have surpassed the existing ways of interaction. In the process of teaching, a new way of discourse is achieved, and the teaching content is effectively communicated to protect and expand the coverage and influence of the educational discourse and enhance the sense of the times and science of higher education. In view of the new situation of university education and self media, it is necessary to clarify the specialization direction, main contents and main measures of university education under the new situation. The various types of self-media and related educational resources are integrated to realize the promotion effect of media platform on teaching. Putting forward relatively complete and more feasible ideas can meet the needs of university operation and management.

7.1. Research Contribution

(1) From the perspective of self-media platform, the operation and management mode of higher education is studied in this paper.

(2) In the process of identifying and extracting the influence factors in the self-media platform, the Delphi method and particle swarm optimization are innovatively combined to improve the operation and management of university education.

(3) In the analysis of the influence factors of higher education operation and management, the best path to improve the operation and management of higher education is obtained.

7.2. Research Status and Problems

(1) Operation management method and mode are too single, and the actual operation effect is poor.

(2) The existing research method plays a role of bridge between universities and students.

(3) The current study does not show the most efficient operation and management method of the universities' education.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Analysis on Influencing Factors of Consumer Trust in E-Commerce Marketing of Green Agricultural Products Based on Big Data Analysis

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In order to avoid consumers' irrational purchase behavior due to e-commerce marketing and affect the normal operation of e-commerce market, this paper analyzes the influencing factors of consumer trust in e-commerce marketing of green agricultural products based on big data analysis. We construct the influencing factor model of consumer trust and analyze the types of influencing factors of consumer trust. The K-means clustering method is used to collect the relevant data of green agricultural products' e-commerce marketing and consumers' irrational purchase behavior in the big data environment. The influencing factors of consumers' trust in green agricultural products' e-commerce marketing are analyzed with the professional degree, credibility, and attraction of e-commerce marketing as independent variables; consumers' purchase behavior as dependent variables; and consumers' purchase emotion as intermediary variables. The experimental results show that the designed method has certain reliability and good effectiveness, and plays a positive role in irrational purchase behavior.

1. Introduction

In the big data environment, network information has the characteristics of a large amount of data and high dimensions [1, 2]. There are important changes in people's shopping methods [3]. People have changed from traditional shopping methods to online shopping methods. Online shopping can meet the personalized shopping needs of consumers. It has the characteristics of diversity and portability [4], and has become the main shopping way in human life. Purchase behavior is a complete process composed of a series of links and elements, in which purchase decision is at the core; whether the decision is correct or not directly determines the occurrence mode, direction, and utility of purchase behavior. Under big data analysis, human beings can obtain information quickly and intuitively [5, 6]. Among them, big data analysis refers to the analysis of large-scale data, which can be summarized as five Vs, including large volume, velocity, variety, value, and veracity. With the rapid development of the We-media platform in the network, social software widely exists in people's life, and e-commerce marketing capital has become an important way of capital. E-commerce marketing is a new way for people to buy products [7]. With the rapid rise of e-commerce marketing industry, the concept of online red economy came into being. When consumers buy products, they are vulnerable to the influence of online red economy [8] and cannot judge the product quality through a mature consumption view. In the big data environment, consumers' shopping methods are vulnerable to bad atmosphere [9, 10], which makes consumers form a large number of irrational buying behaviors. Therefore, it is very important to study the influencing factors of consumer trust in e-commerce marketing of green agricultural products.

Relevant scholars have put forward many studies. Reference [11] studies the impact of culture and moral ideology on consumers' moral concept of online retailers and its impact on their loyalty. The main purpose of this study is to develop a comprehensive model and empirically test it. This model examines the antecedents and results of consumers' moral cognition of online retail. Quantitative methods were used to collect data from 797 consumers, and Amos 22.0 was used to evaluate the association between potential variables. The results show that uncertainty avoidance and power distance are the key drivers of idealism, while masculinity and individualism are the key predictors of egoism. Idealism is negatively correlated with consumers' cognition of e-retail ethics, while egoism has a positive impact. Finally, there is a positive correlation between customers' cognition of e-retail ethics and customer loyalty. The impact on practitioners and scholars is discussed. Reference [12] pointed out that due to the emergence of Indian online store model, consumers' views on physical store discounts have changed. The end-of-quarter sale has always been one of the most important long-term promotions/discounts for physical retailers and consumers in India. However, since the emergence of the online retail model in India, consumers now have a wider range of choices and can buy products at discounted prices. It is worth noting that consumers' views on physical store discounts are expected to change as online stores in India take product discounts as one of the key drivers of consumers' purchases. This change in consumer views has put most physical retailers in trouble in India, and they are slowly losing market share to online retailers. In this study, the author attempts to investigate the evidence, mode, scale, importance, and the impact of this change on discounts from the perspective of stakeholders, and translate the research results into suggestions to enable physical retailers to design appropriate promotional activities. Although some progress has been made in the above research, the research under the background of big data analysis is not enough to deeply analyze the analysis and impact of the economy on consumers' irrational purchase behavior. Therefore, taking big data analysis as the research background, this paper analyzes the influencing factors of consumers' trust in e-commerce marketing of green agricultural products. First, the model of influencing factors of consumer trust is constructed, and the types of influencing factors of consumer trust are analyzed based on the model.

2. Analysis on Influencing Factors of Consumer Trust in E-Commerce Marketing of Green Agricultural Products Based on Big Data Analysis

Consumer behavior is dominated by motivation, so consumers' purchase behavior should first analyze consumers' needs and desires. The main factors affecting consumer behavior are as follows:

(1) *Product Factors*. It includes the characteristics of green agricultural products, the price of green agricultural products, the convenience of shopping, safety and reliability, etc.

(2) *Psychological Factors*. Consumers' personality psychology, including consumers' needs, motivations, interests, ideals, beliefs, world outlook, and other personality psychological tendencies, and ability, temperament, personality, and other personality psychological characteristics, are internal factors that affect consumers' behavior. Consumers are affected by many main psychological factors in purchase decisions. It mainly includes motivation, perception, learning, beliefs, and attitudes.

(3) *Income Factor*. The economic environment of marketing mainly refers to the external social and economic conditions faced by enterprise marketing activities. In particular, it mainly refers to social purchasing power. Generally, the factors that affect the purchasing power level include the following three aspects: consumer income, consumer expenditure, and household savings and consumer credit.

(4) *Social Factors*. Social factors refer to the influence of people around consumers on them, among which reference group, family, and role status are the most important.

(5) *Cultural Factors*. Culture refers to the complex of values, morality, ideals, and other meaningful symbols established by human beings over lifetime. Culture is the basic factor that determines human desires and behaviors.

2.1. Model of Influencing Factors of Consumer Trust

For a long time, a large number of high-quality green agricultural products have stopped in the traditional business model, with low brand sales and poor influence [13, 14]. In order to enhance brand influence and promote enterprise development, it is imperative to do advanced marketing with the help of brand social responsibility. Social responsibility makes consumers emotionally dependent. Only by establishing the loyalty between agricultural products and consumers can we recommend products with the highest recognition. While undertaking social responsibility, we can make intelligent recommendations according to the consumption decision-making behavior and complete the transformation of competition [15]. We build a model of influencing factors of consumer trust, as shown in Figure 1:

As shown in Figure 1, the influencing factor model of consumer trust is mainly divided into three parts: information collection, decision-making behavior analysis, and intelligent recommendation calculation [16, 17]. The information collection module mainly classifies consumer behavior habits and basic information, the decision-making behavior analysis module mainly classifies consumer information and behavior, and the intelligent recommendation calculation module recommends the classification results to consumers through different channels.

2.1.1. Part I: Information Collection Module

It is the entrance of the recommendation tie line to collect consumer information and submit it to the intelligent recommendation calculation module [18, 19]. First, we determine the

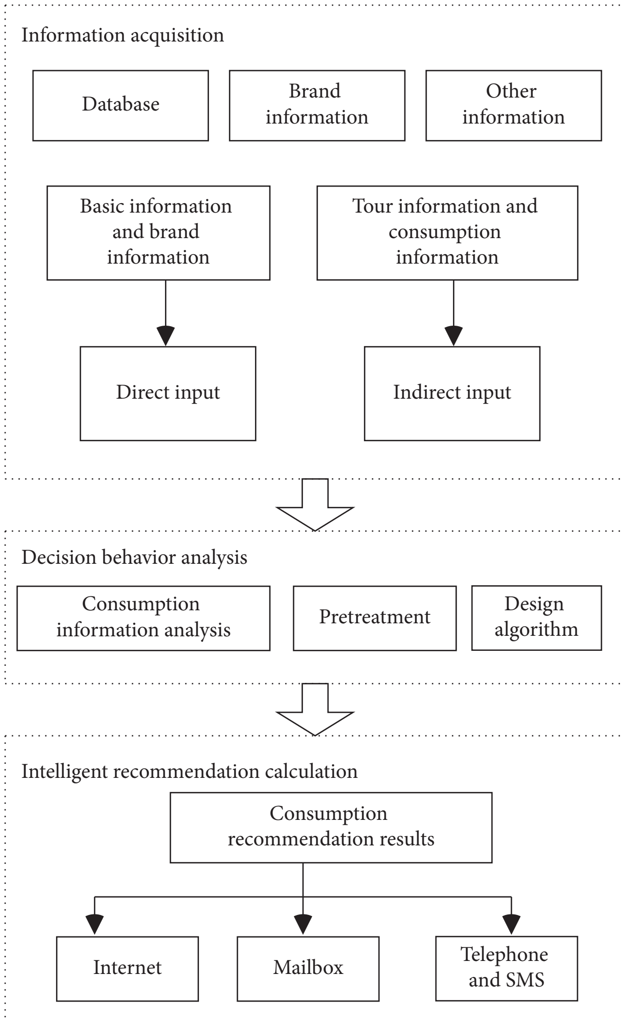

Figure 1: Model of influencing factors of consumer trust.

information sources. There are many new information sources for green agricultural products, including brand and other information in addition to consumer information. After classifying the information sources, there are mainly two input methods.

(1) *Direct Input*. It is the main way for the system to extract information and the highest recommendation basis of value type. It mainly comes from consumption information, social evaluation, brand sale strategy records, etc. In the design of the influencing factor model of consumer trust, relevant information should be recorded in detail to ensure the integrity and accuracy of first-hand data, so as to better analyze consumers' preferences and needs.

(2) *Indirect Input*. It is the unlimited mining of consumer information through data mining or artificial intelligence means to analyze consumer psychology.

2.1.2. Part II: Decision Behavior Analysis Module [20]. We feedback the score and evaluation of green agricultural products. For the intelligent recommendation model designed in this paper, most of the recommended objects are users who pay attention to green agricultural products, so they directly output in the form of SMS to feedback the impact of social responsibility of green agricultural products on brand sales [21, 22].

2.1.3. Part III: Recommended Calculation Module. The core factor affecting consumer trust is the analysis of the consumer trust module [23, 24]. In order to cooperate with the next calculation, the next choice is judged according to the data representation model. The recommendation results are generated from the data results generated by the decision behavior analysis module, as shown in Figure 2.

In the process of intelligent processing, the recommended results are quickly transmitted to a variety of situations, which is shown in Figure 2. The basic principle is that consumers not only care about the purchased goods but also consider the possibility of other goods. Consumers will regret and rejoice at other results when purchasing goods, and try to avoid the probability of regret [25, 26]. Consumers' decision-making behavior is affected not only by their own behavior but also by other factors, that is, imitating neighbors' decision-making behavior. Individual imitation of others is related to personality characteristics. The greater the similarity between them, the higher the probability of imitation; on the contrary, the lower the similarity, the smaller the imitation probability [27].

2.2. Types of Influencing Factors of Consumer Trust. Based on the framework of the above intelligent recommendation module, the decision variables affecting the consumption of green agricultural products include cost price and sale price. The decision variables affecting agents are retail price, as shown in Figure 3, which is the analysis of consumers' choice of purchase channels in an intelligent recommendation.

In order to avoid the unreasonable situation of informal channel sales, assuming that the brand responsibility value in the green agricultural product market obeys the uniform distribution condition [28], the consumption types of influencing factors of consumer trust are shown in Figure 4:

As shown in Figure 4, consumers, whose trust influencing factors are $T1$ and $T2$, consider purchasing the product from the agent. When the consumer judges the value of the product as positive, the consumer affirms the value and purchases the product; $T3$ and $T4$ prove that consumers do not agree with the product [29]. Similarly, $T5$ and $T6$ consumers consider buying from direct sale channels, and consumers intend to buy the product.

In order to make brand social responsibility affect consumers' purchase intention, it is necessary to fully grasp the impact of corporate social responsibility on consumers' purchase decision-making process [30, 31]. The influence of brand social responsibility on consumers' purchase intention can be divided into three stages: purchase cognition, information collection, and purchase decision. If brand social responsibility becomes the standard of consumer decision-making, it will affect consumer willingness. First of all, we should pay attention to the social responsibility of

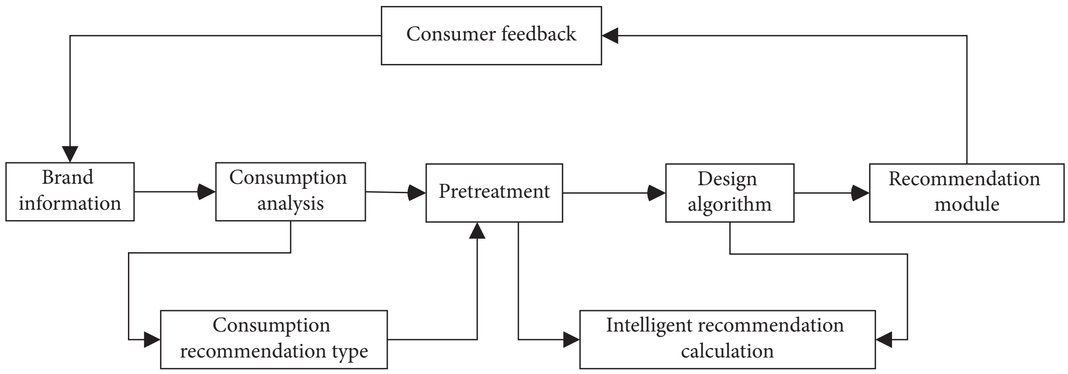

Figure 2: Composition framework of intelligent recommendation module.

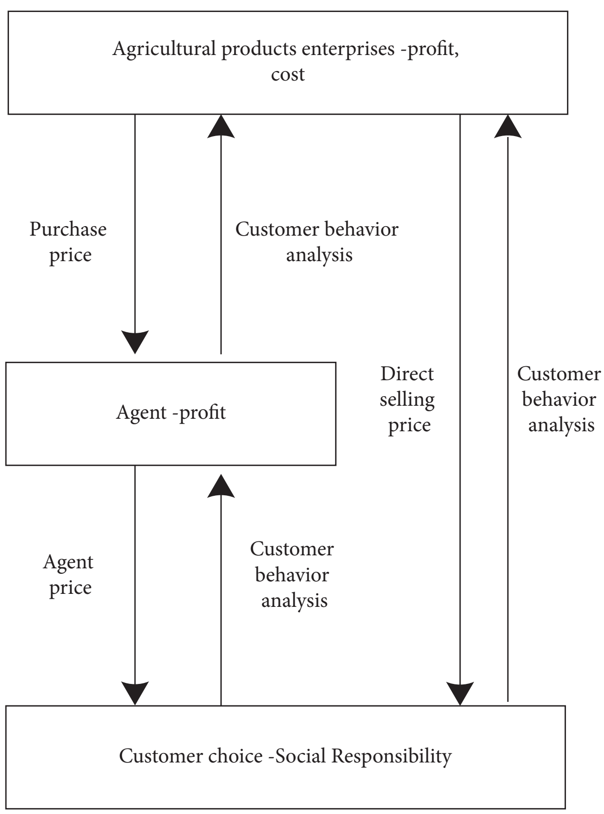

Figure 3: Analysis of purchase channels.

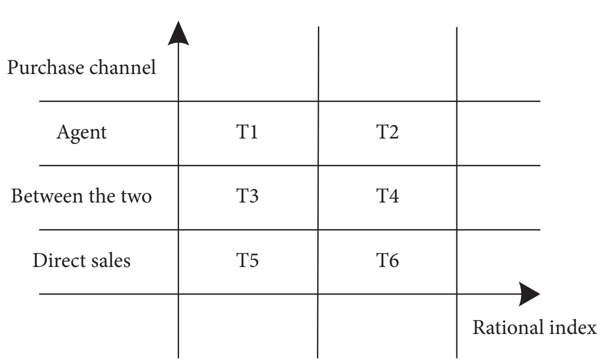

Figure 4: Types of influencing factors of consumer trust.

consumers to purchase products [32]. If consumers' satisfaction after purchasing the agricultural product is not lower than the expected value, consumers will still buy the brand in the future, and social responsibility will have a long-term impact on consumers' purchase intention.

2.3. Data Collection of Consumers' Irrational Purchase Behavior in Big Data Environment. In order to further study the influencing factors of consumer trust in green agricultural products' e-commerce marketing based on big data analysis, the big data collection of consumers' irrational purchase behavior is the data basis of the research. The K-means clustering method is used to collect the big data related to the e-commerce marketing of green agricultural products and consumers' irrational purchase behavior; among them, the K-means clustering algorithm is an iterative clustering analysis algorithm. Its step is to divide the data into k groups, randomly select k objects as the initial clustering center, then calculate the distance between each object and each subclustering center, and assign each object to the nearest clustering center. The cluster center and the objects assigned to them represent a cluster. Each time a sample is assigned, the cluster center of the cluster will be recalculated according to the existing objects in the cluster. This process will continue to repeat until a certain termination condition is met. The expression of the K-means clustering objective function is as follows:

$$X_{FZ} = A_a \times D_l \times \left(H_{\max} - H_{\min}\right). \quad (1)$$

In formula (1), A_a and D_l, respectively, represent the classification weight index and the collected vector in the big dataset of green agricultural products' e-commerce marketing and consumers' irrational purchase behavior; $H_{\max}$ and $H_{\min}$, respectively, represent the maximum search radius and minimum search radius for collecting big data of online red economy and consumers' irrational purchase behavior.

In the process of big data acquisition of green agricultural products' e-commerce marketing and consumers' irrational purchase behavior, the attenuation of the big data acquisition channel has second-order homogeneity [33, 34]. The expression of clustering global kernel function of green agricultural products' e-commerce marketing and consumer irrational purchase behavior big data acquisition obtained by spatial beamforming method is shown in formula (2), in which the spatial beamforming method can be divided into an adaptive algorithm based on direction estimation according to different objects.

$$G = X_{FZ} + \sum_{i=1}^{m} B_i \times J_K. \tag{2}$$

In formula (2), J_K represents the number of samples with the same variance and mean value, and B_i represents the sampling amplitude of the big data mixed kernel function of initial green agricultural e-commerce marketing and consumers' irrational purchase behavior. The updated expression for collecting big data of green agricultural products' e-commerce marketing and consumers' irrational purchase behavior is as follows:

$$J_k = G + \left(L_{\max} - L_{\min}\right). \tag{3}$$

In formula (3), $(L_{\max} - L_{\min})$ represents the threshold value range of collecting big data of green agricultural products' e-commerce marketing and consumers' irrational purchase behavior under the big data environment, $L_{\max}$ represents the maximum value, and $L_{\min}$ represents the minimum value. In order to improve the convergence speed of big data collection related to green agricultural products' e-commerce marketing and consumers' irrational purchase behavior in the big data environment, the fitness function is added to the big data collection process, and the punishment learning in the process of collecting big data related to green agricultural products' e-commerce marketing and consumers' irrational purchase behavior is realized through the fitness function.

Consumers' purchase emotions can reflect the rational degree of consumers' consumption behavior. When consumers shop rationally, their purchase emotion is usually firm; when consumers shop irrationally, their buying emotions are usually accompanied by regret and hesitation [35]. Consumers' purchase emotion is controlled by personal will. As one of the emerging economic models, e-commerce marketing of green agricultural products can transmit information in a low-cost way across space and time. E-commerce marketing has rapidly developed in a short time [36] and has become one of the important economic modes in China. There are many advantages in the development of e-commerce marketing, which has high development potential and growth space.

We establish the research model of green agricultural products' e-commerce marketing and consumers' irrational purchase behavior under the big data environment, as shown in Figure 5.

The professionalism, credibility, and attractiveness of e-commerce marketing are important variables for the online red economy to drive consumers' purchase behavior in the big data environment. The above three characteristics are set as independent variables of the research model of green agricultural products' e-commerce marketing and consumers' irrational purchase behavior in the big data environment. We set consumer purchase as the dependent variable of the model and consumer purchase emotion as the intermediary variable, so as to complete the analysis of influencing factors of consumer trust in green agricultural products' e-commerce marketing based on big data analysis.

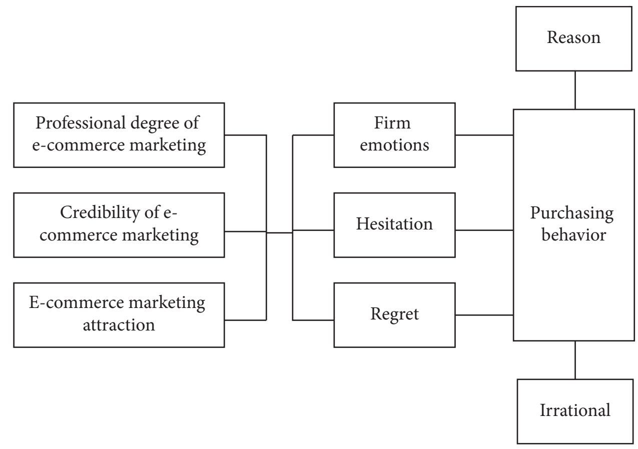

Figure 5: Research model of e-commerce marketing and consumers' irrational purchase behavior.

3. Experimental Analysis

From the perspective of big data analysis, based on the above action mechanism and related concepts, we set the e-commerce marketing of green agricultural products as the independent variable and the influencing factors of consumers' trust as the dependent variable. According to the marketing means used by green agricultural products' e-commerce marketing platform merchants in the network, the corresponding research hypotheses are put forward. This hypothesis is based on the fact that consumers' purchasing behavior is not only influenced by the enterprise and product, but also by the location and industry of the enterprise. These factors at different levels will form consumers' trust at different levels: consumers' trust in the product/enterprise at the lower level and consumers' trust in the social environment at the higher level. These two levels of trust can have a direct impact on consumer purchasing behavior. The setting of research assumptions is shown in Table 1.

According to Table 1 in hypothesis 1, for example, in the big data analysis perspective, its advantage is in green electricity marketing of agricultural products, the price discount is a more common way of. E-commerce can directly sell the normally sold green agricultural products to consumers by reducing the product price and can take various forms, such as direct price reduction. Economically, when the sellers of green agricultural e-commerce offer discounts to their products, the price of the products will be lower than their psychological maximum price, and a consumption surplus will be generated to increase the amount of consumers' shopping.

Modeling and testing are one of the commonly used analysis methods of multivariate statistics. Combining factor analysis and path analysis, this paper discusses the

Table 1: Research hypothesis setting table.

Hypothesis number	Independent variable	Dependent variable	Influence relationship
Hypothesis 1	Commodity discount intensity	Degree of irrational consumption of consumers	Positive correlation
Hypothesis 2	Platform full reduction activity		Positive correlation
Hypothesis 3	Limited time second kill		Positive correlation
Hypothesis 4	Consumption mode of advance payment		Negative correlation

relationship between variables, and obtains the direct and indirect effect of independent variables on dependent variables. The construction equation model is effective and needs to be established on the basis of theory and experience. If the model needs to be modified, it should also be adjusted according to relevant theories. The observed variables in the measurement model can obtain data through direct measurement, while the potential variables need to be abstractly defined through the characteristics formed between the observed variables. There must be at least two observed variables to estimate a potential variable in the model. The e-commerce marketing variables of green agricultural products can be expressed by formula (4)as follows:

$$Y_x = D_F \times S + \theta. \tag{4}$$

In formula (4), D_F represents the coefficient matrix of the relationship between D and F, S represents the external potential variable, that is, the dependent variable, and θ represents the measurement error. Then, the structural model expression is as follows:

$$C_X = H_G \times Y_F + \lambda. \tag{5}$$

In formula (5), C_X represents the observed variable, H_G represents the regression coefficient, and λ represents the residual value. Through the construction of the structural equation model, more variables can be calculated at the same time, and all dependent variables can be taken into account, so as to improve the consistency between the model and practice. In addition, the structural equation model allows covariance between independent variables, thus allowing the existence of high-order factors. The analysis process of the constructed structural equation model is shown in Figure 6.

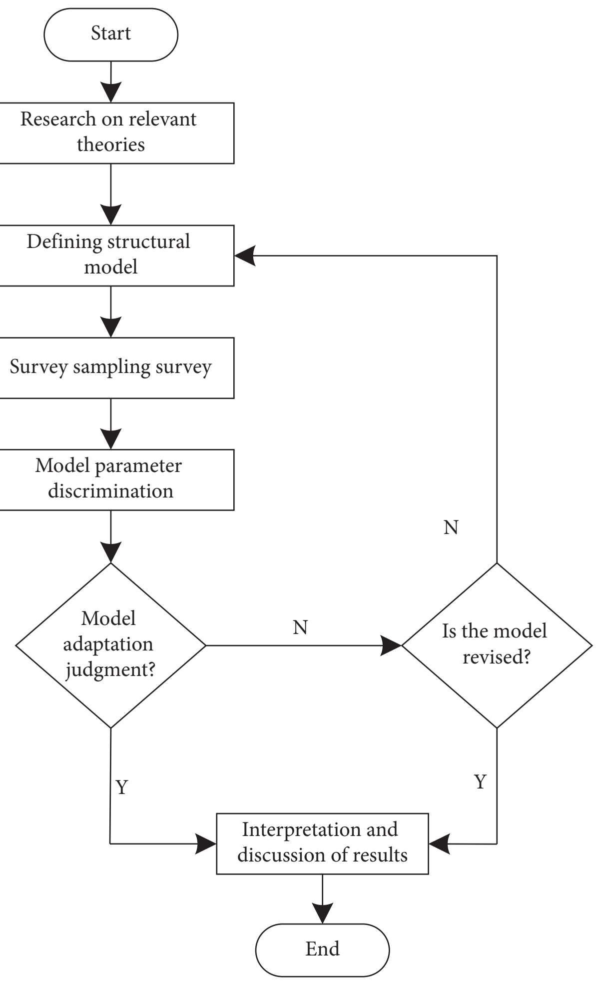

Figure 6: Flowchart of the structural equation model analysis.

The assumption of causality in Figure 6 needs to have a certain theoretical basis; otherwise, the results of the model may be quite different from the actual situation, so that the model has no popularization value. The empirical research objects are randomly selected in the form of voluntary and recruitment. The research objects of empirical analysis are 1000 in total. The basic information of consumers is shown in Table 2:

As can be seen from Table 2, the proportion of male and female consumers is about 40% and 60%. In terms of age, most of the research objects are young people aged 18–30 years old. In addition, from the perspective of occupation, the selected research objects involve all walks of life, specifically including students, office workers, housewives, and other social workers, among which office workers account for 45%; the income level of 2000–6000 yuan is the majority, accounting for 64%. We collect the consumption data of the research object in daily life and double 11 online festivals, respectively, store the data according to time, and count the amount of irrational consumption of researchers and the reasons for irrational consumption behavior.

Trust is an important index to measure the degree of reliability. The Cronbach coefficient is set for the reliability test. This coefficient is a method to measure the reliability of the scale or test. It measures the internal consistency of the test according to a certain formula. As an index of reliability, it overcomes the shortcomings of the partial halving method. It is the most commonly used reliability analysis method in social science research. The calculation formula is as follows:

$$\alpha = \frac{N_n \times R}{(N_n - 1) \times R}. \tag{6}$$

Table 2: Basic statistics of consumer samples.

Essential information	Category	Number of samples	Percentage (%)
Gender	Male	400	40
	Female	600	60
Age	18–30 years old	518	51.8
	31~45 years old	359	35.9
	Over 45	123	12.3
Occupation	Student	350	35
	Office worker	450	45
	Housewife	200	20
Monthly income level	Below 2000 yuan	200	20
	2000~6000 yuan	640	64
	6000~10000 yuan	160	16

In formula (6), α represents the coefficient calculation result, and N_n and R represent the assumed quantity and average correlation coefficient of the scale, respectively. Effectiveness refers to the approximation between the observed value and the actual value of the variable in the study. The higher the effectiveness, the more consistent the observed value is with the actual situation of the tested object. Through the statistics of multiple sample data, the analysis results of research reliability and effectiveness are obtained, as shown in Table 3.

Table 3: Reliability and validity test results.

Research variables	Cronbach's alpha	Reliability evaluation
1	0.911	Excellent
2	0.859	Good
3	0.854	Good
4	0.840	Good
5	0.744	Preferably
6	0.712	Preferably
7	0.695	Preferably
8	0.685	Preferably

It can be seen from Table 3 that the Cronbach coefficient obtained from the test is greater than 0.6, that is, the reliability of the scale is good. When the variable is 1, the Cronbach coefficient is the highest, which is 0.911, and the reliability evaluation grade is excellent. The empirical research results have a certain degree of reliability and good validity.

By counting the order frequency of the research object in the e-commerce marketing platform of green agricultural products during the presale period, we can detect the influencing factors of consumer trust. Generally speaking, the presale marketing of online festivals is mostly set one week before the official festival. The statistical results of online shopping frequency are shown in Table 4.

As can be seen from Table 4, the number of orders placed by 2 or less people in the research sample before and during the advance payment is 412 and 350, respectively, while the number of orders placed after the advance payment is 315. In 3–5 orders of purchase frequency, the number of people before, during, and after the advance payment period is 301, 275, and 265, respectively; in order frequency 6–10, the number of people before, during, and after the advance payment period is 150, 190, and 148, respectively; the advance payment of online festivals increases the number of irrational purchases of consumers to a certain extent; that is to say, this marketing mode plays a positive role in irrational purchases.

4. Discussion and Analysis

In the big data analysis environment, in order to avoid the irrational purchase behavior of consumers, we realize the win-win situation between consumers and sales enterprises, and avoid the irrational purchase behavior of consumers, and the proposed strategies are as follows.

4.1. Strictly Control the Quality of Green Agricultural Products and Improve Consumers' Purchase Confidence. In the big data environment, the quality of green agricultural products includes product safety, integrity of appearance, freshness, edible taste, etc., which will affect consumers' confidence in businesses. Most of the products sold on the fresh e-commerce website are green agricultural products, mainly including fruits, vegetables, meat, seafood, eggs, and dairy products. Therefore, some pesticides will remain in the growth process of agricultural products. In addition, additives are likely to be used in the primary processing of products, which will endanger the lives and health of consumers. Therefore, consumers attach great importance to product quality. Merchants must strictly control the quality and safety of products and provide the safety certificate of the origin of green agricultural products and the quality and safety certificate of relevant inspection departments. In advertising, we should focus on the publicity of product safety, good health, and green nature, which is conducive to reducing consumers' perceived risk and improving consumers' sense of trust.

4.2. Enrich Product Categories, Expand the Depth and Width of Categories and, Meet the Needs of Consumers to the Greatest Extent. Some green agricultural products have no sale source offline but can be provided online, which is one of the important reasons why consumers choose to buy online. The rich categories include not only fresh food

Table 4: Statistical results of online shopping order frequency.

Online shopping order frequency	Before the advance payment period	Advance payment period	After the advance payment period
Number of persons with 2 orders and below	412	350	315
3–5 orders	301	275	265
6–10 orders	150	190	148
11–15 orders	80	99	135
15–20 orders	50	60	85
More than 20 orders	7	26	52

nationwide but also overseas products, which can greatly meet consumers' pursuit of product categories. While enriching product categories, we also need to do a good job in product portfolio design, so as to expand the width and depth of product categories, and strengthen warehouse management and cost control on the basis of enriching categories.

4.3. Improve Cold Chain Logistics and Improve the Quality of Distribution Services and Logistic Services. Logistic services have a positive impact on consumers' trust. High-quality logistics and distribution services can win consumers' trust and support. Green agricultural products are different from other products. Due to the short preservation period, it requires faster logistics and transportation speed and ensures product quality. In order to ensure the product quality, there must be a certain temperature control in the whole supply process of green agricultural products to ensure that the products can enter the market completely within the shelf life. In addition to improving the cold chain logistic system, we should also realize the whole process of supervision and control to improve the logistic efficiency and quality. In addition, the product sale adopts the presale mode to determine the consumption demand in advance and provide distribution to consumers in time after the supply period, which can reduce the time of green agricultural products in logistics, transportation, warehouse, and market.

4.4. Strengthen the Service Awareness of Customer Service Staff, Increase the Number of Service Training, and Improve Customer Service Quality and Business Image. Customer service has a positive impact on consumers' trust. It can be said that high-quality customer service level will improve consumers' trust in the e-commerce marketing of green agricultural products. Customer service includes prepurchase and postpurchase services. A good service experience will improve consumers' shopping confidence. In the prepurchase service, the quality of goods and the reasonable arrangement of resources are guaranteed from the source. The customer service personnel timely solve the purchase problems of consumers in the process of shopping guide, and ensure the quality and freshness of products in the process of product transportation. In the postpurchase service, the events that occurred shall be handled in time. In this process, the customer service personnel shall actively guide the processing of green agricultural products, give timely feedback to the opinions and problems put forward by consumers, and refund the full amount in case of product quality and safety problems. This needs to improve the website system, do a good job in the training of customer service staff, and improve the consumer service experience.

4.5. Improve the Website System, Strictly Fulfill Service Commitments, and Protect Consumers' Rights and Interests. The website system has a positive impact on consumers' trust. Therefore, a perfect and comprehensive website system can improve consumers' trust in e-commerce marketing sellers of green agricultural products. The website rules and systems of service commitment, after-sale service, and safety guarantee enhance consumers' sense of purchase security. A perfect website system needs the cooperation of the feedback system and receives feedback information from all aspects. We monitor the transaction process to prevent credit value scoring, so as to protect the rights and interests of consumers.

5. Conclusions and Prospects

5.1. Conclusions. The influencing factors of consumer trust in green agricultural products' e-commerce marketing based on big data analysis are analyzed. The research shows that the Cronbach coefficients obtained from the test are greater than 0.6, which has certain credibility and good effectiveness. The consumption mode of prepayment in online festivals increases the number of irrational purchases of consumers to a certain extent; that is to say, this marketing mode plays a positive role in irrational purchase behavior.

5.2. Prospects

(1) The selection of influencing factors of consumer trust in e-commerce marketing of green agricultural products is based on previous studies. Each factor has an impact on consumer trust, but the impact of other factors on consumer trust cannot be ruled out. Future research can consider studying consumer trust from the perspective of consumer perceived risk.

(2) E-commerce for selling green agricultural products through the internet does not distinguish between specific e-commerce models. The research scope is

relatively large. In order to realize the fine research of e-commerce marketing of green agricultural products, in the future works, we can divide the e-commerce marketing mode of green agricultural products and study the problem of consumer trust on the basis of division.

(3) In big cities, consumers with higher income levels pay more attention to the quality of life, are not sensitive to the price of green agricultural products, and are willing to accept high-price products. Their trust tendency is also relatively high. Therefore, this kind of consumer group can be divided into potential customers, and a combination of online and offline marketing modes can be carried out to improve the consumer experience.

Data Availability

The raw data supporting the conclusions of this article can be obtained from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding this work.

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Research Article

Financial Time Series Model Based on Least Squares Support Vector Machine Predictive Control Algorithm in Financial Market

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China's financial market also faces some outstanding problems, namely, obvious structural imbalance in the size of the financial market, on the one hand, the absolute dominance of the size of the indirect financing market, mainly the bank lending market and on the other hand, the imbalance in the size of the direct financing market and the indirect financing market. At the same time, there is also a structural imbalance of the financial market among regions in China. How to verify the objective existence of such structural imbalance in different regions and measure the difference in the level of financial market development among regions is the focus of this paper. This paper constructs a financial market development level indicator system from three dimensions, equity market, bond market, and lending market, and measures the financial market development level by using inter-provincial panel data from 2001 to 2020 through neural network algorithm, time series model, and support vector machine algorithm, and analyzes the regional heterogeneity of financial market development on this basis. The results show that the overall market level of the financial industry in the eastern coastal region of China is the highest, but the intra-regional differences are also the most obvious; the overall market level of the financial industry in the northeastern region of China is the lowest, and the differences with the eastern region rise significantly; the market level of the financial industry at the provincial level in the central and eastern regions shows an all-time decreasing trend, while the western and northeastern regions of China show a convergence, then divergence, and then convergence trend. Therefore, differentiated financial policies should be implemented according to the stage of regional development in order to enhance the financial development level of each economic region and gradually narrow the regional financial development gap.

1. Introduction

Under the premise that the goal of economic development is shifting from high-speed development to high-quality development, financial development and financial deepening may become an appropriate breakthrough for the transformation of the economy from capacity-intensive to quality-intensive. Studies by foreign scholars on western developed countries show that financial development can have a significant positive impact on the economic growth of a country. But this positive impact is due to the highly developed financial system and sound financial system. China's current financial market and financial system are not very sound, and the role of the financial system on economic growth is not particularly significant. In the context of the current deepening financial reform, exploring the relationship between financial development and economic growth remains a valuable issue for the economy to achieve stable and healthy development at this stage [1]. On the other hand, the current global economic downturn has led to the introduction of quantitative monetary easing policies in various countries. Quantitative monetary easing may stimulate economic growth, but historical experience also shows that excessive release of liquidity can sow the potential risk of inflation. Inflation brings purchasing power risk and distorts commodity prices, while large fluctuations in capital flows as well as asset prices can cause macro-financial risks, which may have a huge impact on China's financial openness and stability, and thus affect the process of high-quality development of our economy; but moderate inflation may also affect market investment in the short-term through monetary and real interest rates. Therefore, the financial time series model of least squares support vector machine predictive control algorithm has an uncertain effect on the financial development for economic growth. Therefore, it is of practical significance to study the relationship between financial development and economic growth from the perspective of financial time series models of the least squares support vector machine predictive control algorithm [2].

Although China's financial system is very unsound, high savings in China still support economic growth for forty years, and it has become one of the important components of China's market economy as it has been effective in promoting corporate financing and helping the development of enterprises. However, China's financial market is also facing some outstanding problems, namely, the obvious structural imbalance in the size of the financial market, on the one hand, the absolute dominance of the scale of the indirect financing market, mainly bank lending market and on the other hand, the imbalance between the scale of the direct financing market and the indirect financing market. At the same time, there is also a structural imbalance of the financial market among regions in China. How to verify the objective existence of this structural imbalance in different regions and to measure the differences in the level of financial market development among regions is the focus of this paper [3].

2. Research Background

The academic community has conducted in-depth discussions on the composition and influencing factors of financial markets. Richard pointed out that interest rates are the key indicator of financial markets [4]. Further, Calvo et al. explored the link between exchange rates and financial crises and found that exchange rates are a key factor in the stability or otherwise of financial markets [5]. Billah et al. argue that markets that can be accounted for by rates of return, in addition to interest rates, are an important component of financial markets [6]. Then, money and bond markets based on interest rates, equity markets based on yields, and foreign exchange markets based on exchange rates are important components of financial markets. This is widely used in academic circles; for example, Yang Zirong et al. mainly use the relevant variables in the credit market and the stock market as the core indicators of financial development, Szczygielski et al. point out that the stock market plays the role of direct financing in the financial market, Yan et al. measure the financial structure and financial development of China through the stock market and the credit market, and Yang Ke et al. consider the stock, bond, and exchange rate markets as important components of the financial market [7]. Scholars select suitable sub-markets to study according to different topics, e.g., Yin Zhentao et al. explored the relationship between competition avoidance and financial innovation in the credit market, Wu Shinnong et al. used the stock market and bond market to construct a financial market security index, and Li Minbo et al. screened indicators from the bond market, equity market, money market, and foreign exchange market to construct a financial market stress index in China. Regional financial markets are an important component of the national financial market, but the influence of national indicators needs to be excluded when comparing the differences between different regional financial markets, such as the foreign exchange market which is more national in nature [8]. Lin et al. use the credit, bond, and exchange rate markets as key objects to measure global systemic financial risk, and it is for this reason that the foreign exchange market is not appropriate as an indicator of inter-provincial financial market development. For this paper, it is particularly important to find an indicator system that reflects the inter-provincial characteristics [9].

In terms of the dimensions of the selection of measurement indicators, Yang et al. measured the financial market by the share of deposits in GDP, stock market turnover ratio, and bank reporting coverage ratio [10]. Kulish et al. measured the level of regional financial development in terms of the ratio between the scale of capital goods (including bonds, stocks, and funds) transactions and GDP in the process of studying the impact of regional financial development and economic fluctuations on income distribution [11]. At the level of the choice of the measurement method, scholars would measure through the theories calculated by Tobin's q-theory calculus, Tobin's correlation theory, and other calculations, all of which provide some support for this study [12].

In general, the financial market development level measurement needs to focus on the bond market, equity market, money market, and foreign exchange market [13]. The selection of sub-markets for the inter-provincial financial market development level mainly focuses on the first three markets, but it should be noted that the money market belongs to the ranks of the short-term market, while the bond and equity markets belong to the medium- and long-term market. Therefore, it is more appropriate to study the money market from the perspective of the lending market, i.e., it is more feasible to consider the impact of the medium- and long-term interest rate market changes on the financial market development [14]. At the level of indicator selection, existing studies do not construct a complete indicator system for financial market measurement and are not uniform at the level of market selection and indicator selection, and there are fewer relevant studies on regional differences in inter-provincial financial market development, so this study will measure the level of inter-provincial financial market development and further analyze the regional differences.

3. Materials and Methods

3.1. Basic Theory

3.1.1. Least Squares Method. The least squares method is a mathematical tool widely used in the fields of error estimation, uncertainty, system identification and forecasting, prediction, and other data processing. The first asteroid was discovered by the Italian astronomer Biazzi in 1801. After 40 days of tracking Pilarz Ceres and looking toward the Sun, he would lose his position. Scientists around the world used Piza's diagram to find Ceres, but most of those who looked for Ceres came up empty in their calculations. Only Gauss (24 years old at the time) calculated the orbit of Ceres (Ceres), which was confirmed by the observations of the Austrian astronomer Heinrich Erbos, so that astronomers could predict the exact position of Ceres [15]. Many astronomical discoveries were made, including Halley's comet. In his Book of Celestial Motions, published in 1809, Gauss used the method of least squares. In fact, in 1806, the French scientist Legendre invented independently the "method of the smallest equation," but it was not known to the world.

The least square method (also known as the least quadrilateral) is a mathematical optimization method. It multiplies the square of the error by the series to get the most accurate function of the data. The unknown data can be easily obtained with the least quadratic method and the sum of the error values between the data delivery and the actual data can be minimized. The least square method can also be used to correct curves, while other optimization problems can be expressed in the form of energy minimization or entropy maximization.

A simple linear fit was performed with the least square number. However, how close the estimated parameters are to the true parameters of the overall, and whether there are other better estimates, involves least squares estimation or least variance of the estimate (or best), linear and unbiased, or BLU for short. This is the main reason why ordinary least squares are widely used to estimate econometric models. Ordinary least squares estimation has the three properties mentioned above. They are shown in Figure 1.

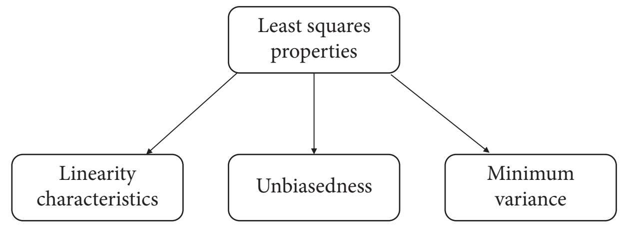

Figure 1: Least squares properties.

3.1.2. Financial Markets. The financial market is also known as the capital market, i.e., the money market and the capital market, i.e., the financial market. It implies the "integration of finance," i.e., the supply and demand for money in the business life of an economy using various financial instruments to regulate activities. Financial markets trade various instruments, such as stocks, bonds, and deposits. Finance refers to financial resources, which usually include direct and indirect funding. Direct financing is a financial measure between the supply and demand of financial resources, i.e., the direct provision of financial resources through financial markets to institutions and individuals who have surplus funds in society. Indirect financing is a financial resource provided by banks, as well as financial resources provided by banks and other financial institutions. Financial markets have a direct and far-reaching impact on all aspects of economic activity, individual wealth, corporate behavior, and economic efficiency that directly depend on financial market activities [16].

The composition of financial markets is very complex. It is a large system of different markets. However, depending on the maturity of the instruments traded, financial markets are divided into money markets and capital markets. The foreign exchange market is a short-term money market (less than one year) and the capital market is a long-term money market (more than one year). The money and capital markets can be further subdivided into many different submarkets. The foreign exchange market includes the interbank market, the repo market, the commercial foreign exchange market, the market for bank deposits and debt securities, the short-term government bond market, and the large amount of negotiable deposit money. The capital markets include the medium- and long-term credit and securities markets. The medium- and long-term credit market represents the credit market between financial institutions and firms [17]. The securities market is the market for financing through the issuance and sale of securities and includes the bond and stock markets, the fund market, the insurance market, and the financial and leasing markets. The formation of financial markets is shown in Figure 2.

3.2. Research Methodology

3.2.1. Algorithm of Support Vector Machine. Support Vector Machine (SVM) is a learning monitoring method which can be used to label, correct, and search for sample anomalies. The main idea is to create a hyperplane in a selected fabric so that the distance between each point and each point is optimal. There are many ways to go where. In the 1990s, before deep learning was available, vector supports became most popular at the time because they could solve nonlinear classification problems and predict them very accurately. The vectors supported in the responder are, on the one hand, linear death gas pedals and, to a lesser extent, nonlinear death gas pedals, called linear death gas pedals. The winning one proposes the idea of maximizing the segmented circle to create a better sense of prediction. On the other hand, traditional two-symbol algorithms often stop the iterative algorithm after finding the antidote [18].

The advantage of support vector machine is that it is still valid in high-dimensional spaces and can still be used when the dimensionality of the space is larger than the number of samples. Some feature points cannot be linearly separated in two-dimensional space, but after dimensional augmentation, a hyperplane can be perfectly found to reasonably separate the two types of sample points. Support vector, using basic functions instead of computation, solves the complex computation problem, effectively overcomes the huge local miniature problem, and solves the linear separation problem in low-dimensional space. At the same time, support vector machines are versatile in that they can select different kernels as decision functions and construct different hyperplanes to obtain different classification results, allowing researchers to get the desired classification method according to their requirements [19].

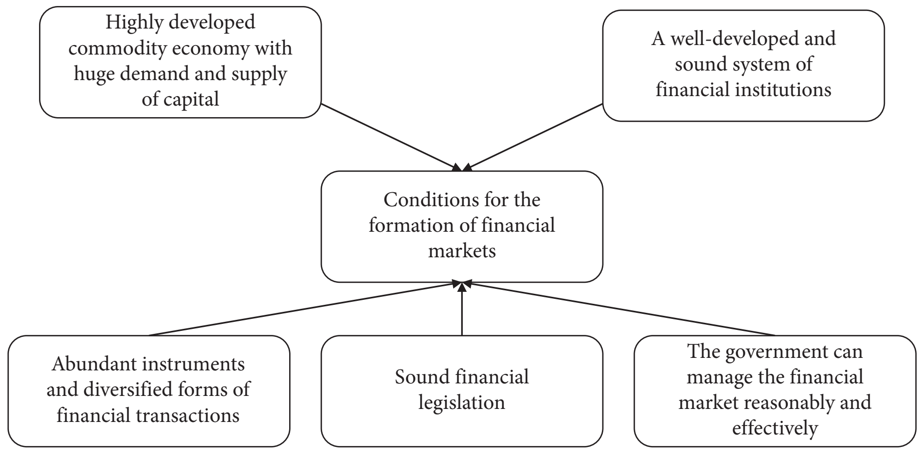

Figure 2: Conditions of formation of financial markets.

3.2.2. Time Series Model. Time series analysis is a theory and method for computing mathematical models based on time series calculated from an observation system. Usually, curves are combined and parameters (e.g., nonlinear multipliers) are calculated. Time series are often used in national macroeconomic management, integrated planning of regional development, business management of enterprises, forecasting market opportunities, meteorology, hydro-meteorological forecasting and prediction, earthquakes, prevention and control of diseases and predicted skulls, prevention and control of environmental damage, and balance of marine ecosystems [20].

The purpose of the "time-rice" model is, first of all, to objectively describe a system based on the time series transmitted to the observed system. Changes in the time series can be explained if the mechanisms occurring in the time series are understood using the values of more than two variables. Time series are usually interpolated with correlation models that predict the future values of the time series. In a time series, the input variables can be adjusted so that the system development maintains its target values. This means that controls are needed to predict that the process will deviate from the target. This is shown in Figure 3.

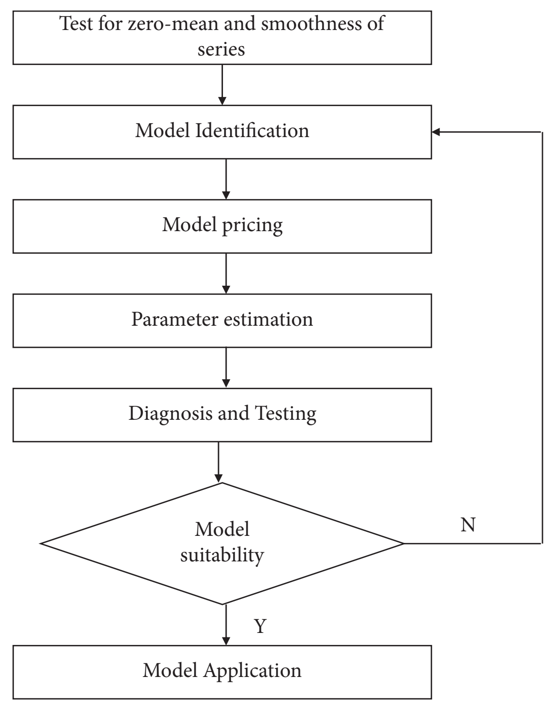

Figure 3: Overview diagram of time series model.

3.2.3. Generalized Regression Neural Network Research Method. The generalized regression neural network (Radial Basis Function Neural Network, or RBFNN) is a most typical three-layer forward neural network structure, which, in addition to having the information processing of traditional neural networks, uses radial basis functions in its implicit layer for nonlinear mapping of input data, which is then passed to the next layer after linear computation. The structure of the radial basis neural network is shown in Figure 4.

In the unsupervised learning part, the data are clustered by using a clustering algorithm such as K-means to obtain the centroid of the radial basis function in the hidden layer, and then the width vector of the radial basis function is calculated by using the centroid information, and the width vector is calculated by the following formula:

$$\sigma_j = \frac{c_{xy}}{\sqrt{2h}}, \tag{1}$$

where c_{Xy} is the maximum distance before the centroid and h is the number of nodes.

After that, the input data are related to the scattering through the implicit layer and the output layer, respectively, and the output x_i of the first node j of the input sample in the implicit layer is calculated by the following equation:

$$\phi(x_i, j) = \exp\left(-\frac{1}{2\sigma_j^2}x_i - c_i\right), \tag{2}$$

where c_j and σ_j are the centroid and width m vector of the first node in the hidden layer, respectively.

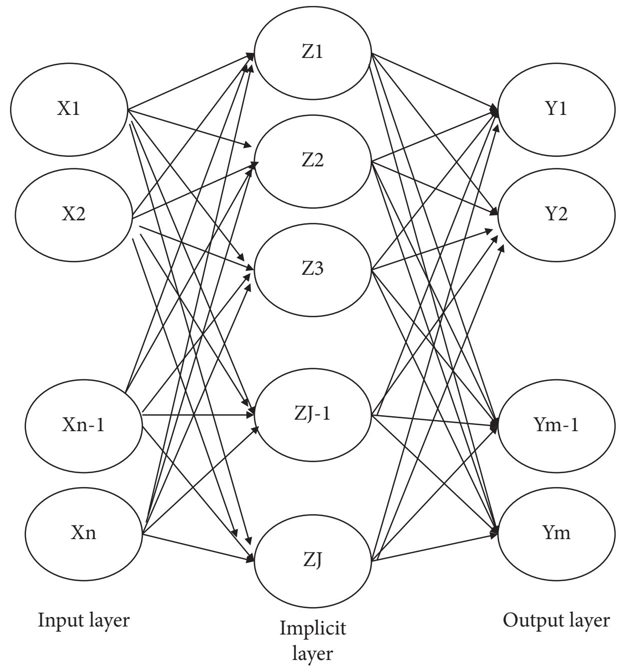

Figure 4: Structure of generalized regression neural network.

The output of x_i the first node of j the input sample in the output layer is calculated by the following equation:

$$y_m = \varphi(\phi(x_i, j) * w_m), \tag{3}$$

where w_m is the weight of the φ node and is the activation function.

In the supervised learning part, it is mainly a process of continuous correction of the parameters in each layer, this process is mainly through the error function to calculate the gradient value of each parameter, and then use the traditional gradient descent method such as stochastic gradient descent (SGD) to continuously correct the parameters, taking the output layer for linear calculation of the weights as an example, the update formula is as follows:

$$w_t = w_{t-1} - u * \frac{\sigma E}{\sigma w_{t-1}}, \tag{4}$$

where E is the error function and u is the learning rate.

In addition to the above methods, the centroids and width vectors of the hidden layer can be directly generated randomly, after which they are updated according to the gradient correction formula of the supervised learning process.

4. Results and Discussion

4.1. Spatial and Temporal Distribution of Financial Market Development Level in Each Province. By measuring the level of financial market development in 31 provinces from 2001 to 2020, four representative years are selected to form interprovincial data spanning 20 years to explore the temporal evolution characteristics of the development history of China's financial market. The analysis of the spatial and temporal distribution of the financial market development level of each province in the representative years (2001, 2007, 2013, and 2020) shows that: in 2001, only three provincial administrative units, Beijing, Shanghai, and Guangdong, had financial market development level values higher than 0.1, and the highest one, Beijing, was only 0.1258; in 2007, except for Shanxi, Jilin, Chongqing, Tibet and in 2007, except for Shanxi, Jilin, Chongqing, Tibet, and Ningxia, the value of financial market development level of other provinces was higher than 0.05, among which the value of Beijing exceeded 0.25; in 2013, the financial market development level higher than 0.15 has reached 5 provinces, among which both Beijing and Guangdong have exceeded 0.25; in 2020, the financial market development level higher than 0.2 reached 12 provinces, and higher than 0.25 reached 7 provinces. All provinces have a financial market development level higher than 0.05. Overall, the development level of China's financial market has been steadily improving over the past 20 years, but there are always differences in the development level among regions, but the developed eastern region is always in a distant lead.

4.2. Trends in the Evolution of Financial Market Sub-Dimensions. The equity market shows obvious up and down fluctuations in the development process, and after reaching the highest point in 2016, it has shown a downward trend in recent years; the development level of bond market continues to improve after 2014, but it declined in 2017, recovered in 2018, and reached a new high in 2020; the lending market has been developing rapidly since 2010, and maintains a continuous rapid growth trend. As can be seen, there are various factors that influence the further development of finance, especially national policies and industry norms, and the development of each specific dimension is not entirely consistent.

In Figure 5, "Evolution of the mean value of financial markets in each dimension from 2001 to 2020," the equity market in all regions of China was underdeveloped before 2006, and the role of regional financial markets was relatively low in the traditional economic model based on the real economy, coupled with China's residents'. The overall development of the equity market remained slow due to the limited awareness of the population in China. Entering 2006, the completion of the equity share reform as well as its further deepening, China's stock market entered an unprecedented bull market. At the same time, the first wave of brokerage firms, pension funds and insurance funds poured into the stock market, driving the first step of the stock market up, i.e., the rise in 2006. The entry of foreign capital, the issuance of QFII, a large number of new fund offerings and the follow-up of private savings power in the stock market in the later part of the year led to the emergence of a bull market in China in 2007. Since April 2007, inflationary pressures began to appear in China, and China implemented a policy of double-high reserves and interest rates, further contracting our monetary policy and suppressing the momentum of the stock market's excessive rise, which, together with the lifting of the ban on IPOs in China and the withdrawal of foreign capital, brought the stock market back

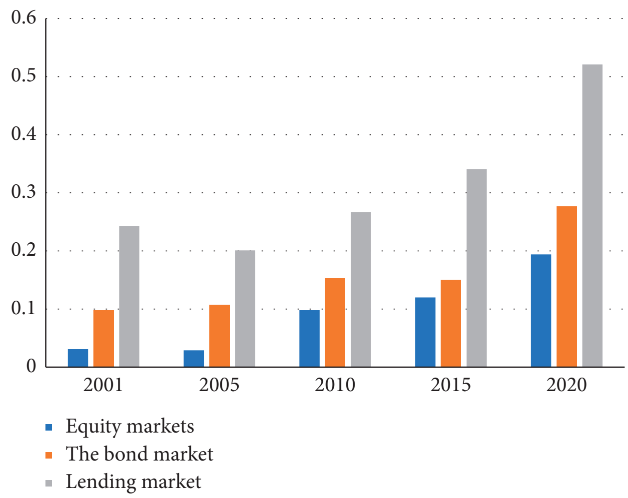

Figure 5: Evolution trend of financial market mean in each dimension from 2001 to 2020.

down. However, the major cause of the massive decline in the equity market in 2008 relative to 2007 came from the impact of the international financial crisis, which directly led to the decline in the level of equity market development in various regions of China in 2008. After 2009, China's equity market entered a cyclical fluctuation, driven by two fusion of over-the-counter matching discs in 2015, the rising PE of GEM, high leverage brought about the overvaluation of the equity market, under the strong de-risking of the regulator, the equity market in China was basically stable in the later period as shown in Figure 5.

As for the bond market, the steady development of the bond market was achieved after 2007 by gradually expanding the scale. In 2007, due to the overheating of our economy, there was a greater risk of inflation, which was able to reduce the economic risk of the market to a greater extent. The General Bureau of the State Council in 2009 issued a number of opinions on the current financial to promote economic development. In the process, he clearly proposed to increase the scale and actively expand the debt of enterprises such as bonds and debt financing instruments and good corporate short-term and medium-term paper money. In addition, in 2009, the provincial local governments not only issued bonds, but also promoted the development of the bond market. In addition to the impact of economic fluctuations in the later period, infrastructure construction is an important influence on the level of local bond development. It can be found that the higher the economic level, the better the bond market development, mainly because the government relies only on fiscal revenue to develop urban construction, which is seriously insufficient to meet the needs of rapid development, and can only get financial support by issuing local bonds. The better the economic level of the region, the greater the demand for infrastructure, and the local government needs to issue bonds to better solve the funding gap; while the general economic level of the region, based on the principle that bonds are not higher than the fiscal revenue, it is difficult to issue more bonds. By comparison, it can be found that the bond market tends to develop to a greater extent in the following year when the equity market is overheated.

The lending market reflects the scale of market capital application. With the acceleration of China's infrastructure construction and real estate industry construction, coupled with industrial support from different regions, and accompanied by the liberalization of China's medium- and long-term loan interest rates in 2005, the lending market in all regions of the country gained rapid development. In 2008, the U.S. subprime mortgage crisis swept the world, the lending business of China's financial institutions was also significantly affected, manifesting as a significant decline in the development level of the lending market; after experiencing the international financial crisis, the lending market in 2009 showed a retaliatory rebound, with a steep increase in the scale of lending, promoting the development level of the lending market in that year; after 2010 to the present decade, the development level of China's lending market has basically been rising year by year, and this rising trend has not weakened, and the lending market still has sufficient vitality.

4.3. Regional Financial Market Variability Analysis. This paper measures the regional disparity in the development level of financial markets and its subgroup decomposition disparity from 2001 to 2020 for the national and four major economic regions. The specific measurement results are shown in the detailed analysis below.

4.3.1. Intra-Regional Gap and Its Evolution. According to the Dagum Gini coefficient method, the results of the Gini coefficient measurement of the level of financial market development of China's national and four major economic regions from 2001 to 2020 are shown in Figure 6.

The Gini coefficient of the national financial market development level: First, the Gini coefficient of the national financial market development level in China always remains high and is basically higher than that of the four major economic regions in China, with values ranging from 0.1762 to 0.2811. This indicates that, compared with the four economic regions, the financial market development level among the 31 provinces in China is more different, and the development of the national financial market is more unbalanced. Second, the Gini coefficient of China's national financial market development level shows a fluctuating change of "rising, then falling, then rising," and has been increasing since 2005. This indicates that although China's financial market is developing in general, the difference in the level of financial market development among the 31 provinces in China is also widening, and the development of the national financial market shows a significant imbalance.

The Gini coefficient of financial market development level in China's four major economic regions is seen: First, the Gini coefficient values of financial market development level in China's four major economic regions are mainly expressed as Eastern region > Western region > Northeastern region > Central region. It can be seen that, in the process of China's financial market development,

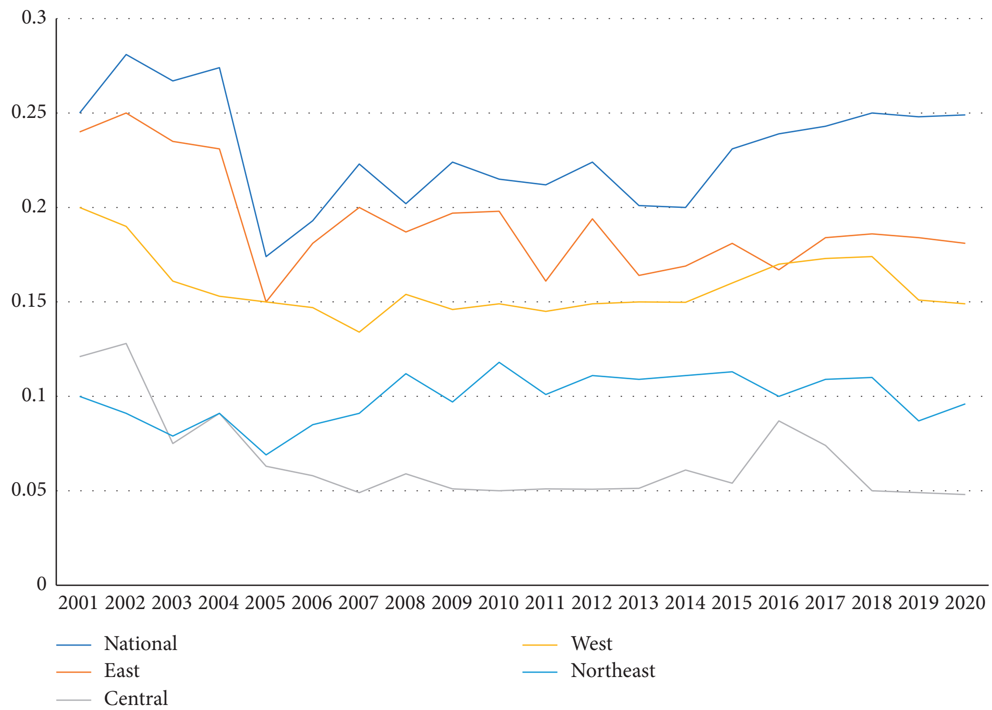

Figure 6: Gini coefficient of financial market development level of national and four major economic regions.

although the development level of the eastern region has always maintained a leading position, but the difference in the level of financial market development among its internal provinces is also relatively greater, and the problem of financial market development imbalance is also relatively more prominent. Second, the Gini coefficients of financial market development levels in China's four major economic regions show different trends of evolution. The magnitude of the volatility of the Gini coefficient of financial market development level in each region (the difference between the maximum and minimum values of each economic region during this period) is in the order of Eastern region (0.1043) > Central region (0.0787) > Western region (0.0756) > Northeast region (0.0527). Specifically, the Gini coefficient of the development level of the financial market in the east shows a fluctuating upward and downward trend, the Gini coefficient of the development level of the financial market in the central region shows a fluctuating and continuous downward trend, the Gini coefficient of the development level of the financial market in the western region shows a trend of first decreasing and then slowly increasing and then decreasing, and the Gini coefficient of the development level of the financial market in the northeast region remains basically unchanged in a small fluctuation.

In the process of continuous development of China's financial market, although the financial markets in different regions have achieved greater development, the financial market development gap between provinces within each region shows different evolutionary trends. In general, the differences in financial market development levels among provinces in the eastern, central, and western regions show a trend of significant decline, then a slight increase, and finally a gradual decrease, while the gap in financial market development levels in the northeast region has always been the smallest among the four major economic sectors, with little change over the past 20 years. Although the central region started its economic development late, it has developed quickly and effectively in the last decade, with a high degree of industrialization and a steadily increasing level of financial market development. The eastern region, on the other hand, is in the center of China's financial market development and has more provinces, which results in a large value of provinces with a high level of financial market development, while provinces with a low level of financial market development have a more sluggish financial market development, and the polarization phenomenon is most obvious in this region.

4.3.2. Inter-Regional Disparity and Its Evolution. According to the Dagum Gini coefficient method, the results of the Gini coefficient measurement of the financial market development level among the four major economic regions in China from 2001 to 2020 are shown in Figure 7.

It can be seen that, firstly, the numerical importance of the inter-regional Gini coefficient indicates that there are obvious differences in the level of financial market development between regions. East and West > East, Northeast- > East, Central > Central, West > West, Northeast > Central, and Northeast average Gini coefficient during the continental period. Secondly, between regions, the change in the Gini coefficient can be divided into two phases: the first phase, from 2001 to 2005, showed a downward trend upward, then downward, and then a large change in all regions,

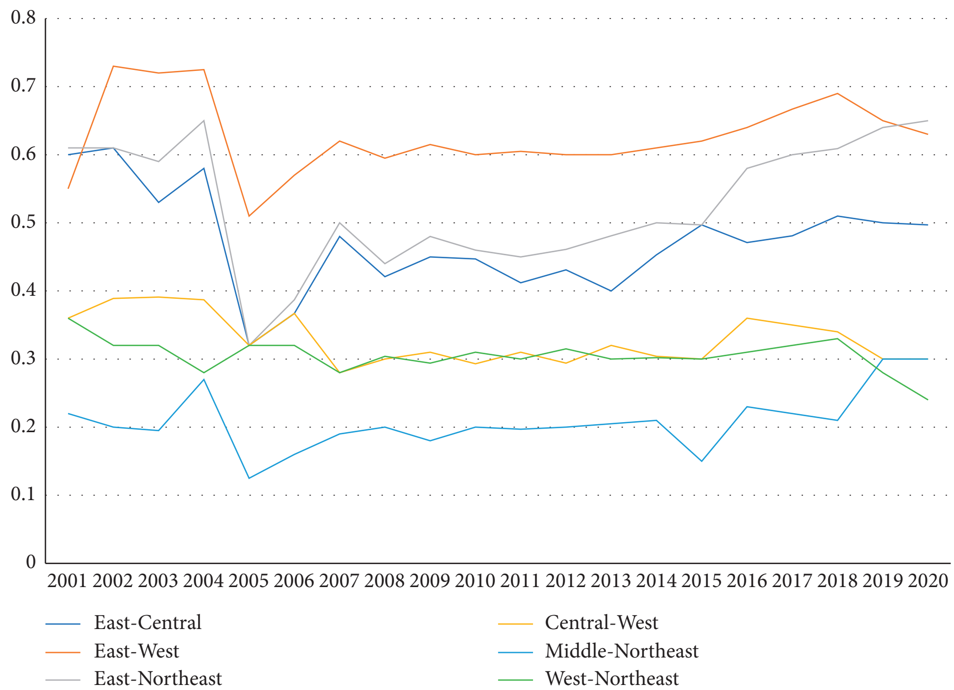

Figure 7: Inter-regional Gini coefficient of the level of financial market development in China's four major regions.

which indicates that most inter-regional disparities have clearly fluctuated; the second period (2006–2020) is characterized by a relatively stable, albeit slightly different, development of the regions during this period. The Gini coefficients of East and Central, East and West, and East and Northeast fluctuate gradually, while those of Central and West, Central and Northeast, and West and Northeast fluctuate from top to bottom and have a smaller range, and have basically not changed much in the past 15 years.

There is a big gap between the development level of the financial market in the East and that in the West, Central, and Northeast, which is much higher than that in the other three regions. From 2001 to 2005, the Gini coefficient between the east and the west changed a lot, increasing from 0.4389 to 0.7323, and was at its highest value in 2002; it ranged from 0.5228 to 0.6838 from 2005 to 2020, and reached its maximum value in 2018. The Gini coefficient between the eastern region and the northeastern region also changed dramatically between 2001 and 2005, between 0.3218 and 0.6488, and showed a significant upward trend from 2006 to 2020, indicating that the level of financial market development in the eastern region has gradually widened with that of the northeastern region in the past 15 years. Compared with the other two regions, the difference in the level of financial market development between the central region and the eastern region is not large, and although there is an upward trend in the past 15 years, the magnitude is relatively slow, so although there is a gap in the development of the financial market between the two regions, it is not an insurmountable distance. The trend of changes between East and West, East and Central, and East and Northeast is very consistent, which is highly correlated with the rapid development of financial markets in the East and the relatively close development rate of financial markets in Central, West, and Northeast. Except for the obvious regional differences between the East and the other three regions, the other three regions are not as different from each other. Between the central region and the western region, the maximum value of the difference between 2001 and 2020 is 0.4191, and the minimum value is 0.2688, with a relatively stable change in the difference in general; between the western region and the northeastern region, except for the up and down trend of the difference between the two before 2009, the difference between the two in 2009 and after is almost on a horizontal line, and the difference between the regions for many consecutive years is kept. The difference between the central region and the northeastern region is the smallest, at 0.2261 in 2001 and 0.2935 in 2020, with a mere change of 0.0674 in the past two decades. The financial market is also actively approaching and learning from the eastern region, while the gap between the central region and the northeastern region is also gradually widening because the northeastern region has been experiencing a continuous economic downturn in recent years and the development of the regional financial market is also significantly lagging behind.

4.4. Analysis of the Convergence of Financial Market Development. The evolution of temporal stages and the evolution of spatial forms are the two most significant aspects of financial market development. The change of regional spatial pattern is an important measure of the evolution of regional differences, and the factors affecting the evolution of regional differences show different characteristics in different periods. In order to explain the level of

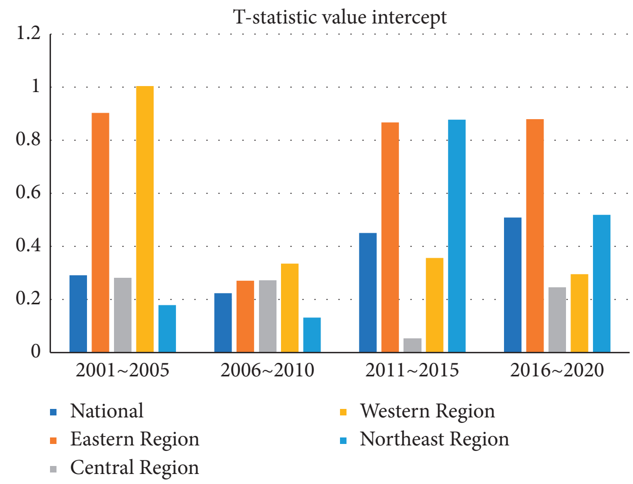

Figure 8: Convergent measurement results.

development of our financial markets from a convergent temporal perspective, taking into account the geographical factors that influence the level of development of financial markets in different provinces, as well as the reduced impact due to the heterogeneity of the results, we will try to introduce a matrix of distances spatial geographical latitude and longitude of the spatio-temporal model fusing the measurements of the relevant indicators and the level of development of each Chinese financial market. The relevant parameters were also studied. The study period is divided into four phases: 2001–2005, 2006–2010, 2011–2015, and 2016–2020, with convergence measures as shown in Figure 8.

5. Conclusion

Looking at the level of financial market development in China from an overall perspective, it is found that the spatio-temporal correlation convergence feature is obvious and the development of financial market is also in the convergence stage during the period under examination. That is, the correlation coefficient estimates for each period greater than zero show that the less developed regions are catching up with the developed regions. In other words, the level of development of financial markets in each region (i.e., the central region) is growing slower, and the regions with a lower level of development of financial markets (i.e., the periphery), and therefore the level of development of financial markets, is gradually decreasing over time. The correlation of the convergence speed coefficients shows that the speed of convergence first decreases and then increases in the considered time period. Among them, the maximum convergence rate has peaked according to the relevant parameter estimates for the period from 2016 to 2020, which indicates that, since the economy entered the new normal, a series of policies and measures such as the comprehensive deepening of economic system reform, strategic adjustment of the economic structure, and the promotion of coordinated regional development have been implemented with significant effects, and the rate of convergence of the level of development of China's financial markets has increased significantly.

From a partial perspective, the degree of convergence and the speed of convergence of development levels in different regions are obviously different. As with the country as a whole, the eastern region showed convergence during the period under review, with the correlation coefficient of the level of financial market development estimated to be greater than zero for the four periods, with a "V" shaped trend. By looking at the convergence rate, it is found that the eastern region is higher than the national region for the period 2001–2015. This also implies that the eastern region caught up faster than the national level and experienced strong economic development during this period. This is because the eastern direction of economic policy gives it the advantage of gradually establishing an integrated coastal economic zone, which will concentrate the central force of economic development and accelerate the process of regional integration; from 2016 to 2020, China's economy has entered a new normal. The eastern region also shows a convergence trend, and its convergence rate is much lower than the national level. This suggests an urgent need to improve the dynamics of economic development with the decaying effect of the marginal pull on the higher level of development of financial markets in the eastern region and with the slowing down of financial markets in the regions with lower levels of development to catch up.

Similar to the eastern region, in all four periods, the financial market development level in the central region also converged, but the rate of convergence is much higher than the national average and the other three regions. The economic pull effect of the higher level of financial market development in the region is obvious. The reason for this phenomenon is that after the implementation of the Central Rising Strategy, the central region has given full play to its latecomer advantage and fully learned from the experience of developed regions, so that the financial markets in its relatively lagging regions can develop in a coordinated and rapid manner, gradually narrowing the gap with the regions with higher levels of financial market development.

In contrast, the situation in the western region is completely different from the first two regions, with a continuous trend of convergence and differentiation in the level of financial market development. Its level of development converged significantly between 2001 and 2005, diverged between 2006 and 2010, and then converged again, but at a slower pace. This convergence increased significantly after the economy entered the new normal. The main reason for the two convergence states before and after maybe the western development strategy in the early stage and the formation of the comprehensive economic zone of the Great Southwest and Great Northwest in the latter stage, which led to the rising proportion of investment in the western region and the increasing degree of opening to the outside world, thus driving the rapid development of the regional economy and deepening the degree of coordinated regional development, as well as making the less developed regions in the western region continuously converge with the developed regions in terms of the level of financial market development, forming a radiation effect.

The level of financial market development in the Northeast region first shows a slight convergence feature from 2001 to 2005 and then shows an obvious divergence from 2006 to 2015 and then convergence feature from 2016 to 2020. The first convergence is in line with the economic development level of the Northeast region, i.e., the Northeast region implements the revitalization strategy and presents a catch-up state from the less developed regions to the developed regions, while the economic development in the eastern region slows down at this time and the economic gap narrows, and the difference in the regional financial market development level is slightly reduced again by this influence. The divergence of financial markets in the Northeast region was particularly obvious during the period from 2006 to 2010, which led to a significant reduction in the degree of convergence in the development of the country's financial markets during this period. With the implementation of the Northeast revitalization strategy, the continuous optimization of the economic structure and the acceleration of the modernization of industrial transformation contributed to the development of the Northeast economy. In recent years, the economic downturn in the Northeast is evident, and the level of financial market development, which also presents a small downward trend within it, reflected in the "measured regression," is the different characteristics of the financial market development in the Northeast, replacing the convergence from 2016 to 2020.

Data Availability

The dataset can be accessed upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

The Construction of University English Translation Teaching Model Based on Fuzzy Comprehensive Assessment

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With the deepening of economic globalization, the communication between countries is getting closer and closer. The common topic of communication between people of different cultures and environments is English. Since the country has established English as a subject, the importance of English has become one of the main factors for the all-round development of students. In recent years, higher vocational education in China has once again developed towards high quality, all-round diversification, and innovation. According to the continuous reform and innovation and independent innovation, college English has been proved to be an important part of higher vocational education and an important measure to promote the development trend of higher vocational education all over the country. With the progress of science and technology and the development of economy, the level of education in China is still improving. People have put forward stronger teaching standards and regulations for English, a course with strong adaptability and practicality. Part of Chinese translation in college English shows its comprehensive ability and high-level thinking ability. In order to integrate this trend, this paper proposes the formulation and use of college English translation teaching model. The experiment proves that the accuracy of the traditional fuzzy evaluation method in the comment module design of college English translation teaching mode is low, only 82% at most. In order to solve this problem, BP optimization algorithm is introduced. The precision and reliability of BP optimization algorithm are improved. Because of the learning effect of the college English translation teaching mode based on the fuzzy evaluation BP optimization algorithm proposed in the certification paper, the certification is carried out according to the questionnaire and the final evaluation method. The students' satisfaction and favoritism at the assessment level and the final results of their classmates have proved the proposed college English translation teaching model. The article has excellent learning effect.

1. Introduction

College English is a comprehensive course integrating listening, speaking, reading, and writing. The goal of college English is not only to let students understand English as a language expression, but also to let them know how to use English to exchange information and cultural expressions. By applying this kind of college English teaching mode, we can build a high-quality talent team with all-round development for students to learn English. Finally, students' Comprehensive English application ability is improved. The ultimate goal is to improve students' Comprehensive English application ability and understanding of English culture and express their thinking in English as fluently as Chinese [1]. In essence, college English is an overall summary of junior middle school English, an improvement in the level of English application ability, and an organic unity of reading, writing, listening, speaking, and translation. College English translation is a major branch of college English classroom teaching and a major factor for students to learn English. Therefore, how to build a college English translation teaching model that integrates the development of the times and the current educational concept is the main situation and orientation that scholars must consider [2].

The scientific research on how to do a good job in the classroom teaching of Chinese translation in the direction of college English has never stopped. For example, some researchers have taken the college English translation teaching model as a breakthrough and put forward corresponding analysis and countermeasures for this breakthrough. Please put forward some innovative points on this basis.

At the end of the graduation thesis, it puts forward the proposal of university capital construction, emphasizing that the effect evaluation of English translation teaching model is a big problem. In addition, some experts also proposed to integrate the collaborative teaching model into the college English translation classroom teaching and put forward how to build the practical application of the collaborative college English translation teaching model from seven aspects [3]. In this article, the author first put forward four questions. These four questions are as follows: first, we considered the problem of what the current college English rotation teaching model should look like. Secondly, how to popularize the cooperative teaching model of college English translation. Third, how to choose materials suitable for students' learning and training. Fourth, we pay attention to the selection of Chinese translation raw materials, which should not be oversystematized. Due to the excessive systematization of Chinese translation, the fourth problem is the crowd problem in the collaborative teaching model and emphasizes how to divide the crowd. Based on the discussion of the above four issues, this paper analyzes the advantages and disadvantages of the collaborative teaching model of college English translation and finally summarizes the basic theory of cooperative learning. In the brief introduction of the basic theory of cooperative learning, the creator first analyzed the meaning of cooperative learning and put forward that the core concept of this kind of teaching model is the division of responsibilities to achieve the goal. Finally, the author clearly put forward the application of such a collaborative teaching model to practical activities and put forward three stages, namely, the preparation stage, the management method stage, and the evaluation stage. In the evaluation stage, the author proposes to carry out mutual evaluation according to group cooperative learning and give full play to the guiding significance of teachers in teaching, so as to improve the motivation of students' learning English and strengthen their comprehensive Chinese translation ability. There are many other scientific research papers, such as this one, but most of them have basic theoretical characteristics similar to the above [4].

In general, according to the analysis of relevant papers, it can be seen that most of today's papers are about the theory and practice of how to build a college English translation teaching model, or about the theoretical research on the evaluation of the teaching content of the college English translation teaching model. However, this kind of theoretical research has not been well applied to practical activities. Practice is the only standard to test true knowledge. In order to better build the college English translation teaching mode and, at the same time, combine the educational concept with the teaching mode to make it more suitable for the fashion trend and development trend of the times, on this basis, combine the fuzzy comprehensive evaluation of independent innovation with the construction of the college English translation teaching mode, and finally build a college English translation teaching mode suitable for the characteristics of students at this stage. According to the questionnaire, the traditional college English translation teaching model based on fuzzy comprehensive evaluation method is compared with the technological innovation college English translation teaching model mentioned in this paper. Then, the fuzzy comprehensive evaluation and BP optimization algorithm are applied to objectively evaluate the college English translation teaching model mentioned in this paper. Finally, according to the analysis of subjective factors, the author constructs all college English translation teaching models.

2. Research Background

2.1. Analysis of Problems Existing in English Translation Teaching. From the first section, it can be seen that college English teaching is a unified organism integrating listening, speaking, reading, writing, and translation, and college English translation teaching is an indispensable part of English teaching at this stage, which is directly related to students' comprehensive English ability [5]. However, due to the harm of the traditional concept of examination taking, English teaching has always regarded Chinese translation teaching as a testing tool in China. Since the harm of English translation teaching to the actual effect of teaching is not significant, there is no test centered on "eating without distinguishing students." Therefore, in the case of teaching, the purpose of English translation teaching is to test all teaching [6]. More importantly, in order to be able to pass the English test, some colleges and universities feel that "readers win the world" and then spend a lot of time reading articles, thus reducing the length of other parts of English, such as college English translation, which generally reduces the length of classroom teaching. In addition, more importantly, because of the diversified development trend of understanding at this stage, the traditional teaching mode is no longer suitable for the characteristics of students at this stage. At this stage, college English translation teaching modes do not fully use students' initiative, and students' overall Chinese translation quality has not been greatly improved. In order to better build a college English translation teaching model suitable for the diversified development trend of today's students, this paper first analyzes in detail the deficiencies in the current college English translation teaching link and then builds a college English translation teaching model in line with the current teaching concept and the current situation of students' development according to these problems [7].

Firstly, college English translation has not been paid enough attention, which has seriously endangered the development trend of English translation teaching and scientific research [8]. Translation is a kind of comprehensive ability, which provides a bridge for people with different cultural characteristics and language expressions. However, the teaching of English translation has been neglected, which has already caused many students to neglect the learning and training of English translation. For example, under the pressure of relativism, many English students learn English every day just to brush their teeth and gargle and recite English words. Just because they choose the correct answer, there is not much professional knowledge and specific content related to Chinese translation. Because there are no such professional examination questions and norms as oral

English, Chinese translation in college students' English teaching has not been paid attention to.

Second, there is lack of mastery of Chinese traditional culture [9]. In China, Chinese is used to communicate and express feelings. A person's historical and cultural heritage is closely related to his Chinese. China has a long, extensive, and profound history. Chinese has experienced thousands of years of progress. The same word can have different meanings in different contexts, but it is different from English. English is simpler than Chinese in terms of vocabulary. Therefore, many students may misunderstand differences in different contexts when learning English. Especially under the test-oriented education mode in China, teachers are usually utilitarian in teaching, pay insufficient attention to language and culture teaching, and then ignore the differences in ideological status and cultural expression between the east and the west, resulting in the unclear language expression ability [10]. Therefore, based on establishing college English translation teaching methods, we should first pay attention to English translation, then pay attention to English language expression and culture, and pay attention to the differences between Chinese and English cultures.

In the case of teaching, it can not only shape students' ability to use English, but also improve their understanding of English.

Thirdly, in the traditional English translation classroom teaching, the teaching strategies are out of date, and the educational ideas do not conform to the characteristics of students [11]. Many teachers still adopt a step-by-step teaching method in the teaching process, blindly following the trend in writing scripts, thus failing to effectively translate words into certain technical progress and broaden professional knowledge. More importantly, because the course content and its source are from daily life, students are also interested in English translation [12]. In addition, because the teachers did not interpret the use of professional skills and professional knowledge development related to translation in their teaching courses, many students did not accept the learning, training, and learning of technical professional translation knowledge and skills. As a result, many students' translation ability is slowly improved, their participation is very low, and their professional learning is boring.

The fourth reason is that the course content is old, and the translation raw materials are not updated. In the teaching of English translation in colleges and universities, many colleges and universities do not attach importance to English translation, and the content of teaching materials on English translation has not been updated and filled. The content of old teaching materials is difficult to closely integrate the basic theory of the concept of sustainable development with the times, and it is difficult to connect with students' daily life and technical majors. Therefore, students' interest can not be enhanced, and the development concept of today's students is reversed [13]. In addition, there is a key problem; that is, nowadays translation software is more excellent, and many students and even teachers rely on translation software. Overreliance on translation software causes teachers and students to pay more attention to English translation and even lose thinking about the translation process from English to Chinese and from Chinese to English.

Applicability to intelligent system: in addition, another problem is that the current translation software is only a software after all, and intelligent translation is not omnipotent. Under the complex semantic and historical background, translation software has been unable to surpass human logical thinking, especially in the ability of human thinking and manipulating difficult language expression [14].

2.2. The Role and Significance of Translation for English Language Teaching. This paper definitely puts forward a more detailed teaching method of college English translation in order to build a more detailed teaching method of college English translation.

Firstly, there is a connection between the characteristics of college students' English and translation. The social development attribute and historical and humanistic attribute of college English teaching have been known to all over the years. The attribute of social development refers to the use of English in daily life for mutual communication and leisure activities, while the attribute of people is to express ideas and emotions in English. It happens that these two attributes are closely related to the whole process of English translation, either explicitly or implicitly. When college students learn English in colleges and universities, through long-term learning and training, they have had a rich and colorful foundation and formed their own learning methods. It happens that this kind of relatively solid foundation for English words, reading, and writing enables them to skillfully apply English grammar and relevant sentence patterns as the basis for English translation [15].

Secondly, English translation can further improve students' English learning and training ability and enable them to have a more in-depth and correct understanding of oral English and a more comprehensive cognitive ability. Compared with college students, they can improve vocabulary memory, reading, and understanding, English grammar use and creative expression ability through many translation practice activities. In addition, English translation requires not only a certain vocabulary foundation, but also a more solid English grammar foundation and reading ability. A certain amount of English translation training can comprehensively improve college students' English dictation, reading and writing ability, and translation ability, reading time, and the ability to understand the theme of the article content or the meaning of some paragraphs of the article content [16].

Translation classroom teaching can reasonably improve college students' creative ability and quickly improve their creative ability and English listening skills. In a word, English translation is an indispensable foundation and an important part of college English. It can be said that it is at the core of relativity in all college English teaching situations.

Thirdly, the relationship between English translation and western culture learning was discussed. English learning is not only the learning of language expression, but also the learning and understanding of culture. Language expression and culture are closely related. Therefore, cultural concepts are particularly important in English learning, and mastering western culture is one of the necessary ways to learn English. As the creative thinking of Chinese-English transformation, Chinese translation is the core area of cultural communication between China and the West [17]. As a road bridge for cross-cultural interpersonal communication, college English students learn western culture according to Chinese translation and comparison between Chinese and Western culture. On the one hand, they can deepen their understanding of local culture and external culture, and on the other hand, they can improve their working ability in cross-cultural interpersonal communication.

In general, English translation learning and classroom teaching not only conform to the characteristics of actual English, but also enhance college students' grasp of English at the level of vocabulary and reading. More importantly, according to the classroom teaching of Chinese translation, students can deepen their understanding of the cultural differences between China and the west, deepen their understanding of their own culture and foreign culture, and better grasp the vocabulary English, the grammatical application of English, and their writing methods in different situations, so as to further improve students' English level.

3. Materials and Methods

3.1. Fuzzy Integrated Assessment. Comprehensive assessment can be distinguished between subjective and objective levels. The subjective level is essentially a qualitative analysis, often called the subjective empowerment evaluation method, and the specific methods commonly used are the hierarchical analysis method and the fuzzy integrated assessment method. From the objective level, it is essential from the correlation or the coefficient of variation of each index, and the commonly used methods are the gray correlation method, TOPSIS method, and principal component analysis. The specific relationships can be shown in Figure 1.

It can be seen from Figure 1 that the fuzzy comprehensive evaluation method belongs to the subjective value evaluation method, that is, the method of using doctors' experience and professional knowledge to award a certain weight value to new projects, and the weight value reflects the quality level of evaluation. Fuzzy evaluation should be based on fuzzy set. Under the condition of mathematical model, the comprehensive basic principle of fuzzy relation should be applied to carry out quantitative analysis on some elements with unclear boundaries and not easy to quantify analysis and then carry out comprehensive evaluation on the membership of the evaluated things from several elements.

In the process of English translation teaching, traditional translation teaching is to gradually teach translation professional knowledge or skills according to the content of teaching materials or translation raw materials. These methods are not conducive to shaping students' logical thinking ability and sufficient English translation initiative. However, there are many uncertain factors in the process of English translation teaching, such as students' acceptance of basic English knowledge, or students' different situations in English teaching. From the perspective of practical activities, simple English translation teaching is not suitable for the teaching orientation of polymorphism and the specific acceptability of students [18]. In contrast, the fuzziness assessment method can quantitatively analyze this uncertainty and generate a fuzziness drainage matrix. Finally, the weight values of uncertainty are all over the world, and the uncertainty is limited in a quantitative way, which can give some practical significance for English translation classroom teaching, which can further improve students' Chinese translation ability and their vocabulary, reading, and writing abilities. More importantly, according to this kind of comparative method, more importantly, according to this kind of comparative method, students' understanding of the differences between Chinese and Western cultures can be further improved. Finally, students' consciousness can be fully used to produce a closed-loop control learning method of active learning.

3.2. Neural Network under Fuzzy Comprehensive Judgment. In this paper, firstly, the uncertainties of English translation will be determined by fuzzy evaluation method, and then the softmax layer of neural network will be used to classify these uncertainties, and then the classified results will provide teachers with certain reference in the teaching process of English translation, and finally a mixed-mode university English translation teaching model will be formed. Therefore, the next part of this paper will introduce the neural network under fuzzy evaluation.

Neural network is abbreviated as NN, which can also be called artificial neural network, and the basic units of neural network are all neurons, in which classification, adaptive noise filtering, and system identification can be implemented [19]. The basic structure of one of the neurons is shown in Figure 2.

From Figure 2, it can be seen that the basic structure of neuron under deep learning can be composed of basic linear function and excitation function. Among them, the equations of the basic linear functions are generally shown as follows:

$$f1 = wx + b. \tag{1}$$

From (1), W is the weight value of all neural network models, where B is the error function formula or error value, which is set as an adjustable error value in this article [20]. In the neural network model, input x is first used for SVM algorithm according to the input layer, and then it is immediately sent to the linear function formula together with the input according to the obtained weight value. However, if it is only solved according to the linear function formula, the accuracy of this kind of linear neural network model is very low, and the convergence performance is also poor, which is not conducive to convergence. Therefore, generally, nonlinear solutions will be added after linear solutions. That is, the part of F shown in the Figure is usually added after the linear solution. This part is generally called the activation

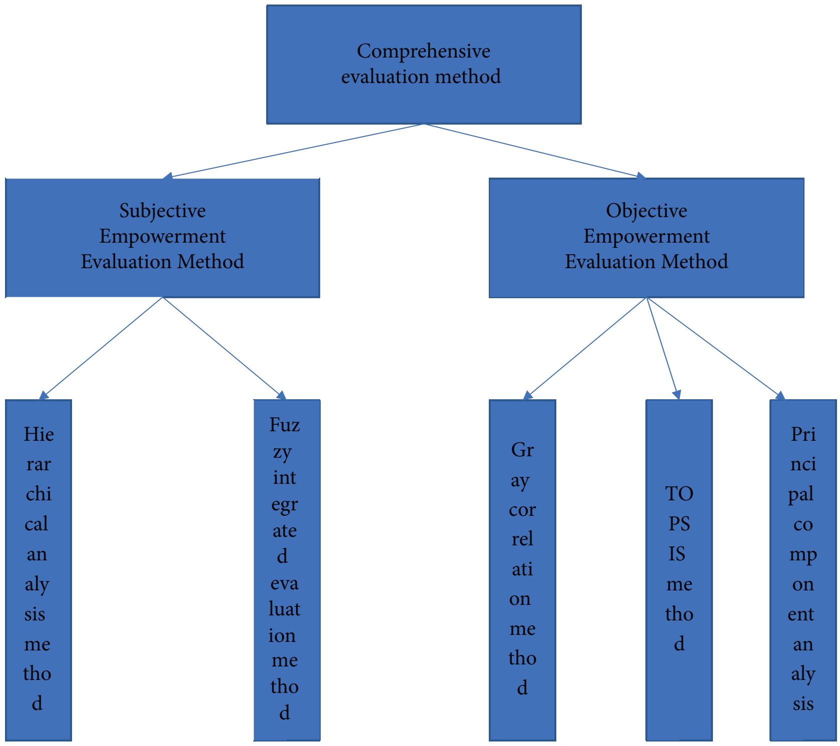

Figure 1: Specific block diagram of comprehensive evaluation method and its branches.

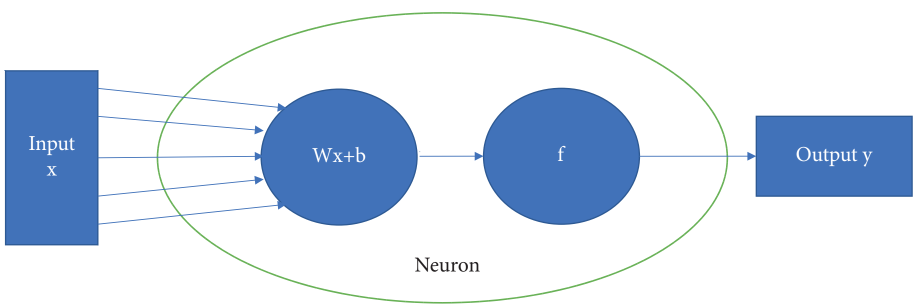

Figure 2: Basic structure of neurons under deep learning.

function. After the nonlinear solution, it realizes the derivation of Y according to the derivation layer, in which the activation function can be regarded as a nonlinear projection again. The introduction of activation function makes all neural networks look richer and more complicated, thus enhancing the language expression ability of all the Internet. If only one linear relation is applied, the neural network model obtained from linear accumulation only has the effect of linear projection, which is not very practical in real life.

It can be seen from Figure 2 that, in terms of network architecture, the neural network can be divided into input layer, export layer, and pooling layer, as well as convolution layer and pooling layer in the neural network. The key method in the work of neural network is to gather the difference data signals in the input layer according to the linear combination entity model. Each data signal has different weight values, and then determine whether to export according to the activation function. In the neural network model, the final value is the weight value, because the selection of the weight value determines the orientation.

Neural network model, on the contrary, determines the convergence performance of neural network and other main factors that can finally achieve the most advantage. The common activation functions are generally sigmoid function formula and linear rectifier function formula ReLU function. The actual formula calculation is shown in (2) and (3).

$$f(x) = \frac{x}{1 + |x|}, \tag{2}$$

$$f(x) = \begin{cases} 0, x < 0, \\ x, x \geq 0. \end{cases} \tag{3}$$

The relationship between the activation function and the linear combination can be shown in (4), where b denotes the bias function, and w denotes the weight. From (4), it can be seen that the relationship between the linear and nonlinear functions in the neural network is nested. And it is because of this nested relationship that the neural network has a strong learning ability and self-adaptive ability, with a certain degree of complexity of the nonlinear system making the whole neural network model fully imitate the human thinking activities and then in the learning aspect to show a certain intelligence and intelligent thinking.

$$y = f\left(\sum_{i=1}^{n} w_i x_i - b\right). \tag{4}$$

The role of fuzzy judgment in the neural network model is not only to determine the judgment criteria, but also to derive the fuzzy matrix, which is used as the input of the feature matrix of the neural network after the feature extraction is completed.

4. Results and Discussion

4.1. General Framework. In order to better reflect the advantages and innovative ability of the college English translation teaching model mentioned in the article, the paper integrates the basic knowledge of in-depth learning to formulate and build the teaching model. Deep learning is one of the best ways for learners to learn independently and improve their professional skills of independent innovation. Deep learning not only cares about learning, but also cares about the depth of learning. Today's students spend very little time learning the professional knowledge in the teaching materials, let alone increasing their understanding, but according to the in-depth learning, they can further improve the shaping of high-level thinking, promote students to actively carry out classroom teaching and learning theme activities, and deal with learning problems. On the premise of solving problems, students can increase their understanding of knowledge, so as to optimize all college English translation learning, produce a closed-loop control learning method of "continuous breakthrough and continuous expansion," gradually improve students' college English translation learning management system under the condition of pioneering learning, and finally improve students' subjective learning motivation. In this article, we have studied the deep learning method scientifically and applied it flexibly. Therefore, on the premise of comprehensive scientific research on the theory of in-depth learning knowledge, the paper puts forward a basic framework for building a college English translation teaching model, as shown in Figure 3.

In Figure 3, the text is carried out under the premise of machine learning. The college students' English translation teaching plan is designed as a mixed teaching mode, which selects online learning and offline self-study, respectively, comprehensively considers the normative situation of the epidemic situation, integrates the teaching mode of smart classroom mobile students' autonomous learning, and divides it into pretranslation personal behavior, translation personal behavior, and posttranslation behavior. According to the above methods of online learning and offline learning, promote and implement the mixed teaching mode and cultivate students' innovative thinking ability, students' autonomous learning ability, and problem-solving ability. The key points in this paper are to conduct personal behavior before translation according to online learning, including video online prelearning training, defining daily tasks in Translation Classroom Teaching, and conducting classroom students' autonomous learning. Change the translation teaching mode into a "creative cooperation" translation teaching mode. Personal behavior after translation is the key to this thesis. At the level of personal behavior after translation, the key points in this paper can be divided into three parts: preparation for examination and work, comments, and retranslation. In the comments, the paper selects the BP optimization algorithm of fuzzy evaluation neural network to distinguish the variability of primary and secondary school students and teachers in college English translation teaching and carry out horizontal zoning, so that teachers and students can better learn, train, and teach translation professional knowledge, improve college students' English translation ability, and promote the learning effect together.

In general, in order to build a more comprehensive and detailed English translation teaching model, due to the subjectivity of fuzzy evaluation, when the index value set u is relatively large, the relative membership power index is usually small, resulting in the mismatch between the power space vector and the fuzzy drainage matrix R.

In more serious cases, it may also happen that the screen is too fuzzy. On the contrary, it will cause poor screen resolution, unable to distinguish the membership of different matters, and even may cause unsuccessful discrimination. In addition, when there are too many index values, there are no effective data statistics, and the weight value is difficult to be clear. More importantly, there are too few quantitative data for pure fuzzy evaluation, there are too many judgment components, and the evaluation conclusion is usually unreliable. To solve the above problems, a neural network model based on ambiguity resolution is introduced, as shown in Figure 4.

In Figure 4, the neural network entity model is completed as fuzzy judgment, and a BP algorithm fuzzy judgment entity model with fuzzy judgment and neural network embedded each other is generated. It can be seen from the overall framework steps in Figure 4 that the text will first define the element set and comment set according to the evaluation and discussion of doctors and students on English translation teaching methods, crawl according to the evaluation of the online teaching platform by the web crawler, then define the weight value of the index value according to the evaluation of subjective values, then define their attribution to the spatial vector, and then carry out the fuzzy judgment matrix of over, Finally, fuzzy solution is carried out for the fuzzy judgment matrix. Finally, the obtained data is normalized to generate samples with suitable sample format. Such samples can be transmitted to the introduction layer of the neural network as the input of the central nervous system transmission layer. Subsequently, learning, training, and practice are carried out for the BP algorithm of the neural network, and finally the results are output.

4.2. Implementation of BP Algorithm under Fuzzy Judging. It can be seen from Section 3 that the neural network is mainly composed of three parts, namely, network

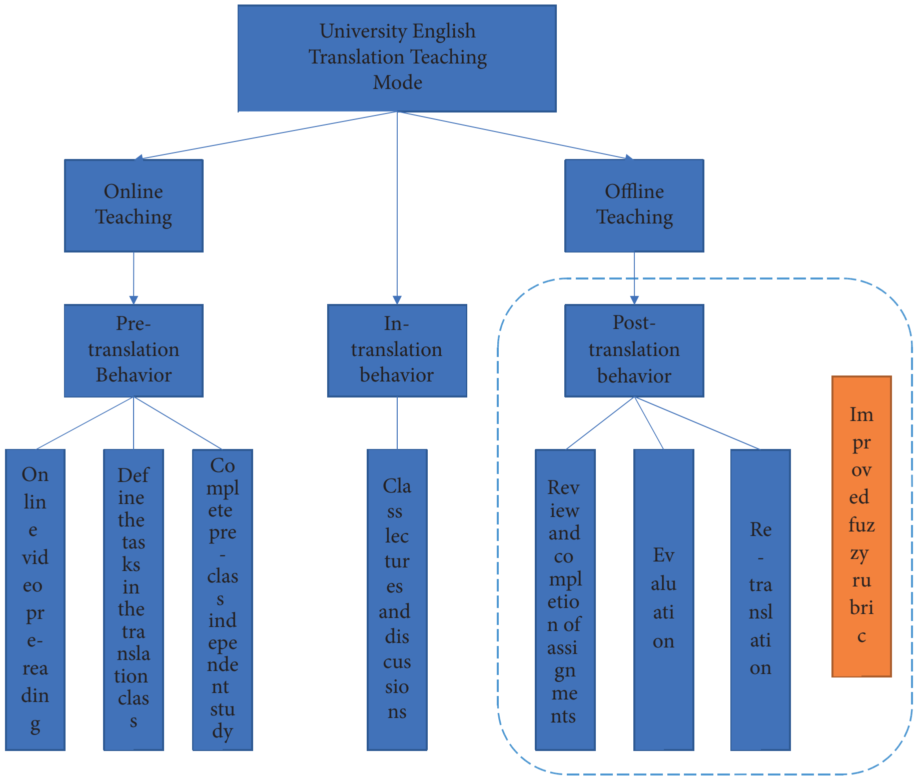

Figure 3: Based on the improved university English translation teaching model.

architecture, activation function, and main parameter learning and training algorithm, so as to find the best weight value. In the third part, BP algorithm is a more common main parameter learning and training algorithm, which is a double-layer feedforward control neural network practiced according to the error back propagation algorithm. The general whole process of BP algorithm is to calculate FP first, that is, the spread of sperm motility, type in the sample, taking the above fuzzy drainage matrix obtained after fuzzy evaluation as the original weight W and error item B, and calculating the error between the actual value and the derived value, that is, the error difference. If the damage value is not within the given range, it is the second step of BP algorithm, that is, backpropagation; otherwise, the upgrade of weight W and error value B will be terminated. In the case of backpropagation, it is mainly based on the backpropagation of the error. The error will be backpropagated from the derived layer to the imported layer in a certain way, and the error will be spread to all nerve cells in each layer, so as to obtain the error data signal of each layer module, and then take it as the basis for calibrating the weight size of each nerve cell module.

In general, the purpose of BP algorithm is to continuously adjust the correct direction of all neural network models according to the upgraded weight value and error value, so that it finally converges to the optimal value. In this article, as shown in Figure 4, we will first get the corresponding evaluation based on the crawling technology and then get the corresponding data based on some data preprocessing technology. Finally, the index value set and comment set are obtained according to the arrangement, and then fuzzy processing is carried out to obtain the ambiguity.

Then, the fuzzy and relevant overall planning is carried out for the Y drainage matrix to make it suitable for the original weight and error function formula of the neural network clear. Finally, the weight and error value are continuously innovated according to the BP algorithm and backpropagation, and finally the accuracy of its evaluation is obtained. In order to obtain faster precision, the ReLU function formula is used as the activation function in this paper. Because the standard evaluation interval in this paper is [0100], there can be no evaluation lower than 0. In addition, when the gradient direction exceeds 1, the ReLU function formula can ensure stability, and it is not easy to fade in the gradient direction. Because of the effectiveness and accuracy of part of the evaluation of college English translation teaching methods based on the fuzzy evaluation method clearly proposed in this article, the simple fuzzy evaluation method is first used to comment on all matters. According to the statistical analysis of data, the accuracy chart of fuzzy prediction analysis is shown in Figure 5.

It can be seen from Figure 5 that if the traditional fuzzy evaluation method is used to predict and analyze the comments on college English translation teaching mode, its accuracy is in the middle of [0.65, 0.83], but this accuracy is not high enough. Therefore, in this prediction and analysis case, the frequency with a success rate of more than 80% is far less than the frequency in the middle of 60%–70%, mainly because in the traditional fuzzy identification method, the

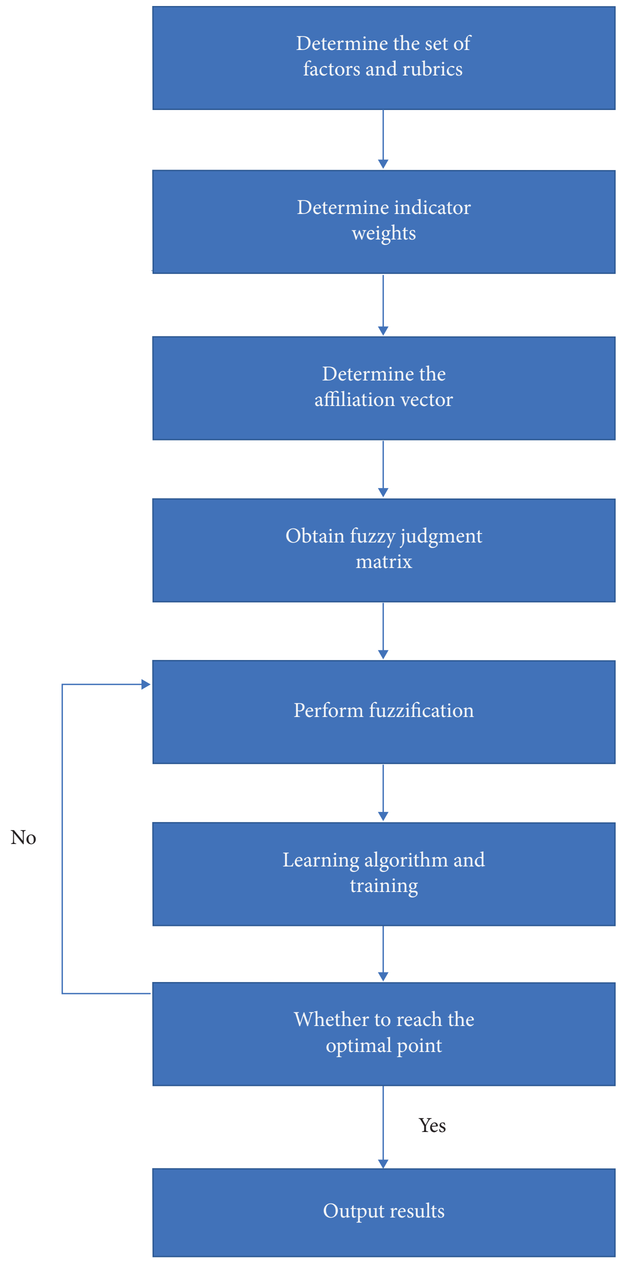

Figure 4: The general framework flow implemented in this paper.

fundamental reason for this is that, among the traditional ambiguity resolution methods, the purpose of the assessment method is to be subjective, which is also very subjective, which will improve the error rate of the assessment prediction and analysis. Therefore, the accuracy of the assessment prediction and analysis of the college English translation teaching model based on the traditional ambiguity assessment method needs to be improved.

According to the above analysis, it can be seen that the traditional fuzzy evaluation method mainly carries out comments on college English translation because of the harm of subjective reasons. In order to improve the problem of low accuracy of the traditional fuzzy evaluation method, we must reduce the harm of subjective reasons. Therefore, this paper introduces the BP optimization algorithm into the traditional fuzzy evaluation method and adjusts the weight value and error according to the back propagation to improve the objective reasons, so as to achieve the goal of reduction. Therefore, this paper introduces BP optimization algorithm into the traditional fuzzy evaluation method, adjusts the weight value and error according to the backpropagation, improves the objective reasons, reduces the subjective reasons, and finally improves the effectiveness of the teaching mode. The precision of comment prediction analysis of college English translation teaching mode based on the improved fuzzy evaluation method is shown in the Figure, in which the dark blue curve shows the precision of comment prediction analysis of college English translation teaching mode based on the traditional fuzzy evaluation method.

ZY resolution method and orange curve chart illustrate the accuracy of the evaluation and prediction analysis of the college English translation teaching model based on Fuzzy ambiguity resolution method after introducing BP optimization algorithm.

As can be seen from Figure 6, the success rate of the improved fuzzy evaluation method is significantly better than the traditional fuzzy evaluation method for the evaluation and prediction of college English translation teaching mode. From the comparison of precision value, the average precision in this paper is increased by 5% after introducing BP optimization algorithm. In terms of the main production range of accuracy, the success rate above 80% is significantly higher than the traditional fuzzy evaluation method, and only one value is less than 80%. In the smoothness level of the curve, the improved fuzzy evaluation method in this paper has smoother prediction effect than the traditional fuzzy evaluation method, and the neural network model of the improved fuzzy evaluation method in the explanatory text has scalability and robustness as shown in Figure 6.

4.3. Analysis of Teaching Indexes Based on the Traditional and the Improved Fuzzy Judgment Method. In order to better reflect the actual effect of the improved fuzzy evaluation control module mentioned in the article on the college English translation teaching model, the traditional fuzzy evaluation method and the improved fuzzy evaluation method are selected for the college English translation teaching model, and the teaching practice is carried out in two classes of a university. The effect of the questionnaire is shown in the figure. Class 1 is a college English translation teaching mode based on the traditional fuzzy evaluation, and class 2 is a college English translation teaching mode using BP optimization algorithm to introduce fuzzy evaluation. The number of students in both classes is 60. The English level of the two classes is basically the same, and there is no significant difference in the number of students with different degrees.

It can be seen from Figure 7 that, under the evaluation module of the two ambiguous evaluation methods, the survey report on the degree of satisfaction and favor of college English translation teaching methods is as follows. For class 1, the number of satisfactory students is

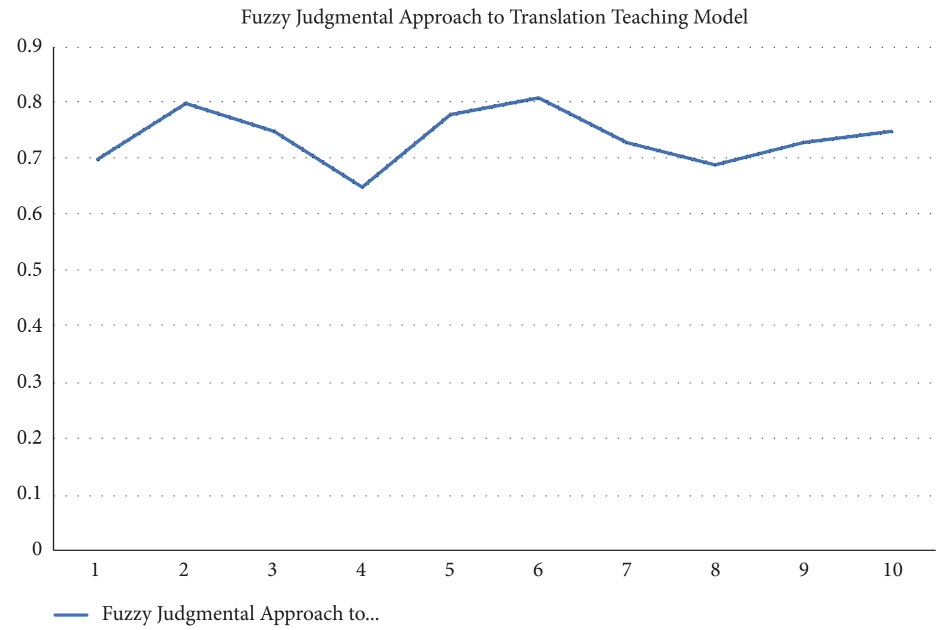

FIGURE 5: Accuracy rate of evaluation prediction of university English translation teaching mode by traditional fuzzy judgment method.

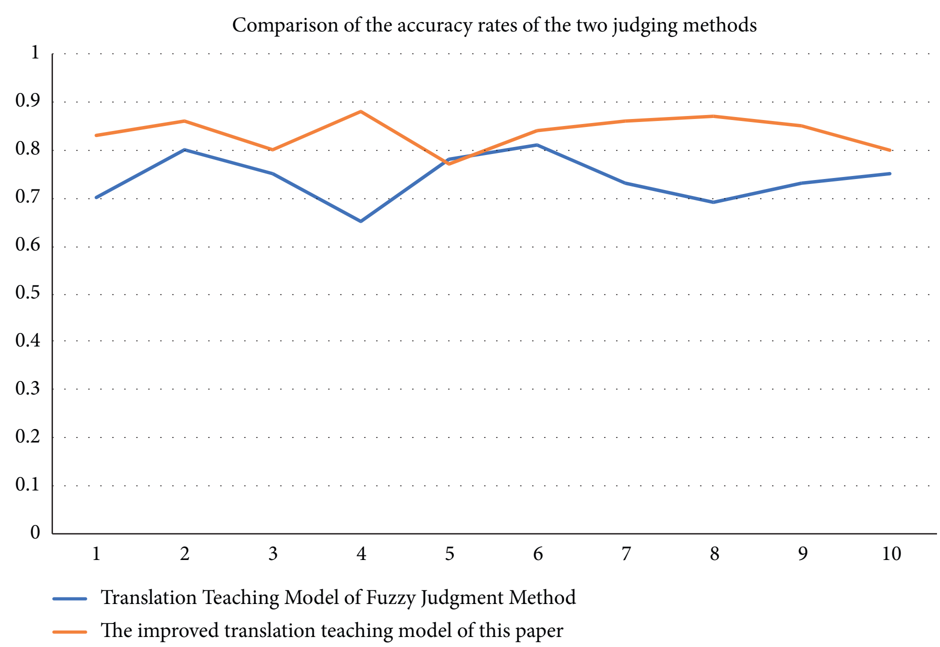

FIGURE 6: Accuracy of evaluation prediction between the improved and the traditional fuzzy judgment method of university English translation teaching model in this paper.

significantly lower than that of class 2. The number of satisfactory students is basically the same, but the relative height of the column chart is still slightly lower than that of class 2. The number of dissatisfied students and disliked students is much higher than that of class 2. It can be seen that, according to the application questionnaire, the conclusion is drawn that, compared with the evaluation module under the traditional fuzzy evaluation method, students prefer to choose the evaluation module of post-fuzzy evaluation method integrating BP optimization algorithm. See Figure 7.

Figure 8 shows the comparison of the final research results of the evaluation control module of college English translation teaching methods by two different ambiguous evaluation methods. In order to ensure the fairness of the test and the universality of the experimental results, all the

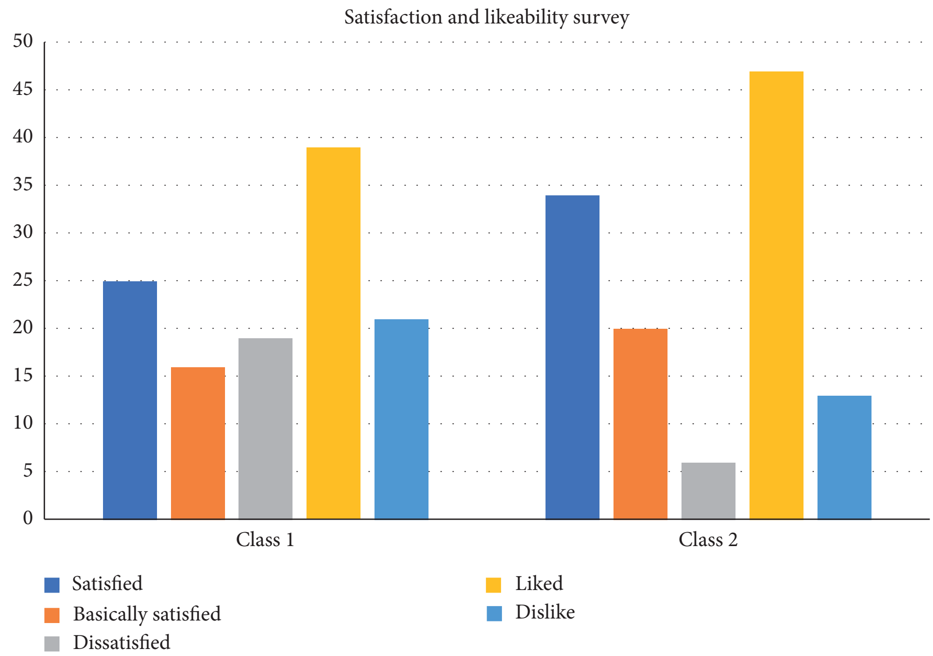

Figure 7: Satisfaction and liking survey of evaluation modules of university English translation teaching mode with two different fuzzy judgment methods.

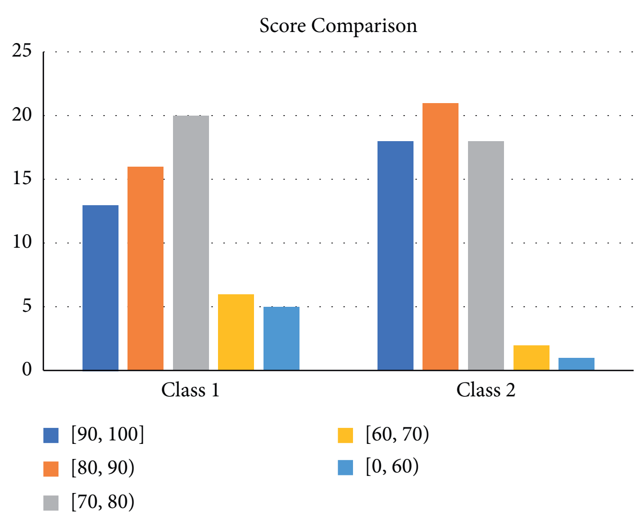

Figure 8: Comparison of the final grades of the evaluation modules of two different fuzzy judgment methods of university English translation teaching models.

papers in this round of test are one paper, and the class level of students is basically the same. It can be seen from the figure that the number of students in class 2 with scores above 80 is significantly better than that in class 1, indicating that the fuzzy evaluation method with BP optimization algorithm is more effective and easier for students to recognize; However, in the score of [70, 80], within the score range of [70, 80], the number of students in class 1 is higher than that in class 2, which means that the improved fuzzy discrimination method in the text should be improved for junior students as shown in Figure 8.

5. Conclusion

This paper takes the college English translation teaching mode as the research object, and the selected implementation method is the fuzzy evaluation BP optimization algorithm. In order to get a faster learning effect, and whether college students' acceptance of the college English translation teaching model and their translation level have been improved after scientific research to improve the fuzzy evaluation method, this paper puts forward some solutions from the shortcomings of the traditional college English translation teaching model. It also proposes to apply fuzzy evaluation method and neural network together in terms of materials and analysis methods to complete the basic theory based on in-depth learning in this paper. According to the deep application of this basic theory, the online and offline teaching modes are fully integrated, and finally, the overall structure of college English translation teaching mode is obtained. Introduce BP optimization algorithm based on this structure and more traditional fuzzy evaluation methods and fuzzy evaluation methods, The comment control module is improved. On the premise of comprehensive consideration of human factors, the satisfaction and liking of students are investigated according to the method of questionnaire. At the same time, in order to fully verify the effectiveness of the college English teaching model proposed in this paper in enhancing the students' foreign language level, the graduation thesis is finally certified according to the final examination conclusion.

In general, the above test results show that the accuracy of the improved comment module is about 3%–5 points higher than the traditional fuzzy evaluation module, and the overall performance is more stable. In terms of final examination results, the improved fuzzy evaluation method is more reasonable in enhancing students' learning results and has a good learning effect.

Data Availability

The dataset can be accessed upon request.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Construction of Primary and Secondary School Teachers' Competency Model Based on Improved Machine Learning Algorithm

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In order to quantitatively evaluate the competence of primary and secondary school teachers, a competency model of primary and secondary school teachers based on an improved machine learning algorithm is proposed. The fitting parameter analysis model of primary and secondary school teachers' competency is constructed, and the fitting benefit degree parameter of primary and secondary school teachers' competency is extracted based on the analysis results of reliability index parameters. The improved machine learning algorithm is used to carry out quantitative analysis and characteristic element analysis in the process of primary and secondary school teachers' competency evaluation and determine the competency elements of the model. According to the machine learning model, the competency elements are conceptualized and classified, and the theoretical parameter analysis model of online teaching competency of primary and secondary school teachers is constructed to realize the assessment and quantitative analysis of primary and secondary school teachers' competency. Factor analysis and reliability tests were performed using the KMO test and Bartlett test. The empirical simulation analysis results show that the reliability and accuracy of the evaluation of primary and secondary school teachers' competence by this method are good, and the level of credibility is high.

1. Introduction

In recent years, when studying teachers' competence, domestic scholars often divide the teaching stages of teachers from different perspectives, such as kindergarten teachers, primary and secondary school teachers, and college teachers, or according to the division of disciplines, study art teachers, and physical education teachers. Later, with the advancement of digital teaching, some scholars gradually began to study teacher competency based on digital learning, such as teacher competency for maker education, WeChat promoting teacher competency, and teacher digital competency [1]. On the basis of competency, other studies have matched the relationship between competency and teachers' performance, the relationship between competency and teachers' teaching happiness, and so on. However, in the process of reading the literature, it is found that no scholars have specifically studied the online teaching competence of primary and secondary school teachers. The reason may be that primary and secondary school teachers and students in China spend less time on online learning. Under traditional classroom teaching, online teaching may only exist on weekends or holidays to answer questions. However, under the "COVID-19 epidemic" environment, teachers and students in primary and secondary schools all over the country have participated in online teaching and learning, which is an opportunity to study the online teaching of primary and secondary school teachers [2]. With the continuous expansion of research areas, we should gradually break through the relatively lacking content in research in the later period. In recent years, with the continuous development of educational informatization, various regions have also launched many training to improve teachers' informatization ability, and held many teaching informatization competitions, such as Liaoning Province's "Educational Informatization Competition" and "Primary and Secondary

School Microcourse Quality Competition." All kinds of training and courses are aimed at improving teachers' informatization level, which provide a good foundation for online teaching. However, there is little training dedicated to "online teaching." According to the feedback from teachers in the interview, the front-line teaching is very busy, and teachers cannot watch videos for a long time to learn. This requires the education system to know the difficulties and problems existing in the online teaching process of teachers, what help they need to get, and to carry out targeted guidance and training. I hope to provide better training methods and help teachers improve their online teaching competence. Studying the competency model of primary and secondary school teachers is of great significance in improving the teaching quality of primary and secondary school teachers [3].

Under the premise of the rapid development of online teaching, this research is based on the full online education of teachers and students in primary and secondary schools in the epidemic situation, and solves the practical problems and needs to be encountered in the development and use of online teaching. It has certain theoretical and practical significance to carry out the "online teaching competency model construction and empirical research of primary and secondary school teachers." On the basis of summing up and drawing lessons from predecessors' competency elements and building competency models, this article uses the interview method and "onion model" to study the structure of competency, which expands the research field of domestic competency. Combining with the practical needs of primary and secondary school teachers, studying the elements of primary and secondary school teachers' competency in different dimensions enriches the theory of teachers' competency and innovates the competency of online teaching [4]. After determining the elements and structure of primary and secondary school teachers' online teaching competency, it has practical significance to educational administrative departments, educational administrators, and teachers who participate in online teaching. For the administrative department of education, it can provide a basis for teacher recruitment and training. For educational administrators, the online teaching competency model can provide a measurement basis for teachers' assessment, evaluation, and post-assignment. For teachers themselves, they can define their daily development goals and promote the development of teachers and the traditional education industry. While improving teachers' quality, it directly affects the level of "education" and improves students' learning quality.

In recent years research, when domestic scholars study teachers' competence, they often start from different perspectives of teachers' competence and make great efforts in the teaching stage, such as Qiu and Xiao teachers. Later, with the advancement of digital teaching [5], or according to the division of disciplines, teachers of fine arts disciplines and physical education disciplines will be studied. In the later period, with the advancement of digital teaching and the continuous expansion of research areas, we should gradually break through the relatively scarce content of research in the later period. The teacher's competency is not a single structure, but a multidimensional fear, which develops friendship, continuity, planning and organizing ability, certain working standards, quick response ability, eight-border creation, control and innovation, sexual learning, technical or professional knowledge, counseling, decision-making, learner-centered, quality concern, and quality concern. These 15 factors play a vital role in implementing successful online teaching behavior. By comparing the characteristics of "teacher competency" at the level of state institutions, it can be seen that the United States pays more attention to the mutual respect of excellent managers when proposing the competency of teaching managers, and the characteristics of "teacher competency" proposed by relevant institutions in Britain and Australia are more universal and applicable to most teachers, and these characteristics of teacher competency include general abilities. The starting point and content presentation of these two competencies play a complementary role. This is also Spencer's "excellent performance" and "effective performance" in the ability research, which is very popular among scholars in the later research of teachers' competency characteristics. In reference [6], a comprehensive evaluation of clinical teacher competency was carried out on 80 newly appointed young teachers in May 2019, and an indicator system was constructed. However, the convergence of this method for competency evaluation of primary and secondary school teachers was not good. In reference [7], principal component analysis, nonnegative matrix decomposition, local linear embedding method, and uniform manifold approximation and projection method are used to reduce the dimension, respectively. After extracting the key features, regression is carried out in polynomial model and random response surface model. Finally, simulation modeling analysis is carried out on the dataset of peat soil and electrical system. However, there are some problems with this method, such as poor convergence and large ambiguity.

In view of the above problems, this article proposes a competency model for primary and secondary school teachers based on improved machine learning algorithms. According to the principle of machine learning, the competency elements are conceptualized and classified, and the theoretical parameter analysis model of online teaching competency of primary and secondary school teachers is constructed to realize the assessment and quantitative analysis of primary and secondary school teachers' competency. Factor analysis and reliability tests were performed using KMO test and Bartlett test. Finally, the empirical analysis is carried out, and the validity conclusion is drawn.

2. Theoretical Analysis and Parameter Model Construction

2.1. Theoretical Analysis of Primary and Secondary School Teachers' Competency Model. On the basis of the previous literature review, it is found that there is no unified cognition and perfect system model for online teaching competency of primary and secondary school teachers in the research field of teacher competency. Therefore, based on the existing research on competency theory and methods, according to the relevant theories and methods of competency, the online teaching competency model of primary and secondary school teachers is theoretically constructed [8]. Especially during the "COVID-19 epidemic" in 2020, primary and secondary school teachers all over the country successfully completed the "suspension of classes and nonstop study," and all teachers realized the challenges brought by online teaching to teachers themselves, which gave me a great premise and practical support to study the competency model of online teaching for primary and secondary school teachers.

According to the concept of applying the grounded theory and the online teaching competence of primary and secondary school teachers, the extracted competency elements are analyzed and summarized from the bottom up to determine the competency elements. Then, according to the above theoretical standards, the onion model is used to conceptualize and classify the competency elements, and build a theoretical model of online teaching competency for primary and secondary school teachers. The specific process is shown in Figure 1.

In Figure 1, first, build the competency factor extraction model. The first step is to search the relevant literature. As there is no specific related research in CNKI based on the keyword "online teaching competence of primary and secondary school teachers," I take online teaching of primary and secondary school teachers as the research point. First of all, 37 documents, 5 online teaching abilities, and 53 information-based teaching abilities in primary and secondary schools were searched by using "primary and secondary school teachers' competence" as the keywords [9]. According to the guiding needs of grounded theory in this study, 24 of them were selected as the basic basis for this study to preliminarily summarize teachers' competence, forming the first-level code of grounded theory. Online teaching for primary and secondary school teachers is a teacher at first, therefore, in the process of reading and searching literature, we should first consult the abilities that a primary and secondary school teacher should have. Second, the difference between online teaching and ordinary classroom lies in one more medium. Or teachers give video lectures through WeChat, Tencent, and other software with video functions, or give feedback on homework through online learning spaces and learning platforms, which means that teachers should use information technology in online teaching. Therefore, combining the teachers' information technology application ability advocated by the state at this stage with the particularity of online teaching teachers' competency in the process of determining, we have made targeted integration in the process of literary analysis.

2.2. Primary and Secondary School Teacher Competency Model Parameters. According to the sample standard, 10 excellent teachers are selected in a city to form an excellent performance group, and 10 ordinary teachers form an ordinary performance group. Excellent group teachers must meet one of the following three conditions: they have won the honors of excellent teachers, special teachers, model teachers, and backbone teachers at or above the municipal level; in the past 5 years, they have won the education and teaching award above the municipal level; excellent on-the-job teachers with teaching performance appraisal in recent 5 years. Ordinary teachers in the group randomly choose other teachers in the school where the excellent teachers are located [10]. Build a big data information flow model of primary and secondary school teachers' competency model distribution, use cloud computing and big data analysis methods to schedule the information flow of primary and secondary school teachers' competency model, build a resource information flow model [11–13], and combine big data mining and feature parameter fusion methods to get the cluster headset of primary and secondary school teachers' competency model distribution as follows:

$$E = \{e_1, e_2, e_3 \ldots e_M\}. \tag{1}$$

Here, M is the number of cluster components of primary and secondary school teachers' competence, and $e_1, e_2, e_3 \ldots e_M$ represent the characteristics of primary and secondary school teachers' competence elements.

Online scheduling of primary and secondary school teachers' competency parameters, in the directed edge set E, the element distribution set of primary and secondary school teachers' competency is constructed as follows:

$$V = \{v_1, v_2, v_3 \ldots v_N\}. \tag{2}$$

Here, N is the number of nodes of key events of primary and secondary school teachers' competency, $v_1, v_2, v_3 \ldots v_N$ represent multidimensional hierarchical parameters of competency characteristics. The information features of primary and secondary school teachers' competency evaluation are recorded as follows:

$$D = d_m(t) = \sum_{k=1}^{K(m)} p(t - \tau_{mk}), m = \{1, 2, \cdots N\}\}. \tag{3}$$

Here, $d_m(t)$ is the characteristic parameter of basic knowledge of educational theory, τ_{mk} is the characteristic parameter of professional discipline knowledge, $p(t - \tau_{mk})$ is the parameter of online teaching innovation ability, and SF is the parameter of professional development intention. According to the statistics of 20 teachers interviewed by the recorder, the characteristic components of primary and secondary school teachers' competency model distribution are as follows:

$$P = \{p_1, p_2, \cdots p_m\}, m \in N. \tag{4}$$

Here, $p_1, p_2, \cdots p_m$ is a dynamic evaluation parameter of primary and secondary school teachers' competency [14]. After screening, 28 competency elements are retained, and multidimensional parameters such as online discussion ability, adaptability of online teaching means, online teaching enthusiasm, and online teaching investment are extracted. The distribution of competency elements evaluation parameters is given in Table1.

According to the parameter analysis in Table 1, the basic elements of competency are: basic knowledge of educational theory; professional knowledge; online teaching innovation

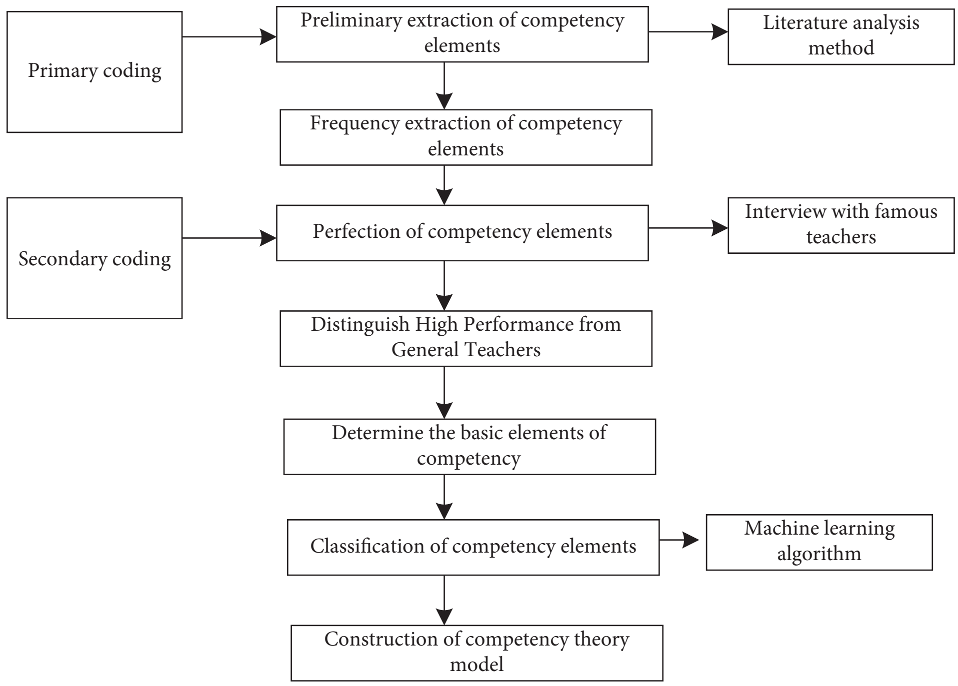


Figure 1: Implementation process of the online teaching competency theory model for primary and secondary school teachers.

ability; informatization ability; multimedia resource selection and application ability; online teaching classroom design ability; online teaching interaction ability; proficient in online teaching software operation; online teaching evaluation feedback ability; online classroom organization ability; the ability to integrate online teaching with disciplines; online reflection ability after class; team cooperation ability; communication skills; time management ability; strain capacity; emotional management ability; have love and patience; affinity, tolerance, and humor; respect students; empathy ability; democratic fair consciousness; sense of responsibility; professional development intention; forward thinking; lifelong learning ability; self-learning ability; emotional awareness; professional sense of accomplishment; online seminar ability; adaptability of online teaching means; online teaching enthusiasm; online teaching investment; unique online teaching style; and concentration. Thus, the explanatory variables of the competency model of primary and secondary school teachers are given in Table 2.

According to various influencing factors in Table 2, different sampling sample numbers, similarity, and fitness are set in the design model.

3. Model Optimization Design

3.1. Mining Association Rules. Teacher competency model is a collection that reflects the characteristics of a teacher's knowledge and skills [15]. The analysis of the competency model not only includes competency elements but also carries out the dimensional structure and hierarchical analysis of competency elements. After the determination of the content of the competency model in online teaching [16–18], the competency elements are sorted objectively, and finally, the competency model is determined, and the sorting results of competency elements are obtained:

$$h(t) = H \sum_{m=1}^{M} \sum_{k=1}^{K(m)} \alpha_{mk} \delta\left(t - T_m - \tau_{mk}\right). \tag{5}$$

Here, H is the dynamic element of basic knowledge of educational theory, α_{mk} is the characteristic quantity of professional accomplishment distribution, T_m is the teaching classroom engagement, and $K(m)$ is the constraint parameter of unique online teaching personal style, and is the dynamic parameter of time management. Under the guidance of grounded theory, this study first collected, analyzed, and integrated the existing online teaching competence of primary and secondary schools according to literature analysis, screened out the competency characteristic elements from the practical sense [19], and added six competency characteristic elements according to the interview text of teachers. From the practical sense, the distributed information flow was recorded as follows:

$$\text{flow}_k = \left\{n_1, n_2, \cdots, n_q\right\}, q \in N. \tag{6}$$

Here, q represents the statistical characteristic quantity of primary and secondary school teachers' competence, n_q represents the equilibrium coefficient of primary and secondary school teachers' competence distribution, and N represents the characteristic elements of primary and secondary school teachers' competence. According to the above analysis, 34 competency elements are finally obtained by refining the competency elements [20]. Finally, after getting the general competency elements, the characteristics of competency are classified and summarized, the relationship between each element is found, and the competency model is established. The dimensions, attributes, and other aspects are continuously screened and classified, and they are connected in series to provide the direction for the later application of

Table 1: Parameter distribution of competency factor evaluation.

Ability elements	Frequency	Frequency ratio
Basic knowledge of educational theory	416	22.474
Professional knowledge	410	12.307
Knowledge integration ability	431	6.266
Online teaching innovation ability	416	0.540
Informatization teaching ability	409	32.118
Multimedia resource selection and application ability	405	35.853
Online teaching classroom design ability	418	8.783
Online teaching interaction ability	408	33.753
Proficient in online teaching software operation.	415	10.522
Online teaching evaluation feedback ability	430	20.356
Online classroom organization ability	419	33.216
Online teaching and discipline integration ability	430	28.487
Ability to reflect after class in online teaching.	1	36.941
Team cooperation ability	408	11.556
Communication skills	38	11.175
Time management ability	40	27.790

theory and practice. Finally, based on the prototype of "Onion Model," combined with literature analysis and interview results, a complete online teaching competency model of primary and secondary school teachers is constructed [21], and the statistical information model is as follows:

$$S_i = \left\{ (\overline{n}_1, \overline{n}_i) = \operatorname{argmin}_{\substack{\widehat{n}_1 = 0,1,\cdots,\gamma_1 - 1 \\ \widehat{n}_i = 0,1,\cdots,\gamma_i - 1}} \left| \widehat{n}_i M_i + \widetilde{r}_i - \widehat{n}_1 M_1 - \widetilde{r}_1 \right| \right\}. \tag{7}$$

Here, $S_{i,1}$ represents the priority attribute, $\widehat{n}_i$ is the inner motivation parameter, M_i is the correlation parameter of knowledge and skills, M_1 is the characteristic quantity of the connection between each element, $\widetilde{r}_1$ is the characteristic moment, $\widetilde{r}_i$ is the outermost dynamic parameter, machine learning is carried out on the online teaching competence of primary and secondary school teachers, and the frequency characteristic parameter of online teaching competence of primary and secondary school teachers:

$$S_{i,1} \longrightarrow \{\overline{n}_1\colon\ (\overline{n}_1, \overline{n}_i)\ \in S_i\}. \tag{8}$$

Here, $\overline{n}_1$ is the similarity and S_i is the fuzzy domain. By analyzing the characteristics of primary and secondary school teachers' teaching competence, the statistical characteristic quantity is obtained, which is expressed as

$$\begin{aligned} \widetilde{A}_1 &= (G_1^* G_1 + G_2^* G_2) A_1 + G_1^* M_2 + G_2 M_2^*, \\ \widetilde{A}_2 &= (G_1^* G_1 + G_2^* G_2) A_1 - G_1 M_2^* + G_2^* M_1. \end{aligned} \tag{9}$$

Here, G_1 and G_2 are directed graph models, A_1 is the contribution of teamwork, and $\frac{1}{M}$ is the element of exploratory factor analysis competency. The online competency theoretical model of primary and secondary school teachers is expressed as. Self-adaptive distribution of information flow of primary and secondary school teachers' competency model [22, 23], and the transfer probability of the associated rule items of primary and secondary school teachers' competency is $p_{ij}(k) = p\left\{A_{k+1}^j / A_k^i\right\} \geq 0$, then

$$p_{ij}(k) = p\left\{ \frac{A_{k+1}^j}{A_k^i} \right\}. \tag{10}$$

Here, when $i \in I$, $j \notin I$, A_{k+1}^j is the dimensions of competency elements, and A_k^i is the model parameter of primary and secondary school teachers' online teaching competency, the dynamic parameters of primary and secondary school teachers are obtained by using the adaptive link configuration method [24], and the distribution factors of each competency trait are given in Table 3.

Given the distribution objective function f of primary and secondary school teachers' competency model, self-adaptive optimization is carried out in the solution space, $U \in R^n$, and a point is found in A, so that the distribution association rules of primary and secondary school teachers' competency model satisfy

$$0 \leq p_{k+1} \leq p_k - \sum_{i \notin I} \sum_{j \in I} p_i(k) p_{ij}(k) \leq p_k \leq 1. \tag{11}$$

Here, p_k is the basic dynamic parameter of the survey object, $p_i(k)$ is the correlation distribution coefficient, and $p_{ij}(k)$ is the joint index. According to the mining results of association rules, data clustering analysis is carried out [25] and machine learning algorithm is adopted to analyze the dynamic characteristics of competency traits.

3.2. Statistical Model and Autonomous Learning Optimization. By using literature analysis and interview with famous teachers, the primary coding and secondary coding of the competency elements are carried out. By using the characteristic parameter analysis of the whole factor process, the conceptual classification of the competency elements is carried out according to the machine learning model, and the analytical model of the theoretical parameters of the online teaching competency of primary and secondary school teachers is constructed to realize the evaluation and quantitative analysis of the competency of primary and secondary school teachers [26]. When

Table 2: Explanatory variables of primary and secondary school teachers' competency model.

Ability elements	Sample number	Similarity	Fitness
Online classroom organization ability	4197	1.234	0.332
Ability to integrate online teaching with disciplines	4289	0.992	0.333
Reflection ability of online teaching after class	4326	0.393	0.388
Team cooperation ability	4322	0.784	0.369
Communication skills	4250	1.220	0.375
Time management ability	4291	1.028	0.386
Strain capacity	4333	1.049	0.326
Emotional management ability	4174	0.438	0.386
With benevolence	4266	0.714	0.345
Patient	4308	0.626	0.349
Affinity	4316	0.490	0.392
Tolerate	4333	0.297	0.331
Humorous	4126	0.068	0.364
Respect students	4304	0.977	0.355
Empathy ability	4167	0.801	0.325
Consciousness of democracy and fairness	4059	0.534	0.362
Conscientiousness	4076	1.144	0.346
Professional development intention	4053	0.735	0.342
Forward thinking	4272	0.200	0.367
Lifelong learning ability	4232	0.699	0.349
Self-learning ability	4172	0.722	0.380
Emotional awareness	4131	1.244	0.386
Professional accomplishment	4057	0.011	0.372
Online seminar ability	4104	0.275	0.352
Adaptability of online teaching means	4269	0.401	0.395
Online teaching enthusiasm	4105	0.098	0.334
Online teaching investment	4233	0.102	0.401
Unique online teaching style	4135	0.100	0.348
Concentration	4063	0.100	0.324

$\lim_{n\longrightarrow\infty} X_n = X^*$, the reference model of the competency model of primary and secondary school teachers is

$$\min_{\beta} \|\mathbf{Y}(i) - \mathbf{X}(i)\boldsymbol{\beta}\| = \min_{\beta} \|\mathbf{Y}(i+1) - \mathbf{X}(i+1)\boldsymbol{\beta}\|. \quad (12)$$

Here, the rank of $\mathbf{X}_{ij}$ is r_{ij}, $r_{ij} \le m$, $\mathbf{U}_{i1}'$ is the exploratory factor analysis parameter, $\mathbf{Y}_{i1},\ldots, \mathbf{Y}_{ip(i)}$ are the competency expression parameter, β is the trust parameter, and the transmission control function of the competency model of primary and secondary school teachers is expressed as

$$u_i = \frac{1}{N}\sum_{i=1}^{N} u_i = \frac{1}{MN}\sum_{m=1}^{M}\sum_{i=1}^{N} x_{mi}. \quad (13)$$

Here, u_i is the descriptive parameter of teaching competency, x_{mi} is the dynamic distribution value of teaching competency, M is the embedded dimension, N is the sampling point, and the semantic ontology information feature quantity of primary and secondary school teachers' competency model is extracted to realize the quantitative evaluation of primary and secondary school teachers' competency model. The implementation process of the improved algorithm is shown in Figure 2.

According to the algorithm flow shown in Figure 2, the evaluation of primary and secondary school teachers' competency evaluation is optimized.

4. Simulation Analysis

In order to test the application performance of this method in the analysis of primary and secondary school teachers' competency, a simulation experiment is conducted. The experiment is based on Visual C++ simulation software, and the data processing algorithm of primary and secondary school teachers' competency is designed with Matlab 7. The initial values of primary and secondary school teachers' competency parameters are $m = 100$ and $n = 30K$, $m = \{20, 50, 100\}$, and the number of large data packets of primary and secondary school teachers' competency model is 100. The average transmission frequency of dynamic characteristics of primary and secondary school teachers' competence is 1200, the load of primary and secondary school teachers' competence is 200 MBps, the fuzzy cluster center of primary and secondary school teachers' competence is (0.21,0.45), the sampling interval of characteristic sampling is $t_0 = 12$s, and the environmental parameters of dynamic distribution of primary and secondary school teachers' competence are given in Table 4.

According to the above simulation environment and parameter settings, taking 411 teacher competency literature in the core database of Web of Science (2008–2017) as the research object, the teacher competency model scheduling

Table 3: Distribution factors of primary and secondary school teachers' competency traits.

Ability elements	Morphological component	Correlation dimension
Online classroom organization ability	0.139	396.137
Ability to integrate online teaching with disciplines	0.138	511.357
Reflection ability of online teaching after class	0.132	167.329
Team cooperation ability	0.136	315.086
Communication skills	0.138	503.388
Time management ability	0.130	251.623
Strain capacity	0.135	332.840
Emotional management ability	0.134	158.676
With benevolence	0.139	343.437
Patient	0.133	68.739
Affinity	0.136	497.530
Tolerate	0.139	321.700
Humorous	0.133	6.347
Respect students	0.136	234.277
Empathy ability	0.136	335.865
Consciousness of democracy and fairness	0.137	451.977
Conscientiousness	0.134	226.130
Professional development intention	0.130	503.029
Forward thinking	0.133	326.749
Lifelong learning ability	0.131	132.172
Self-learning ability	0.133	207.449
Emotional awareness	0.133	185.344
Professional accomplishment	0.134	436.587
Online seminar ability	0.132	523.324
Adaptability of online teaching means	0.139	223.224
Online teaching enthusiasm	0.137	43.140
Online teaching investment	0.139	42.922
Unique online teaching style	0.130	41.736
Concentration	0.136	40.329

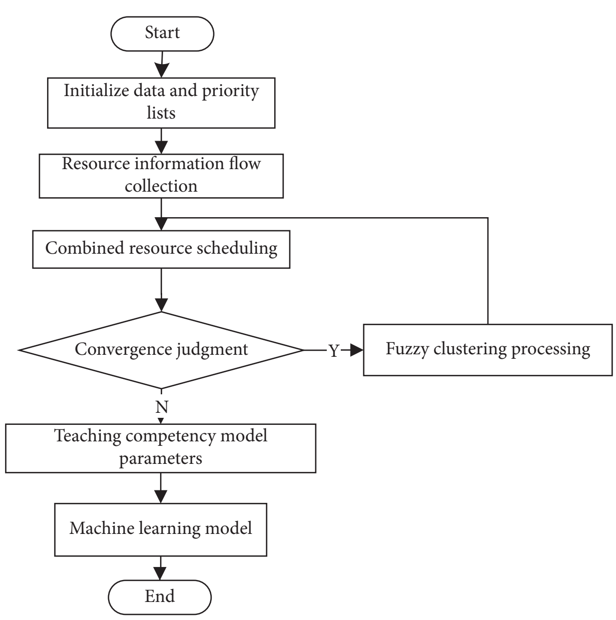


Figure 2: Implementation process of algorithm.

and information fusion in primary and secondary schools are carried out, and the assessment of primary and secondary school teachers' competency is obtained. The statistical results of the data are shown in Figure 3.

Taking the big data of Figure 3 as the research object and the test sample set, the model mining and information fusion of primary and secondary school teachers' competency are carried out under the machine learning model, and the ontology information feature quantity of primary and secondary school teachers' competency is extracted, and the result of the feature extraction of primary and secondary school teachers' competency is shown in Figure 4.

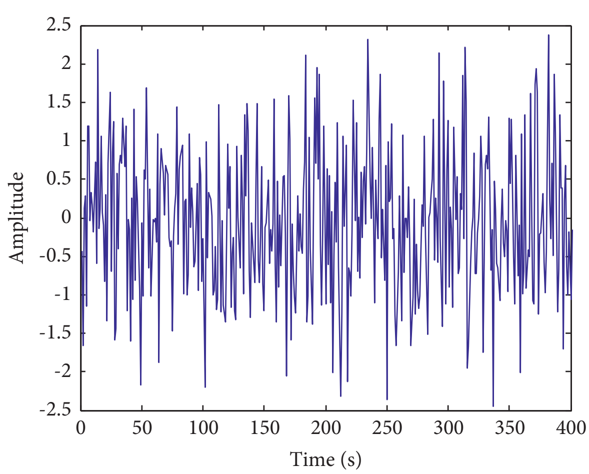
According to the analysis shown in Figure 4, the ability to extract the characteristics of primary and secondary school teachers' competency is better by using this method, with the decibel number of anti-interference suppression reaching 12.4 dB, the ability to suppress redundant information being strong, and the information gain being increased by 12.5%. Based on this, data clustering is carried out, and KMO test and Bartlett test are used to realize factor analysis and reliability test, and the accuracy of primary and secondary school teachers' competency is analyzed. The comparison results are shown in Figure 5.

Figure 5 shows that the correlation coefficient of primary and secondary school teachers' competency assessment is 0.89, which indicates that primary and secondary school teachers' competency assessment has an obvious promotion effect, which is 8.34% higher than the traditional method, and the calculation time is 21.34% lower, with superior performance.

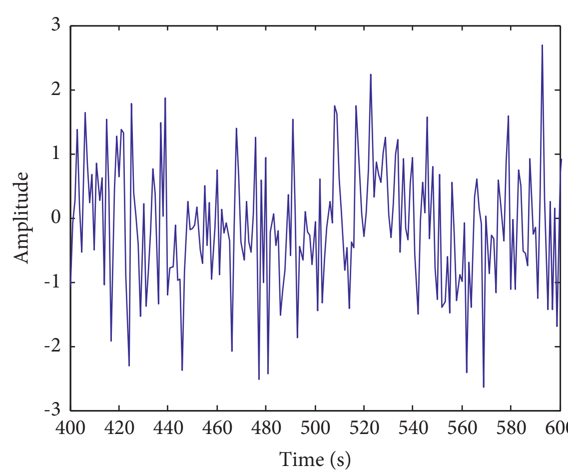
The experimental objects are evaluated by using the model in this article, the model in reference [6], and the model in reference [7], respectively. The efficiency results of the evaluation are given in Table 5.

Table 4: Parameter setting.

Ability elements	Joint matching coefficient	Regression analysis value	Variance
Online classroom organization ability	4.238	29.576	0.381
Ability to integrate online teaching with disciplines	4.021	7.967	0.339
Reflection ability of online teaching after class	4.012	20.820	0.344
Team cooperation ability	4.121	2.528	0.363
Communication skills	4.034	17.428	0.401
Time management ability	4.239	28.468	0.367
Strain capacity	4.295	27.863	0.330
Emotional management ability	4.222	4.174	0.391
With benevolence	4.163	20.569	0.353
Patient	4.216	28.386	0.396
Affinity	4.174	12.994	0.353
Tolerate	4.071	18.608	0.384
Humorous	4.333	19.532	0.364
Respect students	4.047	8.106	0.399
Empathy ability	4.275	11.689	0.387
Consciousness of democracy and fairness	4.271	26.232	0.338
Conscientiousness	4.118	13.650	0.334
Professional development intention	4.004	20.537	0.357
Forward thinking	4.006	14.204	0.327
Lifelong learning ability	4.114	12.075	0.385
Self-learning ability	4.177	12.022	0.396
Emotional awareness	4.324	11.418	0.341
Professional accomplishment	4.048	9.521	0.383
Online seminar ability	4.205	0.694	0.404
Adaptability of online teaching means	4.259	32.040	0.361
Online teaching enthusiasm	4.053	2.430	0.378
Online teaching investment	4.025	2.484	0.374
Unique online teaching style	4.299	2.449	0.334
Concentration	4.075	2.598	0.397

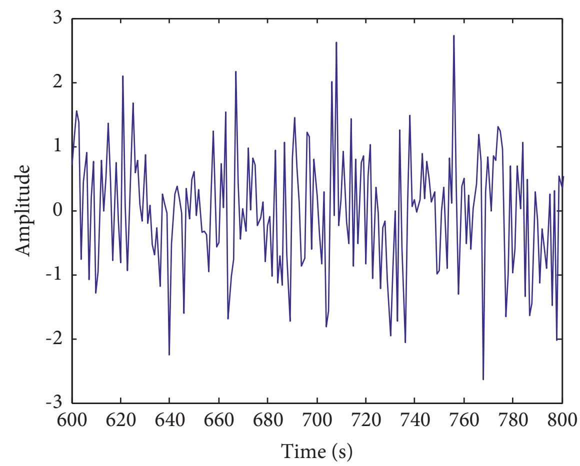


(a)



(b)

Figure 3: Continued.



(c)

Figure 3: Statistical analysis results of primary and secondary school teachers' competency data: (a) sample 1, (b) sample 2, and (c) sample 3.

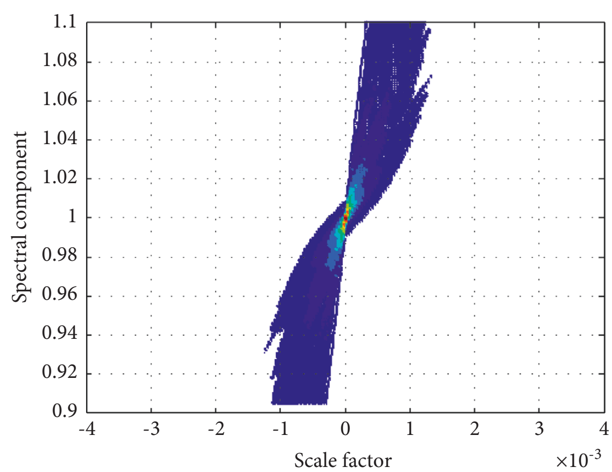


Figure 4: Results of extracting the distribution characteristics of primary and secondary school teachers' competence.

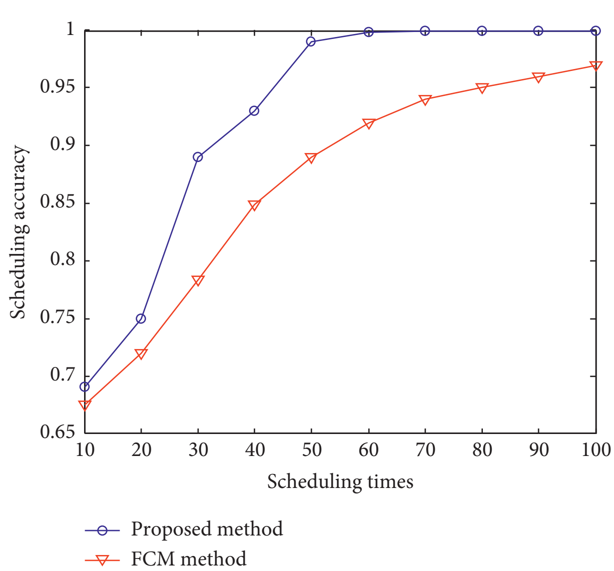


Figure 5: Comparison of the accuracy of primary and secondary school teachers' competency assessment.

Table 5: Comparison results of evaluation time of three models.

Data volume/GB	Model of this article/s	Wang et al.' [6] model/s	Jia et al.' [7] model/s
10	3.12	6.32	7.24
20	4.98	8.11	9.38
30	5.06	11.69	11.78
40	6.57	15.98	14.29
50	7.36	18.56	18.28
60	8.11	23.46	24.69
70	9.89	28.91	29.17
80	11.24	34.67	33.78
90	13.99	40.15	41.53
100	15.33	50.78	51.57

According to Table 5, it can be seen that with the continuous increase of the amount of data, the risk assessment time of the three models has been improved. The improvement of the evaluation time of the model in this article is significantly lower than that of the other two models, and the overall evaluation time is also significantly lower than the other two models. The average evaluation time of the model in this article is 8.57 s, the average evaluation time of reference [6] model is 23.86 s, and the average evaluation time of reference [7] model is 24.17 s. Experiments show that the evaluation time of the model in this article is less, that is, the evaluation efficiency is high.

5. Conclusions

In this article, a competency model of primary and secondary school teachers based on an improved machine learning algorithm is proposed. Construct a fitting parameter analysis model of primary and secondary school teachers' competence, combine with reliability index parameter analysis, extract fitting benefit parameters of primary and secondary school teachers' competence according to teacher assessment, evaluation, post allocation and other index parameters, adopt difference data analysis method, according to the corresponding characteristic elements that participants should have to complete a certain task and achieve a certain achievement goal. The improved machine learning algorithm is used for quantitative analysis and feature factor analysis in the process of primary and secondary school teachers' competency assessment, and the internal content of primary and secondary school teachers' teaching competency model is determined, that is, the competency factors are encoded at the first level and at the second level by literature analysis and interview with famous teachers, and the competency factors are conceptually classified according to the machine learning model, and the analytical model of online teaching competency theory parameters of primary and secondary school teachers is constructed to realize the competency assessment and quantitative analysis. KMO test and Bartlett test are used to realize factor analysis and reliability test. The results of simulation analysis show that the reliability and accuracy of primary and secondary school teachers' competency assessment by this method are good, and the level of credibility is high.

According to the questionnaire survey and interview, although there are some problems in teachers' online teaching competence, teachers have a positive attitude toward improving their online teaching competence. After the normalization of epidemic teaching, the teaching mode of combining online teaching with offline teaching will be further applied, and it is still very important to develop teachers' online teaching competence. Based on the information and problems obtained from the above surveys and interviews, the following suggestions are put forward for reference: according to the current survey of teachers' competency, it can be seen that teachers' "self-development" awareness is not very strong in teachers' online teaching competency. To improve teachers' online teaching competency, teachers need to improve their subjective awareness of progress, which requires the education management department to summarize and refine the excellent experience and practices in the online teaching process, set up corresponding incentive measures for teachers, set examples, and encourage them from point to area. For example, first, if excellent and effective teaching activity design is widely promoted, excellent teaching activity cases can be selected in schools and teachers can be rewarded according to the situation. Second, to carry out the twinning activities, young teachers and old teachers can help each other. Young teachers help old teachers to improve their information-based teaching ability, and old teachers impart young teachers' teaching experience, which can promote each other's online teaching. School administrators can reward outstanding teachers and apprentices at the end of the semester. Third, encourage teachers to innovate. In the era of rapid development of multimedia, teachers who can innovate online teaching methods should be widely publicized and set a typical example.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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Research Article

Construction of Network Organization Structure of College Students' Education Management Based on Distributed Network

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To construct the network organizational structure of college students' educational management and realize the informatization development of college students' educational management, the construction method of network organizational structure of college students' educational management is proposed based on the distributed network. MySQL and PostgreSQL are used as the bottom data structure models of the network-based organizational structure of college students' education management, and the multisource information scheduling method, which is used to construct the transaction identifier (TID) labeling tuple model of college students' education management network. The initial topological structure model of the network-based organizational structure nodes of college students' education management network is constructed by the 4-tuple model, and the linear structure decomposition of the construction nodes of the network-based organizational structure of college students' education management is carried out. The correlation characteristics of the transmission channel of the network organization structure of college students' education management are extracted; the three-layer architecture system of data layer, network layer, and application layer is adopted; the architecture model of the network organization structure of college students' education management is established; the multinode distributed network transmission technology is used to build a tree structure model, so as to realize the design of the network organization structure model of college students' education management and the scheduling of multisource information parameters; and the fuzzy multi-attribute decision-making method to realize the adaptive scheduling of the network organization structure of college students' education management is adopted, so as to improve the storage management, fault tolerance, and safe access ability of the network organization structure of college students' education management. The test results show that the network organizational structure of college students' educational management is designed by this method, which improves the ability of information transmission and scheduling and improves the informatization level of college students' educational management.

1. Introduction

Management without education is management without soul, and education without management is weak education. The educational management of colleges and universities is related to the important mission of cultivating qualified talents. Colleges and universities must recognize the situation, keep up with the pace of times, accurately grasp the characteristics of times, groups, and psychology of contemporary college students, constantly enrich the educational content, and improve the educational means. The construction of network organizational structure of college students' education management is the key to promote the informatization development of college students' teaching management. With the development of network-based organizational structure of college students' education management, combining cloud platform and big data information processing methods, it is necessary to construct network-based organizational structure of college students' education management, realize college students' education management, and optimize the design of network topology. In the process of constructing network-based organizational structure of college students' education management, it is necessary to analyze the characteristics of the data graph model by the method related to the network-based organizational structure of college students' education management [1]. Using semantic feature analysis, node optimal deployment control, and the optimal design of query languages (such as SQL, XPath, XQuery, and SPARQL) to realize the construction of network organization structure of college students' education management and studying the methods of network organization structure of college students' education management are of great significance in improving the ability of data storage and management [2–4].

College students' educational management network organization structure is a communication network that uses wireless sensor nodes to realize data transmission. College students' educational management network organization structure carries a large amount of data information [5]. It is necessary to reorganize the topological structure of college students' educational management network organization structure, build an optimized network structure model of college students' educational management network organization structure, reduce the path overhead of college students' educational management network organization structure transmission, and improve the transmission capacity of college students' educational management network organization structure. Studying the topological structure design method of the network organization structure of college students' educational management is of great significance to improve the transmission capacity of the network organization structure of college students' educational management, and the related research on the structural design of the network organization structure of college students' educational management has attracted great attention. The topological structure design of the network organization structure of college students' educational management is based on the optimized network design [6]. By adopting the node topological model of constructing the network organization structure of college students' educational management, large-capacity data storage and high-bandwidth network transmission can be realized. Reference [7] used the shortest path method to construct the network organizational structure of college students' education management; this method has a high cost for large-scale reorganization of the network organizational structure of college students' education management, and its adaptability is not good. Reference [8] puts forward a search algorithm for students with similar living habits based on the campus behavior information network, which uses big data analysis and deep learning technology to expand and fuse more data sources according to students' existing similar living habits, so as to obtain students' behaviors. This method is computationally intensive and prone to redundancy.

Therefore, this paper puts forward the construction method of network organization structure of college students' education management based on distributed network topology. The 4-tuple model is used to construct the initial topology distribution structure model of the network organization structure node of college students' education management. The improved ant colony algorithm is used to construct the network organization structure of College Students' education management, and the distributed optimization design of the nodes of the network organization structure of college students' education management is realized. The test results show that the designed structure can improve the transmission performance of the network organization structure of college students' education management.

2. Overall Design Framework and the Network Organizational Structure Construction Model System of College Students' Education Management

2.1. Overall Design Framework of College Students' Educational Management Network Organizational Structure Construction. In order to realize the construction of network organization structure of college students' education management, the overall structure model of network organization structure of college students' education management is constructed, and the bus structure model of network organization structure of college students' education management is established by the VIX bus design method [9]. The ARM control protocol is adopted to control the program loading of network organization structure of college students' education management at the bottom end of network organization structure of college students' education management. By integrating and distributing the limited resources of the data center through the data layer [10], under the ANSI-SQL standard protocol, the client realizes the resource allocation of the network organizational structure of college education management through DSG (Direct Serialization Graph) diagram, and the network organizational structure of college education management supports the resource description framework (RDF for short). In the Knowledge Graph Database (KGDB), a network-based organizational structure management system of college students' education management and a knowledge graph storage model of the network-based organizational structure of college students' education management is constructed by using the method of attribute graph and entity graph model design.

The application environment of MySQL is: Linux as the operating system, Apache or nginx as the web server, MySQL as the database, and PHP/Perl/Python as the server-side script interpreter. Since these four software are free or open source software (floss), a stable and free website system can be established without spending a penny (excluding labor costs) in this way, which is called "lamp" or "LNMP" combination in the industry.

The PostgreSQL storage system is composed of the following sub modules:

(1) Page management sub module defines the organization structure of PostgreSQL buffer pages and provides methods for page operations.
(2) Buffer management sub module manages the buffer of PostgreSQL, including local buffer and shared buffer.

(3) Storage device management sub module: the database records are stored on the storage medium. The storage device management sub module will shield the differences of interface functions of different physical storage devices (block devices and stream devices) and provide unified access interface functions to the upper buffer management sub module.

(4) File management sub module: the general operating system has a limit on the number of files allowed to be opened by a process, while the PostgreSQL server sometimes needs to open a large number of files. Therefore, in order to break this bottleneck, the PostgreSQL file management sub module encapsulates the file reading and writing operations. Here, an LRU linked list is established to manage the open files through a certain replacement algorithm. The number of files that can be opened is not limited by the operating system platform.

To sum up, MySQL has the advantages of supporting multiple threads, having fast query speed, and supporting multiple storage engines. PostgreSQL supports multitype indexing and avoids the transmission of a large number of original SQL statements. To this end, in this paper according to the unique identification id (primary key) and the attribute property owned by the entity are used as index objects, MySQL and PostgreSQL are used as the bottom storage method of the network organization structure of college education management. The transaction identifier (TID) labeling tuple model is constructed according to the types of entities and relationships, and the platform construction of the network organization structure of college education management is divided into user domain, service domain, management domain, distributed network transmission domain, and object domain by adopting the three-layer architecture system of data layer, network layer, and application layer, and an entity parameter set of no type is constructed. According to the semantic information of RDF data, the network organizational structure of college students' education management based on multimodel graph is constructed, and the structural model is shown in Figure 1.

According to the structural model of the network organization structure of college education management shown in Figure 1, a three-tier architecture system is adopted, and the query terminal of the network organization structure of college education management is established by using relations and JSON key values. In order to save storage space, the tag node classification method is adopted to classify the entity set of the network organization structure of college education management, and the unique identification id (primary key) and entity model are obtained by the attribute diagram storage method based on relations [11–13]. The extended SQL and Gremlin query scheme are adopted to construct the attribute graph model of the network organizational structure of college students' education management. Based on the definition of RDF graph and attribute graph, the attribute list obtained is shown in Table 1.

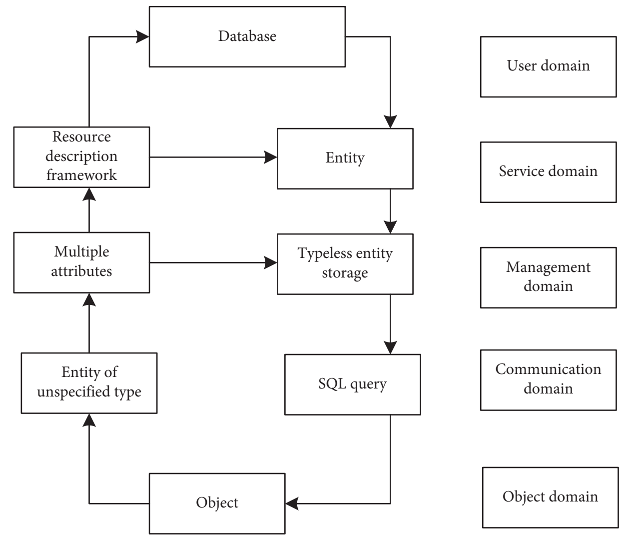

Figure 1: Structural model of network organizational structure of college students' education management.

2.2. Model System of Network Organizational Structure Construction of College Students' Education Management. Contemporary college students are in a new era of educational reform, their ideas are generally positive, healthy, and conducive to their own development, but the development of The Times also impacts college students' physiology, psychology, and bring some adverse effects. It should be noted that some of the original management methods and education methods are not suitable for the education and management of college students in reality. Modern education and management mode suitable for the development of The Times should be introduced to improve the education and management system of college students. According to Figure 2, the three-tier construction system of the network organization structure of college education management is established under the service-oriented architecture (SOA), and the system platform construction of the network organization structure of college education management is realized under the bus architecture through the integration control of mobile terminals, and the operation and maintenance system construction scheme is collected. Through reading and writing operations under different network platforms, the network transmission layer is constructed, and the network architecture adopts the Internet of Things, Internet and wireless sensor networks, and the XML and Web middleware of the network organization structure of college education management is established [14]. Based on the microservice architecture system, the XML bus control model of the network organization structure of college education management is established, and a three-tier architecture system of the network organization structure of college education management is constructed as shown in Figure 2.

The application layer is used to manage the daily teaching situation of students, and its main tasks are: formulating rules and regulations to manage college students; select and allocate educational management resources to select and assess tutors. In the network layer, teachers use the

Table 1: List of attributes of network organizational structure of college students' education management.

Symbol	Meaning	Symbol	Meaning
$G = (V, E, \Sigma)$	Mapping graph of vertex pairs	$\phi\ (t)$	Triple classification
$G = (V, E, \eta, src, tgt, \lambda, \gamma)$	Attribute graph g	$I_C\ (s)$	Or vertex and label feature sets
$t = (s, p, o)$	Triad	$hist\ (C)$	Finite set of entities
$\alpha = (a, \mathrm{Lab}, \mathrm{Map})$	Attribute point pattern	$DC\ Scluster\ (Cj, Ck)$	Query the distance between data attributes Cj and Ck
$\beta = (d, \mathrm{Lab}, a, \mathrm{Map})$	Attribute graph edge mode	$\lambda\colon\ (V \cup E) \longrightarrow \mathrm{L}$	Label mapping of names and attribute values
T	Triple finite set	$\gamma\colon\ (V \cup E) \times \mathrm{K} \longrightarrow Val$	Index vector mapping of college students' educational management network organizational structure
μ	Knowledge map matching	$\mathrm{lab}\colon\ E \longrightarrow \Sigma$	Take the label of edges in RDF graph

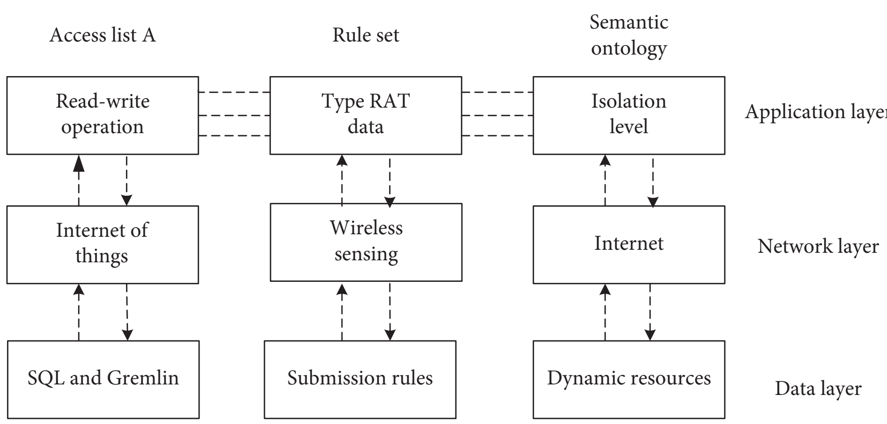

Figure 2: Three-layer construction system of network organizational structure of college students' education management.

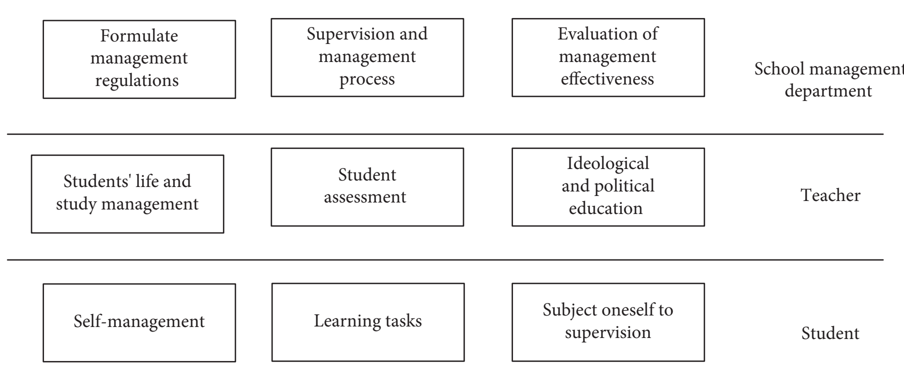

Figure 3: Distributed linear education management mode.

network platform to build an information data management center and guide and educate college students' lives and studies by evaluating their educational management information. Through dynamic resource information query and other methods, the data layer can improve the information feedback and activity training ability of college students' education management, cultivate the habit of independent thinking and team cooperation ability of college students, shape team spirit, and improve the effect of college students' education management. On this basis, combined with the attribute list distribution of the network organization structure of college education management shown in Table 1, the architecture model of the network organization structure of college education management is established, and the entity set under the unified storage scheme is constructed by combining the multi-node distributed network transmission technology [15–17]. Through the acquired entity set data, a distributed linear education management mode is constructed, so as to improve the typed parameter index of college students' education management mode. The specific linear education management mode is shown in Figure 3.

As shown in Figure 3, the distributed linear education management model has clear responsibilities and clear tasks, which is convenient for the supervision and management of students. It can effectively avoid the hindrance of students' development space, especially for colleges and universities with an increasing number of students and increasing social expectations. It can improve the educational management ability and effect of college students, give full play to their initiative and creativity, and achieve good educational management effect.

The attribute map $G = (V, E, \eta, src, tgt, \lambda, \gamma)$ of the network organization structure of college education management is obtained by the method of entity type parameter identification. College students will be assigned and managed according to their majors in classes or grades, so as to enhance the extensive communication and mutual learning among college students. Where: V represents the top limited set of management modules of the network organization structure system of college education management; E represents a finite set of edges responsible for managing and maintaining the application layer and satisfies; represent the distribution mapping between the function mapping process and resource scheduling [18], such as the directed graph E between the access nodes of the network organizational structure of college students' education management. The src: $E \longrightarrow V$ function represents the fuzzy grey relational mapping of university students' educational management network organizational structure access. The obtained mapping can be expressed as the mapping from edge to terminal vertex. A variable can be a tuple or a record, and the set of transactions is marked as $\gamma(v, \text{property}) = val$, $\gamma(e, \text{property}) = val$). Then the set of operation variables in the construction of the network-based organizational structure platform for college students' education management is, and the value of the attribute property on the vertex V (or edge E) is val. All conflicts in the scheduling S are formed into a directed vector set, and compatibility processing is carried out based on the attribute values composed of "reading" and "writing" to improve the college students' education management network [19–22].

3. Optimization and Realization of the Network Organizational Structure Construction of College Students' Education Management

3.1. Algorithms Related to Network Organizational Structure Design of College Students' Education Management. Under the dynamic resource distribution structure system, the data classification and retrieval of college students' educational management network organization structure is realized by fuzzy clustering. Fuzzy clustering is one of the clustering analysis methods, which integrates fuzzy mathematics with K-means and divides data into disjoint category data sets, that is, each data will eventually belong to one and only cluster through calculation. Fuzzy clustering expands the breadth of the algorithm. By using membership, each data can be assigned to all clusters, so that each data may eventually belong to multiple clusters. In the network organizational structure, college students can receive educational guidance according to their future development and interests, which is conducive to mobilizing their enthusiasm and forming an interactive educational atmosphere [23]. Designing the network organization structure access and optimizing the retrieval algorithm of college students' education management can effectively improve the interactivity and feedback of college education management. Through the information interaction between the network information platform and the network-based organizational structure system of college students' educational management, this paper analyzes the dynamic characteristics of data, provides basic data for the content of college students' educational management, and promotes the improvement of the educational management system. Directed graph analysis is a method to judge the relationship between objects, and it is the basic research object of graph theory. A graph is composed of vertices, nodes, and straight lines or curves connecting these nodes. If each edge of a graph is given a direction, then the graph obtained is called a directed graph, and the connectivity of algorithm calculation can be strengthened through the directed graph. Therefore, based on the directed graph analysis, this paper constructs the operation and maintenance management model of the network organizational structure of college students' educational management and obtains the optimal scheduling fusion model of the network organizational structure of college students' educational management.

$$\text{Link\_}r_{ik} = \frac{\sum_{p=1}^{q}\left(aE_p + bC_p + cB_p + dM_p\right)}{q^2}, \tag{1}$$

where p is the number of variables in the data access node, and q is the transaction multivariate partial order ring, that is, $q = Hop_{ik} - 1$; Ep represents the energy distribution of the bivariate characteristic distribution of two transactions at node P, and A is the distribution weight of any number of transactions and variables; Cp indicates the type of cross exception in node p. By using similarity fusion, the two-transaction univariate feature distribution of the network organization of college students' education management is expressed as follows:

$$D_k = \alpha Hop_{ik} + \beta \text{Load\_intensity}_k + \gamma \text{Link\_}c_{ik} + \eta \frac{1}{\text{Link\_}r_{ik}}, \tag{2}$$

where $Hopik$ represents the transmission sequence between the access node i and the gateway k in the network organizational structure of college students' education management, and α is the fitness weight; $\text{Link_}r_{ik}$Link_rik represents forwarding packets.

Definition 1. Set the data flow samples of the network organizational structure of college students' education management in the time period $S = \overline{X_1}, \overline{X_2}, \ldots, \overline{X_k}, \ldots$, respectively. The search block function of the network organizational structure of college students' education management is $T_1, T_2, \ldots, T_K, \ldots$, and the structural parameters of the graph model solution are dimension [24], which are recorded as $\overline{X_i} = (x_{i1}, x_{i2}, \ldots, x_{i\,d})$. The transmission capacity between the associated nodes of the network organizational structure of college students' education management and another point are as follows:

$$\operatorname{dist}\left(\overline{X_i}, \overline{X_j}\right) = \sqrt{\sum_{k=1}^{d}\left(x_{ik} - x_{jk}\right)^2}, \tag{3}$$

wherein x_{ik} and x_{jk} represent the differentiated characteristic quantity of the cluster center of the network organization of college students' education management, and X_i and X_j are cluster connection components. The sparse matrix is used to collect data, and the sampling time interval of the distribution data of the network organization of college students' education management is T. After the initial clustering, the distance from the center point of the compressed transmission cluster $M_1, M_2, \ldots, M_q$ of the network-based organization of college students' education management after M rounds of transmission is $\operatorname{dist}(\overline{X_i}, M_j)$, $(1 \le j \le q)$, and the distance of merging the two clusters of the bottom access sequence of the network-based organization structure of college students' education management is obtained by distributed compressed sensing measurement as follows:

$$\text{Clustdist}\left(M_i, M_j\right) = \text{mergedistance}, \tag{4}$$

wherein mergedistance is Steiner tree of node.

Given a data map $G = (V, E)$ of the network organization model of college education management and a set of query keywords $Q = \{q_1, \ldots, q_l\}$, a Steiner tree with the current access node as the root node is obtained. When the transmission power in the network organization structure construction node of college education management tends to a constant value, the cooperation between the historical data of i-node and the reliable neighbor data decreases, and the edge set between nodes is

$$D_j = \log\left(\sum_{i=0}^{j-1} E_i - \sum_{i=1}^{j} L_i p_i\right), \tag{5}$$

wherein E_i is the energy of the network organization of college students' educational management, L_i is the node dispersion, and p_i is the power spectrum of the network organization structure of college students' educational management. The discrete control model of the network-based hybrid sink node of college students' education management network is constructed. When the equilibrium scheduling factor m_j is less than 1, the spatial spectrum of the data of the network-based hybrid sink node of college students' education management network is extracted, and the probability density function of optimal data transmission is obtained as follows:

$$f\left(p_i\right) = \frac{-L_i}{2}\log\left(1 + p_i\right). \tag{6}$$

Assume that the initial position of the routing node of the network organization structure of college education management is Z, and the link cost of the node is expressed as $\{S_1, S_2, \ldots, S_L\}$ by 4 tuples. A graph is composed of a finite set of vertices and a set of edges between vertices, where G represents a graph, V is the set of vertices in graph G, and E is the set of edges in graph G. No vertex or edge is allowed in the graph. If the edge between vertices V_i and V_j has no direction, it is called an undirected edge. The adjacency matrix of undirected graph is a symmetric matrix because its edges do not distinguish directions. 0 in the adjacency matrix indicates that the edge does not exist, and all 0 main diagonals indicate that there is no self-loop in the graph. Therefore, undirected graph has the advantages of simple structure and convenient operation. The network organization structure node of college education management adopts undirected graph design, and the Euclidean distance from U to V in the structure diagram $G = (V, E)$ of the network organization structure of college education management is represented. Euclidean distance is a commonly used definition of distance, which is the true distance between two points in m-dimensional space. The Euclidean distance in two and three dimensions is the distance between two points. Euclidean distance is simple, easy to operate, and widely used. The initial weight of the output layer and the bandwidth of link communication are used for adaptive optimization. Combined with fuzzy feature extraction method, the cluster node transmission control of college students' educational management network organization structure is carried out, and the cluster head node $v = \text{head}(e)$ represents the head of the entire transmission link E of college students' educational management network organization structure. The undirected graph of college students' educational management network organization structure is designed, and the minimum hop number from U to V in the graph $G = (V, E, W)$ is used to represent the network organization structure of college students' educational management. In the connected graph area, the topological structure is constructed. The node set representing the network organizational structure of college students' education management represents any two-point edge set. According to the extracted correlation feature of the wireless network transmission hybrid convergence node, the gain control in the data transmission process is carried out by using the spectrum beamforming method, so that the node optimal deployment and topology reorganization of the network organizational structure of college students' education management are realized [25], and the stability of network output is improved. Micro-Clusters algorithm is a method of data transfer between existing sites. Through the cluster analysis of micro-clusters, it makes full use of network data resources, defines the boundaries between data clusters, and ensures the security of data transfer. Then, Micro-Clusters algorithm is used to access and design the network organizational structure of college students' education management.

3.2. Implementation of Development Software for Network Organizational Structure of College Students' Education Management. On the basis of algorithm design, the network organization structure construction and software development design of college education management are carried out. Under the three-dimensional SOA framework agreement, the bottom protocol development of network organization structure of college education management is carried out, and the protocol processing and bus control module of network organization structure of college education management is established. Under the integration agreement of Spring and Hibernate framework, construct the service agency center of the network organization structure of college students' education management, establish the man-machine interaction center of the network organization structure of college students' education management by adopting the hierarchical architecture system, and use MultiGen Creator technology to generate the man-machine interaction module of the network organization structure of college students' education management [26]. Based on analyzing the access environment parameters, the client control of the network organization of college students' education management is carried out in the man-machine interaction control center. The access demand of the requester who serves the network organization of college students' education management and control the object access in the process of information interaction is analyzed, so as to obtain the software implementation structure system of the network organization structure retrieval of college students' education management as shown in Figure 4.

The platform supports basic database functions such as adding, deleting, and searching, and can perform multiple operations on multiple tables at the same time. The database interactive terminal can carry out the permission correction operation, and the school administrator has the permission to add, delete, and check and can authorize these permissions to other teachers. The service requester can query the updatable field set to get the basic data information of education. The network structure model of college students' education management embodies the idea of setting up education links with college students as the center and according to their own development needs, which is in line with the development trend of humanization and personalization of education management. On the basis of meeting a certain educational and social environment, the application of college students' educational management structure model has created a broader space for the development of college students.

4. Simulation and Result Analysis

In order to test the performance of this method in the construction of college students' educational management network organization structure; in the environment of MATLAB R2019b, the corresponding program is simulated with MATLAB coding algorithm in the environment with the main frequency of 1. The hardware and software parameters in the test process are as shown in Table 2:

The transmission rate of data acquisition symbols in network-based organizational structure of college students' educational management is 20 k Baud, the output carrier frequency is 24 KHz, the output signal-to-noise ratio is −15 dB, the parameter attribute matching feature set size in network structure is 160, and the distribution sequence of network-based organizational structure of college students' educational management is shown in Table 3.

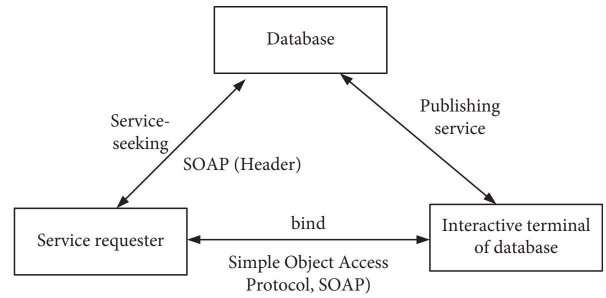

Figure 4: Software implementation structure system of network organizational structure of college students' education management.

Table 2: Details of hardware and software parameters.

Computer system	Project	Parameter
Hardware aspects	CPU	i3 2120
	Basic frequency	3.3 GHz
	Physical memory	32 GB
Software aspects	Operating system	Windows 10
	Development language	C++
	Corpus extraction tool	NLP
	Vector training tool	FastText
	Database processing tool	SQL server 2019

According to the experimental parameters in Table 3, the network organization structure of college education management is designed under different distribution dimensions of network organization structure of college education management. Taking the collected real-time related data of college education management as input, the code sequence of network data transmission and output is obtained as shown in Figure 5.

Taking the data of Figure 5 as input, the optimized control transmission is realized in the network, and the output characteristic sequence is shown in Figure 6.

From the analysis of Figures 5 and 6, it can be seen that the combination design of network organization structure of college students' education management by this method has good output performance and high stability of data transmission. On this basis, the energy expenditure of network organization structure of college students' education management is analyzed, and the comparison is shown in Figure 7.

According to the analysis of Figure 8, the output energy cost of constructing the network organizational structure of college students' education management by the improved method is small, and the output error code and transmission delay are tested, and the comparison results are shown in Figure 8.

Table 3: Distribution sequence of network organizational structure characteristics of college students' educational management.

Network node	Morphological components	Correlation dimension	Dimension	Information entropy
1	5.6626	4.037	12.433	2.150
2	8.6303	4.076	12.064	2.758
3	3.7464	4.828	12.586	2.441
4	0.6493	4.378	12.176	2.002
5	5.8649	4.792	12.580	2.329
6	0.8582	4.846	12.730	2.931
7	8.1668	4.647	12.016	2.213
8	5.7069	4.735	12.302	2.782
9	4.9235	4.127	12.388	2.306
10	4.2008	4.711	12.575	2.504
11	3.5323	4.475	12.220	2.547
12	9.6712	4.951	12.484	2.340
13	7.4159	4.233	12.844	2.639
14	0.3219	4.991	12.017	2.787
15	1.5257	4.320	12.121	2.990
16	7.6172	4.235	12.889	2.750
17	9.1560	4.087	12.043	2.147
18	7.3147	4.081	12.667	2.904
19	2.1150	4.044	12.406	2.957
20	7.8358	4.602	12.608	2.700

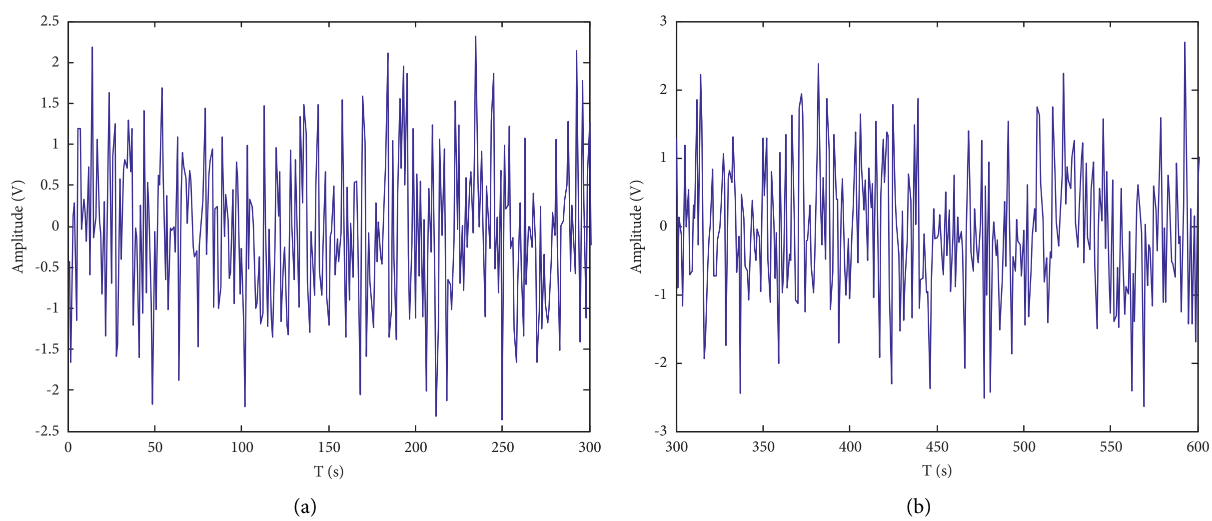

Figure 5: Output symbol sequence of network data transmission. (a) Network input sequence 1. (b) Network input sequence 2.

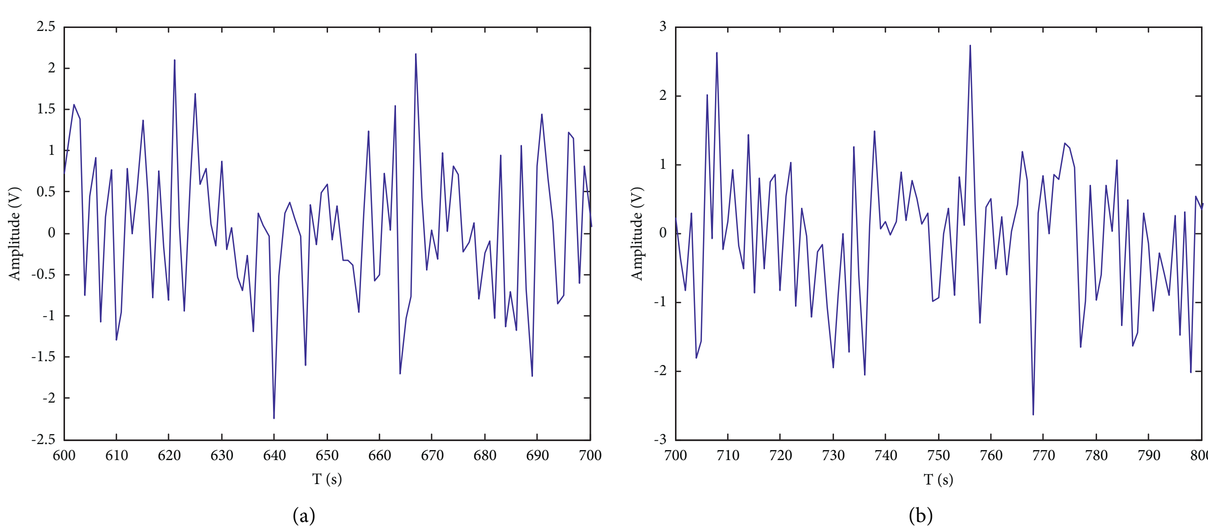

Figure 6: Output characteristic sequence of network organizational structure of college students' education management. (a) Network input sequence 1. (b) Network input sequence 2.

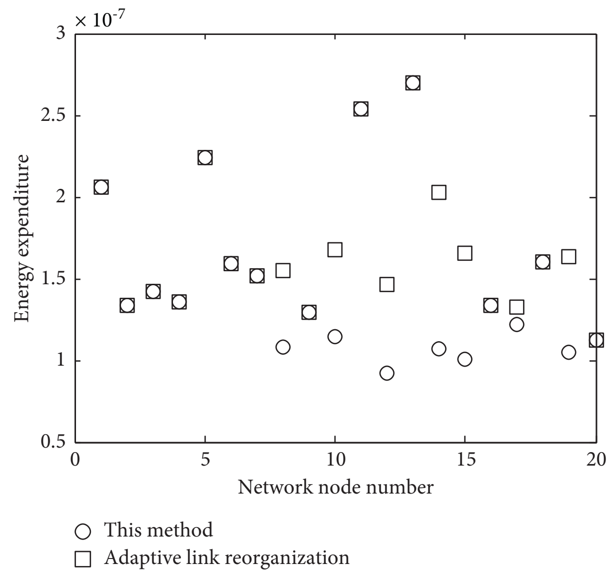

Figure 7: Comparison of energy expenditure.

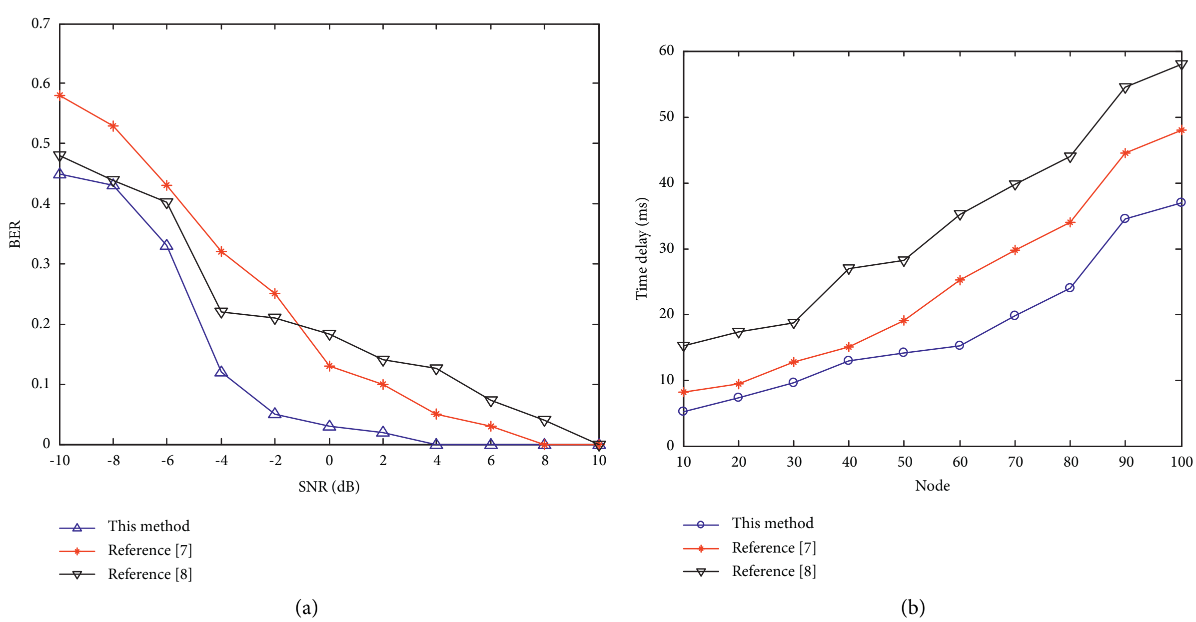

Figure 8: Comparison of output performance of network topology reorganization. (a) Error rate comparison. (b) Comparison of transmission delay.

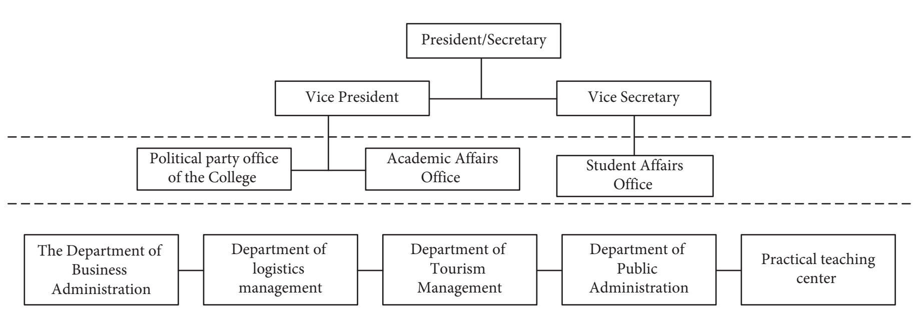

Figure 9: Organization structure of education management network.

Analysis of the above simulation results shows that using this method to construct the network organization structure of college students' education management can improve the connectivity of the network with better output stability and a lower transmission error rate (35 ms). The main reason is that the fuzzy clustering method can improve the information interaction effect between the network information platform and the network-based organizational structure association system of college students' educational management, and can effectively search the resources of college students' educational management.

Using this method, a university is taken as the research object to design its educational management network organization structure. The results are shown in Figure 9.

According to the analysis of Figure 9, the organizational structure of the education management network designed in this paper is divided into three layers, which is basically consistent with the education management mode shown in Figure 3. Therefore, this method has good effectiveness.

5. Conclusions

In this paper, the construction method of network organization structure of college students' education management based on a distributed network is put forward. The three-tier architecture system is adopted, and the query terminal of the network organization structure of college students' education management is established by using relations and JSON key values. The entity set of the network organization structure of college students' education management is classified by the method of label node classification, and the attribute diagram model of the network organization structure of college students' education management is constructed by the attribute diagram storage method based on relations. The four-tuple model is used to construct the initial topological distribution structure model of the network organizational structure nodes of college students' education management, and the linear structure decomposition of the network organizational structure nodes of college students' education management is carried out. The related feature quantity of the transmission channel of the network organizational structure of college students' education management is extracted, and the node topological structure design of the network organizational structure of college students' education management is realized by using the spectrum feature decomposition method. The improved optimization algorithm is used to construct the network organizational structure of college students' educational management, to realize the distributed optimization design of the nodes of the network organizational structure of college students' educational management, and to improve the transmission performance of the network organizational structure of college students' educational management. The analysis shows that the network organizational structure construction of college students' education management by this method can improve the connectivity of the network with good output stability and a low transmission error rate, so it has good application.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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Research Article

Energy Saving Control of District Heating System Based on MATLAB

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In order to offset the lag and delay in the heating process and solve the problem of excessive heating in the heating season, an energy-saving control method of district heating system based on MATLAB is proposed. Based on MATLAB/SIMULINK software, the simulation model of district heating system is established to study its dynamic characteristics. The short-term load forecasting method is introduced to guide the system to conduct centralized regulation and observe the dynamic response of indoor temperature and operating energy consumption. Compared with the constant water supply temperature and the outdoor temperature compensation method, the results show that the proposed method can reduce the indoor temperature fluctuation range to $20 \pm 1^{\circ}$C, and the energy saving rate of the whole heating season can reach 14.5% compared with the conventional regulation method.

1. Introduction

With the rapid development of the construction industry [1], the proportion of building energy consumption in the total social energy consumption has reached more than 27.45% in recent years, and the proportion of heating energy consumption in northern cities and towns is as high as 36%. However, at present, the problem of excessive heating in China's heating season is quite serious [2], resulting in the actual heating consumption of buildings in China exceeding about 35% of the average building heat demand, and the building energy consumption is 2~4 times that of some Nordic countries at the same latitude. Jiachen et al. [3] aimed at the mismatch between heat supply and demand, in order to study the feasibility of nuclear intermittent heating, taking the 49-2 pool heating reactor as the research object, based on the MATLAB/SIMULINK software platform, the pool reactor heating system simulation model is established by using the lumped parameter method, the room heat load is calculated and modeled by using DeST software, and the model is verified by using the test data. However, the whole system operates under the outdoor temperature unchanged and without regulation. The dynamic response of the system under different regulation schemes is not explored. In order to better guide the energy-saving and efficient operation of the heating system, many scholars at home and abroad have made relevant research on heat load forecasting. Lisiqi and Jiang [4] and others proposed the method of building a prediction model for the heating load based on a BP neural network optimized by a differential evolution algorithm. Zhang et al. [5] proposed an SVR heating load prediction model based on the genetic algorithm by analyzing the parameters that affect the performance of the support vector regression machine. Combined with outdoor meteorological parameters and the heat demand of end users, the heat supply of the heat exchange station is regulated through heat load prediction [6, 7]. In addition, there are state estimation method and time series method [8, 9], which can achieve the prediction accuracy. However, the mechanism and programming are complex, and they are not widely used in the heating automatic control system. Therefore, this paper uses computer simulation technology to study the dynamic characteristics of the heating system under different regulation schemes. By establishing the heating mathematical model and simulation model, the heating regulation is realized based on the short-term load forecasting results. Simulation results show that the proposed method reduces heating energy consumption and improves energy efficiency.

2. System Mathematical Model

Taking the directly connected district heating system as an example, the whole system is divided into four parts: heat source, heat network, radiator, and building area. Based on the mass and energy conservation formulas of the four parts, the mathematical models of each part are established by using the heat capacity particle system method.

2.1. Boiler Model. Ignoring the heat dissipation from the boiler to the outside, the mathematical model is established according to the fact that the hot water storage heat contained in the boiler is equal to the net heat supplied to the boiler through fuel combustion minus the heat required for heating the makeup water and circulating water of the heat supply network, as shown in formulas (1) and (2), where the lower corner symbol "boiler" represents the boiler, makeup represents the makeup water, *dw* represents the heat supply network, and *r* represents the return water.

$$C_{\text{boiler}}\frac{\mathrm{d}T_{\text{boiler}}}{\mathrm{d}t} = u_{\text{boiler}}Q_{\text{boiler}} - c_w G_{\text{makeup},w} \cdot \left(T_{\text{boiler}} - T_{\text{makeup},w}\right) - c_w u_{dw} G_{dw}\left(T_{\text{boiler}} - T_{rw}\right), \tag{1}$$

$$Q_{\text{boiler}} = G_{\text{fuel. max}} h_{\text{fuel}} \eta_{\text{boiler}}, \tag{2}$$

where C represents heat capacity, J/°C; T represents temperature, °C; u represents control parameters; Q represents design heat load, W; $G_{\text{fuel , max}}$ represents rated fuel consumption rate of boiler, kg/s; h_{fuel} represents calorific value of fuel, J/kg; η represents thermal efficiency; c_w represents specific heat capacity of water, J/(kg·°C); G represents flow, kg/s. Through the above formula, the boiler mathematical model can be obtained.

2.2. Heat Supply Network Model. Assuming that the pipes and insulation materials are uniform, ignoring the heat storage in the insulation layer, a mathematical model is established according to the relationship that the heat stored in the n pipe section is equal to the transmitted heat of the upstream pipe section minus the heat dissipation loss and leakage loss of the n pipe section, as shown in formula (3), where the subscript n represents the pipe section number, leak represents the leakage loss, and soil represents the soil.

$$C_n\frac{\mathrm{d}T_n}{\mathrm{d}t} = c_w G_n\left(T_{n+1} - T_n\right) - G_{\text{leak}-n} c_w \left(T_n - T_{\text{makeup},w}\right) - K_n L_n \left(T_n - T_{\text{sur,soil}}\right), \tag{3}$$

where L represents the length of the pipe section, m; K represents the heat dissipation coefficient of the pipe section, W/(m·°C). Through the above formula, the mathematical model of the heat supply network can be obtained.

2.3. Radiator Model. Ignoring the heat storage of the radiator pipe wall and the axial heat storage of the fluid, a mathematical model is established according to the fact that the heat supplied by the heating pipe network to the radiator minus the heat supplied by the radiator to the room is equal to the net heat obtained by the hot water in the radiator, as shown in formula (4) [10], where the lower corner mark heat represents the radiator.

$$C_{\text{heater}}\frac{\mathrm{d}T_{\text{heater}}}{\mathrm{d}t} = c_w G_g\left(T_g - T_{\text{heater}}\right) - q_{\text{heater}}, \tag{4}$$

where q represents heat dissipation, W. Through the above formula, the mathematical model of the radiator model can be obtained.

2.4. Building Area Model

2.4.1. Enclosure Structure Model. The engineering physical model simulated in this paper is four residential buildings with a total heating area of 74880 m^2. When modeling the building envelope, the air in each building is first regarded as a temperature node, then the ground, roof, and wall are divided, respectively, and the dynamic balance formulas of different material layers and corresponding simulation modules are established. Finally, the heat loss calculation formula (5) of the building envelope is obtained by comprehensively considering the heat loss of the building's outdoor heat dissipation and cold air infiltration, in which the lower corner zone represents the simulation area, wall, roof floor represents an exterior wall, roof, and ground, respectively, in represents indoor air, out or 0 represents outdoor air, glass represents glass, and solar represents solar radiation.

$$q_{zone} = h_{\text{surface,in}}\left[A_{\text{wall}}\left(T_{\text{in}} - T_{wall,\text{in}}\right) + A_{\text{roof}}\left(T_{\text{in}} - T_{\text{roof,in}}\right) + A_{\text{floor}}\left(T_{\text{in}} - T_{\text{roof,in}}\right)\right] + K_{\text{glass}}A_{\text{glass}}\left(T_{\text{in}} - T_0\right) + 0.278 n_k V_{\text{in}} c_{\text{in}} \rho_{\text{in}}\left(T_{\text{in}} - T_0\right). \tag{5}$$

where A represents area, m^2; h represents convective heat transfer coefficient, W/(m^2·°C); ρ represents density, kg/m^3; n_k represents ventilation times, times/h; V represents volume, m^3. Through the above formula, the envelope model can be obtained.

2.4.2. Indoor Temperature Model. According to the formula that the heat provided by the radiator plus the solar radiation heat obtained through the outer window minus the heat consumption of the enclosure structure equals the indoor air heat storage, the indoor temperature mathematical model is established, as shown in formula (6), where the lower corner z represents the simulation area.

$$V_z c_z \rho_z \frac{\mathrm{d}T_{\text{in}}}{\mathrm{d}t} = q_{\text{heater}} - q_{\text{zone}} + S_{\text{solar,glass}}. \quad (6)$$

According to the calculation result of formula (6), the indoor temperature change can be obtained.

2.5. Simulation Model Establishment

2.5.1. Theoretical Basis. MATLAB is a simulation software integrating numerical processing, mathematical modeling, dynamic simulation, and signal processing [11, 12]. MATLAB has launched the dynamic system modeling and simulation software package "SIMULINK" for interactive operation. The emergence of the SIMULINK software package greatly facilitates the modeling and simulation of dynamic systems and frees researchers from the complicated coding work. Using the unique modular operation of SIMULINK, the dynamic system is modeled, and users can more intuitively conduct system modeling and simulation.

SIMULINK is widely used not only in the modular modeling and simulation environment but also as a powerful simulation tool with universal applicability. It can be used to simulate and realize linear and nonlinear, continuous and discrete, or mixed dynamic systems. It is very suitable for process control simulation.

The SIMULINK module library is divided into 16 submodule libraries according to functions: common simulation module library, continuous system module library, nonlinear system module library, discrete system module library, logic operation and bit operation module library, mathematical operation module library, signal attribute module library, simulation receiving module library, simulation input source module library, user-defined function module library, etc. These existing module libraries provide users with rich modeling resources, save a lot of repeated programming time, and devote more energy to model building and simulation debugging, which improves work efficiency.

According to the mathematical models of the district heating system established in 1.1~1.4, the forms of mathematical equations between some nodes are the same, which provides great convenience for the establishment of simulation models. It only needs to establish models for mathematical equations of the same form, which will greatly reduce the workload of establishing simulation models. The main task of this section is to establish a "general simulation module" through SIMULINK.

2.5.2. Establish Simulation Model of District Heating System. The simulation modules corresponding to the above mathematical models are established in the MATLAB/SIMULINK software environment, and the modules are combined and connected based on the actual engineering physical model to obtain the simulation model of the whole district heating system, as shown in Figure 1.

3. Regulation Control Model

3.1. Unadjusted Model. In order to better compare the energy consumption of the direct connected heating system in the process of system operation guidance by the conventional regulation method and the regulation based on the prediction method, the heating system simulation model under the constant flow and constant water supply temperature operation scheme is first established; that is, the parameters u_b and u_{dw} controlling the gas consumption and the relative flow are fixed values. On this basis, the energy consumption of the following two regulation scheme models is compared.

3.2. Outdoor Temperature Compensation Regulation Model. Adjusting the water supply temperature at the heat source according to the outdoor air temperature is a commonly used heating control method at the heat source of the district heating system. The quality regulation method of changing the flow in stages is adopted [13]. The circulating water flow is divided into two stages: 100% and 80% based on the outdoor temperature of −5°C. The corresponding relationship between the supply and return water temperature and the outdoor temperature conditions is shown in Figure 2.

3.3. Regulation Model Based on Load Forecasting. This section mainly introduces the comprehensive outdoor temperature $t_{w,i,e}$, which combines the average temperature in the next four hours, the first 24 hours, and the first 25 to 48 hours, and obtains the linear relationship between the building heat load and the comprehensive outdoor temperature based on the least square method [14]. The results obtained by data mining are used to advance the adjustment operation parameters, in order to obtain a simple and easy-to-operate operation adjustment scheme suitable for the practical application of the project. Finally, the expression of comprehensive outdoor temperature and predicted heating load is obtained as follows:

$$\begin{aligned} t_{w,i,e} &= 0.6513t_{w,i} + 0.2306t_{w,i-1} + 0.1181t_{w,i-2}, \\ Q_i &= -8.9629t_{w,i,e} + 59.6494, \end{aligned} \quad (7)$$

where $t_{w,i-n}$ is the average temperature corresponding to the three time periods, and Q_i is the predicted load. In the operation regulation, the design heating load $Q^{'}$ can be

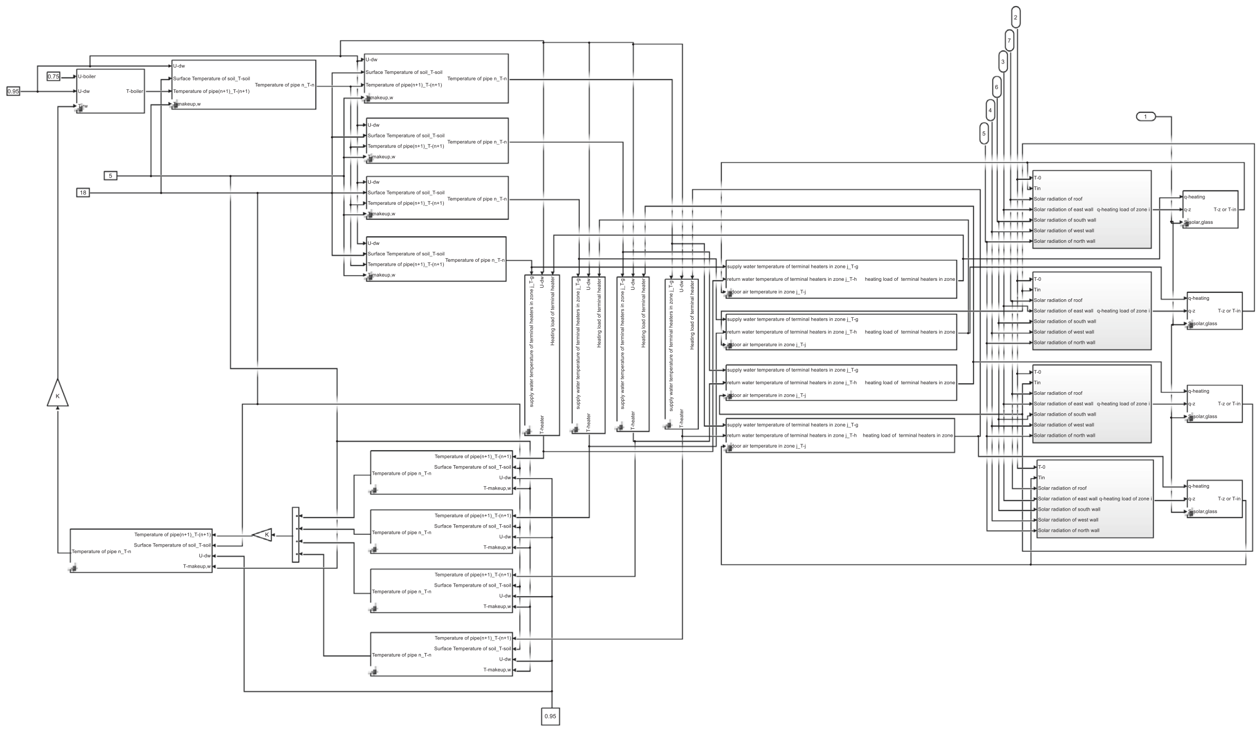

Figure 1: Simulation model of district heating system.

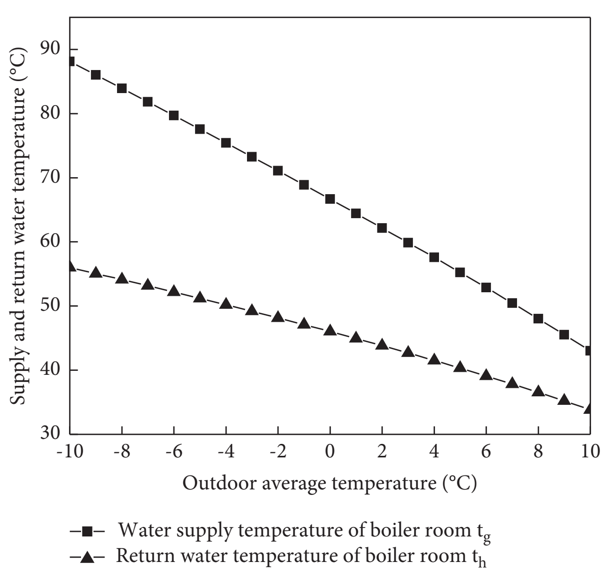

Figure 2: Operating temperature curve of boiler room.

obtained by substituting the indoor heating design temperature into formula (7). The ratio of predicted load to design load is the relative heating load ratio $\overline{Q}$, which meets the following formula:

$$\overline{Q} = \frac{\left(t_g + t_h - 2t_n\right)^{1+b}}{\left(t'_g + t'_h - 2t_n\right)^{1+b}} = \overline{G}\frac{t_g - t_h}{t'_g - t'_h}. \tag{8}$$

Finally, a modified comprehensive quality regulation method [15] is selected; that is, when the heat load is large, it is quantity regulation, and when the heat load is small, it is quality regulation. Combined with the above formula and regulation strategy, the operation regulation curve of the heat supply network can be obtained, as shown in Figure 3.

In the process of regulation, if the calculated load ratio is used to predict the heating parameters in the next four hours, the regulation action can be made in advance, so as to offset the mismatch between supply and demand caused by the large lag and delay of the system.

4. Simulation Results and Analysis

In the simulation test, the constant flow variable water supply scheme that maintains the same water flow and changes the water supply temperature is taken as scheme I, the outdoor temperature compensation scheme that installs outdoor temperature compensator on the heating system is taken as scheme II, and the scheme based on load forecasting is taken as scheme III for comparison test. Run the simulation modules under each regulation scheme, and observe the indoor temperature fluctuations. The comparison results are shown in Figure 4.

Observation of Figure 4 shows that on the premise that the load forecasting module makes the guiding adjustment action to the heating system in advance, the fluctuation range of the indoor temperature response curve is reduced to 20 ± 1°C. Compared with the conventional adjustment method, the up and down floating value from the indoor design temperature is reduced by 1.5°C, which greatly improves the control effect.

Assuming that the hydraulic condition is balanced, it shows that the heating load prediction model established by

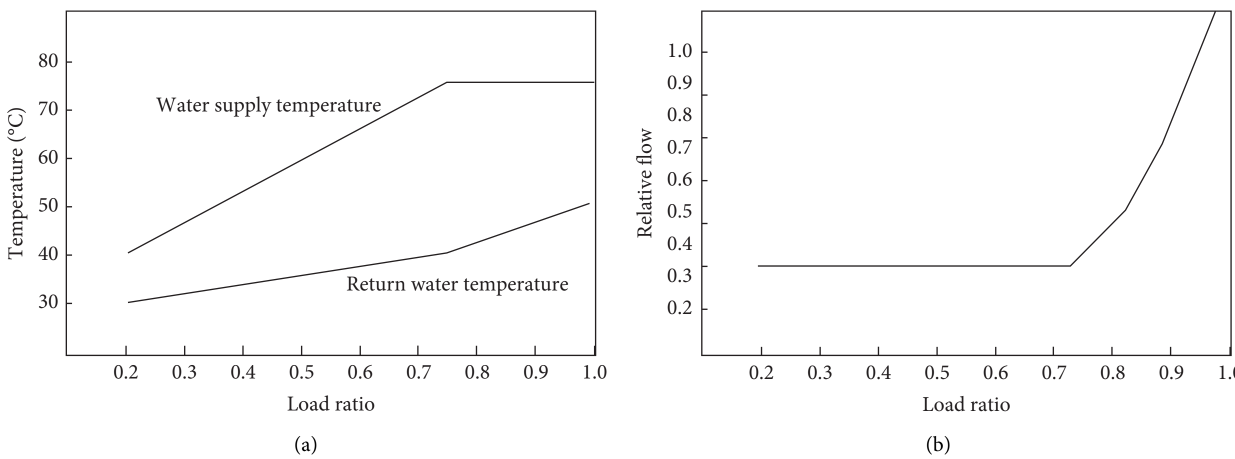

Figure 3: Comprehensive quality adjustment curve. (a) Supply and return water temperature. (b) Relative flow.

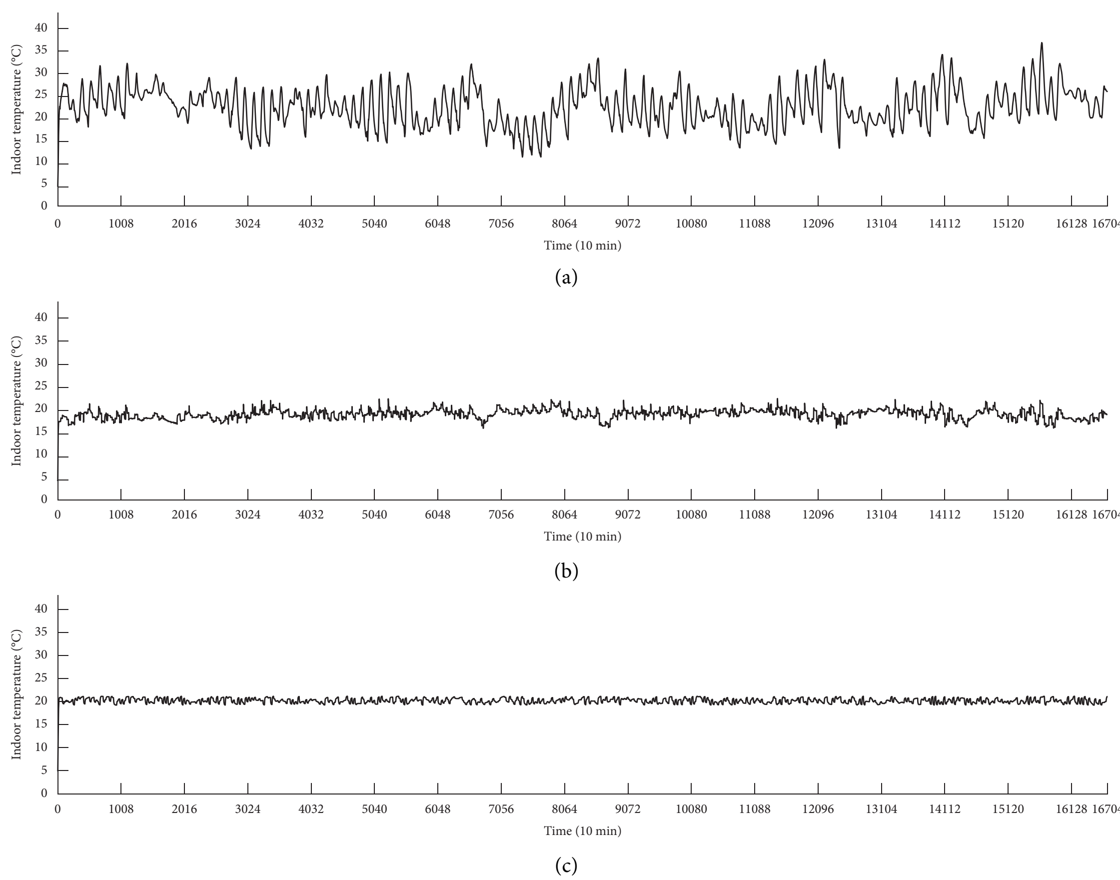

Figure 4: Indoor temperature response under three adjustment schemes. (a) Indoor temperature response of scheme I. (b) Indoor temperature response of scheme II. (c) Indoor temperature response of scheme III.

using the improved mass flow regulation method has an ideal effect on the control of the district heating system. In order to further explore the energy conservation of this scheme, the boiler fuel consumption calculation module and the pipe network circulating water pump energy consumption calculation module are established to observe the changes in energy consumption during operation, as shown in Figure 5.

It can be seen from the comparison of gas and power consumption statistics of boilers and water pumps in the whole heating season that the total gas consumption of boilers and power consumption of water pumps in scheme III vary greatly. The total energy consumption of the three schemes in the heating season is calculated and converted into standard coal for comparison. The results are shown in Table 1.

(a)

(b)

Figure 5: Comparison of energy consumption in the heating season. (a) Comparison of boiler air consumption of three regulation schemes. (b) Comparison of water pump power consumption of three regulation schemes.

Table 1: Simulation results of energy consumption in the heating season.

Comparison scheme	Gas consumption ($10000/m^3$)	Power consumption (kWh)	Total energy consumption (standard coal t)	Energy saving rate (%)
Scheme I	141.76	90368.28	1746.61	
Scheme II	116.86	77164.99	1440.11	17.55
Scheme III	100.03	49720.74	1230.75	29.53

According to the calculation results, the total energy consumption of load forecasting-based regulation is 1230.75 t standard coal, which is 29.5% compared with scheme I and 14.5% compared with scheme II.

5. Conclusion

Through the above theoretical research and experimental demonstration, it can be seen that the implementation process of the heat supply load forecasting method based on the data mining mechanism introduced in this paper is simple. The simulation results show that the model can achieve the ideal regulation effect. Based on the simulation model of the heating system established in this paper, it can be seen that the energy-saving rate of the load forecasting regulation method adopted in this paper can reach 29.5%. At the same time, the fluctuation range of indoor temperature response curve is reduced to $20 \pm 1^{\circ}$C, which is 1.5°C lower than that of conventional regulation. Therefore, the proposed method realizes the energy-saving control of district heating system.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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Research Article

Personalized News Recommendation Algorithm for Event Network

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In order to improve the level of personalized news recommendation efficiently and accurately, an event network-oriented personalized news recommendation algorithm is proposed. First, the event network is used to analyze, predict users' interests and preferences, and actively push information content to meet users' personalized needs, so as to build a personalized news recommendation model. Under the mobile Internet technology, combined with the characteristics of the Internet, through the position and title similarity of sentences in the document and other features, the combined features are formed to calculate the sentence weight. Finally, the sentences are extracted according to the weight ranking to generate the news summary, so as to realize the research on personalized news recommendation algorithm for event network. The experimental results show that the proposed algorithm has high recall and coverage, short time, good recommendation effect, and strong recommendation performance.

1. Introduction

In the process of the continuous updating of network technology, the traditional way of reading has no longer played a major role, and the public is gradually inclined to read online [1–3]. News recommendation as a means of news filtering and user positioning. It can recommend news topics that may be of interest to users based on their historical reading habits, ensure that users can quickly and effectively obtain the data information they need, reduce the cost of reading, avoid the occurrence of information overload, and provide high-quality and personalized services to users [4–6]. At present, in the process of developing e-commerce activities, the recommendation system under the condition of information overload will be applied, while there are few personalized recommendation systems for news. However, as news is an indispensable part of daily life, the update speed of network news is extremely fast, which leads to users' inability to accurately find the required information in a large amount of information [7–9]. Therefore, personalized recommendation for news is of great significance.

At this stage, scholars in related fields have conducted research on news recommendation algorithms. Reference [10] proposed an improved news recommendation algorithm based on text similarity. A blockchain-based distributed collaborative recommendation protocol is developed. Considering the characteristics of the news industry itself, the proposed TF-N algorithm is more suitable for stabilizing public opinion and has positive and negative control effects on the outbreak of the Internet. Through the verification of the experimental data set, the algorithm is superior to the traditional information retrieval and text mining technology TF-IDF in both the time dimension and the emotional dimension and is not affected by citizens' privacy rights. Reference [11] proposed a hybrid algorithm for personalized news recommendation. The personalized news recommendation system extracts news sets from multiple press releases and presents the recommended news to users. This paper proposes a personalized news recommendation framework and a hybrid personalized news recommendation algorithm. Hybrid personalized news recommendation combines collaborative filtering and content-based filtering. The framework aims to improve the accuracy of news recommendation by solving the scalability problems caused by large news corpora, enriching users' personal information, representing the exact attributes and characteristics of news items, and recommending different sets of news items. However, the above methods still have the problems of poor recommendation effect and weak recommendation performance.

To solve these problems, a personalized news recommendation algorithm for event network is proposed. Based on the analysis of event network, a personalized news recommendation model is constructed. With the help of mobile Internet technology, sentence weights are calculated based on sentence combination features, and sentences are extracted according to the weight order to generate news summaries, so as to realize personalized news recommendation. Among them, weight ranking is a relative concept, aiming at a certain index, and the weight of an index refers to the relative importance of the index in the overall evaluation. Weight refers to the quantitative distribution of the importance of different aspects of the evaluated object in the evaluation process, and the role of each evaluation factor in the overall evaluation is treated differently. In fact, evaluation without focus is not an objective evaluation. This paper uses event network to analyze, predicts users' interest preference, actively pushes information content to meet users' personalized needs, and constructs personalized news recommendation model. Under the mobile Internet technology, combined with the characteristics of the Internet, through the position of sentences in the document and the similarity of the title and other features, the combined feature is formed to calculate the weight of sentences, and finally, according to the weight order, the sentence is extracted to generate a news summary. The experiment proves that the algorithm has good recommendation effect and strong recommendation performance.

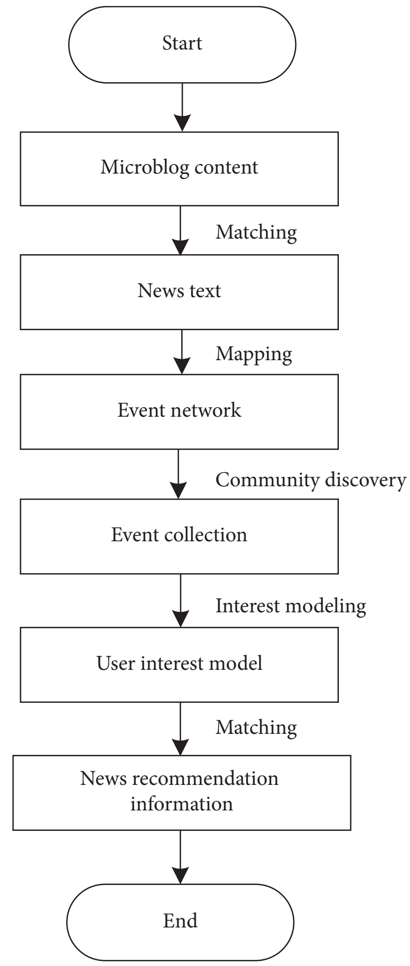

Figure 1: Overall flow chart of personalized news recommendation based on event network.

2. Personalized Recommendation Algorithm for Web News under Event Network

First, the user's microblog content is matched to the news in the network media, and then the news text is represented as an event network, and community discovery is performed on the text event network to obtain a collection of events and represents them as topics. Using the semantic information of the topic, predict the user's interest and preference, actively push the information content to suit the differentiated needs of different users, and build a personalized news recommendation model. The overall process of personalized recommendation of web news under event network is shown in Figure 1.

According to Figure 1, a good news recommendation can deal with news resources in a timely manner, recommend personalized news to users, greatly increase user satisfaction, and bring large user flow and income to news websites. News recommendation has gradually become a hot topic on the Internet. Major companies in the industry compete to develop the field of news recommendation, hoping to gain user traffic and monetize the user traffic. News recommendation is now a hot area on the Internet, and companies are hoping to capture a slice of the region, user traffic, and profits.

2.1. Event Network Model. Text is the carrier of information, so the text representation method is the basic problem of text information processing research. Event network is a semantic model with events as the basic unit. This paper will use the event network model to represent text, so as to realize the semantic information processing of text [12–14]. The theoretical basis of the event network model is that the model is composed of many units that are actually interwoven into a network form. It takes the event type unit as the core and has the knowledge expression method of event unit and concept unit at the same time. The so-called event is an objective event that occurs in the characteristic time and space; is composed of multiple entity roles; and has the characteristics of action, behavior, and change; The event granularity is divided differently in different fields. For example, in the field of linguistics, there are window granularity such as sentences, paragraphs, and chapters.

2.1.1. Event Definition. Events developed in the field of cognitive science and play an important role in the processing of natural language and information currently. Events are the basic unit of human understanding and memory of information. Based on the understanding of events in cognitive science, events are regarded as the basic unit of knowledge representation. Through induction and reasoning, it can be expressed in a formal way, so that the syntax and semantic analysis of event sentences can be realized and applied to various fields [15–17].

Events are defined as things that occur by different roles, showing multiple differentiated action characteristics under a specific environment and time. Q can be used to represent events, defined as a six-tuple:

$$Q = \text{def}\langle Z, X, C, V, B, N\rangle. \quad (1)$$

In formula (1), actions, times, objects, environments, assertions, and language representation can be expressed through the six event elements contained in a sextuple.

(1) Z (action element): it represents the process and characteristics of the event change and is a description of the degree, method, method, and tool of the action.

(2) X (object element): it includes a collection of role objects participating in the event, which can be divided into subject objects (actors of actions) and object objects (actors of actions).

(3) C (time element): it represents the time period of the event, that is, from the beginning to the end of the event, including relative and absolute time periods.

(4) V (environmental elements):it indicates the place where the event occurred and the characteristics of the environment.

(5) B (assertion elements): it includes the pre-assertion, intermediate assertion, and postassertion of the event occurrence. Preassertion refers to the constraints or trigger conditions satisfied by each element at the beginning of the time; intermediate predicate refers to the conditions satisfied by each element during the occurrence of the event; postcondition refers to the conditions satisfied by each element at the end of the event.

(6) N(language representation element): it indicates the language law of the event, including the collection of core words, the expression of core words, and the collocation of core words. The core words refer to the commonly used symbolic words of events. Core words represent the positional relationship between the representation of each element in the sentence and the core word. Core words can be matched with related words to form core word collocations.

2.1.2. Event Ontology. As an event-oriented representation model, event ontology is more in line with the laws of objective reality and the laws of human cognition [18–20]. The history of the world is a long history of evolution and change of events. To describe the objective world that is constantly changing, it is necessary to reasonably describe events and their relationships. Event ontology can represent rich event information, so that a rich event knowledge base can be constructed as the basis for computer event semantic information processing.

Collect events with the same characteristics to obtain an event class. Event classes can be represented by W:

$$W = (E, R_1, R_2, \ldots, R_6). \quad (2)$$

In formula (2), event set E means to extend the event class. $R_i = \{r_{i1}, r_{i2}, \ldots, r_{im}\}\,(1 \le i \le 6, m \ge 0)$ is called the connotation of the event class, which is the set of common features of the i element of each event in E, and r_{im} is a common feature of the i element of each event in the event class.

Ontology refers to the refinement of formal specification based on shared conceptual model. Based on this, event ontology can also be defined as a formal of objectively existing, shared, and event-like system model. The event ontology is represented as a triple:

$$T = (Y, U, I). \quad (3)$$

In formula (3), Y is the set of all event classes, U is the set of relations between event classes, including categorical and noncategorical relations, and I is a rule expressed by a logical language, which can be used for event transformation and reasoning.

The classification relationship of events is also called parent–child relationship or upper and lower relationship, which belongs to is an inheritance relationship and is static; nonclassification relationship includes composition, causality, following, accompanying, concurrent relationship, and so on:

(1) Composition relation: a big event can be divided into a number of small events, then they are said to have composition relation, the big event is composed of small events. For example, "building a house" is composed of "laying foundations," "laying bricks," "painting," and so on.

(2) Causality: if the occurrence of one event is caused by another, they are said to be causal. Causality is a kind of important relationship between events, which can not only reflect the relationship between events but also reflect the sequence of events. For example, "earthquake" and "house collapse" is the causal relationship, "earthquake" is the cause, "house collapse" is the result.

(3) Follow-through relationship: follow-through relationship reflects the sequence of occurrence of two events, but the two events do not necessarily cause each other. Such as "get up" and "brush your teeth."

(4) Concurrency: two or more events occur at short intervals, almost simultaneously. These events are sometimes a series of events triggered by the same event. Such as "wind" and "rain."

2.1.3. Event Network. Events are the basic unit of human cognition, understanding, and memory. Text representation should take events as the starting point and develop towards semantics. The six elements of the event itself have rich semantic information and can describe the event information in detail. The event network uses higher granularity events as the basic unit to represent the text content, which is more in line with the laws of the objective world and the laws of human cognition. The event is regarded as the feature item of text representation, and the event network is used as the text representation model, and the properties and operations of the event network are studied, so as to lay the foundation for the semantic processing of text.

An event network is a directed acyclic graph composed of many different event nodes. Each node stands for an independent event, every edge represents the relationship between the two events connected by the edge. The event network includes two different ancestors:

$$O = (E, P). \tag{4}$$

In formula (4), the set of event relationships is represented as P. There are many kinds of event relationships, the common ones are composition, inheritance, following, accompanying, causation, and so on. An event network is a special kind of graph in which each node and each edge on the graph carry information, and there can be multiple edges between two nodes. By analyzing the structure of the event network, we can get a lot of information such as the importance of the events in the network, the characteristics of the events, and the dynamics of the events. Due to the characteristics of the event network, it not only has the properties of a graph but also nodes and edges carry more semantic information. Combining this information and applying some properties and operations in graph theory to event networks, the classification, clustering, reduction, expansion, merging, and even mining and reasoning based on event networks can be realized. Therefore, event networks have unique properties and special computing methods that are different from general graphs. The event network hierarchy is shown in Figure 2.

Using mathematical methods to calculate at the abstract level of the event network can solve many problems. In the specific application of the event network model, events represented by different event models and methods can be abstracted into an event node. Instead of ignoring its internal structure, only focus on the external features of events, which is helpful for analyzing the flow of events in the objective world from outside to inside. On the basis of network operation, it can realize text logical level division, classification and clustering, automatic summarization, topic detection and tracking, and so on. For example, using the method of node strength analysis in complex networks, the nodes are clustered. Using the method of node association, mining important nodes, and realizing key sentence discovery and automatic text summarization, combining with community structure detection algorithms in complex networks, event network can be processed by community discovery method, and event clusters can also be obtained, which can realize the detection and tracking of text topics.

2.2. Community Detecting Algorithm. The community detecting algorithm is used to semantically process the event network [21–23]. The event network has the characteristics of a complex network. The community discovery algorithm of the complex network can be used to divide the event nodes in the event network. In the result of the division, the similarity of the events belonging to the same community is high, and the similarity of the events belonging to different communities is low.

In the process of quantitative description of network community, it is necessary to clearly divide community structure and define modular function A. Among them, the difference between the expected value of the proportion of the two internal nodes in the connected network and any network is modularization. Modular function A is described as follows:

$$A = \frac{1}{2\alpha} \sum_{ij} \left[a_{ij} - \frac{\beta_i \beta_j}{2\alpha} \right] \times \chi\left(\delta_i, \delta_j\right). \tag{5}$$

In formula (5), δ_i, δ_j are the community number of the node, and the adjacency matrix element of the network is represented as a_{ij}, the edge in the network graph' number is represented as χ, and the node order is represented as β_i, β_j.

2.3. Building a Personalized News Recommendation Model. The goal of this research is to effectively recommend targeted and personalized news to users. Personalized news recommendation refers to providing each user with personalized information according to user preferences and interests, and realizing active information acquisition and efficient information filtering for users. Personalized news recommendation model calculates vector similarity between news content model and user interest model and judges news recommendation results by defining a threshold value. In news recommendation, news that has not generated interest preference is recommended to users, so as to prevent excessive convergence of recommendation topics and increase the diversity and novelty of recommendation. Find news B that is similar to the "nearest neighbor" of news A being visited. The larger the similarity value is, the more similar news A and news B will be, and the greater the weight value of news B's score will be in the process of news recommendation prediction. Cosine similarity algorithm is also used to calculate the similarity between news. The calculation results are sorted according to the weight from high to low, and the first three of them are recommended to be inserted into the recommendation list of news interest together with the user. If the user is interested in this kind of news, the user's theme preference will change with the user's access behavior.

The content-based personalized news recommendation model is to find out the news list similar to the user's historical browsing news. This method avoids the occurrence of cold start of the project. When publishing news in the network, with this method, the personalized recommendation score of news can be obtained by calculating the user's historical search information and the similarity of network news. With the increase of the user's browsing record data,

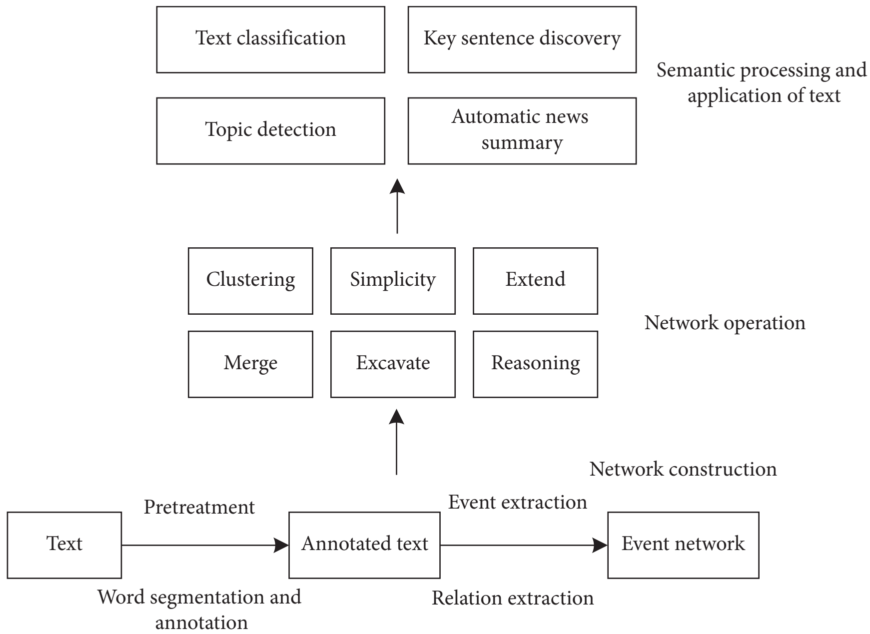

Figure 2: Event network hierarchy diagram.

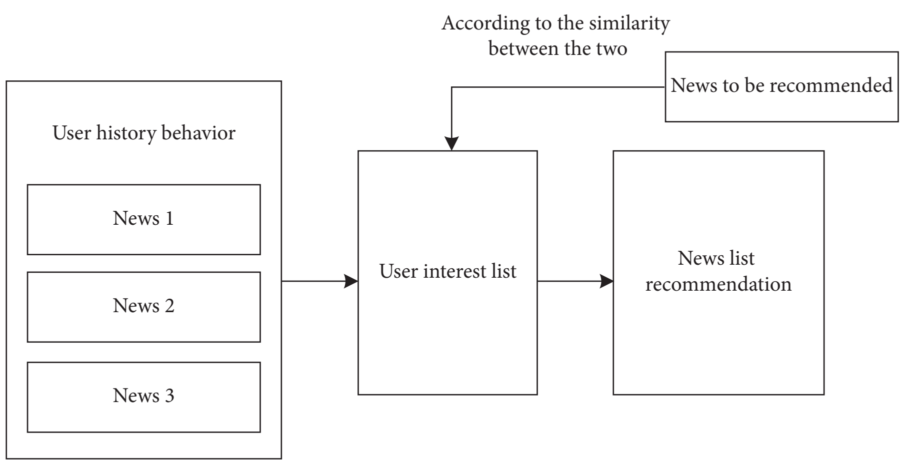

Figure 3: Content-based personalized news recommendation model.

the recommendation effect of this method will become more and more precise. Usually, the keywords of the news in the user's reading history are extracted as the user interest preference model. The content-based personalized news recommendation model is as follows:

According to Figure 3, it can be clearly found that the recommendation algorithm generates several keywords that can show the interests of user as the user's hobby model based on historical search record and calculate the similarity between the news to be recommended and the interest preference of user to give a recommendation list. At present, the most commonly used text feature representation method is the vector space model, which constructs a keyword table by extracting keywords. The user's interest features and news features are mapped to a high-dimensional vector, and the degree of similarity of user interests and items is measured according to the similarity of the vectors.

Suppose a user interest preference and news features can be expressed as a vector shown in the following formula:

$$D = (v_1, v_2, \ldots, v_k). \tag{6}$$

In the above formula, v_k represents the weight of the feature, that is, the user's preference for this keyword. The operation formula of TF-IDF algorithm is given by:

$$TF - IDF_{i,d} = TF_{i,d} \times IDF_i. \tag{7}$$

In formula (7), the number of occurrences of the word i in document d is represented by $TF_{i,d}$, its inverse document frequency is represented by IDF_i, and the inverse document frequency is used to measure whether a word is a stop word and other words that have no effect on the meaning of the sentence. In theory, the more times a word appears in an article, the more important the word is, but there are too many stop words. In order to prevent this from happening, the inverse document frequency is introduced. That is, when a fixed word is repeated in some documents, it means that the word is unimportant, and the function of inverse document frequency is to balance the keyword extraction error caused by stop words. The content-based personalized news recommendation model is mainly implemented through three steps: first, determine the range of items to be recommended and extract the features of each item to be recommended as the feature representation of the item to be recommended. Second, extract the user's interest distribution model according to the user's historical browsing records. Finally, it is necessary to calculate the similarity of user interest characteristics and recommended items and determine the recommendation document based on the maximum similarity. The similarity measurement formula is as follows:

$$\mathrm{Sim}(A, B) = \sum_{i \in m} TF - IDF_A \times TF - IDF_B. \quad (8)$$

The advantage of the content-based personalized news recommendation model is that it solves the problem of cold start of items. For example, when a new news is released, the text feature vector can be extracted, and the similarity with the user's interest features can be calculated to generate recommendations for users. Describe the main structure of personalized news recommendation model, further improve user interest expression, improve the more accurate expression of the hidden meaning of news text topic, meet the differentiated needs of users for news recommendation services, and improve the accuracy of personalized news recommendation and user satisfaction.

3. News Summarization Algorithm Based on Combined Feature LDA

3.1. Mobile Internet and Its Characteristics. Mobile Internet refers to the use of mobile devices by users to access the Internet through mobile communication networks, which is the product of the combination of mobile communication networks and the Internet. The main online behaviors of current mobile users include mobile news reading, mobile search, mobile web browsing, mobile music and video playback, mobile application download and use, mobile social services, mobile network office, mobile e-commerce, and so on.

Mobile Internet has major attributes such as mobility, context awareness, and personalization of mobile devices. For mobile users in the Internet environment, their identities are more specific and detailed. Such as the amount of the mobile users can be obtained according to the information filled in when the mobile users register to access the network or some machine learning and data mining techniques. In addition, other mobile user information such as the geographic location information of the mobile user can be obtained through GPS. In terms of mobile terminal devices, mobile devices used by mobile users have many brands and models, which are more personalized and diversified. Due to the small screen of the mobile Internet access device, the display and description of the recommendation results need to be changed to adapt to the mobile user's sword browsing behavior, so as to improve the mobile user's use experience. In order to alleviate the limitation of the mobile terminal, various applications in the mobile Internet are generally small software and small applications. In the process of the rapid development of network information technology, future mobile devices will be more intelligent and more functional. In addition, the development and wide application of cloud storage technology and cloud computing technology has contributed to the rapid popularization of smart mobile devices in various fields. Relying on the advanced wireless Internet technology, the majority of users can combine their own needs to facilitate the application of the network, search for the data they need, but also accept the news pushed in real time. In different time periods, the news topics that mobile users pay attention to when accessing the mobile Internet are also different.

3.2. Linear Discriminant Analysis (LDA) Topic Model. As a highly applied subject model, LAD is a three-layer Bayesian probability model that can effectively connect documents with words by using potential topics. Similar to many probabilistic models, by constructing the word package, the LDA model only analyzes the word frequency by ignoring the influence of word order and grammar factors [24–26]. The LDA model is a probabilistic sampling process that describes how to generate words in documents based on latent topics. The generation steps of word package are:

(1) Generate a φ for document d under corpus;
(2) Consider the generation of word θ_i in document d: generate a topic q_j, generate a discrete variable ϑ for topic q_j, and generate such that $P(\theta_i|\vartheta, \rho\sigma)$. Among them, the value of ρ represents the weight distribution of each topic before sampling, and the value of σ represents the prior distribution of each topic to words. The probabilistic model of the LDA generation process is shown in Figure 4.

In Figure 4, the outer rectangles represent the topic distribution repeatedly in every document distribution d under set D, and the inner rectangles represent the words that are repeatedly sampled from the topic distribution to generate document d. LDA generates the probability model formula:

$$p(\varpi, \varsigma|\tau, \rho, \sigma) = p(\varpi|\rho) \prod_{n=1}^{N} p(\varsigma|\varpi) p(\tau|\varsigma, \sigma). \quad (9)$$

In formula (9), τ is the observed variable, and ϖ and ς are hidden variables.

3.3. Basic Features of Sentences. Basic features characterize the importance of sentences in documents, including: sentence length, position, and title similarity.

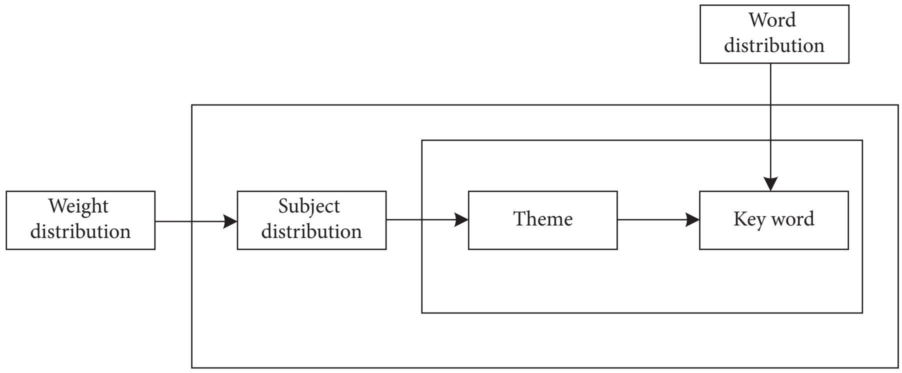

Figure 4: Probabilistic model of the LDA generation process.

(1) Length feature $M(S)$: to avoid the bias of the summary to long sentences, add a weight value to the length of the sentence and define the length feature of the sentence S as:

$$M(S) = 1 - \frac{|l - \varepsilon|}{\varepsilon}. \quad (10)$$

In formula (10), the average value of sentence length under the document set is expressed as ε, and l is the length of sentences.

(2) Location feature $L(S)$: suppose a document has K sentences, and S is the ϕ sentence in it. The location feature that defines sentence S is as follows:

$$L(S) = \frac{K - \phi + 1}{K}. \quad (11)$$

(3) Similarity feature $\mathrm{Sim}(S, J)$: regard the title of a document as the most important sentence, vectorize the title sentence and each sentence in the document and calculate the similarity between them.

$$\mathrm{Sim}(S, J) = \frac{S \times J}{\|S\|\|J\|}. \quad (12)$$

In this paper, the extraction method of the three basic features is used as the baseline. The basic features of sentence S in the baseline system are the weighted sum of the above three feature values, which is expressed as follows:

$$\mathrm{ScoreBase} = M(S) + 2 \times L(S) + \mathrm{Sim}(S, J). \quad (13)$$

News documents are different from ordinary text documents. The summary sentences and key sentences of news generally appear at the beginning of the paragraph, which is early. Therefore, the position information of the sentence has a better indication for judging whether the sentence can be used as a summary sentence, and the weight is larger.

3.4. LDA Topic Probability Features of Sentences. In order to represent the relationship between words, sentences, and documents, this paper adopts a four-layer LDA model to extract the topic probability distribution models of documents and sentences, respectively, and obtains the topic similarity features between the sentence model and the document model.

(1) Sentence weight calculation: in general, if the subject expressed by a sentence in a document is more similar to the subject expressed by the document, the more likely this sentence is to be selected as a summary sentence. Combined with this theory, it is necessary to calculate the similarity of topic probability distribution between sentences and documents when judging the importance of sentences. The higher the similarity, the higher the LDA feature score of the sentence. Among them, the similarity of different probability distributions can be calculated by KL divergence.

$$JSim(S, D) = -\left(D_{KL}(P_S\|P_D) + D_{KL}(P_S\|P_D)\right). \quad (14)$$

In formula (14), the probability of occurrence of sentence S in the topic is represented as P_S, while the probability of occurrence of document D in the topic is represented as P_D. $D_{KL}(P_S\|P_D)$ represents the divergence between two probability distributions, P_S and P_D, as follows:

$$D_{KL}(P_S\|P_D) = \sum_i P_S(i) \log \frac{P_S(i)}{P_D(i)}. \quad (15)$$

(2) Calculation of topic probability distribution: LDA is used to model the document collection, and the news documents are divided into set H topics. Documents can therefore be represented by a G dimensional vector space $P_D = \{P(J_1|D), P(J_2|D), \ldots, P(J_G|D)\}$, where J_H is the H topic, and component $P(J_H|D)$ represents the probability that a given document D belongs to topic J_H. Sentences are represented by a G dimensional vector space $P_S = \{P(J_1|S), P(J_2|S), \ldots, P(J_G|S)\}$, where component $P(J_H|S)$ represents the probability that a given sentence S belongs to topic J_H.

The topic distribution $P(J_H|D)$ of each document can be obtained from φ in the LDA model. Usually, a sentence consists of several words; therefore, by calculating the occurrence probability of word topic in the sentence, the topic distribution probability of sentence can be obtained.

Sentence $S = \{S_1, S_2, \ldots, S_n\}$, where S_n represents a word in the sentence, then the topic distribution $P(J_H|S)$ of sentences can be clarified through the formula.

$$P(J_H|S) = \sum_{s_j \in S} P(s_j|J_H) \times P(J_H|D) \times P(D). \tag{16}$$

According to the above combined features, in the news document, the sentences' weight can be defined. Referring to the weight value, the order of sentences can be arranged, the sentences can be extracted, and the news summary can be formed finally, which can achieve the purpose of recommending personalized news to users.

4. Experimental Analysis

When the algorithm proposed in this study is verified, the data set in the DUC2007 news summary evaluation task and the web crawler to grab the news report data from the Netease website are used as the experimental data. DUC2007 contains 45 document collections, each collection contains 25 documents with a common topic or related topics, and the document sentences are divided by software. The experiment establishes an LDA model for each document set, randomly selects 1000 users from a well-known domestic financial news website-Caixin.com, and extracts all the news browsing records of these 1000 users, a total of 116237 browsing records. Every record covers four major contents, namely news ID, browsing time, news text content, and user ID. The user ID has been anonymized to prevent exposure of user privacy. Divide the experimental data into two parts, among them, 1/5 of the data is the test set, and the rest 4/5 is the training set. Since the news recommendation is time-sensitive, the data are divided according to time to test the pros and cons of the algorithm; 500 registered users were extracted from 1000 registered users, and about 50,000 pieces of behavior data were used for experiments.

To test the personalized news recommendation efficiency of this algorithm, the recall rate is used as the evaluation index. Recall rate is the proportion of the total amount of recommended news that meet the needs of users and the total amount of news that users are interested in. The higher the recall rate, the better the personalized news recommendation effect of the method. Its calculation formula is as follows:

$$\gamma = \frac{\eta}{\kappa} \times 100\%. \tag{17}$$

In formula (17), η is the number of news that the recommended news is really the news that the user likes. Number the news that users are interested in, specifically expressed as κ. A comparative analysis is conducted on the algorithm in this study and the algorithm in references [10, 11], the comparison results of the recall rate of personalized news recommendation are as follows:

According to Figure 5, when the number of all news reaches 50,000, the average recall rate of personalized news recommendation of the reference [10] algorithm is 78.6%, and the average recall rate of the personalized news recommendation of the reference [11] algorithm is 69.2%. The average recall rate of the algorithm in this study is as high as 95.4%. From which it can clear that the recall rate of personalized recommendation algorithm for web news under event network is high, indicating that this algorithm has a good recommendation efficiency.

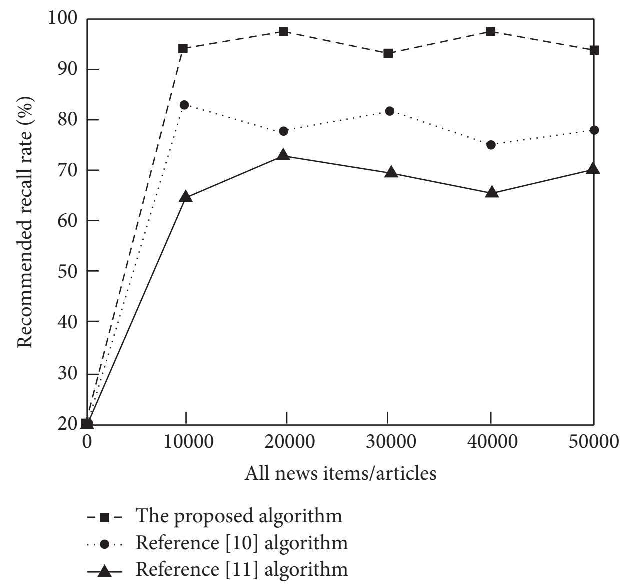

Figure 5: The comparison chart of recall rate of personalized news recommendation under different algorithms.

In the process of verifying the personalized recommendation performance of this research algorithm, the selected evaluation index is coverage. Coverage refers to the ratio of the number of all recommended news to the total amount of news that the user is interested in. The higher the coverage, the stronger the personalized news recommendation performance of the method.

$$\mu = \frac{\nu}{\kappa} \times 100\%. \tag{18}$$

In formula (18), the total amount of the recommended news is expressed as ν. The reference [10] algorithm, the reference [11] algorithm, and the proposed algorithm are used to compare, and the comparison results of the personalized news recommendation coverage are as follows:

According to Figure 6, when the number of all news items reaches 50,000, the average coverage rate of personalized news recommendation of the reference [10] algorithm is 84.8%, and the average coverage rate of personalized news recommendation of the reference [10] algorithm is 74.6%. The average coverage rate of personalized recommendation algorithm for web news under event network is 97.5%. Therefore, the coverage rate of personalized news recommendation of the proposed algorithm is higher than the other two algorithms, which shows that the algorithm in this study has strong performance of personalized news recommendation.

On this basis, the next step is to conduct a comparative study on the time-consuming of personalized recommendation of web news with different algorithms. A comparative analysis is conducted on the algorithm in this study and the algorithm in references [10, 11], and the comparison results

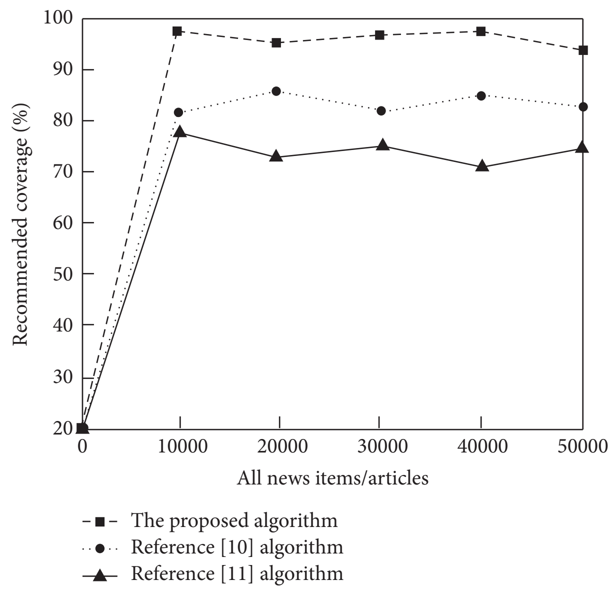

Figure 6: Comparison results of personalized news recommendation coverage of different algorithms.

Table 1: Comparison results of personalized news recommendation response time of different algorithms.

All news items/articles	The proposed algorithm/s	The reference [10] algorithm/s	The reference [11] algorithm/s
10000	0.23	1.97	1.19
20000	0.41	2.37	1.58
30000	0.78	2.51	1.82
40000	1.03	2.76	2.03
50000	1.20	2.85	2.48

of the personalized news recommendation response time are as shown in Table 1:

According to Table 1, in the process of increasing the total amount of web news, the response time of personalized news recommendation by different algorithms also increases. When the number of all news reaches 50,000, the personalized news recommendation response time of the algorithms in reference [10] and reference [11] is 2.85 s and 2.48 s, respectively, and the personalized news recommendation response time of the algorithm in this study is 1.2 s, which indicates that the personalized news recommendation response time of this algorithm is much shorter.

In conclusion, when the number of all news items reaches 50000, the average recall rate of personalized news recommendation of the proposed algorithm is as high as 95.4%. The average coverage rate is as high as 97.5%, and the response time is only 1.2 s, which indicates that the proposed algorithm has good personalized news recommendation performance, strong personalized news recommendation performance, short recommendation response time, and good effect.

5. Conclusion

The personalized recommendation algorithm for web news under event network is studied in this paper, and the event network is used to analyze and construct a personalized news recommendation model. Under the mobile Internet technology, sentence weights are calculated by combining sentence features to form combined features, and sentences are extracted according to the weight order to generate news summaries to achieve personalized news recommendation. The proposed algorithm has good recommendation effect and strong recommendation performance. But the algorithm does not take user experience into account. Therefore, in the following research, the acquired interest preferences of mobile users are used to predict new points of interest for users based on the similarity between mobile users to improve user experience.

Data Availability

The raw data supporting the conclusions of this article can be obtained from the author upon request, without undue reservation.

Conflicts of Interest

The author declared that there are no conflicts of interest regarding this work.

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Research Article

Mental State Assessment in College English Teaching Courses Based on Deep Learning

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College English teaching aims at students with different foundations and characteristics. Also, it is necessary to grasp the mental state of students in time during the teaching process. Based on the bimodal information of facial expressions and speech of classroom students, this paper designs a mental state assessment method based on deep learning. For bimodal emotion recognition of facial expressions and speech, a feature fusion method based on sparse canonical correlation analysis (SCCA) is proposed in this paper. First, the emotional features of the facial expression and speech are extracted, respectively. Then, SCCA is used to fuse the emotional features of the two modalities. Finally, the sparse representation-based classification (SRC) is used as the classifier for emotional prediction. Based on the prediction results, the mental state of different students can be grasped, so as to adjust the teaching strategy in a targeted manner. Experiments are carried out based on public datasets. First, the proposed method achieves the average classification accuracy of 92.4%, which is higher than those from the present methods for comparison. Second, under the condition of noise corruption, the proposed method keeps the superior robustness over the comparison methods. The results show that the proposed bimodal emotion recognition method based on SCCA and SRC can achieve higher recognition rates than some present methods.

1. Introduction

With the development of the economy and society, people begin to pay more attention to their own mental health. In the university stage, due to the rapid changes in the internal and external environment of students, many of them cannot adapt in time, which is prone to psychological problems. According to research statistics, the psychological problems of college students have obvious stage characteristics, and many students cannot detect their own psychological changes in time, which leads to the deterioration of psychological problems and has serious consequences. Taking English teaching in colleges and universities as an example, due to the different foundations of English learning and different interests in the student group, different students may have different psychological emotions towards this course. Therefore, it is an important way to correctly adjust the educational method and improve the teaching efficiency to do a good job of mental state assessment in the classroom in time. It is in this context that this paper aims to support the English teaching based on the emotional analysis of students' expressions and speeches during the English teaching classes to obtain their corresponding mental states [1–3].

In the past few decades, many researchers all over the world have used several commonly used human-computer interaction modalities (such as facial expressions, speech, and gestures) to conduct emotion recognition. Some effective expression recognition, speech emotion recognition, and action gesture recognition methods were developed [4–7]. Among these methods, the vast majority are emotion recognition methods based on a single modality. However, in future applications such as emotional robots, unmanned driving, and intelligent transportation, the emotional interaction between humans and machines is often based on bimodal or multimodality. For example, emotional robots can perform human-computer interaction through both facial expression and speech [8–10]. Therefore, the study of multimodal emotion recognition methods based on facial expressions and speech plays a very important role in the development and progress of future technologies such as emotional robots, unmanned driving, and intelligent transportation [11–13].

At present, some researchers have initially carried out research on bimodal emotion recognition based on facial expressions and speech. Reference [13] proposed a multimodal method of facial expression and speech based on the fusion mechanism of the decision-making layer and achieved certain fusion effects. Reference [14] proposed a multimodal facial expression and speech method based on the multistream hidden Markov model (MHMM), which achieved good performance after fusion. Reference [15] studied a multimodal approach to facial expression and speech based on direct fusion and back-propagation (BP) neural network classifiers. Reference [16] employed the kernel cross-modal factor analysis (KCFA) algorithm to perform feature dimensionality reduction and feature fusion for speech and facial expression modalities. Reference [17] used the kernel entropy component analysis (KECA) algorithm and the decision layer fusion to study facial expression and speech bimodal emotion recognition and achieved high dual-mode emotion recognition on two commonly used emotion databases. In recent years, deep learning models have provided powerful tools for face and speech emotion recognition, and representative methods include convolution neural network (CNN), long short-term memory (LSTM), and generative adversarial network (GAN). [18, 19].

In order to effectively improve the emotion recognition performance during English teaching classes so as to grasp the mental state of different students, this paper proposed a dual-modal emotion analysis method based on facial expression and speech. First, the proposed method extracts the features of facial expression and speech, respectively. Then, the sparse canonical correlation analysis (SCCA) [20–22] algorithm is used to fuse the two kinds of features to obtain a unified feature. Finally, the sparse representation-based classification (SRC) is used for bimodal emotion recognition. Based on the emotion analysis results, each student in the classroom can be observed, and their mental states toward this class can be analyzed. The main contribution of this paper can be summarized as follows. The dual-modal information during the teaching is properly analyzed and fused by SCCA. The fused result can better convey the mental state of the students. SRC performs as the classification scheme and finally gets the result of the mental state. Experiments are performed based on the public dataset. According to the experimental results, the validity and superiority of the proposed method can be verified by comparison with several published methods in this field.

2. Expression and Speech Emotion Feature Extraction

For facial expression and speech bimodal emotion data, this paper first performs feature extraction. For facial expression modalities, this paper uses scale-invariant feature transform (SIFT) to extract features. SIFT feature is a very effective image feature extraction method, which is widely used in action recognition, motion detection, and facial expression recognition, due to its robustness and antinoise advantages.

The previous works show that the SIFT feature extraction process generally includes the extraction of extreme points in the original image, the selection of feature points, the gradient solution of feature points, and the generation of feature point descriptors. In practical applications such as facial expression recognition, the following steps of solving the gradient of feature points and generating step of feature point descriptors are the most critical. The gradient of the feature point is mainly calculated by the following two equations:

$$\rho(x,y)=\sqrt{[\widehat{J}(x,y+1)-\widehat{J}(x,y-1)]^2+[\widehat{J}(x+1,y)-\widehat{J}(x-1,y)]^2}, \tag{1}$$

$$\theta(x,y)=\tan^{-1}\left\{\frac{\widehat{J}(x,y+1)-\widehat{J}(x,y-1)}{\widehat{J}(x+1,y)-\widehat{J}(x-1,y)}\right\}. \tag{2}$$

In equations (1) and (2), $\rho(x,y)$, $\theta(x,y)$, and $\widehat{J}(x,y)$ represent the required gradient size, gradient direction, and Gaussian smoothed image, respectively. After the gradient is obtained via equations (1) and (2), the direction of each feature point is first calculated by the histogram method, and then, SIFT feature vectors of different dimensions are extracted based on the obtained direction.

For speech modalities, this paper uses openSMILE software to extract the emotional features of speech modalities. Compared with the traditional speech emotion feature extraction method, the speech emotion feature based on openSMILE software is more convenient and direct. As long as the corresponding speech audio is input, the rich speech emotion feature can be directly extracted through a simple operation.

3. Classroom Psychological Assessment Based on Emotion Analysis

3.1. Feature Fusion. At first, SCCA is used to fuse the features of the two modalities from facial expression and speech [20–22]. The SCCA algorithm can be expressed as follows:

$$\underset{A_W, A_S}{\operatorname{argmin}} L_{\mathrm{SCCA}} = \underset{A_W, A_S}{\operatorname{argmin}} \left\| \left(WW^{\mathrm{T}}\right)^{-1/2} \left(W - A_W A_S^{\mathrm{T}} S\right) \right\|_F^2 + \eta_W \left\|A_W\right\|_1 + \eta_S \left\|A_S\right\|_1. \tag{3}$$

In equation (3), S is the extracted speech feature matrix; W is the facial expression feature matrix extracted by the SIFT method; A_W is the projection matrix of W; A_S is the projection matrix of S; η_W is the sparse parameter of A_W; and η_S is the sparse parameter of A_S.

According to the relevant researches, the problem in equation (3) can be resolved by the augmented Lagrangian algorithm. Let $\widetilde{A}_W = A_W$ and $\widetilde{A}_S = A_S$, equation (3) can be reformulated as follows:

$$\begin{aligned}
\underset{A_W, A_S, \widetilde{A}_W, \widetilde{A}_S}{\operatorname{argmin}} L_{\mathrm{SCCA}} = \underset{A_W, A_S, \widetilde{A}_W, \widetilde{A}_S}{\operatorname{argmin}} & \left\| \left(WW^{\mathrm{T}}\right)^{-1/2} \left(W - A_W A_S^{\mathrm{T}} S\right) \right\|_F^2 + \eta_S \left\|A_S\right\|_1 + \operatorname{tr}\left[\Gamma_W^{\mathrm{T}} \left(\widetilde{A}_W - A_W\right) + \eta_W \left\|A_W\right\|_1\right] \\
& + \operatorname{tr}\left[\Gamma_S^{\mathrm{T}} \left(\widetilde{A}_S - A_S\right)\right] + \frac{\lambda_W}{2} \left\|\widetilde{A}_W - A_W\right\|_F^2 + \frac{\lambda_S}{2} \left\|\widetilde{A}_S - A_S\right\|_F^2,
\end{aligned} \tag{4}$$

where λ_W is the norm coefficient of $\widetilde{A}_W - A_W$; λ_S is the norm coefficient of $\widetilde{A}_S - A_S$; Γ_W^T is the Lagrangian multiplier matrix of $\widetilde{A}_W - A_W$; Γ_S^T is the Lagrangian multiplier matrix of $\widetilde{A}_S - A_S$.

Equation (4) can be further rewritten as follows:

$$\begin{aligned}
\underset{A_W, A_S, \widetilde{A}_W, \widetilde{A}_S}{\operatorname{argmin}} L_{\mathrm{SCCA}} = \underset{A_W, A_S, \widetilde{A}_W, \widetilde{A}_S}{\operatorname{argmin}} & \operatorname{tr}\left\| \left(WW^{\mathrm{T}}\right)^{-1/2} WW^{\mathrm{T}} \left(WW^{\mathrm{T}}\right)^{-1/2} \right\| - 2\operatorname{tr}\left[\left(WW^{\mathrm{T}}\right)^{-1/2} WS^{\mathrm{T}} \widetilde{A}_S \widetilde{A}_W^{\mathrm{T}} \left(WW^{\mathrm{T}}\right)^{-1/2} \right] \\
& + \operatorname{tr}\left[\left(WW^{\mathrm{T}}\right)^{-1/2} \widetilde{A}_W \widetilde{A}_S^{\mathrm{T}} SS^{\mathrm{T}} \widetilde{A}_S \widetilde{A}_W^{\mathrm{T}} \left(WW^{\mathrm{T}}\right)^{-1/2} \right] + \eta_S \left\|A_S\right\|_1 + \eta_W \left\|A_W\right\|_1 + \operatorname{tr}\left(\Gamma_S^{\mathrm{T}} \widetilde{A}_S - \Gamma_S^{\mathrm{T}} A_S\right) \\
& + \frac{\lambda_S}{2} \operatorname{tr}\left(\widetilde{A}_S \widetilde{A}_S^{\mathrm{T}} - 2\widetilde{A}_S A_S^{\mathrm{T}} + A_S A_S^{\mathrm{T}} \right) + \frac{\lambda_W}{2} \operatorname{tr}\left(\widetilde{A}_W \widetilde{A}_W^{\mathrm{T}} - 2\widetilde{A}_W A_W^{\mathrm{T}} + A_W A_W^{\mathrm{T}} \right) + \operatorname{tr}\left(\Gamma_W^{\mathrm{T}} \widetilde{A}_W - \Gamma_W^{\mathrm{T}} A_W\right).
\end{aligned} \tag{5}$$

Taking the partial derivatives of (5) with respect to $\widetilde{A}_W$ and $\widetilde{A}_S$, respectively, and setting them to 0, we can get

$$\begin{aligned}
\frac{\partial L_{\mathrm{SCCA}}}{\partial \widetilde{A}_W} &= -2\left(WW^T\right)^{-1} WS^T \widetilde{A}_S + \Gamma_W + \lambda_W \widetilde{A}_W - \lambda_W A_W + 2\left(WW^T\right)^{-1} \widetilde{A}_W \widetilde{A}_S^T SS^T \widetilde{A}_S = 0, \\
\frac{\partial L_{\mathrm{SCCA}}}{\partial \widetilde{A}_S} &= -2\left(WW^T\right)^{-1} SW^T \widetilde{A}_W + \Gamma_S + \lambda_S \widetilde{A}_S - \lambda_S A_S + 2\left(WW^T\right)^{-1} SS^T \widetilde{A}_S \widetilde{A}_W^T \widetilde{A}_W = 0.
\end{aligned} \tag{6}$$

Then, the solution is

$$\begin{aligned}
\widetilde{A}_W &= A_W + \frac{2}{\lambda_W} \left(WW^T\right)^{-1} WS^T \widetilde{A}_S - \frac{2}{\lambda_W} \left(WW^T\right) \widetilde{A}_W \widetilde{A}_S^T SS^T \widetilde{A}_S - \frac{\Gamma_W}{\lambda_W}, \\
\widetilde{A}_S &= A_S + \frac{2}{\lambda_S} \left(WW^{\mathrm{T}}\right)^{-1} SW^{\mathrm{T}} \widetilde{A}_W - \frac{2}{\lambda_S} \left(WW^{\mathrm{T}}\right) SS^{\mathrm{T}} \widetilde{A}_S \widetilde{A}_W^{\mathrm{T}} \widetilde{A}_W - \frac{\Gamma_S}{\lambda_S}.
\end{aligned} \tag{7}$$

According to the method introduced in [21], after obtaining $\widetilde{A}_W$ and $\widetilde{A}_S$, the solution of A_W and A_S can be transformed into

$$\begin{aligned}&\underset{A_W}{\operatorname{argmin}} \frac{\eta_W}{\lambda_W}\|A_W\| + \frac{1}{2}\left\|A_W - \left(\widetilde{A}_W + \frac{\Gamma_W}{\lambda_W}\right)\right\|_F^2,\\&\underset{A_S}{\operatorname{argmin}} \frac{\eta_S}{\lambda_S}\|A_S\| + \frac{1}{2}\left\|A_S - \left(\widetilde{A}_S + \frac{\Gamma_S}{\lambda_S}\right)\right\|_F^2.\end{aligned} \tag{8}$$

Then, we can get

$$\begin{aligned}A_W &= \xi_{\frac{\eta_W}{\lambda_W}}\left[\widetilde{A}_W + \frac{\Gamma_W}{\lambda_W}\right],\\A_S &= \xi_{\frac{\eta_S}{\lambda_S}}\left[\widetilde{A}_S + \frac{\Gamma_S}{\lambda_S}\right].\end{aligned} \tag{9}$$

Among them, the function ξ is the threshold function defined in [21].

Finally, the bimodal feature fusion based on SCCA is obtained as follows:

$$\begin{pmatrix} A_W^{\mathrm{T}} W \\ A_S^{\mathrm{T}} S \end{pmatrix}. \tag{10}$$

3.2. Emotion Classification. SRC uses sparse representation for pattern recognition problems, which characterizes the unknown input through training samples of known categories and then determines the category of test samples according to the reconstruction errors of different categories. Supposing $D = [D^1, D^2, \ldots, D^C] \in \mathrm{R}^{d\times N}$ is a global dictionary, where $D^i \in R^{d\times N_i}\,(i = 1, 2, \ldots, C)$ represents N_i training samples from ith class, and the sparse representation process of the test sample y can be built as follows:

$$\begin{aligned}&\widehat{x} = \underset{x}{\operatorname{argmin}} \|x\|_0,\\&\text{s.t.} \|y - Dx\|_2^2 \le \varepsilon.\end{aligned} \tag{11}$$

In the above equations, x represents the sparse coefficient vector. According to relevant works, the algorithms commonly used to solve sparse representation problems include ℓ_1 norm optimization and orthogonal matching pursuit algorithm (OMP) [13–16]. Based on the solution of $\widehat{x}$, the reconstruction errors for the test samples are calculated according to the categories, and finally, the category of the test samples is determined as follows:

$$\begin{aligned}r(i) &= \left\|y - D_i x_i\right\|_2^2 (i = 1, 2, \ldots, C),\\\text{identity}(y) &= \arg\min_i (r(i)),\end{aligned} \tag{12}$$

where x_i is the coefficient vector corresponding to the ith class; $r(i)$ is the corresponding reconstruction error.

Compared with CNN, the classification mechanism of SRC is relatively less dependent on the number of test samples. At the same time, existing research results show that SRC has certain adaptability to complex situations such as noise interference and occlusion. Figure 1 shows the basic process of the proposed method in this paper. Based on the extracted facial expressions and speech features, SCCA is used for feature fusion, and finally, the category is confirmed based on SRC to obtain the emotional and mental state of the current test sample. Specifically, during English teaching courses, the proposed method can be used to automatically obtain the current emotional state of different students, reflecting their psychological acceptance of the current course. Such analysis results can be used to assist in the adjustment and optimization of teaching methods and teaching forms.

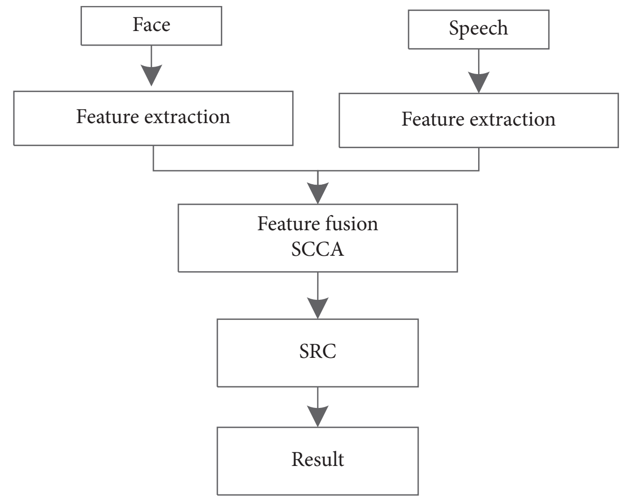

Figure 1: Basic flowchart of the proposed method.

4. Experiment and Analysis

4.1. Introduction of Dataset. The RECOLA dataset is a commonly used dataset for emotion recognition containing speech and visual data, providing audio and video recordings, image, and sound features, some time-specific events, and some other metadata of 46 different experimental participants. The voice module in the dataset contains the original recording, the start and end times of speech, the predicted probability of voice activity, and other characteristics of the voice. The image module in the dataset contains the original videos, the corresponding time of each frame in the video, the predicted probability of face detection, and the features of the image. The original footage was captured by a Logitech webcam, 1080×720 pixels, YUV color mode, and fixed FPS at 25 frames per second. The raw data are annotated with emotion (Arousal and Valence) and type of laughter (silent laughter, normal laughter, talking, and talking laughter). The dataset also provides some other information, such as physiological signals, age, gender, and native language.

In the specific use of this paper, we selected 1200 adult facial expression and speech data samples and selected a fivefold cross-validation strategy for testing. In the process, in order to reflect the performance of the proposed method, several categories of methods from the existing literature are used for comparison, including SVM, CNN, and LSTM. At the same time, the performance test is also carried out under

Table 1: Comparison of performance of different methods.

Method	Average classification accuracy (%)
Proposed	92.4
SVM	85.7
CNN	89.3
LSTM	89.5
Face only	87.1
Speech only	86.2

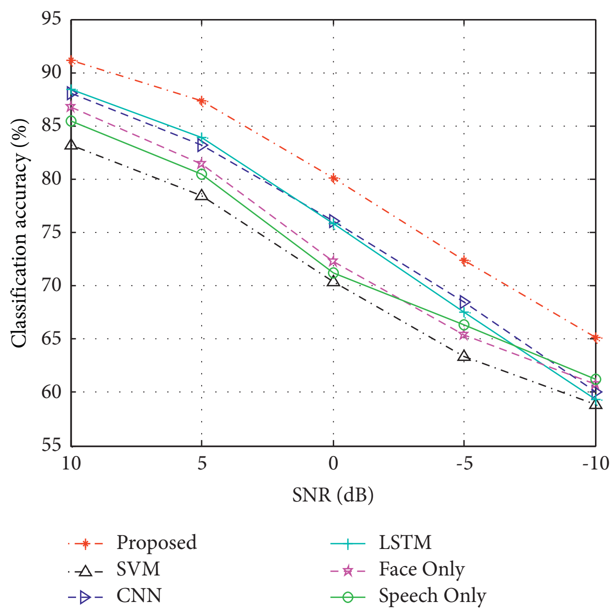

Figure 2: Classification accuracy of different methods under noises.

the condition of facial expression and voice single mode, which is also used as a comparative experiment for the method in this paper. The average classification accuracy is used as a quantitative evaluation index for the performance of various methods, which is the proportion of correctly classified samples to all test samples.

5. Result and Discussion

Based on the constructed dataset, the proposed method and the comparison methods are tested. The statistical results are shown in Table 1. It can be seen that the method in this paper has a performance advantage over the five comparison methods, and the average classification accuracy is at the highest level. Compared with the traditional machine learning methods such as SVM, deep learning models such as CNN and LSTM show more advantageous performance. Compared with the results under the single-modal condition of facial expression and speech, this paper significantly improves the classification accuracy by combining the two modalities, showing the effectiveness of the proposed method.

In the actual process, both the facial expression image and the voice signal may be disturbed by noise. Therefore, it is necessary to improve the ability of emotion analysis under the condition of noise interference. To this end, this paper uses the form of signal-to-noise ratio (SNR) to measure the noise level in the two modalities of facial expression and speech and verifies the classification ability of various methods under the same noise conditions. Figure 2 shows the classification accuracy of different methods with the changing of SNR. It can be seen that the method in this paper maintains the optimal classification performance under various noise levels, showing its robustness.

6. Conclusion

Aiming at the problem of psychological state monitoring in the process of English teaching in colleges and universities, this paper designs an intelligent evaluation method based on emotion recognition. First, the emotional features of facial expression and speech modalities are extracted from the facial expression and speech bimodal emotional database, respectively. Then, the SCCA algorithm is used to fuse the emotional features of the two modalities, and finally, SRC is used to perform emotion recognition. The experimental results show that the dual-modal emotion recognition method based on SCCA and SRC proposed in this paper can achieve a higher recognition rate than some present methods in the same field. The proposed method can carry out targeted analysis for different students and then adjust teaching strategies according to the statistical results, so as to improve the overall quality of English teaching. In the future, the research will be deepened in two ways. First, more available information will be used besides the facial expression and voices. They can be combined to achieve more reliable results. Second, some new intelligent algorithms can be used to process these modalities to further improve the effectiveness and efficiency.

Data Availability

The dataset can be accessed upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

A Denoising Method for Ship-Radiated Noise Based on Optimized Variational Mode Decomposition with Snake Optimization and Dual-Threshold Criteria of Correlation Coefficient

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The ship-radiated noise (SN) is easily affected by other hydroacoustic objects or complex ocean noise when it spreads through water. In order to reduce the impact from the environment, a denoising method for SN based on optimized variational mode decomposition with snake optimization (SO-VMD) and dual-threshold criteria of correlation coefficient (CC) is proposed in this paper. The first step is to optimize the parameter combination, that is, decomposition number K and penalty factor α, of variational mode decomposition (VMD) by snake optimization (SO) with envelope entropy (EE). Then, the input signal using the optimized results is decomposed and the intrinsic mode functions (IMFs) are obtained. After that, the IMFs are classified into three classes with the dual-threshold criteria of CC, including signal components, signal-noise components, and noise components. Finally, all the signal components and the processed signal-noise components denoised by wavelet threshold (WT) are reconstructed together. Simulations performed in this paper demonstrate that SO is the more appropriate optimization for VMD and the proposed method has the more outstanding performance in denoising different kinds of test signals. In addition, experiments on measured SNs show that the proposed method is effective and accurate in denoising.

1. Introduction

Hydroacoustics is one of the hottest topics in marine science, and it is widely applied to many crucial fields. The ship-radiated noise (SN) is definitely one of the most vital research objects in hydroacoustics since it plays such a significant role in detection and defense [1–4]. However, complex ocean environment brings a mass of noise into SN which prevents it from detection, diagnosis, and so on. Thus, it is of paramount importance to denoise the SN effectively and accurately so that it could be processed more efficiently in the next step.

The traditional denoising methods are mainly based on Fourier transform, but unfortunately, it is unsuitable for many kinds of nonlinear and nonstationary signals. Therefore, WT is created with better time-frequency window characteristics. But the wavelet basis function and the number of decomposition layers greatly affect the effectiveness of denoising. To overcome the limitation, Huang et al. proposed a new adaptive decomposition algorithm named empirical mode decomposition (EMD) which can be used in processing nonlinear and nonstationary signals [5, 6]. The new idea aroused heated discussion in signal processing [7–9] but also had boundedness. Mode mixing and the end effect, which are two inevitable obstacles, severely influenced the effect of EMD denoising. In that case, many scholars dedicated themselves to conquering those two barriers. As a result, the progressive algorithms sprung up like mushrooms. Some popular algorithms, such as ensemble empirical mode decomposition (EEMD) [10, 11], complete ensemble empirical mode decomposition (CEEMD) [12], complete ensemble empirical mode decomposition with adaptive noise (CEEMDAN) [13], and so on, are widely used in signal processing including denoising [14–16]. Unfortunately, none of them solved mode mixing and the end effect radically.

Dragomiretskiy and Zosso presented variational mode decomposition (VMD) which matches central frequency and bandwidth of each IMF adaptively [17]. The input signal is successfully decomposed into a series of IMFs recursively according to a precise mathematical model which is the reason why it can avoid mode mixing and the end effect. As the old saying goes, every coin has two sides. The decomposition effect of VMD highly depends on the decomposition number K and penalty factor α, named as parameter combination. At first, scholars focused on K, while being unaware of the influence of penalty factor α or the interaction between them. Scholars were gradually aware of the importance of penalty factor α, and then, optimization algorithms started to be introduced to search both two parameters. Tang et al. presented VMD optimized by particle swarm optimization (PSO) and constructed the fitness function of envelope entropy (EE) at the same time, which is used in rolling bearing fault diagnosis [18]. Yin et al. employed genetic algorithm (GA) to optimize VMD and continued to use EE as fitness function, which was used in structural damage diagnosis [19]. Ding et al. proposed a classification criteria of correlation coefficient (CC) in dividing IMFs into three classes when a new denoising method of MEMS gyroscope was presented [20]. Li et al. introduced gray wolf optimization (GWO) with permutation entropy (PE) and denoised IMFs with wavelet threshold (WT), aiming at denoising speech signals [21]. Chen and Zhao proposed a feature extraction method of early fault signals of rolling bearing based on VMD optimized by whale optimization algorithm (WOA) and creatively combined CC with L-kurtosis as fitness function [22]. They are frequently used in many fields instead of SN denoising. At the same time, the achievements obtained by Li et al. laid the foundation of SN research [23–26].

Recently, Hashim and Hussien presented a brand-new metaheuristic algorithm inspired by the mating behavior of snakes [27]. It strikes a brilliant balance between global searching and local searching and has not been imported in VMD optimizing. Inspired by its success, snake optimization (SO) and dual-threshold criteria are introduced to solve the adaptive parameter selection of VMD and the adaptive classification of IMFs, and a denoising method for SN based on SO-VMD and dual-threshold criteria of CC is proposed.

The structure of this paper is constructed as follows. Section 2 exhibits the theoretical background briefly. Section 3 shows the simulations on optimization algorithms and denoising methods. Section 4 demonstrates the experiments and analysis on actually measured SN of four kinds. Finally, the conclusions are drawn in Section 5.

2. Background Theories

2.1. Variational Mode Decomposition. VMD is a kind of self-adapting and nonrecursive decomposition algorithm which uses Hilbert transform and Wiener filter to construct constrained variational model and iteratively solves it. It is able to effectively decompose the input signal into several IMFs that have their unique sparse features. However, the key points of VMD algorithm are how to construct constrained variational model and solve it.

2.1.1. The Construction of Constrained Variational Model. First, the original signal would be decomposed into different IMFs defined as $u_k\,(k = 1, 2, 3, \ldots, K)$. Then, the algorithm obtains the analytic signal shown as equation (1) with Hilbert transform.

$$\left(\delta(t) + \frac{j}{\pi t}\right) * u_k(t). \tag{1}$$

Second, the algorithm evaluates the central frequency of each IMF and combines both by putting the latter as the exponential term of the former simultaneously, so that the IMF could be modulated into relevant base band shown as

$$\left[\left(\delta(t) + \frac{j}{\pi t}\right) * u_k(t)\right] * e^{-j\omega_k t}. \tag{2}$$

Eventually, the algorithm estimates the bandwidth of each IMF through the square L2-norm of the gradient of the demodulated signal. All the IMFs are FM-AM signals, and sum of them equals the original signal. The constrained variational model is shown as

$$\begin{cases} \min_{\{u_k\},\{\omega_k\}} \sum_{k=1}^{K} \left\| \partial\left[\left(\delta(t) + \frac{j}{\pi t}\right) * u_k(t)\right] e^{-j\omega_k t} \right\|_2^2, \\ \sum_{k=1}^{K} u_k = f, \end{cases} \tag{3}$$

where the value of K is the expected number of IMFs, f is the original input signal, $\omega_k\,(k = 1, 2, \ldots, K)$ is the central frequency of each IMF, $\delta(t)$ represents Dirac distribution, and $*$ represents the convolution operation.

2.1.2. The Solving Method of Constrained Variational Model. The key to solve constrained variational model is to transform it to unconstrained variational model. In that case, a quadratic penalty term α and Lagrangian multipliers $\lambda(t)$ are imported into the model to render it unconstrained. The expanded Lagrangian formula is as follows:

$$L(\{u_k\}, \{\omega_k\}, \lambda) = \alpha \sum_{k=1}^{K} \left\| \partial t\left[\left(\delta(t) + \frac{j}{\pi t}\right) * u_k(t)\right] e^{-j\omega_k t} \right\|_2^2 + \left\| f(t) - \sum_{k=1}^{K} u_k(t) \right\|_2^2 + \lambda(t), f(t) - \sum_{k=1}^{K} u_k(t), \tag{4}$$

where $\langle\cdot\rangle$ represents inner product operation.

By updating u_k, ω_k, and Lagrangian multipliers $\lambda(t)$ in the model, the algorithm uses a kind of iterative sub-optimization called alternate direction method of multipliers (ADMM) to get the saddle point of the expanded Lagrangian formula, which is the solution to the original minimization problem. The updated method is expressed as

$$\begin{cases} \hat{u}_k^{n+1}(\omega) = \dfrac{\hat{f}(\omega) - \sum_{i>k}\hat{u}_i^n(\omega) - \sum_{i>k}\hat{u}_i^n(\omega) + \hat{\lambda}^n(\omega)/2}{1 + 2\alpha\left(\omega - \omega_k^n\right)^2}, \\ \omega_k^{n+1} = \dfrac{\int_0^\infty \omega\left|\hat{u}_k^{n+1}\right|^2 d\omega}{\int_0^\infty \left|\hat{u}_k^{n+1}\right|^2 d\omega}, \\ \hat{\lambda}^{n+1}(\omega) = \hat{\lambda}^n(\omega) + \tau\left[\hat{f}(\omega) - \sum_k \hat{u}_k^{n+1}(\omega)\right], \end{cases} \tag{5}$$

where ˆ means Fourier transform, n means the number of iterations whose initial value is 0, and τ represents the parameter of noise tolerance. The iteration will keep computing until achieving

$$\sum_k \left\|\hat{u}_k^{n+1} - \hat{u}_k^n\right\|_2^2 / \left\|\hat{u}_k^n\right\|_2^2 < t, \tag{6}$$

where $s\,(s > 0)$ is the threshold of iteration stop condition. Eventually, the final IMFs are generated by VMD.

2.2. Snake Optimization. SO is a kind of metaheuristic algorithm inspired by the mating behavior of snakes, proposed by Hashim and Hussien- in 2022. It strikes an appropriate balance of searching solutions between global-searching space and local-searching space.

SO algorithm generates random population in uniform distribution first, and then under the influence of both temperature *Temp* and food quantity Q, the population chooses to enter the exploration phase or the exploitation phase. The exploration phase will lay stress on searching new solutions in the far neighborhood areas while the exploitation phase transforms the crucial searching space into already existed promising area. High exploration and low exploitation matching principle are constantly used by SO algorithm in the first half of iterations, and once it entered the second stage, the weight of the exploitation would dramatically increase to lock in the target. The updating principles of Temp and Q are shown below.

$$\begin{cases} \text{Temp} = \exp\left(\dfrac{-t}{T}\right), \\ Q = c_1 * \exp\left(\dfrac{t - T}{T}\right), \end{cases} \tag{7}$$

where t represents current iteration number, while T means the maximum of iteration number. The constant $c_1 = 0.5$.

When $Q < 0.25$, the algorithm searches for food in the vast searching space randomly, updating the relative position of food simultaneously. Obviously, it is the exploration phase, and the searching formulas belonging to it are shown as equations (8) and (9).

$$\begin{cases} X_{i,m} = X_{\text{rand},m} \pm c_2 \times A_m \times \left(\left(X_{\max} - X_{\min}\right) \times \text{rand} + X_{\min}\right), \\ A_m = \exp\left(\dfrac{-f_{\text{rand},m}}{f_{i,m}}\right), \end{cases} \tag{8}$$

$$\begin{cases} X_{i,f} = X_{\text{rand},f} \pm c_2 \times A_f \times \left(\left(X_{\max} - X_{\min}\right) \times \text{rand} + X_{\min}\right), \\ A_f = \exp\left(\dfrac{-f_{\text{rand},f}}{f_{i,f}}\right), \end{cases} \tag{9}$$

where $X_{i,m}$ represents the position of male snakes, while $X_{i,f}$ represents the position of female snakes, and $X_{\text{rand},m}$ and $X_{\text{rand},f}$ are identified as the random position of male and female snakes. The abilities of foraging of male and female snakes are indicated as A_m and A_f, respectively. $c_2 = 0.05$, and $r \in [0, 1]$ is a random number. $f_{\text{rand},m}$ and $f_{\text{rand},f}$ represent the fitness of $X_{\text{rand},m}$ and $X_{\text{rand},f}$, respectively.

When $Q \geq 0.25$, which is reckoned as the food quantity is sufficient, it is time for exploitation. In this phase, two modes will be chosen: meal mode and courtship mode, and in courtship mode, fighting and mating are two inevitable circumstances. It is meal time for snakes when $\text{Temp} > 0.6$, and the courtship happens when $\text{Temp} \leq 0.6$. Updating principles are as follows:

(a) Meal mode: in this mode, snakes would move close to the food, and the positions are calculated from the following equation:

$$X_{i,j}(t+1) = X_{\text{food}} \pm c_3 \times \text{Temp} \times \text{rand} \times \left(X_{\text{food}} - X_{i,j}(t)\right), \tag{10}$$

where $X_{i,j}$ is the position of all the individuals including both male and female and X_{food} represents the best position obtained so far, $c_3 = 2$.

(b) Courtship mode (fighting circumstance): to get the chance of mating, snakes of both genders would fight, and the relative equations are as follows:

$$\begin{cases} X_{i,m}(t+1) = X_{i,m}(t) \pm c_3 \times F_m \times \left(\left(X_{\text{best},f} - X_{i,m}(t)\right) \times \text{rand}\right), \\ F_m = \exp\left(\dfrac{-f_{\text{best},f}}{f_i}\right), \end{cases}$$
$$\begin{cases} X_{i,f}(t+1) = X_{i,f}(t) \pm c_3 \times F_f \times \left(\left(X_{\text{best},m} - X_{i,f}(t)\right) \times \text{rand}\right), \\ F_f = \exp\left(-\dfrac{f_{\text{best,m}}}{f_i}\right), \end{cases} \tag{11}$$

where F_m is the fighting ability of male snakes and relatively F_f is that of female snakes, and the best position of female snakes is expressed as $X_{best,f}$, while the best position of male snakes is expressed as $X_{best,m}$.

(c) Courtship mode (mating circumstance):

$$\begin{cases} X_{i,m}(t+1) = X_{i,m}(t) \pm c_3 \times M_m \times \left(Q \times X_{i,f}(t) - X_{i,m}(t)\right) \times \text{rand}\right), \\ M_m = \exp\left(\dfrac{-f_{i,f}}{f_{i,m}}\right), \end{cases}$$
$$\begin{cases} X_{i,f}(t+1) = X_{i,f}(t) \pm c_3 \times M_f \times \left(Q \times X_{i,m}(t) - X_{i,f}(t)\right) \times \text{rand}\right), \\ M_f = \exp\left(\dfrac{-f_{i,m}}{f_{i,f}}\right), \end{cases} \tag{12}$$

where M_m represents the mating ability of the male and M_f means the mating ability of the female.

After the eggs are hatched, the new generation is born, and the worst male and female individuals are replaced by the new according to

$$\begin{cases} X_{\text{worst},m} = X_{\min} + \left(X_{\max} - X_{\min}\right) \times \text{rand}, \\ X_{\text{worst},f} = X_{\min} + \left(X_{\max} - X_{\min}\right) \times \text{rand}. \end{cases} \tag{13}$$

It should be noted that $X_{\text{worst},m}$and $X_{\text{worst},f}$ represent the worst individual of the male and female, respectively.

2.3. VMD Optimized by SO. For VMD algorithm, the preset of decomposition number K and quadratic penalty factor α has a great influence on the final effectiveness of decomposition. The close bound between them cannot be ignored; therefore, the searching of optimization should be comprehensive and synchronous. Due to the impressive structure of SO algorithm, it is able to search for the better parameter combination effectively.

Speaking of the goal of searching, i.e., the fitness function, as envelope entropy (EE) shown in equation (14) could indicate the sparse features of a signal, the optimization is available using it as fitness function to obtain a triumph in parameter combination (K and α) searching. In a way, the lower the EE is, the more accurate the decomposition is.

$$\begin{cases} P_{i,j} = \dfrac{a_i(j)}{\sum_{j=1}^{N} a_i(j)}, \\ E_i = -\sum_{j=1}^{N} P_{i,j} \lg p_{i,j}, \end{cases} \tag{14}$$

where $a_i(j)$ is the envelope signal obtained from the signal IMF and $P_{i,j}$ is the normalized form of the signal $a_i(j)$. The flowchart of optimized VMD by SO is shown in Figure 1.

2.4. Dual-Threshold Classification Criteria. CC can reflect the correlation between two signals; the higher the CC is, the more relevant they are, and vice versa. So, in that case, the CC of signal component is higher than that of noise component, which is an excellent evaluating standard in IMF classification.

Initially, CC between each IMF and the original signal is able to obtained with equation (15), and they are normalized to [0, 1]; then,

$$co(k) = \frac{\sum_{i=1}^{N} u_k(i) f(i)}{\sqrt{\sum_{i=1}^{N} u_k^2(i). \sum_{i=1}^{N} f^2(i)}}, \tag{15}$$

where $co(k)$ is the CC of k_{th} IMF and N is the sample number of signal.

In the proposed classification criteria, the high threshold and the low one are both adaptive and are set for classifying the IMFs. The reason why they could be adaptive is that they are calculated according to the maximum CC and the average CC, which would change when signal changes. The IMF is recognized as signal component when its CC is bigger than the high one, while it is recognized as noise component when its CC is smaller than the low one, or the IMF is reckoned as the signal-noise component when its CC is both under the high and over the low. The adaptive thresholds are calculated by

$$\begin{cases} \text{th}H = \dfrac{co_{\max}}{\left(5 \times \left(co_{\max} - co_{\text{avg}}\right)\right)}, \\ \text{th}L = \dfrac{co_{\max}}{\left(7 \times \left(co_{\max} - co_{\text{avg}}\right)\right)}, \end{cases} \tag{16}$$

where th$H$ represents the high threshold and th$L$ represents the low threshold, $co_{\max}$ is the maximum of all CC, and co_{avg} is the average of them.

2.5. Wavelet Threshold Denoising. WT denoising is one of the most popular denoising methods in use currently. It decomposes the input signal according to the chosen wavelet basis function, so as to obtain the relative wavelet coefficient. Then, compare the wavelet coefficient of each component with wavelet coefficient of the original signal, and the one with lower wavelet coefficient would be filtered, while the one with higher wavelet coefficient could be retained, and finally reconstruct them and finish WT denoising.

The effectiveness of the wavelet threshold denoising has a close bound with the set of its threshold and threshold function as well. Equations (17) and (18) give two threshold functions in common use, which are named as hard threshold and soft threshold, respectively.

$$\widetilde{\omega}_{j,k} = \begin{cases} \omega_{j,k}, & \left|\omega_{j,k} \geq \lambda\right|, \\ 0, & \left|\omega_{j,k} < \lambda\right|, \end{cases} \tag{17}$$

$$\widetilde{\omega}_{j,k} = \begin{cases} \operatorname{sgn}\left(\omega_{j,k}\right)\left(\left|\omega_{j,k}\right| - \lambda\right), & \left|\omega_{j,k} \geq \lambda\right|, \\ 0, & \left|\omega_{j,k} < \lambda\right|, \end{cases} \tag{18}$$

where $\widetilde{\omega}_{j,k}$ is the evaluated wavelet coefficient, $\omega_{j,k}$ is the actual wavelet coefficient after decomposition, and λ is the evaluated threshold using unbiased risk estimation.

2.6. Proposed Denoising Method. In accordance with the theory above, the details of the proposed denoising method are expressed below and the flowchart of the SO-VMD-WT denoising method is in Figure 2.

Step 1. Use SO algorithm and EE to optimize the parameter combination, that is, K and α, of VMD algorithm with an appropriate iteration number and a population quantity, so as to obtain the best solution.

Step 2. Decompose the signal based on the best parameter combination and generate IMFs differentiated by their sparse features.

Step 3. Calculate CC of each IMF and obtain both high and low thresholds using the maximum and the average of all CCs, and then all the IMFs would be classified into three classes: signal components, signal-noise components, and noise components.

Step 4. Denoise the signal-noise components with the wavelet soft threshold denoising method. The soft threshold is shown in equation (15).

Step 5. Save the signal components and throw the noise components away and then reconstruct all the signal components and processed signal-noise components together.

3. Simulation and Analysis

3.1. Comparative Test of Optimization Algorithms. Aimed at proving SO algorithm is a much effective optimization

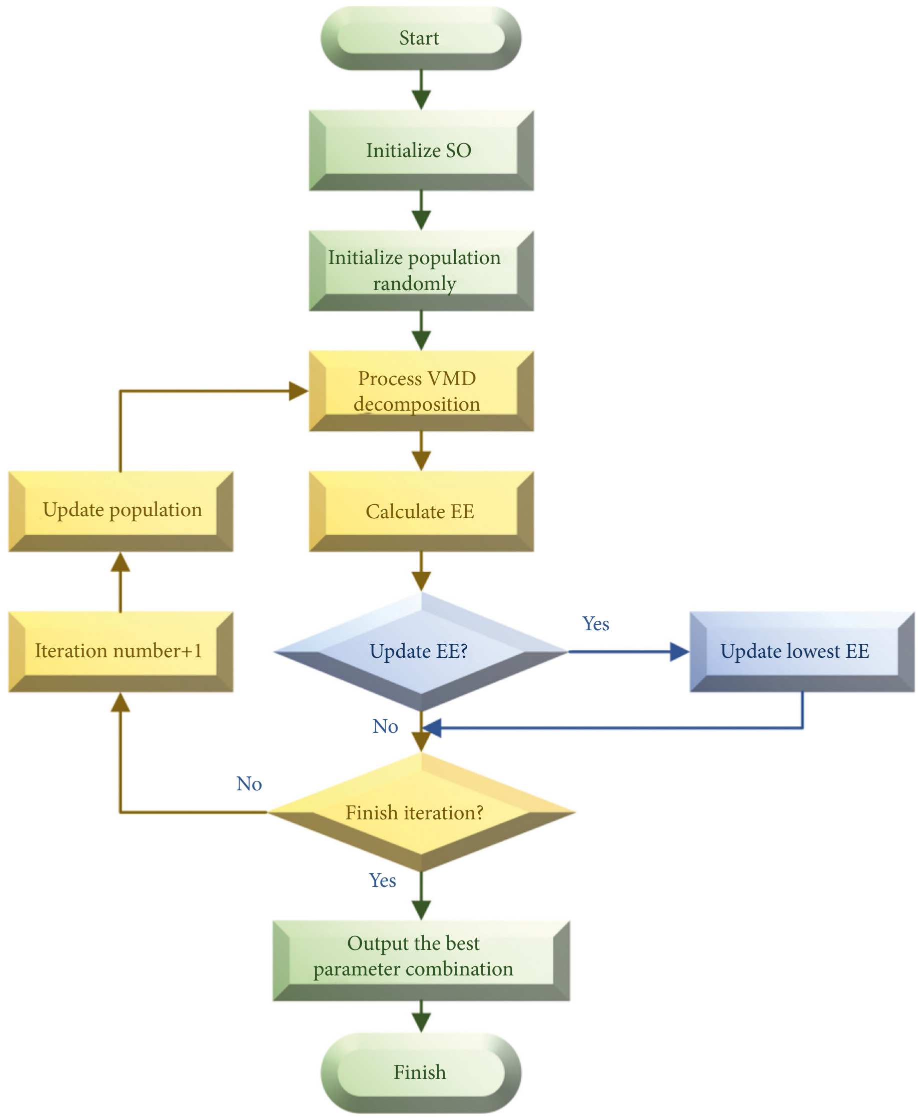

FIGURE 1: Flowchart of optimized VMD by SO.

algorithm than others in searching lowest EE of a signal after VMD, this section would give a statement of a comparative test of optimization algorithm in detail.

The test signal in use without noise is a combined signal shown as in Figure 3(a), which is composed of three different sinusoidal signals. Relatively, the noise signal whose SNR is 4 dB, named as TestSine (4 dB), is as shown in Figure 3(b), and their length $N = 1200$, and sample rate is 9500 Hz. The constituent parts are listed below:

$$\begin{cases} \text{TestSine} = v_1 + v_2 + v_3, \\ v_1 = 0.6 \sin(10\pi t), \\ v_2 = 0.4 \sin(50\pi t), \\ v_3 = 0.2 \sin(100\pi t). \end{cases} \tag{19}$$

Apparently, the signal has dramatically affected by noise and is hardly to diagnose. An immense number of glitches grow on the signal densely.

Three kinds of optimization algorithms are chosen for comparison, including GA, PSO, and WOA. Set iteration number as 50 and size of population as 10 equally in four algorithms. In GA algorithm, the parameter of crossing is set to 0.8, and the parameter of mutation is set to 0.1, while in PSO algorithm, the accelerated factors c_1 and c_2 are 1.5 likewise, the speed of K is limited between −1 and 1, and the speed of α is limited between −300 and 300. Also, the convergence curve of four algorithms in optimizing TestSine (4 dB), using EE as fitness function, is shown in Figure 4.

Figure 4 shows that SO is the best in searching lowest EE and WOA is at the second place, and PSO and GA are worse though. In order to avoid the affection of occasionality, 50 repeated experiments are carried out and the average results of different optimization algorithms are listed in Table 1.

An obvious conclusion could be drawn that PSO is fastest in four algorithms; however, SO is nearly as faster as PSO. On the other hand, SO does have the best searching

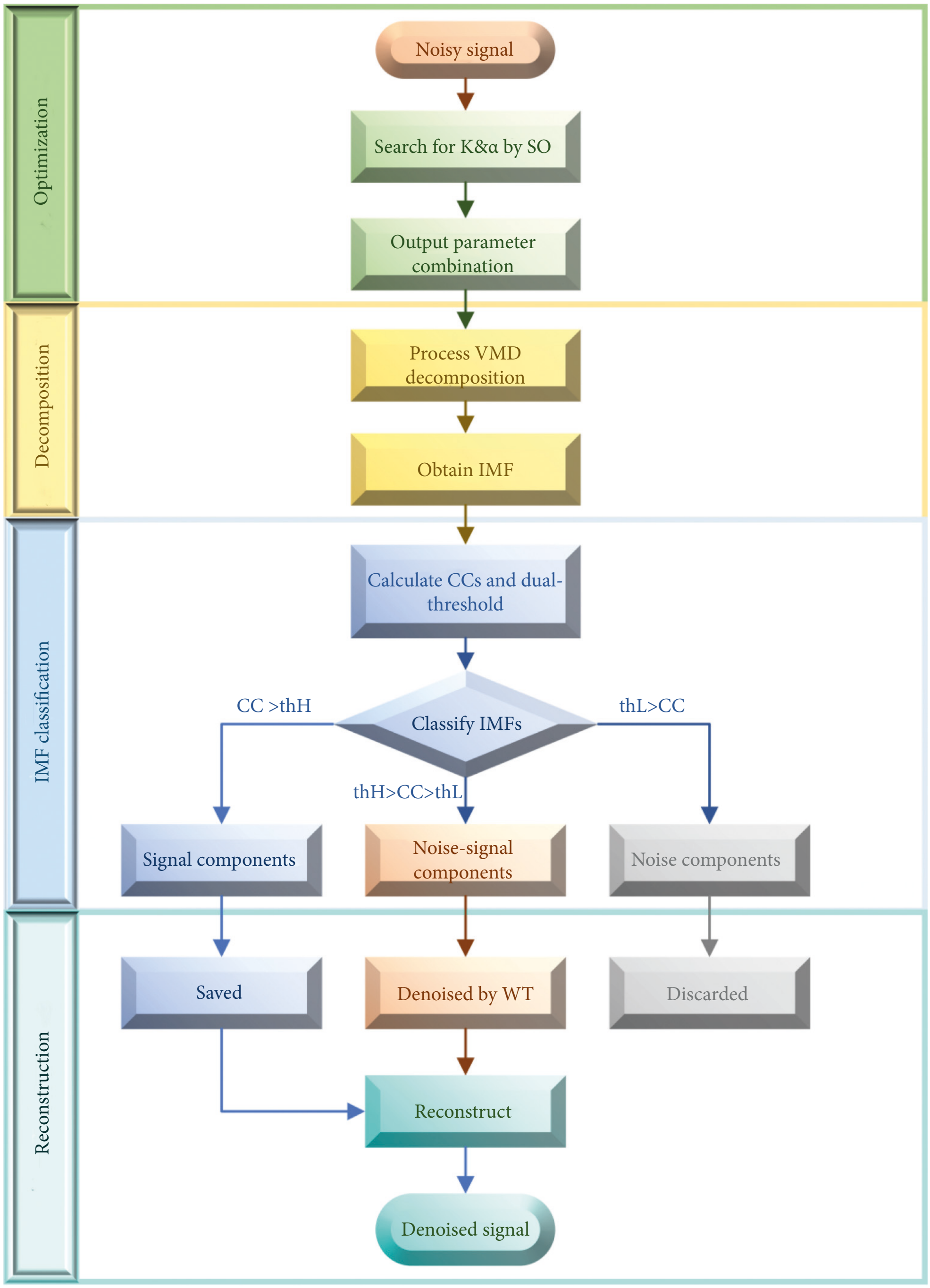

Figure 2: The flowchart of SO-VMD-WT denoising method.

ability, and GA and WOA are better than PSO. Therefore, SO should be used in VMD optimization theoretically and practically for its distinguished speed and precise searching.

3.2. Comparative Test of Denoising Methods. To investigate the denoising ability of the proposed method, the detailed simulation comparative experiments of different denoising methods are performed in this part.

3.2.1. Test Signals. Except for TestSine introduced in the previous section, four commonly used test signals shown in Figure 5 would be introduced as well. They are Blocks (Figure 5(a)), Bumps (Figure 5(c)), HeavySine (Figure 5(e)), and Doppler (Figure 5(g)), all generated by "wnoise" function in MATLAB with the length $N = 1024$. The relevant noisy signals with 4 dB SNR are also shown next. In the experiments, the five signals with six different noise situations are processed.

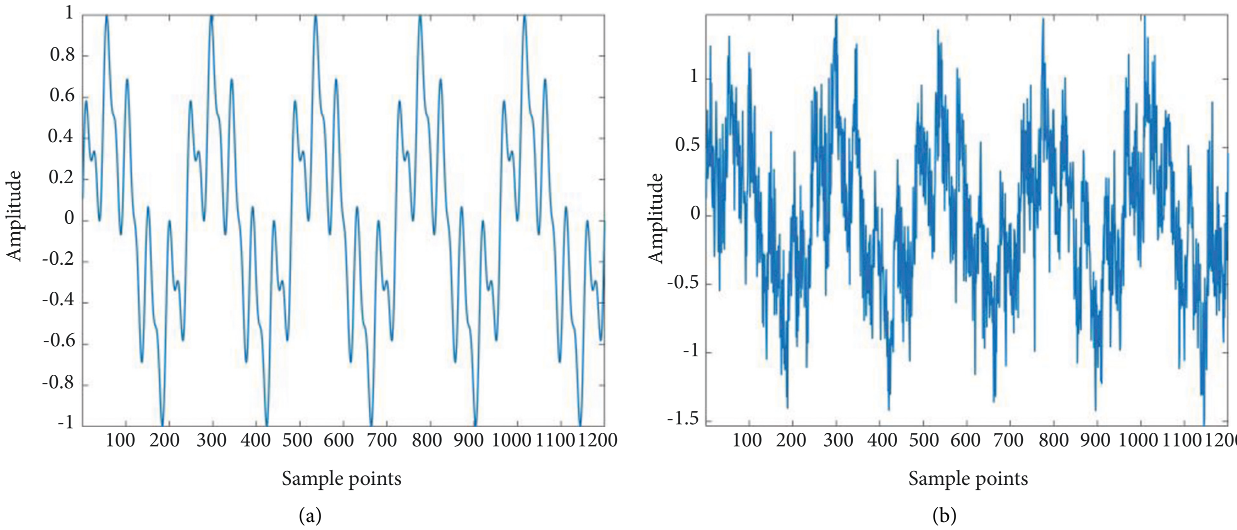

Figure 3: The waveforms of (a) TestSine and (b) TestSine (4 dB).

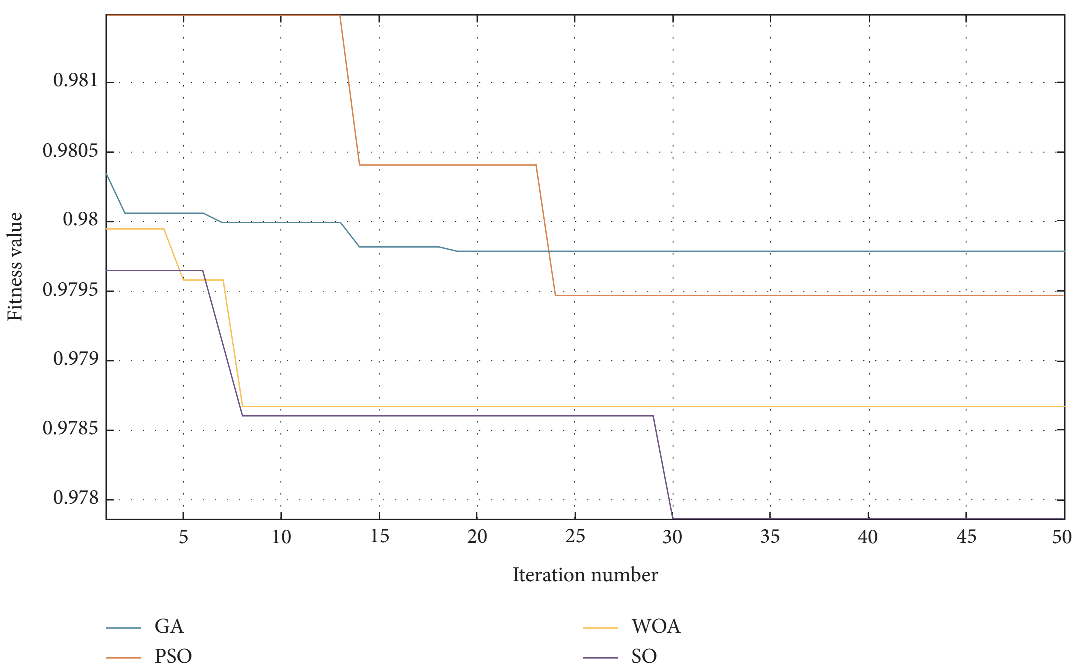

Figure 4: The convergence curve of four algorithms.

Table 1: The average results of different optimization algorithms.

Optimizations	GA	PSO	WOA	SO
The average iteration time	802.315	**690.211**	881.775	702.461
The average fitness result	0.978674	0.980568	0.978677	**0.978579**

3.2.2. Optimization and Decomposition. First, optimize the parameter combination by SO with ten snakes in a generation. After fifty iterations, the solution is obtained as $K = 10$, $\alpha = 1831$. The convergence curve of SO-VMD processing TestSine (4 dB) is shown in Figure 6.

Once the best parameter combination is obtained, the decomposition by VMD algorithm could be launched. The IMFs are all successfully acquired as shown in Figure 7. It is clear from the figure that different IMFs have different sparse features. Thus, the next step is to classify them accurately with effective classification criteria.

3.2.3. IMF Classification and Reconstruction. CC is able to reflect the similarity of signals, and the CC of signal component is much higher, while that of noise component is generally lower. Obviously, an essential step is to calculate the CC between each IMF and the input signal. The CC of IMF of TestSine (4 dB) is shown in Figure 8.

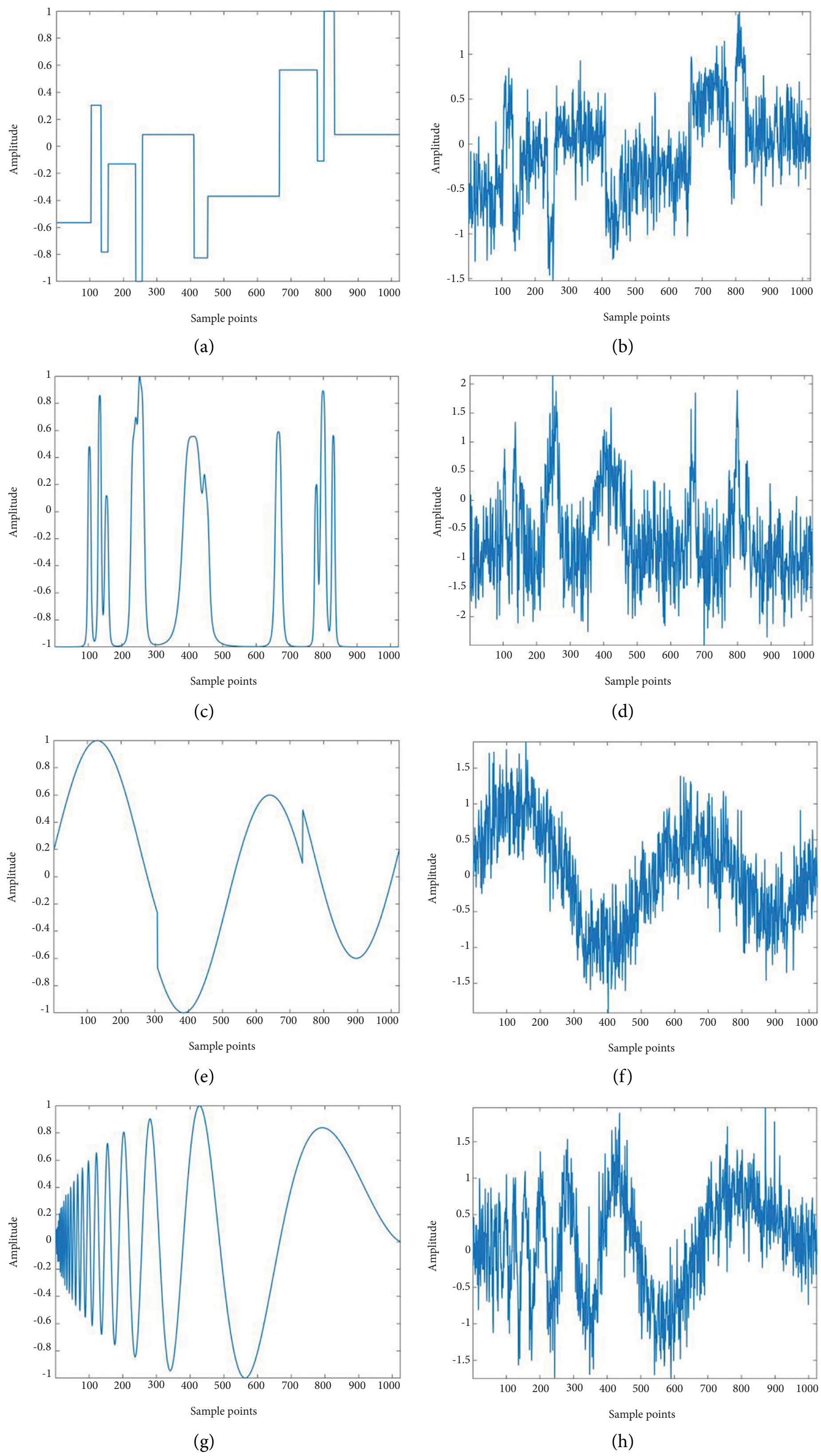

Figure 5: The waveform of four ordinary test signals. (a) Blocks. (b) Blocks (4 dB). (c) Bumps. (d) Bumps (4 dB). (e) HeavySine. (f) HeavySine (4 dB). (g) Doppler. (h) Doppler (4 dB).

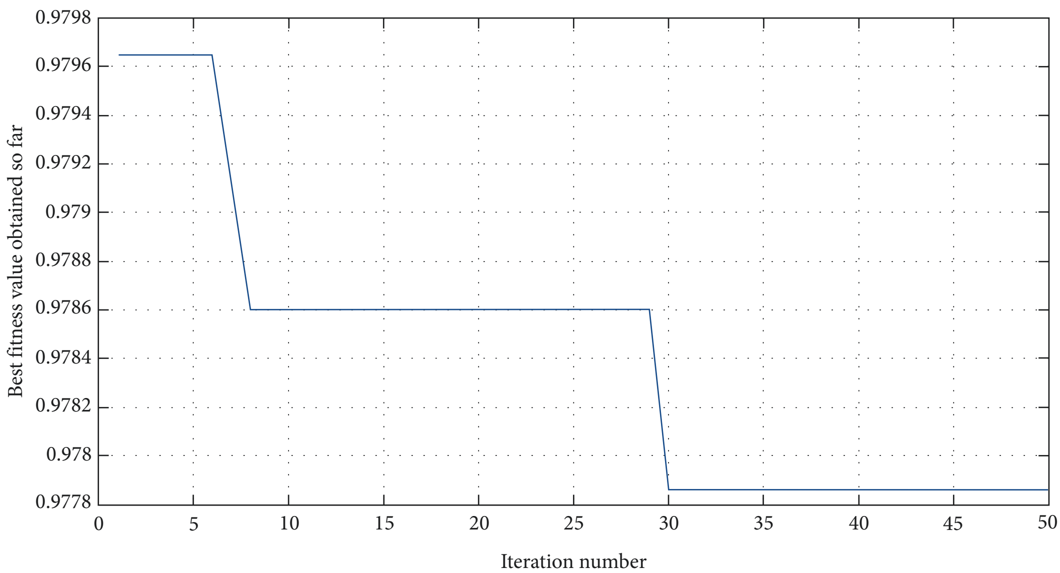

FIGURE 6: The convergence curve of SO-VMD processing TestSine (4 dB).

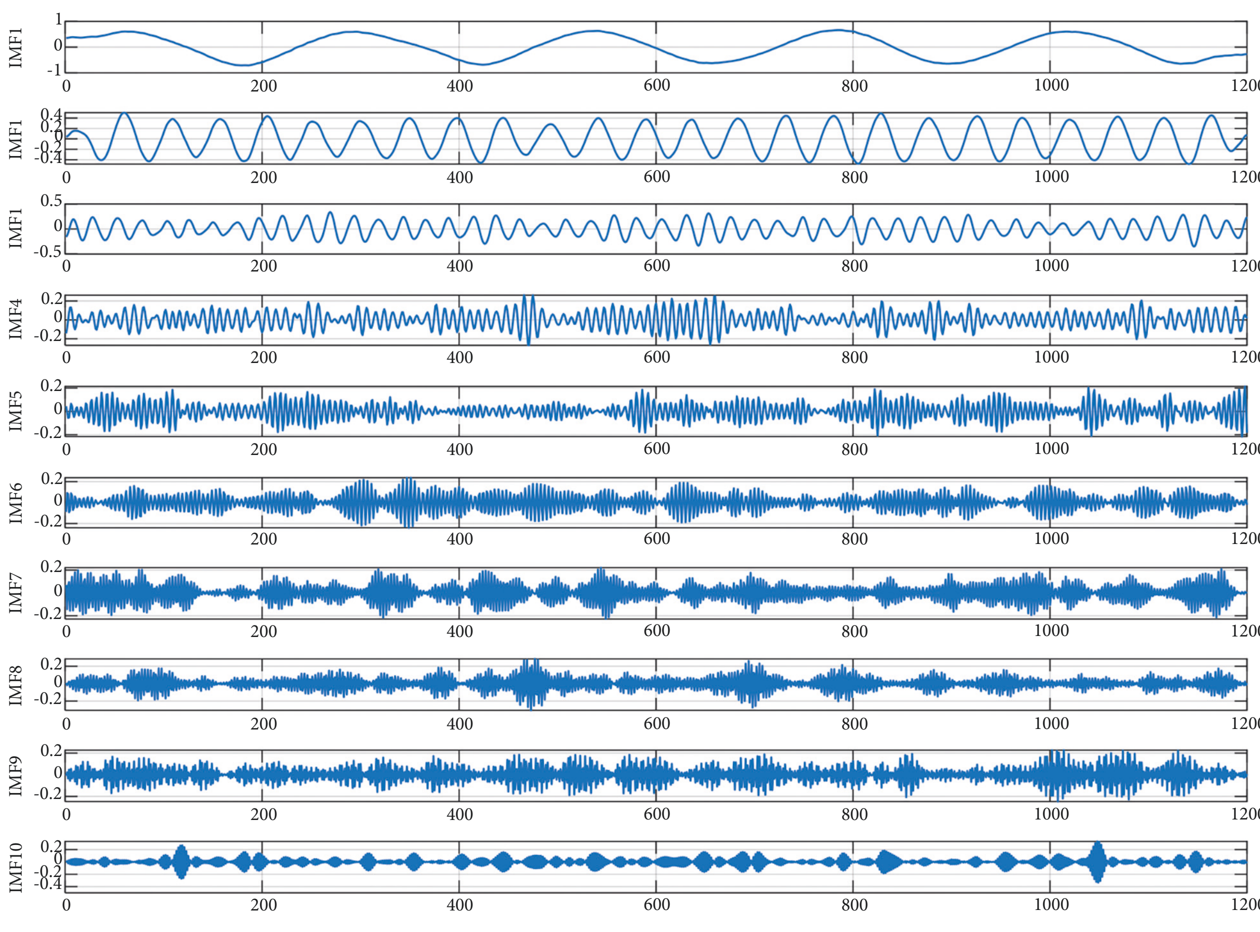

FIGURE 7: The IMFs of TestSine (4 dB) after SO-VMD.

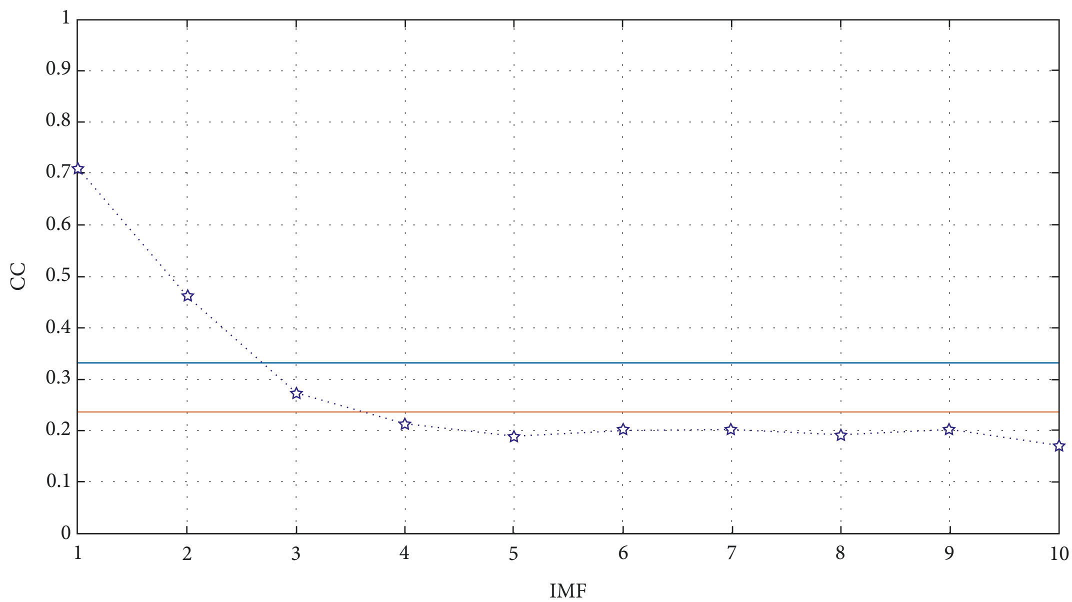

Figure 8: The CC of IMF of TestSine (4 dB).

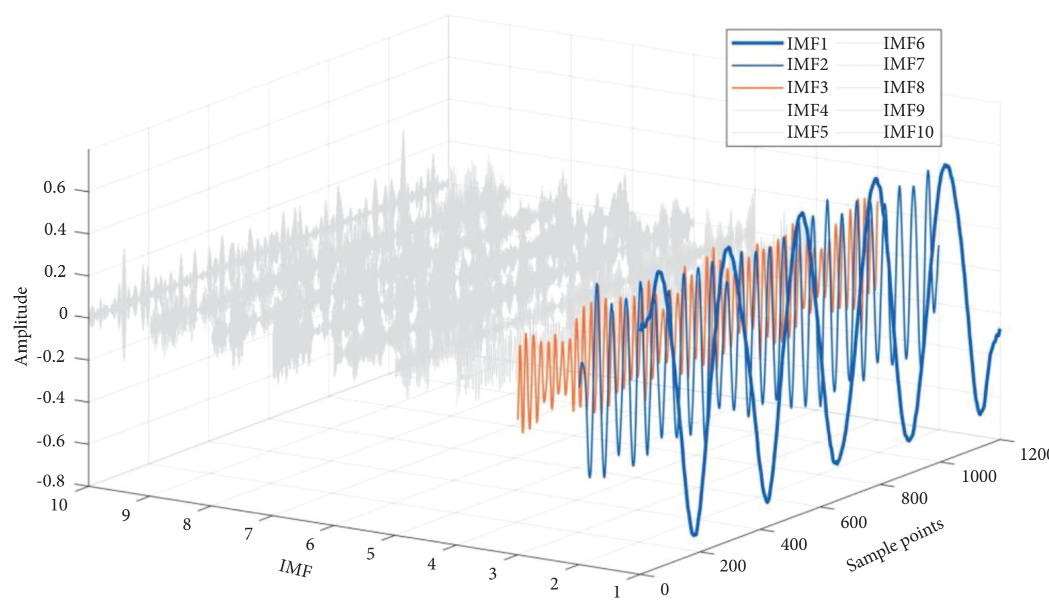

Figure 9: The classification result of IMF of TestSine (4 dB).

The blue horizontal line is the high threshold while the orange one is the low threshold. Obviously, the first two IMFs above the blue line are recognized as signal components, and the third IMF is strictly limited to the signal-noise class, and the rest of IMFs are all noise components whose CCs are nearly the same and below the orange line.

With the classification finishing, the denoising step is carried out. The classification result of TestSine (4 dB) IMF is shown in Figure 9.

As what is designed above and shown in Figure 9 as well, the signal components in blue would be saved, the signal-noise components in orange are supposed to be denoised by WT with soft threshold, and unfortunately, the noise components in gray are all given up for signal residuals barely existing in them.

At last, realize the final reconstruction of all the processed signal-noise components and signal components together. The denoising result of TestSine (4 dB) and the noiseless TestSine is shown in Figure 10.

Indeed, the effectiveness of the proposed method is impressive as the SNR increases from 4 dB to 14.274 dB, the RMSE drops down to 0.1023, and the CC between the denoising signal and the noiseless signal rises to 0.9828.

3.2.4. Comparative Analysis. In the comparative experiments, WT denoising, denoising based on EMD and

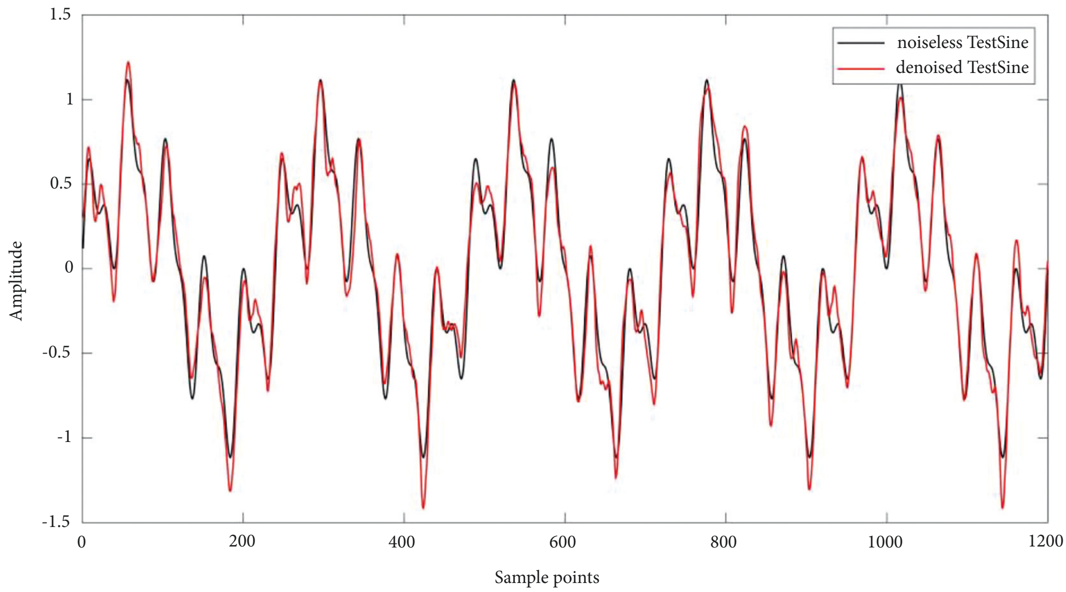

FIGURE 10: The denoising result of TestSine (4 dB).

TABLE 2: Denoising results of TestSine with four methods.

SNR (dB)	Parameters	Denoising methods WT	EMD-WT	EEMD-WT	VMD-WT	Proposed
	SNR	8.1976	8.7099	9.9988	9.5354	**10.3930**
0	RMSE	0.2059	0.1941	0.1674	0.1765	**0.1599**
	CC	0.9229	0.9417	0.9494	0.9461	**0.9548**
	SNR	10.2846	10.2967	11.2981	11.7406	**12.8612**
2	RMSE	0.1619	0.1617	0.1441	0.1370	**0.1204**
	CC	0.9520	0.9534	0.9630	0.9662	**0.9740**
	SNR	11.1976	12.2047	12.4446	13.1963	**14.2740**
4	RMSE	0.1458	0.1298	0.1263	0.1158	**0.1023**
	CC	0.9615	0.9728	0.9711	0.9761	**0.9828**
	SNR	14.8280	14.9080	14.7257	15.4013	**16.0250**
6	RMSE	0.0960	0.0951	0.0971	0.0899	**0.0836**
	CC	0.9834	0.9841	0.9832	0.9856	**0.9880**
	SNR	16.3035	16.8705	16.1931	16.1152	**18.1958**
8	RMSE	0.0810	0.0759	0.0820	0.0828	**0.0651**
	CC	0.9883	0.9897	0.9879	0.9877	**0.9926**
	SNR	17.1184	17.4387	17.5460	16.7752	**19.7818**
10	RMSE	0.0737	0.0711	0.0702	0.0767	**0.0543**
	CC	0.9903	0.9910	0.9914	0.9897	**0.9949**

WT (EMD-WT), denoising based on EEMD and WT (EEMD-WT), and denoising based on VMD and WT (VMD-WT) are used as the compared objects. What should be noticed is that all the WT denoising processes use soft threshold, and in all methods, the IMFs are classified into three classes, the first refers to signal components, the second refers to signal-noise components which need to be denoised by WT, and the third refers to noise components which tend to be discarded. The proposed method is SO-VMD-WT. For VMD-WT, the only difference between itself and the proposed method is that the parameter combination is not optimized in advance but settled directly. The comparative results with different input signals are given in Tables 2–6, and each kind of averaged data is attained after five repeated tests.

For TestSine, different denoising methods improve its SNR in different levels, the proposed method rises it about 10 dB, and others rise it about 7 dB though. Similarly, RMSE decreases and CC increases the most with the proposed method than others. The same phenomenon appears in the other tests. Since other test signals are nonlinear, the results

Table 3: Denoising results of Blocks with four methods.

SNR (dB)	Parameters	Denoising methods WT	EMD-WT	EEMD-WT	VMD-WT	Proposed
0	SNR	0.7476	8.3567	9.3907	9.4306	**10.4939**
	RMSE	2.7252	1.1348	1.0075	1.0029	**0.8873**
	CC	0.7482	0.9322	0.9498	0.9441	**0.9566**
2	SNR	3.2493	10.1978	11.4891	11.7487	**12.6145**
	RMSE	2.0432	0.9181	0.7913	0.7680	**0.6951**
	CC	0.8394	0.9570	0.9649	0.9665	**0.9735**
4	SNR	6.0447	11.3690	12.2761	12.2372	**13.7856**
	RMSE	1.4809	0.8023	0.7227	0.7260	**0.6074**
	CC	0.8936	0.9634	0.9700	0.9697	**0.9794**
6	SNR	9.5823	13.5367	13.5051	13.9071	**14.4972**
	RMSE	0.9855	0.6251	0.6274	0.5990	**0.5596**
	CC	0.9493	0.9783	0.9776	0.9795	**0.9825**
8	SNR	13.8537	14.1308	14.6395	14.7323	**15.3228**
	RMSE	0.6027	0.5838	0.5506	0.5447	**0.5089**
	CC	0.9795	0.9805	0.9829	0.9832	**0.9853**
10	SNR	15.9326	15.4508	15.6854	15.4337	**16.3864**
	RMSE	0.4744	0.5015	0.4881	0.5024	**0.4503**
	CC	0.9872	0.9859	0.9864	0.9856	**0.9885**

Table 4: Denoising results of Bumps with four methods.

SNR (dB)	Parameters	Denoising methods WT	EMD-WT	EEMD-WT	VMD-WT	Proposed
0	SNR	1.7856	7.9196	7.9827	9.1552	**10.6169**
	RMSE	1.4652	0.7231	0.7179	0.6272	**0.5301**
	CC	0.7796	0.9246	0.9220	0.9391	**0.9557**
2	SNR	5.4042	9.3199	9.7503	10.9863	**12.1982**
	RMSE	0.9660	0.6154	0.5857	0.5080	**0.4418**
	CC	0.8737	0.9470	0.9460	0.9600	**0.9698**
4	SNR	10.6910	11.1315	11.3874	12.7153	**13.9820**
	RMSE	0.5256	0.4996	0.4851	0.4163	**0.3598**
	CC	0.9599	0.9613	0.9649	0.9730	**0.9798**
6	SNR	13.6885	13.7245	12.4491	14.5784	**15.3242**
	RMSE	0.3722	0.3706	0.4293	0.3359	**0.3083**
	CC	0.9786	0.9793	0.9715	0.9825	**0.9856**
8	SNR	15.2112	14.0420	14.5142	15.9091	**17.1153**
	RMSE	0.3123	0.3573	0.3384	0.2882	**0.2509**
	CC	0.9851	0.9802	0.9827	0.9874	**0.9902**
10	SNR	16.2731	14.3585	16.6770	16.6911	**18.2476**
	RMSE	0.2764	0.3446	0.2638	0.2634	**0.2202**
	CC	0.9885	0.9815	0.9892	0.9897	**0.9926**

of each methods change distinctly as well. Although signals in various frequencies especially in high frequency, take Doppler for example, are difficult to denoise, the proposed method performs the best of all methods since VMD is good at elaborate decomposing.

In the global view of comparative experiments, the performance of WT is worse than others to some degree, and EMD-WT is better than WT, and EEMD-WT mostly does better in denoising than WT and EMD-WT, while VMD-WT is the second place generally; the proposed method has the most brilliant performance in denoising than the other four denoising methods, whatever the input signal is or how much noise it has.

4. Experiments of SN and Analysis

4.1. Preparations

4.1.1. Four Kinds of SN. In the denoising experiments of actual measured signals, four kinds of SN are chosen with noise of different levels. Figure 11 lists all the waveforms of four classes of SN after they are normalized to [−1, 1] and sampled with length $N = 10000$ and frequency $f = 52734$ Hz. The four signals represent four unique kinds of ships which are under different circumstances.

It could be seen that such bad noises affect each signal because there are a number of glitches appearing on it.

Table 5: Denoising results of HeavySine with four methods.

SNR (dB)	Parameters	Denoising methods WT	EMD-WT	EEMD-WT	VMD-WT	Proposed
0	SNR	0.8011	7.5619	12.1280	12.9952	**13.6321**
	RMSE	2.8139	1.2920	0.7638	0.6912	**0.6423**
	CC	0.7350	0.9193	0.9790	0.9758	**0.9811**
2	SNR	3.0895	11.0908	13.5031	15.4233	**16.1756**
	RMSE	2.1622	0.8607	0.6520	0.5226	**0.4793**
	CC	0.8272	0.9649	0.9782	0.9866	**0.9904**
4	SNR	5.8254	12.6017	15.5310	16.5060	**18.9723**
	RMSE	1.5780	0.7233	0.5162	0.4614	**0.3473**
	CC	0.8897	0.9729	0.9860	0.9889	**0.9942**
6	SNR	8.8552	14.3753	16.9747	19.5505	**20.4007**
	RMSE	1.1133	0.5897	0.4372	0.3250	**0.2947**
	CC	0.9386	0.9822	0.9899	0.9945	**0.9955**
8	SNR	13.8275	16.6044	18.1212	20.7650	**21.5420**
	RMSE	0.6281	0.4562	0.3831	0.2826	**0.2584**
	CC	0.9795	0.9895	0.9928	0.9958	**0.9967**
10	SNR	18.4623	18.8292	19.8101	22.1090	**23.8117**
	RMSE	0.3683	0.3531	0.3154	0.2421	**0.1990**
	CC	0.9930	0.9937	0.9948	0.9973	**0.9979**

Table 6: Denoising results of Doppler with four methods.

SNR (dB)	Parameters	Denoising methods WT	EMD-WT	EEMD-WT	VMD-WT	Proposed
0	SNR	8.4732	8.4764	8.7907	10.4188	**11.1990**
	RMSE	0.1104	0.1104	0.1065	0.0883	**0.0807**
	CC	0.9370	0.9336	0.9369	0.9547	**0.9613**
2	SNR	10.2841	10.2706	10.9017	11.0601	**12.2664**
	RMSE	0.0896	0.0898	0.0835	0.0820	**0.0713**
	CC	0.9592	0.9564	0.9598	0.9600	**0.9702**
4	SNR	11.8894	11.3546	11.3254	11.9327	**12.9705**
	RMSE	0.0745	0.0792	0.0795	0.0741	**0.0658**
	CC	0.9679	0.9639	0.9639	0.9674	**0.9745**
6	SNR	13.4078	12.5488	12.5963	13.1249	**14.1368**
	RMSE	0.0626	0.0691	0.0687	0.0646	**0.0575**
	CC	0.9777	0.9719	0.9721	0.9754	**0.9805**
8	SNR	14.2086	13.8491	13.5727	14.2939	**15.3702**
	RMSE	0.0570	0.0595	0.0614	0.0565	**0.0499**
	CC	0.9810	0.9794	0.9781	0.9813	**0.9854**
10	SNR	15.4667	13.9908	13.9214	15.6713	**16.4196**
	RMSE	0.0494	0.0585	0.0590	0.0482	**0.0442**
	CC	0.9858	0.9799	0.9796	0.9864	**0.9887**

Apparently, dramatic impulses happen accidentally owing to the equipment fault or some other reasons.

4.1.2. Evaluation Criterion. In case of no noiseless signal to be compared, a brand-new evaluation criterion which relies on the attractor trajectories is proposed. Attractor trajectory is a well-known description in chaos theory. It is greatly sensitive to the initial conditions because it exhibits totally distinct shapes with any tiny changes of initial conditions. Speaking of the signal, noiseless signal tends to have a smooth and regular trajectory while noisy signal possesses a disordered and irregular trajectory. Thus, the effectiveness of denoising can be shown as the changing of attractor trajectories.

4.2. Denoising Experiments

4.2.1. Optimization and Decomposition. Take SN-iii for example, a 10000-sample-points-long signal is inputted first. Then, optimize the parameter combination of VMD by SO with the initial conditions preset as 10 for popular number and 300 for iteration number. The iteration chart of SN-iii is exhibited in Figure 12.

The results of optimization after iterative searching are $K = 8$ and $\alpha = 68473$. With the solution of optimization, the

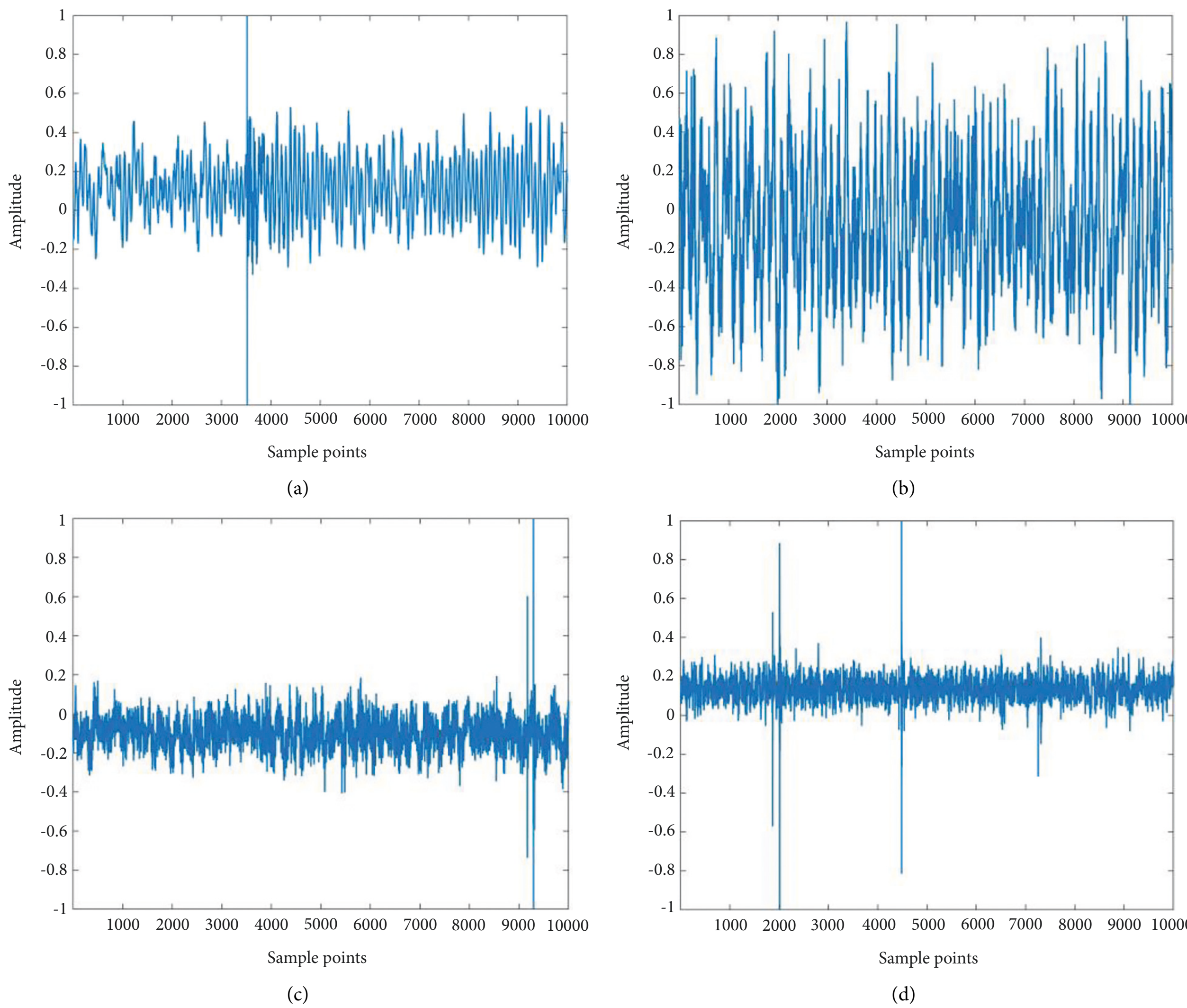

Figure 11: The waveform of four classes of SN. (a) SN-i. (b) SN-ii. (c) SN-iii. (d) SN-iv.

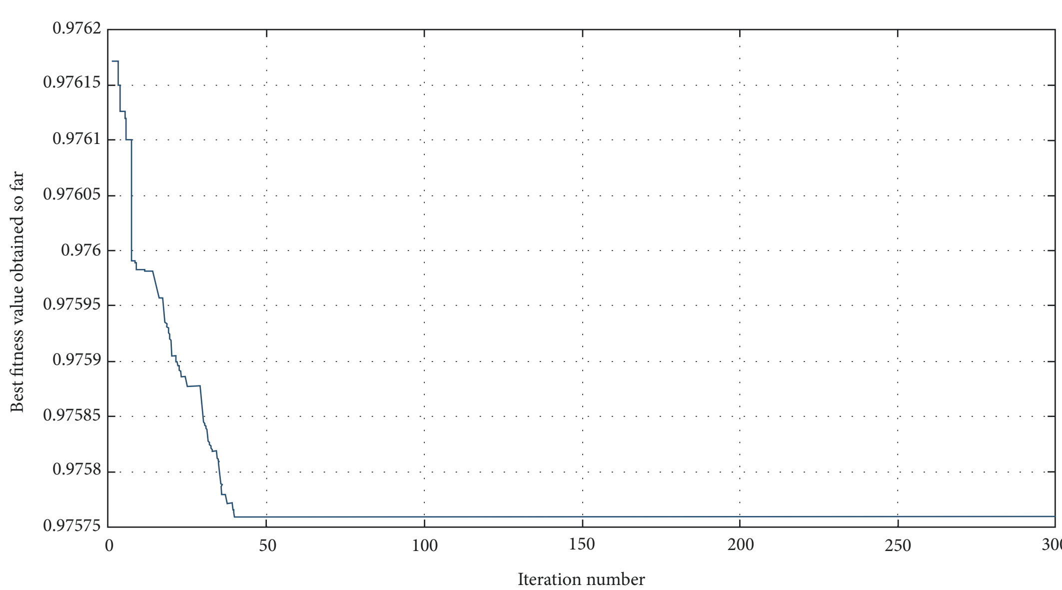

Figure 12: The iteration chart of SN-iii.

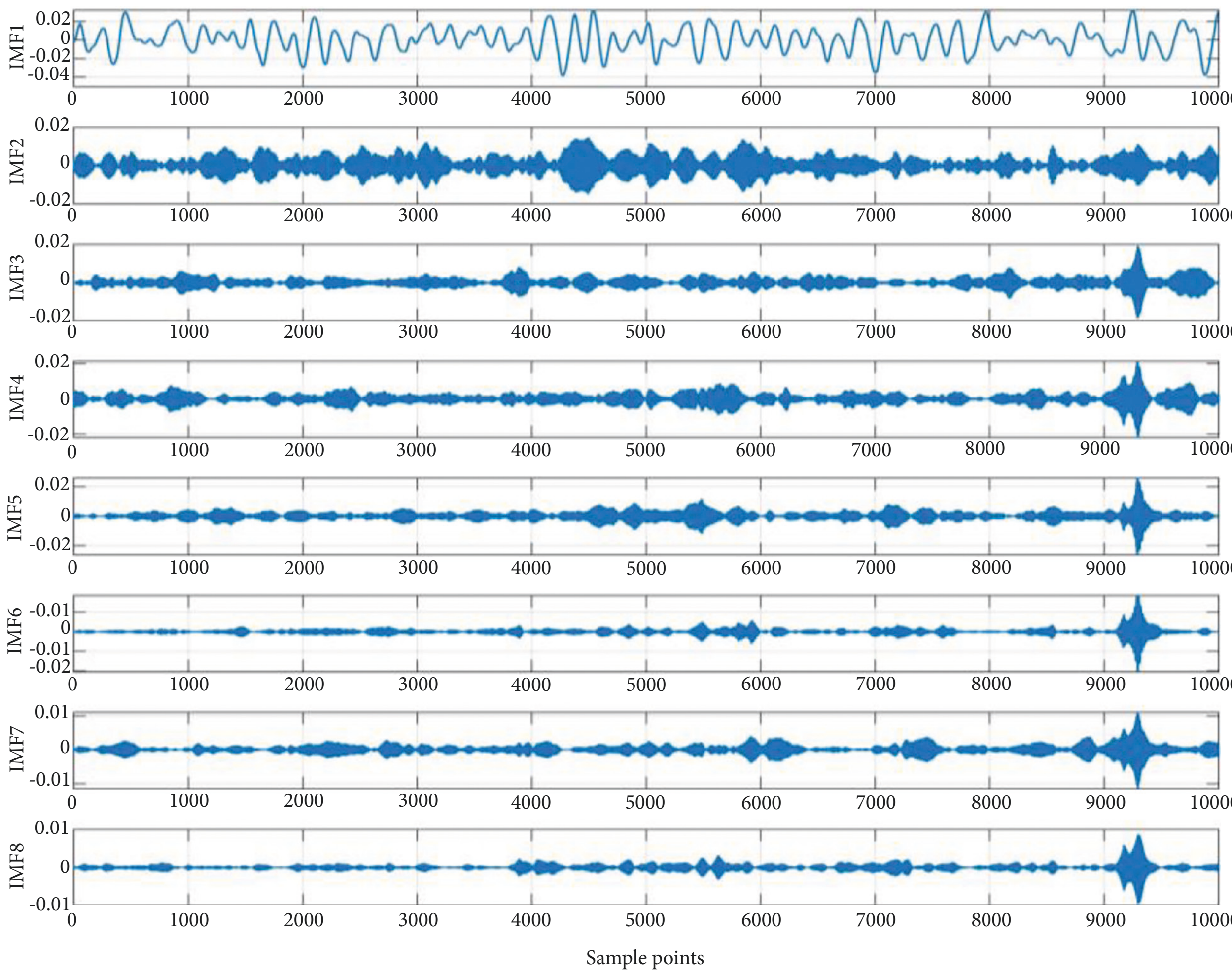

Figure 13: The IMFs of SN-iii.

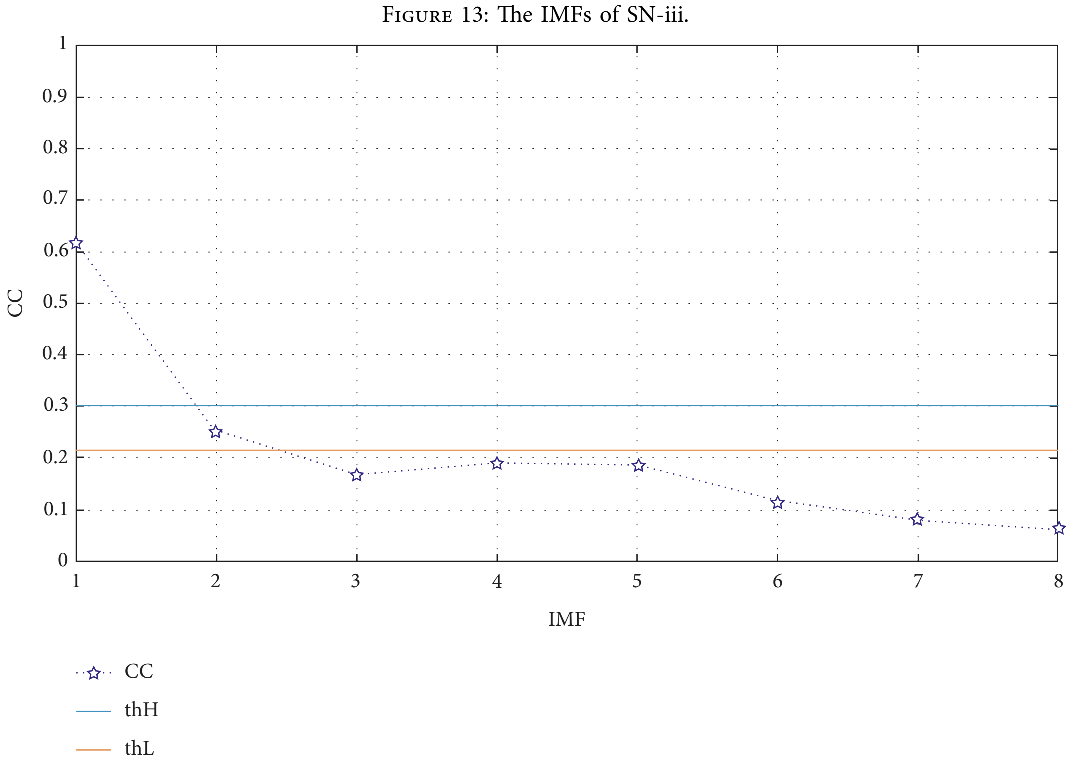

Figure 14: The CC of IMF of SN-iii.

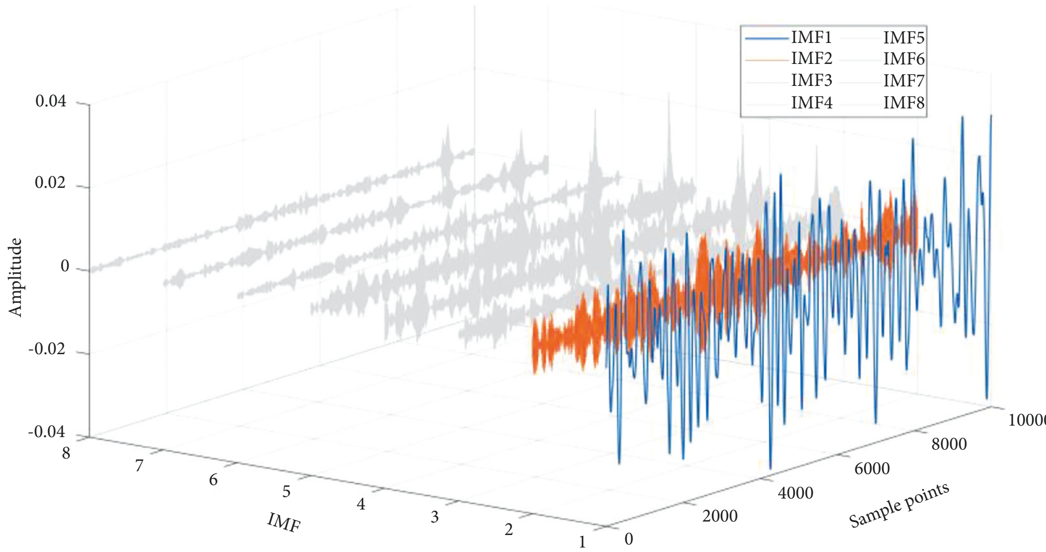

Figure 15: The classification result of SN-iii.

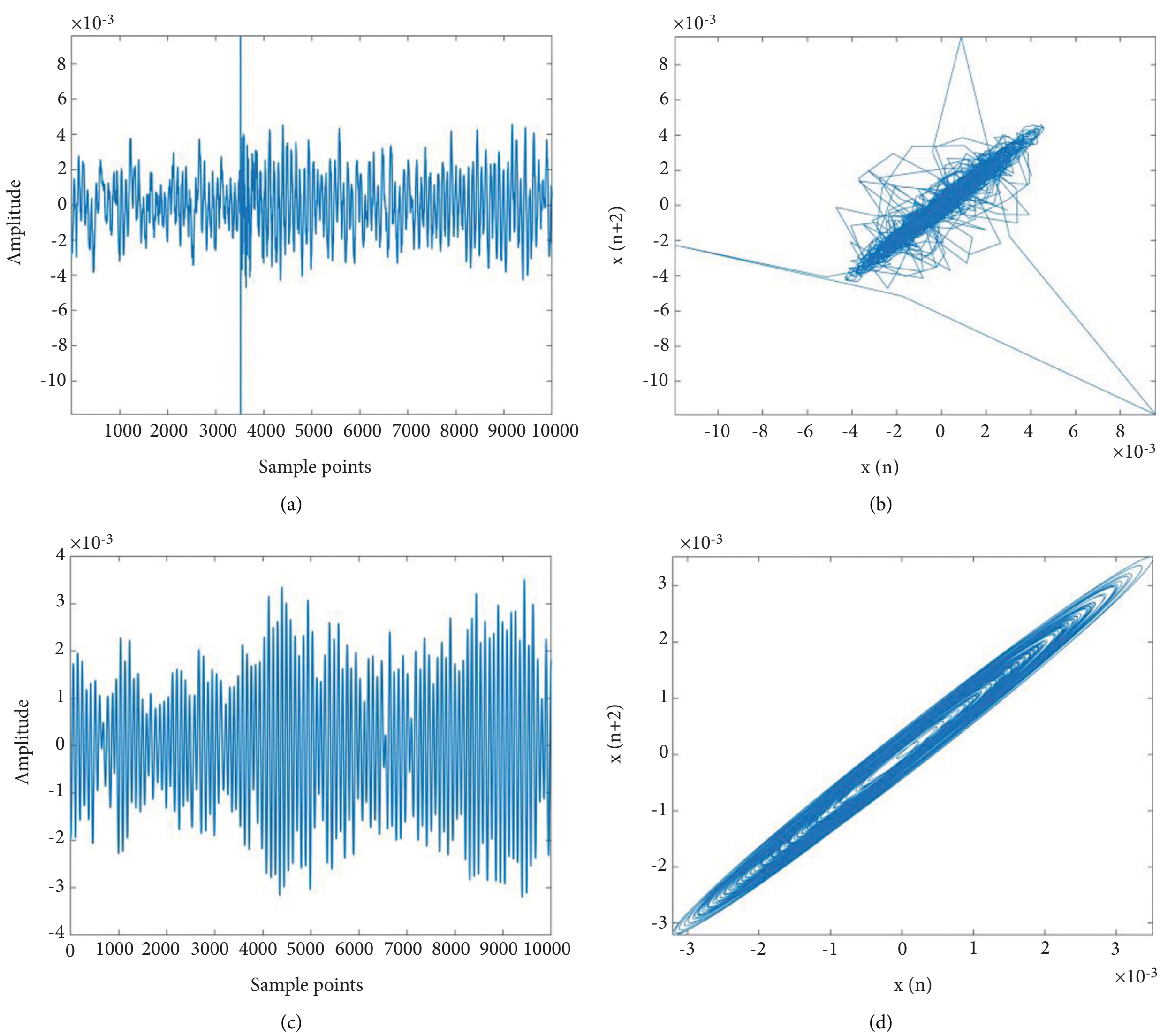

Figure 16: The waveforms and attractor trajectories of original and denoised SN-i. (a) The waveform of SN-i. (b) The attractor trajectories of SN-i. (c) The waveform of denoised SN-i. (d) The attractor trajectories of denoised SN-i.

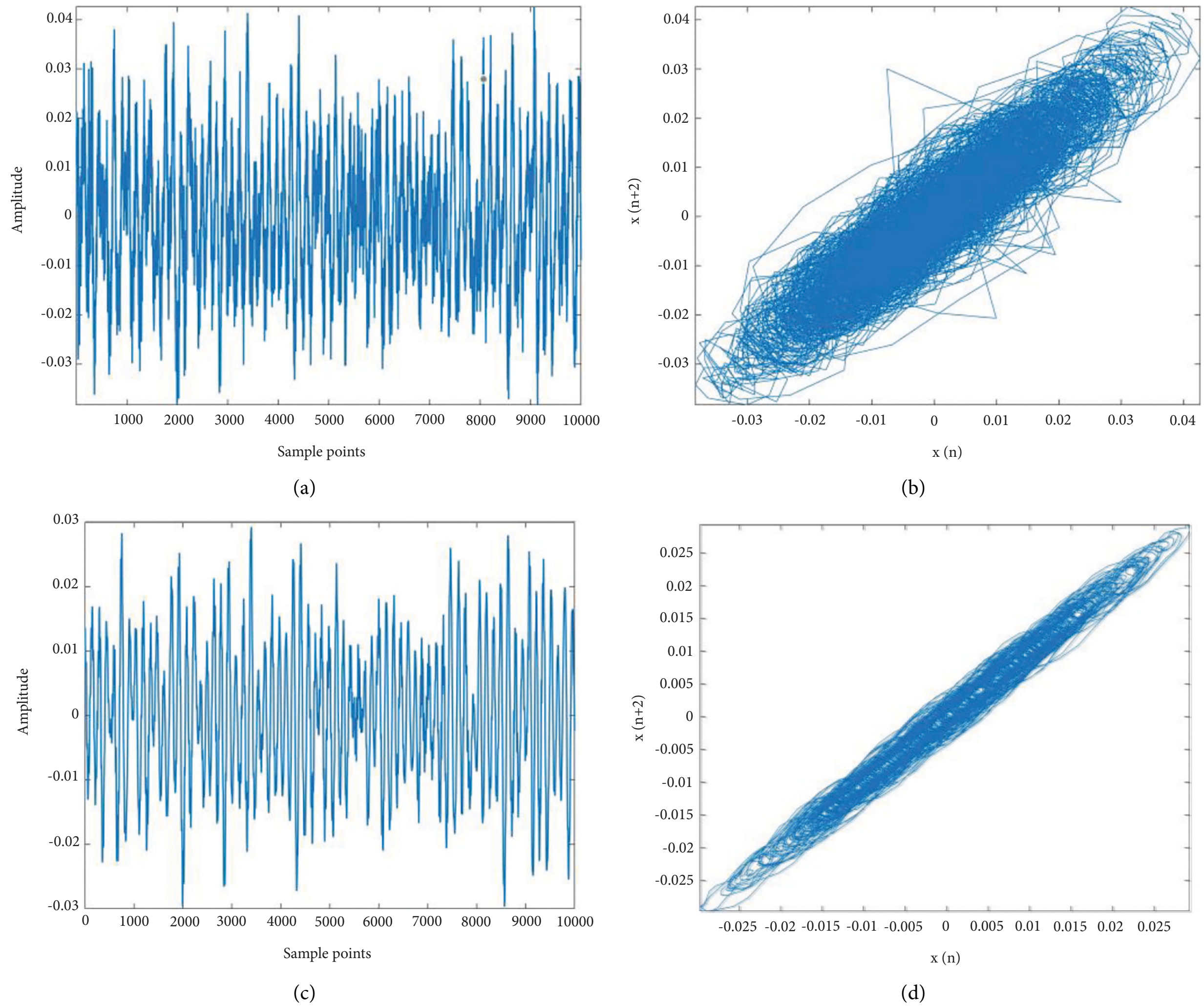

Figure 17: The waveforms and attractor trajectories of original and denoised SN-ii. (a) The waveform of SN-ii. (b) The attractor trajectories of SN-ii. (c) The waveform of denoised SN-ii. (d) The attractor trajectories of denoised SN-ii.

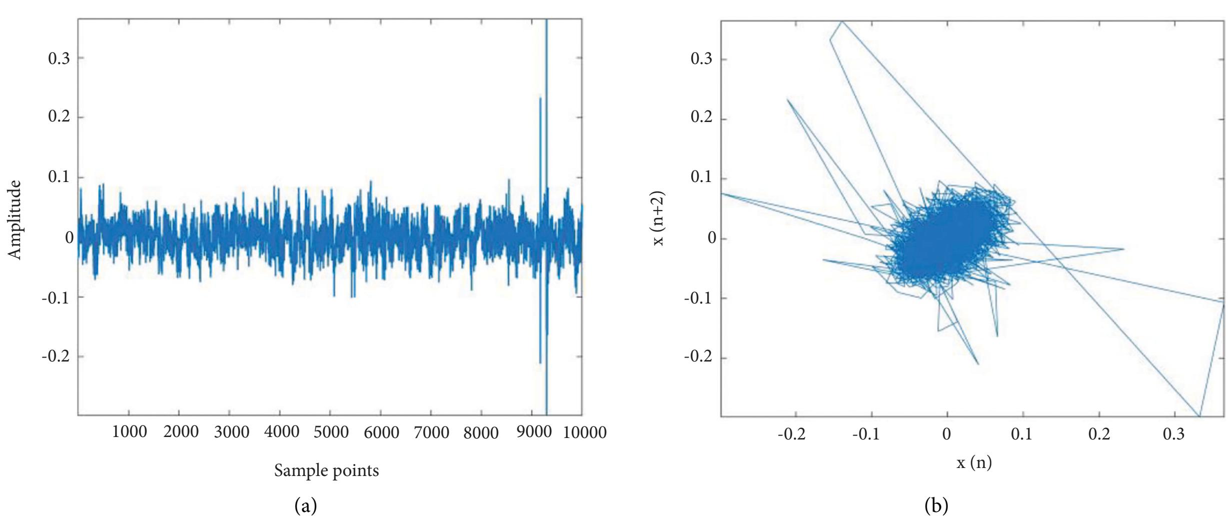

Figure 18: Continued.

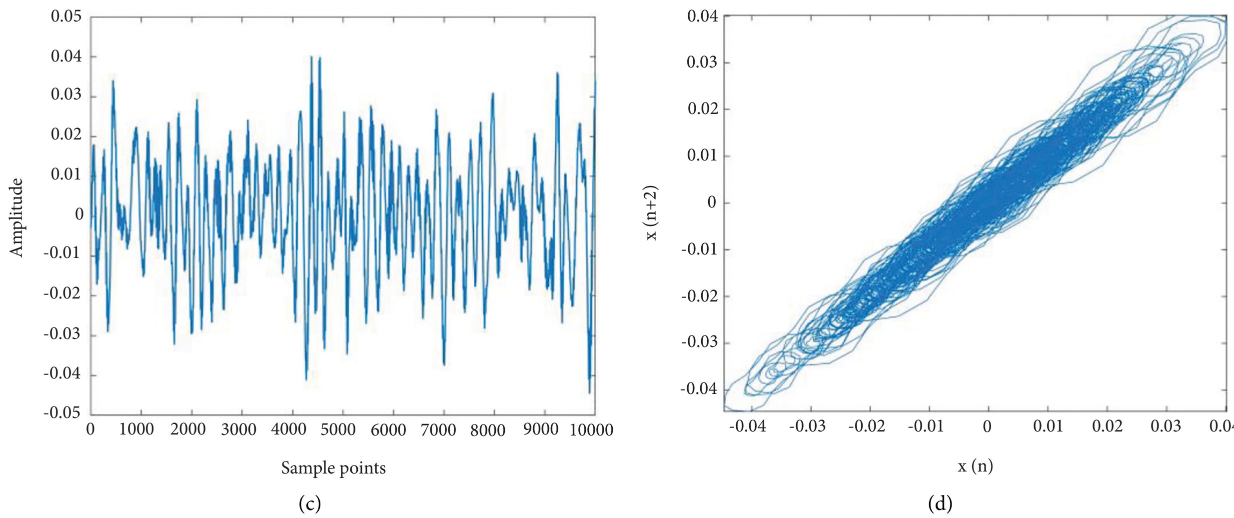

Figure 18: The waveforms and attractor trajectories of original and denoised SN-iii. (a) The waveform of SN-iii. (b) The attractor trajectories of SN-iii. (c) The waveform of denoised SN-iii. (d) The attractor trajectories of denoised SN-iii.

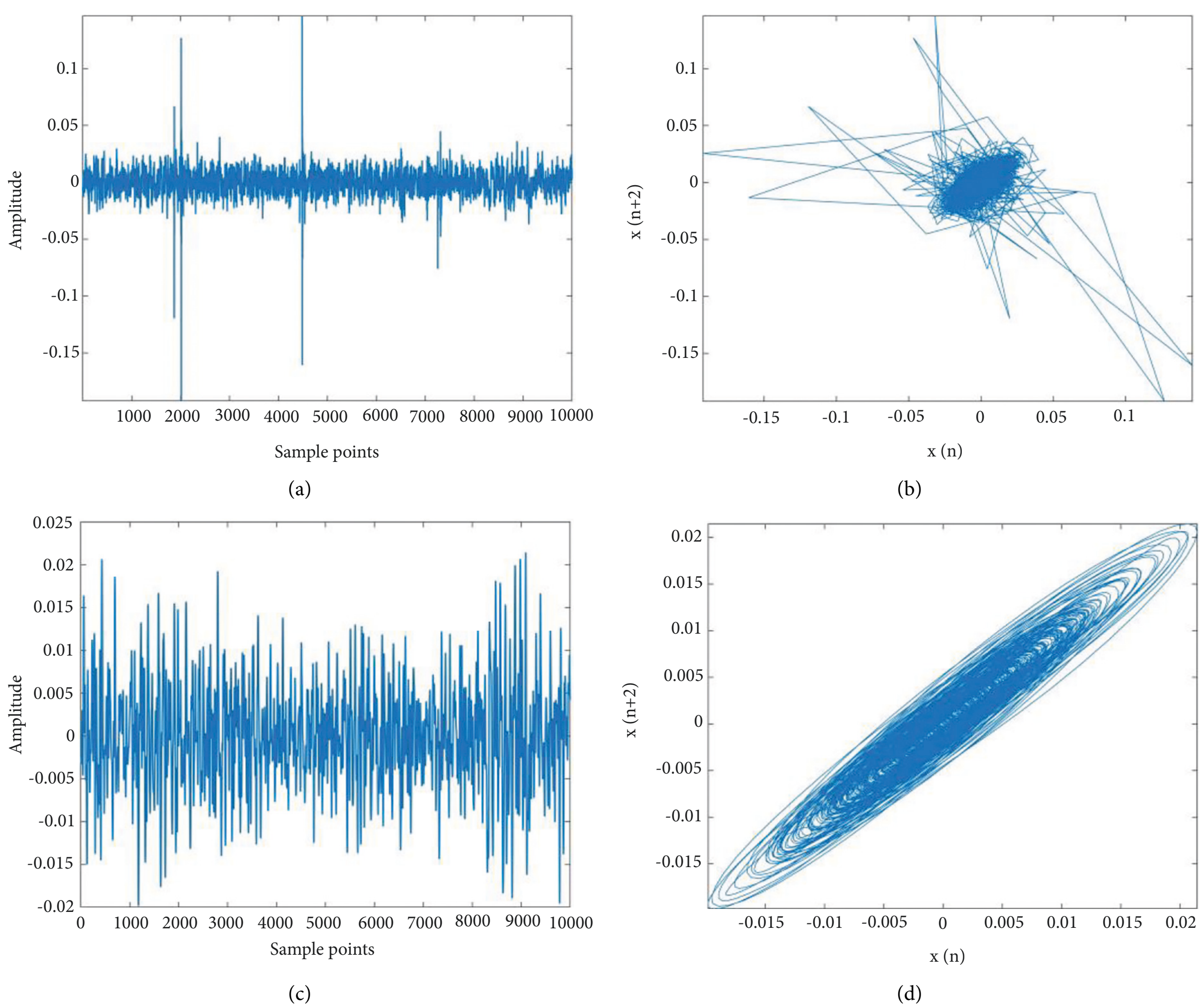

Figure 19: The waveforms and attractor trajectories of original and denoised SN-iv. (a) The waveform of SN-iv. (b) The attractor trajectories of SN-iv. (c) The waveform of denoised SN-iv. (d) The attractor trajectories of denoised SN-iv.

VMD algorithm is ready to start. The decomposition result, that is, the IMFs of SN-iii, is shown in Figure 13.

Eight IMFs have been decomposed precisely. According to the central frequency of each IMF from low to high, they are placed in order and named from IMF1 to IMF8. The amplitude of the first two signals is larger than that of others apparently. A peak of wave repeatedly appears in the range of 9000 to 9500, which tends to be suspected as dramatic noisy impulse.

4.2.2. Classification and Reconstruction. After VMD, calculating the CC of each IMF is essential to classification. At the same time, obtain the dual-threshold with the maximum and the average of CC. The calculated results are given in Figure 14.

The CCs are marked as pentacles in dark blue, and the two horizontal lines are dual-threshold. The blue one is the high threshold and the orange one is the low threshold. Obviously, the IMFs are divided into three parts. The CC of IMF1 is higher than the high threshold over 0.6 actually, and the CC of IMF2 is caught in the middle of two thresholds. The rest of them are under the low threshold with the values hardly reaching 0.2. In accordance with the data above, IMF1 is reckoned as signal component, IMF2 is recognized as signal-noise component, and the rest of IMFs are all noise components. The classification result of SN-iii is shown in Figure 15.

As what is designed previously, IMF1 in blue would be saved, IMF2 in orange is supposed to be denoised with WT, and the rest in gray are unfortunately discarded eventually. Finally, reconstruct them and obtain the final denoising signal.

4.2.3. Results and Analysis. The denoising results of four kinds of SN are displayed in Figures 16–19, which exhibit the waveform and relative attractor trajectories of both original and denoised signals. The trajectories are drawn with the interval of two sample points, so the x-label represents the amplitude of sample point n while the y-label represents the amplitude of $n + 2$.

From the figures above, it can be concluded that after denoising by the proposed method, every waveform is getting cleaner, and furthermore, the attractor trajectories are becoming more regular and smoother. The phenomenon reveals that the proposed method is effective in denoising the SN of all kinds precisely.

5. Conclusions

This paper proposes a brand-new method for denoising SN, which is based on optimized VMD by SO algorithm and dual-threshold criteria of CC. The former is to use SO algorithm and EE to optimize the parameter combination of VMD. The latter is to classify IMFs according to the dual-threshold that is obtained by calculating CC of each IMF. The classified IMFs are processed, respectively, and reconstructed together eventually.

The considerable volume of simulations is performed in this paper so as to verify the distinguished effectiveness of the proposed method. The simulation results not only demonstrate that SO algorithm has more impressive performance than other classical optimizations but also show that the proposed method does better than existing ones in denoising different kinds of test signals with noises to different degrees.

Furthermore, four kinds of SN are introduced and accurately denoised at last. Their attractor trajectories are much cleaner and smoother after denoising, which can powerfully prove that the proposed method is able to denoise the SN of all kinds elaborately.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Grid Information Integration Platform of Student Dormitory Based on Edge Computing

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In order to solve the problem that the average response time of the grid information integration platform in student dormitories is too long, a grid information integration platform for student dormitory based on edge computing is proposed. In terms of hardware, on the basis of clarifying the principle of edge computing, the overall framework of the platform is built based on the B/S structure. The central unit, power supply circuit, LCD display, signal processor, and power supply of voltage regulator in the framework are optimized. In terms of software, a three-level data integration model combined with a two-way mapping strategy is used to establish a grid warehouse in student dormitories. Based on the distributed link structure and the principle of management domain, the distributed data acquisition technology is designed to collect the grid information of students' dormitory in real time and store it in the warehouse. Using the IFB tree structure in the edge computing branch, the edge computing data query model is constructed. Finally, the grid information integration algorithm of student dormitory is designed to realize the grid information integration of student dormitory. The platform test results show that the average response time of the design platform is less than 2.426 s, which meets the timeliness requirements of data integration management.

1. Introduction

With the development of the big data era, many fields have begun to take the data analysis results as the basis for future development [1] and make decisions more in line with the development trend of the times based on historical data. For the grid information of student dormitories, due to its strong relevance, the regularity of grid information of student dormitories can be directly presented through data mining and integrated analysis [2, 3], and the key information contained in grid information of student dormitories can be extracted, so as to ensure the stability of university management and student behavior. Among them, information integration is one of the most basic links, and the existing integration platform is obviously difficult to play a better application effect.

Reference [4] puts forward the grid management mode of college students in the epidemic situation. In this study, it is pointed out that counselors play a positive role in improving students' ideological and political literacy, promoting the smooth operation of student management, and maintaining campus security and stability. Under the epidemic situation, management needs to pay more attention to detail and reality. Grid management has the advantages of rapid response, cross sharing, and efficient linkage. Therefore, based on grid management, combined with the characteristics and opportunities of college counselors during the epidemic prevention and control period, this study will explore the optimization of student management methods. In order to better improve the efficiency of student management in colleges and universities, reference [5] puts forward a people-oriented management concept, that is, colleges and universities should clarify the management responsibilities of student management, increase the resource investment of student management, strengthen students' ideological and political education and guidance, ensure that students' reasonable needs are met, and improve students' comprehensive quality. Reference [6] dialectically analyzes the prominent problems of college student management in the big data environment and analyzes the fit of grid management mode to college student management. Finally, it summarizes the methods of constructing the grid management mechanism of college students in the big data environment so as to provide theoretical reference for relevant research. Reference [7] points out that due to the deviation of the grid management concept of student crisis events in colleges and universities, the imperfect organization system, the aging and slow updating of management platform, the lack of crisis education for college students, and the development and implementation of grid management of student crisis events in colleges and universities are not optimistic. Colleges and universities should establish a scientific concept of crisis event management, improve the systematic crisis event management system, build an efficient crisis event management platform, and strengthen the necessary crisis event education and training so as to further improve the management mechanism of students' crisis event handling.

Although the above platform realizes integrated management, its data query response time is long. Therefore, this paper proposes to integrate edge computing technology into the construction of grid information integration platform in student dormitories. The hardware and software are optimized. By establishing the grid warehouse of the student dormitory and designing the distributed data acquisition technology, the grid information of the student dormitory is collected in real time and stored in the warehouse. The IFB tree structure in the edge computing branch is used to construct the edge computing data query model. The grid information integration algorithm of student dormitory is designed to shorten the response time of the platform and improve the efficiency of information integration.

2. Overall Architecture of Grid Information Integration Platform Based on Edge Computing

Referring to the concept and function of "grid" in computer science, in recent years, the concept of grid management has been widely used in urban and rural grass-roots governance and has become an important method of grass-roots social management [8, 9]. Specifically, it is to divide the people, things, and things carried in the physical space into unit grids according to certain standards; establish a dynamic and all-round management system for each grid area; realize the main functions of resource sharing, collaborative work, dynamic adjustment, and high expansion in the grid; and then implement more diversification and refinement, and personalized management and service to promote the grid management of college student dormitories is the need to improve the school's governance ability. College student dormitories have the characteristics of dense personnel, high mobility, and concentrated accommodation [10]. There is a natural fit between the student community composed of student dormitory areas and urban and rural communities. With the acceleration of the modernization of China's higher education and the expansion of the scale of running schools, the traditional school management mode and student service measures cannot fully meet the requirements of the new era. The ideological and political work and school safety and stability work are facing great pressure, which must be solved by promoting modern management methods and using modern information technology.

2.1. Edge Calculation Principle. Aiming at the functional objectives of resource sharing, collaborative work, dynamic adjustment, and high expansion of student dormitory grid management, this paper selects the edge computing method to realize it.

The edge computing model shares the processing tasks of cloud and data link [11, 12], making subsequent maintenance and repair more timely and accurate. The workflow of the edge computing model is as follows: the edge node on the student dormitory grid generates data related to the running state and sends it to the cloud center together with the generated data of the platform. The edge node puts forward a request instruction to the cloud center, which provides the edge node with data about the running state. Therefore, in the grid information integration platform of student dormitory, the edge computing model shown in Figure 1 is adopted.

According to the edge computing model shown in Figure 1, when using edge computing to design the grid information integration platform of student dormitories, first, the source information is centrally matched by means of data matching, and then the data preprocessing is completed. Second, the data are centrally managed through the monitoring and analysis of big data, so as to complete the data fusion processing. The data fusion process is as follows:

Step 1: check the initialization of the grid information integration platform of the student dormitory;

Step 2: data buffering and setting each serial port;

Step 3: initialize and set parameters such as display;

Step 4: filter the data signal and display the detection result;

Step 5: data fusion.

Based on the above steps, the following will first analyze the overall design framework of the grid information integration platform for student dormitories. Combined with the functional modular analysis and integrated information processing, the integrated framework of the grid information integration platform of student dormitory is carried out.

2.2. Overall Structure. Based on the above edge computing principle, a grid information integration platform for student dormitory is designed. B/S architecture system [13, 14] is adopted for network control at the client, and the grid information integration platform of student dormitory is established on the grid cross networking structure of student dormitory. Using embedded B/S architecture design method, the modular structure design of grid information integration platform in student dormitory is carried out. VIX bus control technology is used to realize the bus integration of student dormitory grid information integration platform, and the hardware development and design of student dormitory grid information integration platform is

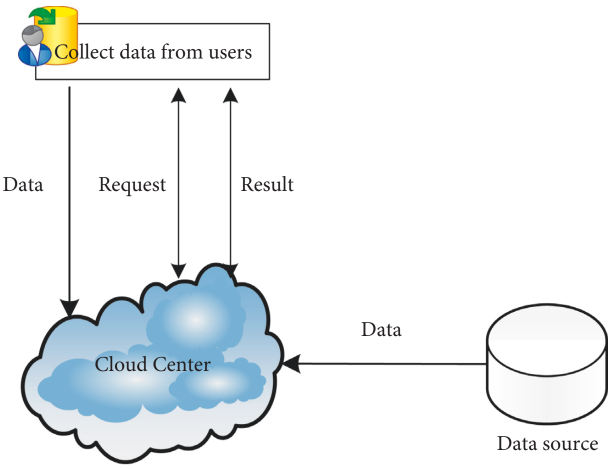

Figure 1: Schematic diagram of the edge calculation model.

realized in the integrated processing environment of DSP and FPGA.

B/S structure, i.e., browser/server structure. The structure has the following advantages:

(1) The maintenance and upgrade of the platform is simple. Most of the business logic is implemented on the server, so the upgrade and maintenance can only be carried out on the server, which greatly reduces the work cost and workload.
(2) Strong compatibility. Software using B/S architecture has more choices on the operating platform, including Windows, Linux, UNIX.
(3) Strong interaction. BS architecture can be directly placed on the WAN, and the purpose of multi-customer access can be realized through certain permission control
(4) High security. The data are centrally stored in the database server of the headquarters. The client does not save any business data and database connection information, and the client does not have to synchronize the data, so the security problem is guaranteed.

Based on the B/S structure, this paper designs the framework of the grid information integration platform of the student dormitory, extracts the dynamic information intelligently monitored by the grid information integration platform of the student dormitory, integrates the grid information of the student dormitory by using the multidimensional information fusion technology, and visually tracks the grid information of the student dormitory by using the visual image processing technology. The platform is divided into information acquisition module, network networking module, program loading module, upper computer communication module, and human–computer interaction module. This paper designs the user control module for input information control, data processing module to carry out the integrated information processing and data analysis of the grid information of the student dormitory, designs the grid information fusion algorithm of the student dormitory, improves the integrated control ability of the grid information of the student dormitory, and realizes the image display and human–computer interaction of the grid information of the student dormitory in the output module [15]. According to the above analysis, the overall module architecture of the grid information integration platform of student dormitory is shown in Figure 2.

According to the overall architecture of Figure 2, the hardware design of grid information integration platform of student dormitory is carried out.

3. Hardware Design of Grid Information Integration Platform in Student Dormitory

3.1. Central Unit. The central unit is the core of the platform, and its main function is to regulate, control, and manage the operation of the whole platform [16]. The unit is equivalent to a microcomputer. The hardware configuration of the central unit is shown in Table 1.

3.2. Power Circuit. Power supply refers to the circuit of the power supply part that provides power to the platform and is the power source for the operation of the whole platform. The power design of this platform is shown in Figure 3.

3.3. LCD Display. LCD display is the only interactive window for users to connect with the platform. The resolution of the display in this platform is 2880×900 pixels, size 32 : 10, brightness 200 cd/m2, contrast 10000 : 1, response speed 0.02 ms. Adobe RGB color coverage is 99.3%, and sRGB color gamut is 100%. This platform connects LCD controller, ram, ROM, LCD, and LCD display through PCB to form LCD module [17, 18].

3.4. Signal Processor. Signal processor is the key hardware of information integration. Taking TMS320F2812 chip as the core, this paper deeply analyzes the pin and serial communication mode of the chip and establishes the signal processor infrastructure combined with Harvard bus architecture. The specific structure of TMS320F2812 chip is shown in Figure 4.

According to Figure 4, the signal processor based on TMS320F2812 chip mainly includes four key parts: flash memory, fast analog-to-digital converter, enhanced can module, and multichannel buffered serial port.

3.5. Regulated Power Supply. As the power guarantee hardware of the information integration platform, the power module is the key to the stability of the platform. According to the actual environment of student dormitory, the power supply with amplitude of 5.0 V and 3.6 V is designed in this paper. Combined with the integrated voltage stabilizing circuit lm2576t-5.0, the design of voltage stabilizing power supply is completed. Among them, a voltage regulator with 3 A output current is adopted, relying on the self-protection circuit contained in the integrated voltage stabilizing switch circuit, a small number of external components are added,

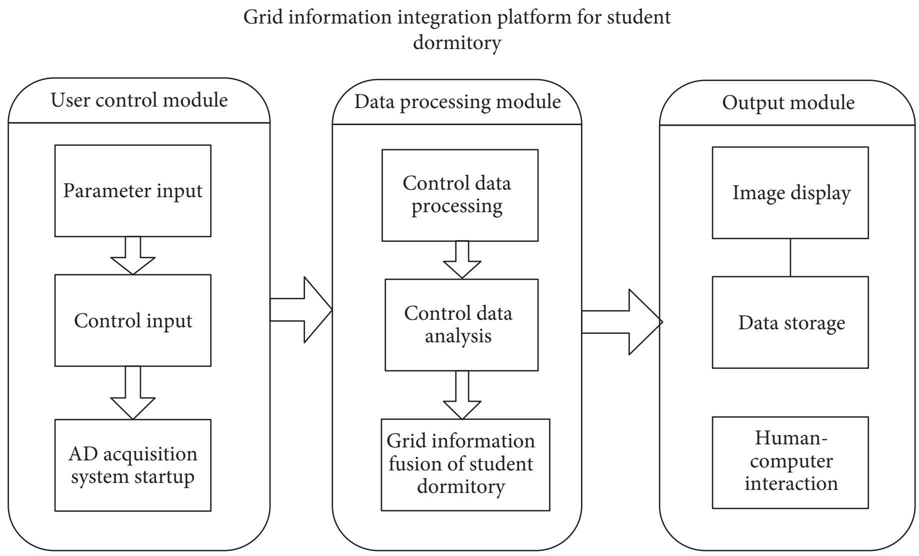

Figure 2: Overall module framework of grid information integration platform for student dormitory.

Table 1: Hardware configuration of central unit.

Hardware type	Configure
CPU type	Quad core amdpteron8387
CPU frequency	2800 (MHz)
Processor description	Number of standard processors
Number of CPUs supported	8
Processor cache	512 KB per core integrates L2 cache and 6 MB per processor integrates L3 cache
Expansion slot	Three X8 PCI express; four X4 PCI express; 2 PCI-X (100MHz); four PCI-E standard slots are used to install the smart array P400 controller
Memory type	PC2-6400 registered DIMM running at 800 MHz
Memory size	16 GB
Maximum memory capacity	256 GB
Hard disk size	3 ∗ 300 GB SAS hot swap hard disk
Hard disk controller	SAS raid card (CACHE ≥256M)
Number of internal hard disk racks	≥8 hot swappable hard disk slots
CD drive	Ultrathin DD drive (8x/24x)
Network controller	Two embedded nc371i capable gigabit network adapters with TCP/IP offload engine, supporting accelerated iSCSI through an optional license suite
Power	910 W/1300 W
Power type	Two hot swap power supplies are standard
Operating platform support	Microsoft@Windows@Server; Microsoft@Windows@Server Hyper V; Red Hat EnterpriseLinux (RHEL); SUSE Linux Enterprise Server (SLES); Oracle Enterprise Linux (OEL)

and a voltage stabilizing circuit with stable and efficient characteristics is set.

So far, the hardware design of grid information integration platform in student dormitory has been completed.

4. Software Design of Grid Information Integration Platform for Student Dormitory

Grid management transforms the past management mode of passive response to problems into active problem discovery and problem-solving. It has the characteristics of agile, efficient, and accurate management [19] and has internal unity with the concept of crisis prevention management. The construction of campus crisis prevention management system through dormitory grid management has important practical significance for the management of college students [20]. Since some colleges and universities in provinces and cities took the lead in implementing grid management, colleges and universities in many parts of the country have begun the preliminary exploration of grid management services of student dormitories, formed valuable experience, established a “horizontal to edge” and “vertical to the end” management network, and built a three-dimensional system of crisis prevention and management of student dormitories. The implementation of grid management is conducive to timely and comprehensive grasp of college student information, improve the timeliness, pertinence, and scientificity of student education service management [21] and is an effective way to

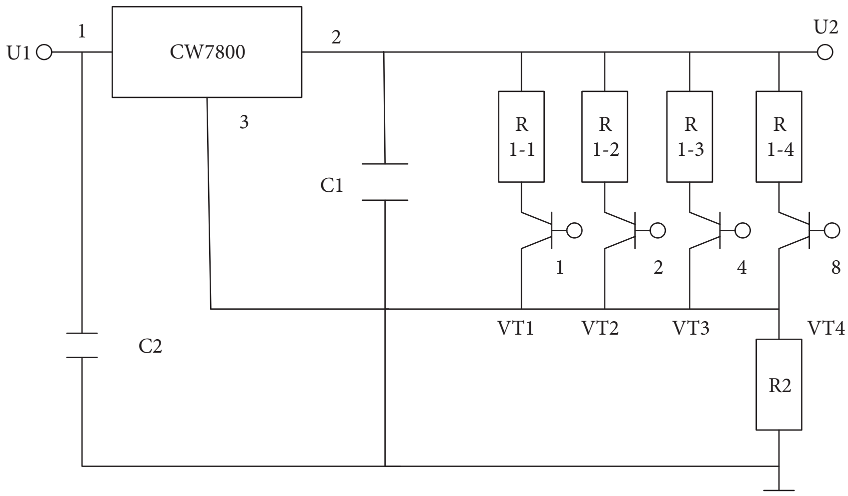

Figure 3: Power supply circuit.

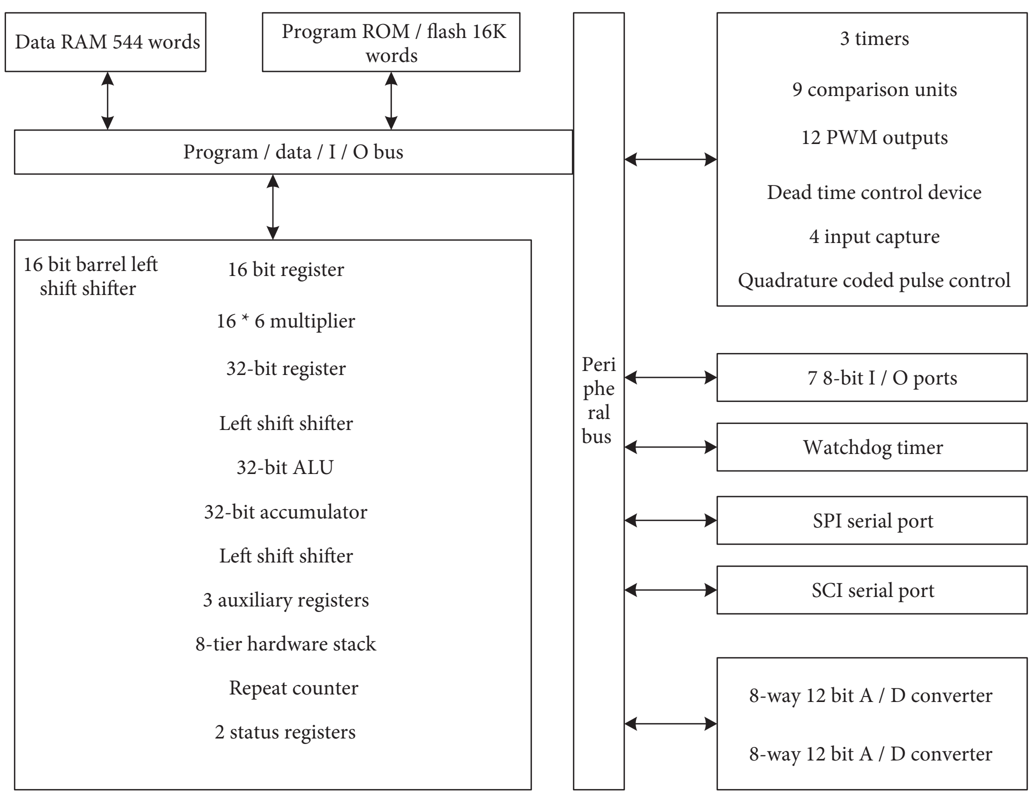

Figure 4: Schematic diagram of TMS320 F2812 chip structure.

realize the modernization of College Governance System and governance ability. Therefore, based on the hardware design, the software algorithm is designed to optimize the grid information integration effect of student dormitory.

4.1. Establish Grid Warehouse of Student Dormitory. Considering that the main purpose of the design of information integration platform is to integrate all aspects of grid information of student dormitories and assist managers to establish decision-making schemes. The establishment of data warehouse needs to be based on providing high-level decision support function [22, 23], and then design low-level query function according to the requirements of detailed data statistics. Based on the above integration content, the grid information integration model of student dormitory is constructed by using the three-level mode. The overall design is completed by summarizing the data layer, data operation layer, and data integration layer. The specific design idea is shown in Figure 5.

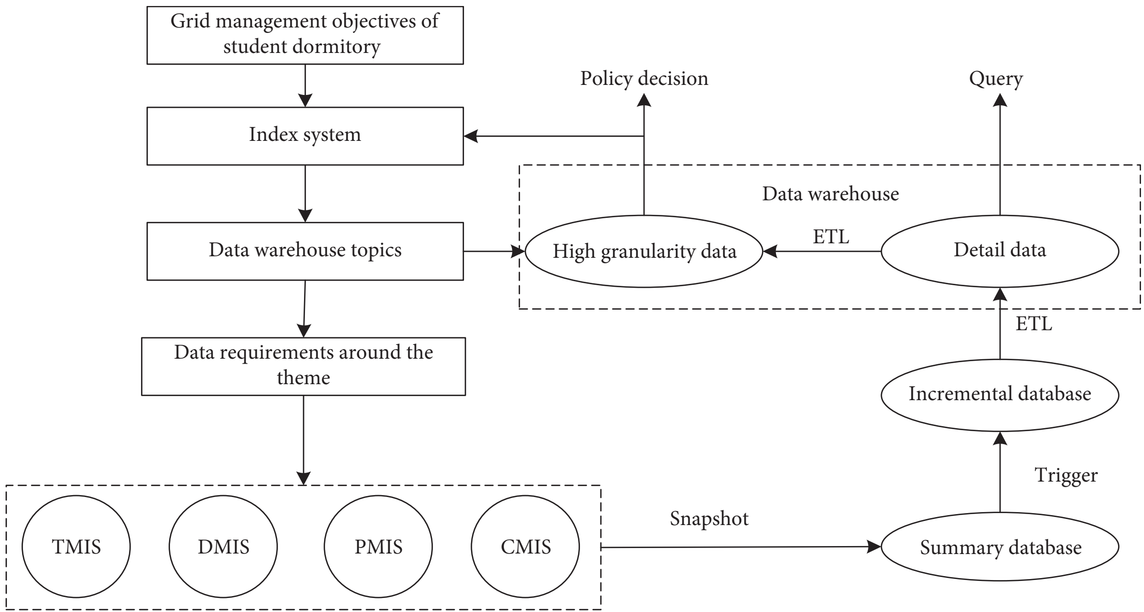

Figure 5: Schematic diagram of data warehouse.

According to the schematic diagram of data warehouse shown in Figure 5, high-granularity data storage is the last step in the decision-making of establishing student dormitory, which directly affects the development goal of student dormitory. Relying on the index system, the information required by the main body of the data warehouse is extracted from the grid information of diversified student dormitories. In addition, in order to reduce the computational complexity of data increment, this paper proposes a simple data aggregation mode for business entities and realizes high-granularity data storage around the decision-making theme as the operation basis of the information integration platform.

Considering the diversity of grid information in student dormitories [24], this paper proposes that in the data warehouse, in addition to using the signal processor for preliminary data processing, and then integrating the two-way mapping strategy based on metadata drive, this paper deeply analyzes the mapping rule formula of grid information in student dormitories and converts the data form based on the parsed parameter information. In order to facilitate the data collection and data integration management of the information integration platform, this paper applies the two-way mapping mode to establish the forward mapping and reverse mapping relationship between the source database and the target database. First, define the source data model and target data model as follows:

$$A = \{Q(x, y, z)\}, \tag{1}$$

$$B = \{C(f, g), D(e, r)\}. \tag{2}$$

In formulas (1) and (2), A represents the source data model; B represents the target data model; Q, C, D represent the grid source information of three student dormitories; x, y, z represent the three attributes of data Q; f, g represent the two attributes of data C; and e, r represent the two attributes of data D.

The forward mapping of grid information in student dormitory refers to the mapping from source data model to target data model, which can be expressed as:

$$\alpha = (A, B, \varphi). \tag{3}$$

In formula (3), α represents forward mapping and φ represents forward mapping rules.

Reverse mapping refers to the reverse operation of the forward mapping relationship, that is, converting the target data into metadata. The specific expression is as follows:

$$\alpha^{-1} = (B, A, \phi). \tag{4}$$

In formula (4), α^{-1} represents reverse mapping and ϕ represents reverse mapping rules.

This paper proposes to integrate the two-way mapping strategy into the establishment of data warehouse to realize the effective preservation of student dormitory grid.

4.2. Design Distributed Data Acquisition Technology. The design of data warehouse provides basic conditions for information collection. This paper proposes link data collection mode [25, 26] and designs distributed data collection technology. Adopt appropriate tools to collect the status data of the communication network, preliminarily convert the link information, and then complete the distributed data collection in combination with the principle of distributed structure and management domain. First, according to the region and organization of the student dormitory, it is divided into multiple domains, and a manager is set for each domain. By collecting the information provided by each domain manager, the grid information collection of the whole student dormitory is completed. The specific form of the distributed collection management model is shown in Figure 6.

The distributed management model shown in Figure 6 mainly adopts the parity structure to allocate the grid collection task of student dormitory to each domain manager. Run the data acquisition technology from the domain head node, set other nodes in the domain as the monitoring host node, and collect the data of the interdomain link through the interaction between the head node of each domain and other domain head nodes. Considering that there are many types of grid in student dormitories, the distributed data acquisition link can be set as wired link and wireless link. In this paper, Ethernet is used to establish wired link, and the corresponding link index measurement method is proposed to clarify the current data acquisition link bandwidth, improve the asymmetric link bandwidth in combination with the actual data acquisition environment, and improve the grid information acquisition accuracy of student dormitories. In this paper, the RI-TAW-PATHCHAR method is used to measure the link bandwidth, and the ICMP echo message used to obtain the message cycle time of the measured packet is given by

$$R = \frac{2sl_m}{u_m} + q_1 + q_2 + q_3 + q_4 + t. \tag{5}$$

In formula (5), R represents the message cycle time, m represents the node, q represents the queuing delay, s represents the length of the measurement packet, u represents the link bandwidth, t represents the processing time of the node for the measurement packet, and l represents the propagation delay. In order to simplify the calculation of formula (5), set the response message as ICMP timeout message, and the calculated message delay time is given by:

$$\eta_m = s\sum_{i=1}^{m}\frac{1}{u_i} + \sum_{i=1}^{m}\left(\frac{R}{u_i} + l_i\right). \tag{6}$$

In formula (6), i represents the link segment and η represents the delay time of the response message. The uplink bandwidth can be deduced according to the message delay time:

$$u_m = \frac{1}{k_m - k_{m-1}}. \tag{7}$$

In formula (7), k represents the slope of linear function $\eta_m(s)$. When the response message is set as ICMP reply message, the message cycle delay time can be expressed as:

$$\eta_m' = s\sum_{i=1}^{m} u_i + l_i. \tag{8}$$

In formula (8), η' represents the delay time of ICMP reply message. Combined with formulas (7) (8), it can be deduced that:

$$u_m' = \frac{1}{\left(k_m' - k_{m-1}'\right) - \left(k_m - k_{m-1}\right)}. \tag{9}$$

In formula (9), k' represents the slope of the linear function $\eta_m'(s)$ and u' represents the downlink bandwidth. According to the calculation results of uplink bandwidth and downlink bandwidth, the link is optimized according to the asymmetric link improvement strategy to effectively improve the anti-interference of grid information collection in student dormitories.

4.3. Build an Edge Calculation Data Query Model. Grid information query of student dormitory is another important content in the design of information integration platform. This paper uses edge computing technology to build an intelligent data query model. Based on the IFB tree index structure, this paper strengthens the data access of the database and uses the edge computing technology to establish a new index structure to promote the index recommendation. The construction of edge computing data query model needs to accurately evaluate the cost of grid information query plan of student dormitory and estimate the query scale.

Considering that the optimization of join order is one of the most important problems in the process of data query, this paper establishes the candidate join order with the minimum cost as the database table and takes it as the optimal query plan. Combined with the heuristic algorithm, the best connection order is extracted, and each time slice is connected through the connection processor. After all time slices are connected, the learning optimizer is used to establish the upper limit confidence interval algorithm to complete the setting of data query search space.

The application of edge computing technology in data query model is based on IFB tree structure. For the data query search space established above, the single value query mode is used to construct the edge calculation data query model. The specific IFB tree diagram is shown in Figure 7.

According to the IFB tree structure shown in Figure 4(b), all leaf nodes in the data query process are in the same layer structure, which contains all keyword information of student dormitory grid. Compared with other data query methods, this paper proposes an IFB tree data query model based on edge computing technology, which can effectively improve the data query efficiency of the integration platform. At the same time, in order to reduce the problem of large time cost in the process of data query, this paper proposes to preliminarily predict the location of query nodes based on auxiliary model, which does not need internal search link, so as to shorten the data query time. During the construction of edge computing data query model, the application of linear interpolation algorithm will not change the structure of IFB tree nor will it affect the theoretical performance of IFB tree data query.

4.4. Realize Grid Information Integration of Student Dormitory. Based on the overall design of the grid information integration platform of student dormitory, the grid information integration processing of student dormitory is carried out.

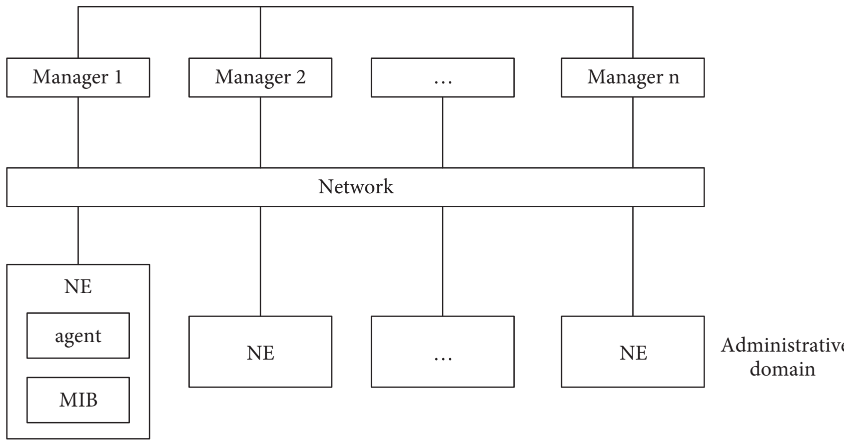

FIGURE 6: Distributed acquisition management model.

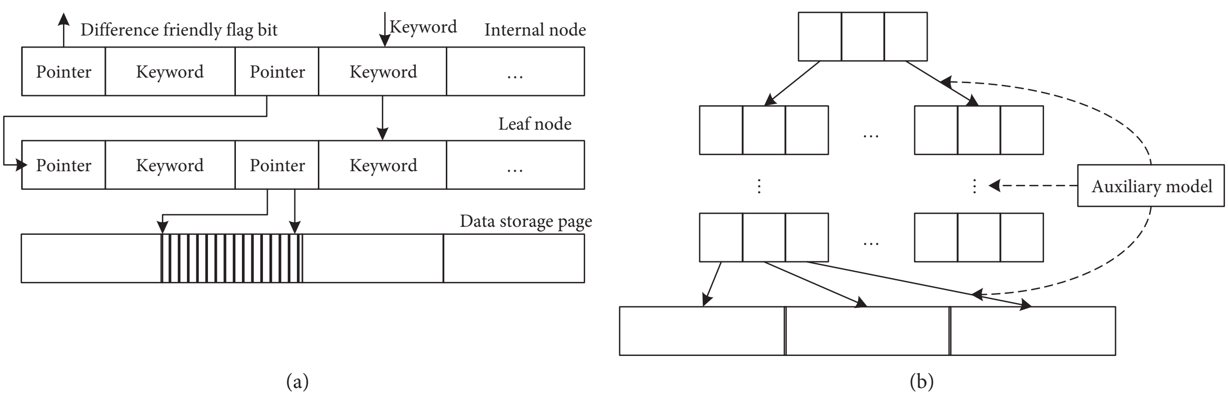

FIGURE 7: Schematic diagram of IFB tree. (a) Difference query (b) Structure diagram.

At present, the data integration of existing clustering integration algorithms mainly depends on the division results of clustering members, which does not have a fixed feature, and the differential characteristics of members are not considered too much in clustering. In actual clustering, members are good and bad, and ignoring these problems will lead to poor clustering results. In view of this phenomenon, further processing is needed to judge the quality of clustering members. Good quality members need to increase their contribution to the clustering results, and poor quality members need to reduce their contribution to the clustering results. The specific processing process is as follows:

Set the initial connection weight in advance, initialize the network before clustering, and randomly assign all connection weights to the value of [0,1] interval. Previous studies have shown that if the input samples of the same network structure are the same, the convergence speed of the algorithm will be faster, and the clustering result will be better. Based on the above contents, the classification of neuron nodes corresponding to the output layer in SOM network is different. For a specific output node, the best sample is output according to formula:

$$d_j = B\sum_{i=1}^{m}\left[x_i(t) - w_{ji}(t)\right]. \tag{10}$$

In the formula, $x_i(t)$ represents the sample data value input at time t, $w_{ij}(t)$ represents the neuron parameter of the i-th data, and B represents the attribute value of the data. In the process of network initialization, due to the large amount of data analyzed, in order to accelerate the convergence speed of the network, the typical sample vector data are processed as the initial weight vector, that is, in the process of sample learning, that is, according to the criterion of Euclidean distance, the approximate probability structure of the input vector is obtained to accelerate the convergence of the network. Based on the above analysis, the weight of cluster members is recorded as follows:

$$w_j^{\rho_{ca}} = \frac{\mathrm{Value}^{\cos(\pi)}}{\sum_h \mathrm{Value}^{\infty a}(\pi_h)}. \tag{11}$$

In the formula, $\mathrm{Value}^{\infty a}$ represents the evaluation parameter of clustering comprehensive quality, π_h represents the weight given by the h-th data, and $\mathrm{Value}^{\cos(\pi)}$ represents the attribute parameter of the new feature space matrix. Through the above process, the attribute weight weighting required by the new feature space matrix is completed, which provides a prerequisite for data visualization integration.

After the above changes in the grid information feature space of the student dormitory, for the data integration processing, considering that the attribute importance of each data is different in the new feature space, it is necessary to further calculate the weight of cluster members during processing.

In the iterative process of SOM algorithm, the weighted distance between the input vector and the neuron is used to find the victory neuron, w^{oep} is recorded as the attribute vector of the new feature space, and the calculation formula of the distance between the network input vector and the neuron is expressed as follows:

$$K = \sum_{i=1}^{m} w^{\mathrm{oep}} \left(x_{ik} + \omega_{ij} \right). \tag{12}$$

In the formula, x_{ik} represents the structure information of data k, and ω_{ij} represents the clustering label of the j-th object.

After the above continuous iterations, the integration results are output, but for some networks, whether the training is completed or not is related to the number of iterations given by the user, which brings a lot of inconvenience to the user. For complex networks and samples, if the given number of iterations is less, it will lead to the termination of training without completing convergence; if too many iterations are given, an overfitting will occur.

In order to better solve the above problems, the convergence criterion of the network is defined to avoid too many or too few iterations.

The learning standard of SOM is the adjustment process of weight vector. Therefore, it is used as the reference parameter to measure the stability of the network. After determining the reference parameter, an energy function $E(t)$ is defined and expressed as

$$E(t) = \sum_{i=1}^{k} \sum_{i=1}^{N} \left[\dot{w}_{i,j}(t-1) - \dot{w}_{i,j}(t) \right]^2, \tag{13}$$

where $\dot{w}_{i,j}$ stands for learning and updating parameters.

Based on the above process, it can provide basis for calculation iteration, so as to complete the design of grid information integration platform of student dormitory based on edge computing.

5. Experimental Test and Result Analysis

5.1. Test Environment. In order to ensure the accuracy of the experiment, build a test environment before the experiment as shown in Table 2.

5.2. Analysis of Test Results. In the above experimental environment, the grid information integration platform of student dormitory based on edge computing designed in this paper is tested. The test results are shown in Tables 3 and 4.

As can be seen from Tables 3 and 4 above, 300 users sent data to the server concurrently for 3 minutes, and the response time of the server to the event was within 3 seconds, reaching the expected goal; the request success rate is 100%, indicating that 300 users have successfully logged in to the platform; although the resource occupancy rate of the

Table 2: Platform test environment.

Testing environment		Name
Server side	Hardware platform	Intel(R)Core(TM)i7-4790 CPU@3.60 GHz.
	Graphics card	NVIDIA geforce GT 705 (1 GB/baolongda)
	A main board	Lenovo sharkbay (intel haswell)
	Operating system	Windows 10 ultimate 64 bit SP1 (DirectX 11)
	IIS server	IIS 7.0
	Programming tools	JavaScript, Microsoft Visua1 Studio 2013
	Background database	MySQL 5.6.17
	Communication bandwidth	4M
Client	Operating platform	Windows 10
	Browser	Internet explorer
	Communication bandwidth	1M

Table 3: Number of concurrent users and transaction execution.

Number of virtual users (PCs.)	Test average response time (s)	Estimated average response time (s)	Average number of concurrent users processed (PCs./s)	Request success rate (%)
25	0.263	0.252	12.36	100
50	0.785	0.782	11.02	100
75	1.036	1.036	10.68	100
100	1.236	1.237	10.22	100
125	1.365	1.368	9.63	100
150	1.523	1.520	9.25	100
175	1.635	1.625	9.14	100
200	1.722	1.725	8.25	100
225	1.782	1.777	8.02	100
250	1.823	1.825	7.23	100
275	1.925	1.936	6.36	100
300	2.425	2.426	5.53	100

Table 4: Number of concurrent users and operation of database host (unit:%).

Number of virtual users (PCs.)	CPU utilization	Estimated CPU usage	Memory utilization	Estimated memory utilization
25	13	≤60	0.26	≤5
50	15		0.69	
75	18		1.02	
100	22		1.36	
125	25		1.52	
150	27		1.89	
175	30		2.36	
200	33		3.02	
225	37		3.36	
250	43		4.02	
275	48		4.45	
300	53		4.88	

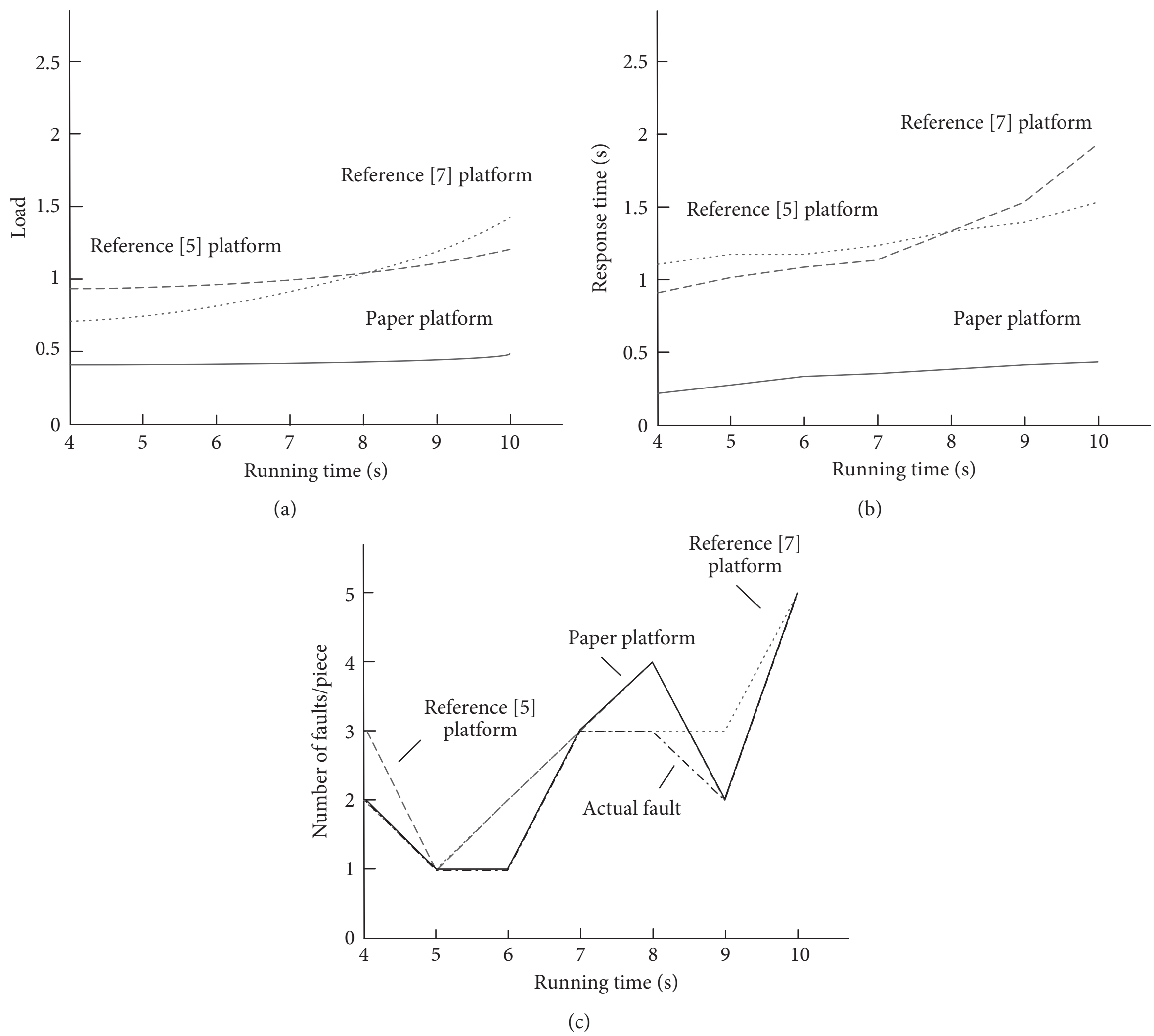

Figure 8: Performance test results of different methods. (a) Processor load comparison, (b) comparison of response time of remote monitoring, and (c) comparison of alarm results.

platform increases with the increase of users, it is also controlled within 60%, and the memory usage accounts for less than 5%, which meets the expected performance goal of the platform.

In order to verify the practicality and feasibility of the platform, the platform designed in references [5, 7] and the platform in this paper are used to detect from different angles such as processor load, remote monitoring response time, and accuracy of alarm results. The results are shown in Figure 8.

According to the performance test results of each method shown in Figure 8, the processor load of the designed platform is less than 0.5, the response time of remote monitoring is less than 0.5 s, and the number of false alarms is less than 1 compared with the actual alarm results. Therefore, the platform uses the edge computing model to share the processing tasks of the cloud and the data link, reducing the overhead caused by multiple establishment and cancellation of multithreads, and improving the processing efficiency of the platform. High priority tasks are handled in real time. Therefore, compared with the literature platform, it not only greatly saves the response time but also makes effective use of the processor time and memory and increases the accuracy of grid fault early warning in student dormitory to a certain extent.

The transmission delay of the three platforms with different frequency band utilization is counted, and the statistical results are shown in Figure 9.

As can be seen from the model test results in Figure 9, the platform in this paper has low transmission delay under different frequency band utilization, and the transmission delay is less than 200 ms. It is verified that the platform in this paper has low transmission delay and good communication performance.

According to the above experimental results, the grid information integration platform of student dormitory based on edge computing designed in this paper has good performance. While ensuring low response time, the transmission delay is reduced.

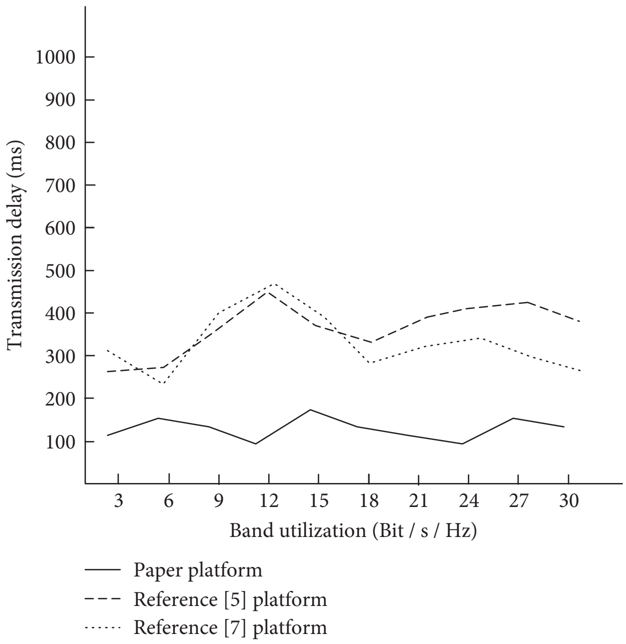

Figure 9: Comparison of transmission delay.

6. Conclusion

In order to realize the grid integrated management of student dormitory and avoid the phenomenon of information island, this paper proposes to design a new data integration platform based on edge computing technology. Through the combined design of software and hardware, the overall design of the integrated platform is completed, and the remote monitoring experiment is carried out on multiple student dormitory grids to explore the applicability of the platform. It is necessary to try to adopt more ideal fault detection and prediction methods to fundamentally increase the monitoring quality of the platform. Based on the market demand and video monitoring technology, the improvement of platform video monitoring function should be taken as the research focus in the next stage. The grid domain knowledge of student dormitory should be introduced to strengthen the performance of data acquisition terminal and fill the database to meet the different needs of different users.

Data Availability

The raw data supporting the conclusions of this article can be obtained from the author upon request.

Conflicts of Interest

The author declared that there are no conflicts of interest regarding this work.

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Research Article

Data Collection and Visualization Application of VMware Workstation Virtualization Technology in College Teaching Management

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In this study of data collection and visualization application of VMware Workstation virtualization technology in university teaching management, data processing is performed by the SQLServer database processor using VMware Workstation virtualization technology, and finally the radial-based teaching comprehensive evaluation neural network index is used to calculate the quality of teaching management to China's teaching team is gradually balanced and the comprehensive quality of teaching team is improving; the academic atmosphere is more open; the fields and perspectives of academic research are richer; the distribution of teaching at all levels in China is more balanced, the comprehensive quality of teaching in China is improving, the system of education and scientific research in China's colleges and universities is improving, and the ecological management system of colleges and universities is improving, and so on. It is also proposed to improve the academic level and establish a strict institutional threshold for the teaching industry in colleges and universities; to effectively implement the policy of freedom and equality in academic and scholarly circles, and improve the system of teaching, principal appointment, and evaluation in higher education institutions; to insist on implementing the principle of academic fairness and optimizing the teaching evaluation system; to innovate and implement the incentive mechanism of teaching in colleges and universities according to the characteristics of talent training of teaching academic career ability; and to establish the access system of teaching career development in colleges and universities to promote academic career development and other suggestions of big data management of teaching in colleges and universities.

1. Introduction

World-class universities have another very important and prominent business characteristic, that is, they have a relatively high-level professional technical faculty, but how to maintain a high-level faculty is a problem worth thinking about. In this regard, some universities in western developed countries have more mature experience in the management of university teachers, which is worth learning and learning from. In the management of universities in China, there are some institutional deficiencies and defects in the recruitment, assessment, promotion, and evaluation of teachers, which have led to many unnecessary disputes [1]. Because of the highly specialized and academic nature of the characteristics of the university faculty group, and how the academic activities of teachers determine the popularity of colleges and universities. The core of a university is to determine high-quality academic activities. In China, the boundary between academic and administrative power is often unclear. Administrative power often interferes excessively with academic power, and academic power is not exercised effectively. This has seriously affected the personal academic creativity cultivation and personal academic motivation of some university teachers and researchers, and has restricted the level of our universities' own research and innovation development capability and continuous healthy forward development. Higher education in the United States began in 1776, and after more than 200 years of development, it has borrowed the advanced management concepts of many countries' higher education institutions. After the Second World War, the quality of higher education in the United Kingdom and the United States gradually came to the forefront of the entire world, forming a system of university faculty management that is politically, economically, and culturally compatible with that of Germany and the United States. The reasons for the growth of a group of American universities from small colleges to influential universities in the academic world are many, of which the establishment and implementation of a scientific university faculty management system is an important part [2]. Therefore, building an excellent faculty and giving it a virtuous cycle is a topic worth exploring. With the intensive development of information technology in the era of globalization, how to make efforts to adapt the school faculty management and its institutional system to the conceptual approach and development philosophy of the world's information technology advanced society, and to build a highly qualified and a well-structured university faculty system has increasingly become the most important practical content of today's research and exploration of higher education development. As an institution is clearly different from other institutions in society, the management function of a university is to provide services for teachers and professors so that they can carry out scientific research, teaching, and social service work more conveniently and effectively. Therefore, this paper attempts to analyze the philosophy and practice of the university faculty management system in China and identify its characteristics in order to provide a reference for the construction of the university faculty management system in China [3].

Therefore, the use of VMware Workstation virtualization technology for our teachers' information management education training and school management can very effectively and quickly help keep up with the pace of changing teaching and learning, improve the level of modern management practices and research level of school teachers, and promote our country's multi-level higher education and high-level development of research universities. The modernization of the teaching staff, the improvement of service satisfaction with society and people from all walks of life further contribute to the improvement of the level of theoretical and scientific research capabilities of future teachers of our universities, the cultivation of the professional and comprehensive quality of our students' talents, and the high-quality development of China.

2. Research Background

Foreign countries had an early start in studying the management and education of teachers. American scholar Burton Clark focused on the academic characteristics of colleges and universities and the rules of academic management of college and university organizations in his book "Higher Education System: A Cross-National Study of Academic Organizations." Li pointed out the feasibility of faculty participation in academic management, which is conducive to motivating faculty members' work and can stimulate faculty ownership" [4]. Hamed et al. believe that teachers' own qualities and professionalism can participate in the management of the school and make it develop in a good and healthy direction, which cannot be achieved by other people [5]. Birnbaum (R), in his book "The University Operating Model", presents a view of the organizational model of college operations, the view of the organizational sector of college operations, for the members of the university, the values of equality and fair authority should be the first priority for all direct participants in the decision-making body of the university, this is because the fish than the external members, it is more concerned with the development of the university itself [6]. Therefore, this fair view of authority and a strong sense of responsibility make the universities run in a healthy and orderly way. As mentioned in the book: Shared governance is both a concept and a form of management. Yang and Kuruva have successively pointed out that the tenure system severely restricts and hinders the recruitment of teachers and free internal mobility of the state workforce in the country's colleges and universities, undermines the normal educational model of society in which students are educated for continuous personal career development, exacerbates the bureaucracy that contributes to the education of some colleges and universities, and is not conducive to the creative expression of teachers outside the system [7]. There are both internal and external reasons for the tenure system reform. After the 1970s, a system of tenure evaluation began to emerge as a way to promote effective development of the teaching profession, a formative evaluation that treats teachers in a developmental manner and compensates for ineffective performance [8]. A rational model would be for institutional leaders to review tenure or other alternatives to tenure and then rationally choose the appropriate institutional hiring policy." This post-tenure review of the tenure system evaluation process ensures the accuracy of peer evaluation and is appropriate for performance evaluation. A major research objective of this peer review approach is also to assess the academic performance of faculty work, to promote the healthy development of young faculty levels, and to require a necessary aspect of progress in the tenure-track faculty.

The domestic study started late, but progressed fast enough to keep up with the rapid development of higher education in China. By comparing the academic management of universities in China and the United States, Rongpointed out that academic management of universities is closely related to government departments and society, and put forward the idea of academic management innovation by combining the operation of academic management and different cultural backgrounds [9]. He pointed out that, as far as the internal relationship of universities is concerned, teachers are the core of university academic management. Yanlun and Huanyangpointed out in the article "Reflections on the Ethical Construction of Academic Management System of Universities": the important role of ethical construction in the academic management system of universities includes bottom-line ethics, responsibility ethics, transaction ethics, and credit ethics; cooperation ethics and sharing ethics, value ethics, and identity ethics constitute the connotation and characteristics of the ethics of the academic management system of universities [10]. The establishment of the academic management system in colleges and universities needs to be based on ethics and morality, improve the system construction related to academic ethics in colleges and universities, and strengthen the status and role of institutional ethics. In addition, Yuanxi and Xiangyangintroduced these five basic stages of the development of the new policy of faculty salary management in Chinese universities implemented in China for more than 60 years: the foundation and adjustment period, the tortuous and turbulent period, the recovery and development period, the reform initiation period, and the reform deepening period, respectively, in their article "Analysis of faculty management policies in Chinese universities" [11]. Two kinds of thinking are proposed: "The identity of state university teachers is "state cadres," which does not reflect the special characteristics of university teachers, and also tends to lead to "officialdom," which allows teachers to be not very precise, and schools encourage teachers to "work," which is not conducive to the development of academics and teaching. The formulation of university teachers' policies should fully reflect the "academic characteristics." In addition, the macroscopic openness of the implementation of university teachers' policies is not sufficiently grasped, the implementation guarantee is not enough, and the overall scientific understanding of the construction of the evaluation index system is not enough, which affects and restricts the assessment of the scientificity, feasibility level, and economic effectiveness of the policies. The author Yiqun has written in the introduction of an article entitled "The Dilemma and the Way Out of the Tenured Professor System in American Universities" that since the late 1990s of the 20th century in the United States, American and other social institutions and domestic academic circles have put forward many critical views and strong questions about the reform of the tenured university professor system in China, and some domestic universities have tried to replace the tenured professor system in the United States with a fixed contract, arguing that China's tenure-track professorship system is inefficient and tends to create lax and lazy thinking among teachers, which is not conducive to attracting outstanding talents to the academic career [12]. In this article, the author of "The Dilemma of the Tenured Professorship," Liu, points out that although the tenured professorship has been questioned since the 1990s, hindering faculty innovation in academia, and many other shortcomings, professors are concerned about the diversity of schools and are less susceptible to changes that would promote school reform in a more effective way [13]. The authors point out that the life of the university lies in debate, and only the outspokenness of professors makes the school face its own shortcomings and deficiencies, and the professorial system needs to be protected and free to express their opinions rather than punish, so the tenured professorship serves to protect professors and thus academic freedom."

3. Materials and Methods

3.1. Basic Theory

3.1.1. Management of Teaching in Colleges and Universities. The management responsibilities of teaching in Chinese universities are closely related to the academic level of teaching. Teaching organization in higher education is generally different from the general disciplinary organization in higher education, which is a professional and technical organization mainly composed of academic personnel related to each profession and so on [14]. The characteristics of modern university organization based on the view of modern academic profession's subject status can be reflected in at least the following characteristics: disciplinary division of labor is the common organizational basis for the existence of all academic professions, loose disciplinary combination approach is the common organizational structure characteristic of all academic professions, and the dual management authority model is the main dual organizational and management structure characteristic of modern academic professions. From the perspective of the development of contemporary academic professional norms, university teaching and its administration should have several basic normative features such as more strict and systematic modern academic standards, autonomy of academic process, freedom of academic activities, recognition of academic achievements, and recognition of personal reputation. Both the management of teaching and the reform of institutional structure are very important components and parts of the administrative management and reform work of teaching in Chinese universities. The system should be institutionally prescriptive and can be closely connected with the practice of knowledge concepts in the corresponding field of teaching [15]. Therefore, an important first step in the system design and innovation of university teaching administration is to establish a human-oriented modern system concept of teaching science, i.e., to establish a "humanized" concept system and to practice the "academic standard" education concept and then to run through the whole process of guiding the system reform and innovation of internal management of university teaching [16]. The further establishment, exploration, and implementation of the innovation system of teaching classification management in colleges and universities must be based on the actual basic situation of the reform of the teaching team in our country, and also widely learn from the international advanced reform experience of international teaching separation management innovation. Therefore, after the innovation of the reform basis to be on the overall principle of dynamic reform and reform and opening up closely, fairness, democracy, competition, and interests, step by step, the theoretical innovation of the new system of university teaching separation management in China must also adhere to the principle of people-oriented, autonomy and freedom, scientific management, and so on [17].

In order to better strengthen the modernization of the quality of the university teaching team, as well as to cooperate with the further smooth and effective implementation of China's education policy "science and education to develop the country, talent to strengthen the country" program, universities in China have implemented a relatively strict and unified high school teaching qualification appointment methods, and teaching and the management assessment system. There is a strict process of teaching appointment, and the qualified candidates are finally incorporated into the teaching system, the specific process is shown in the figure, there are 8 steps, which basically ensures the basic level of our teaching team, as shown in Figure 1.

In the teaching assessment, before the assessment of teaching, the school usually organizes a meeting to promote the assessment, prints and distributes the teaching assessment methods to teaching individuals. After receiving the assessment method, teaching should summarize teaching's thoughts, attitudes and responsibilities in the work, fill in information such as scientific achievements and awards in the work, and submit a work report to the management. The department will evaluate teaching according to its individual situation and submit it to the school and academic department for review. The school and the academic department will grade and evaluate the work and political thoughts of the teaching individuals. The final overall grade of teaching will be derived and reported to the school for acceptance. The assessment mainly includes teaching's ideology, knowledge, business ability, and work performance.

Although the standard of our teaching assessment is relatively backward, it has served the cause of higher education in China for more than 40 years, and after continuous historical evolution, it has also basically adapted to the basic national conditions of China and made indelible contributions to higher education in China. The teaching assessment process of higher education in China is shown in the figure, with a total of 6 links, as shown in Figure 2.

3.1.2. Data Collection. The big data management system utilized today can not only store a large amount of data and form a large amount of the data storage network system, but also analyze and process data extremely fast [18]. Big data management systems are all about analyzing and processing a wide variety of data with reasonable use of media such as computers and networks. It is becoming more and more popular in various aspects of life with fast and convenient digital information transmission and processing, bringing a great degree of information convenience to people's future study and life, updating people's traditional view of data management, providing a more innovative and convenient way to store and process complicated data, and greatly improving people's work efficiency. Big data management system has four main features, such as large storage volume, rapid information processing, real and effective data results, and a wide variety of data types, as shown in Figure 3.

3.2. Research Methodology

3.2.1. VMware Workstation Virtualization Technology. VMware Workstation is a powerful desktop virtualization software that provides users with the best solution for developing, testing, and deploying new applications while running different operating systems on a single desktop. VMware Workstation simulates a complete network environment on a physical machine and a portable virtual machine providing greater flexibility and advanced technology than any other virtual computing software on the market. For enterprise IT developers and system administrators, VMware's features in virtual networking, real-time snapshots, drag-and-drop shared folders, and PXE support make it an essential tool [19].

VMware Workstation software enables user self-service access to cloud and Windows application behaviors, easily accomplishing permission management for new employees. Easy permission management for new applications and new employees. Employees will have a single-touch, one-time login to mobile devices via the industry's first patent-pending secure app token systems (SATS) technology, establishing credit between the user, the device, the enterprise, and the cloud. Once authenticated, employees will immediately gain access to a personalized library of enterprise apps, ordering virtually any mobile, cloud, or Windows app.

Flexible device choice: whether it is a bring-your-own-device or enterprise-owned device, leverage mobile operating systems (iOS, Android, and Windows 10) to manage laptop, smartphone, and tablet configurations and interfaces for instant enterprise use with a new self-service, all-in-one management platform and off-the-shelf device configurations. Employees will be able to control their own mobile devices and choose the level of service and IT restrictions they are comfortable with, thereby increasing mobile workforce penetration and productivity and reducing the risk of data loss.

Secure use of e-mail, calendar, content, and chat applications, employees want to be able to use enterprise mobile apps just like consumer apps. VMware Workspace ONE will support consumer-grade ease of use for e-mail, calendar, contact, content, and chat applications, while invisible security measures will protect the enterprise from data breaches. In addition, Workspace ONE will embed swipe and touch capabilities and integrate with web applications such as Evernote, Gmail, and Yahoo! Mail, and third-party SaaS applications such as Atlassian Jira, GitHub, and Jenkins, allowing developer operations teams to operate and respond from anywhere.

Data security and conditional access security checks. To protect the most sensitive information, VMware Workspace ONE seamlessly integrates identity management, device management, and the industry's first-ever compliance check conditional access to enforce access decisions across any application or device. The approach builds on traditional authentication policies (such as authentication strength and network services) conditionally and adds device compliance policies including GPS location, application whitelisting/blacklisting, and third-party plug-ins from AirWatch mobile security alliance partners. At the same time, the AirWatch compliance engine can fix compliance issues through a series of customizable, automated workflows to ensure greater scale, and higher security.

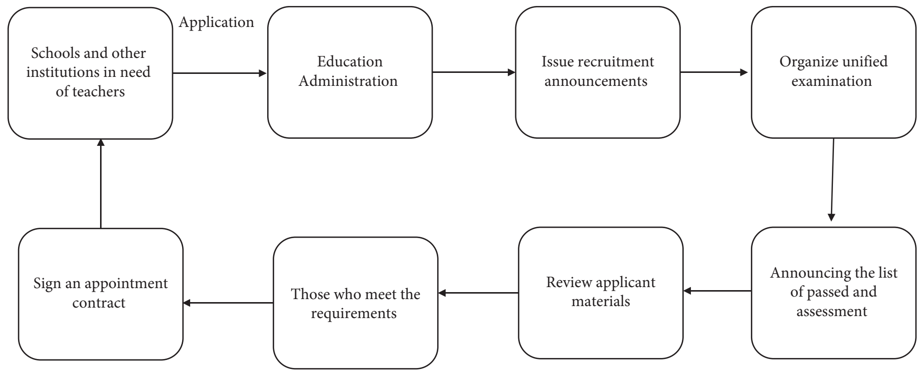

Figure 1: Flow chart of teaching appointment.

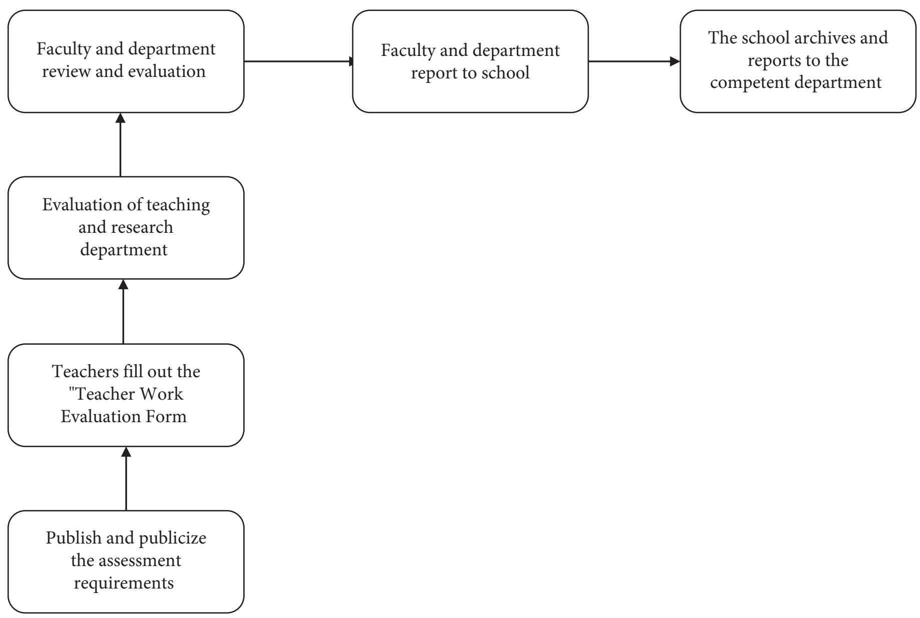

Figure 2: Flow chart of teaching assessment in higher education in China.

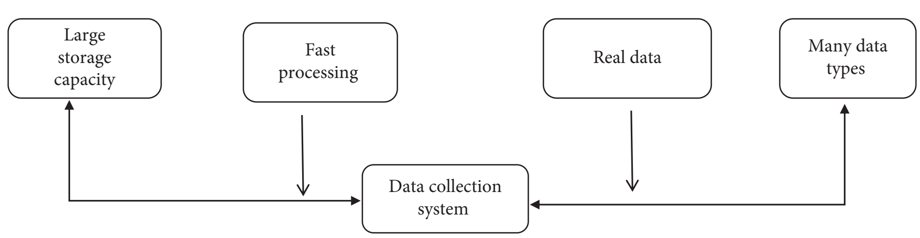

Figure 3: Characteristics of the data collection system.

VMware Workstation has the following features: (1) use Unity to integrate clients with hosts. (2) More robust VM recording and playback capabilities. (3) Support for smart cards and associated card readers. (4) Enhanced ACE. (5) Improved 3D graphics support, as shown in Figure 4.

3.2.2. SQLServer Database Management Methods. Based on today's mainstream Windows and other operating system platforms, SQLSever databases are rapidly becoming widely accepted as a new generation of database and analysis processing platform software by enterprise customers. Unlike other current database platforms, such as FoxPro, and smaller databases, such as Access database, SQLServer has a complete set of powerful and easy-to-use database management and service processing functions. There are engines that support development, standard database languages, such as SQL, and extended feature functionality (such as replication, OLAP, and analytics). It is also significantly ahead of the rest of the market in terms of other key features that only large database software can have to [20], such as stored procedures and triggers.

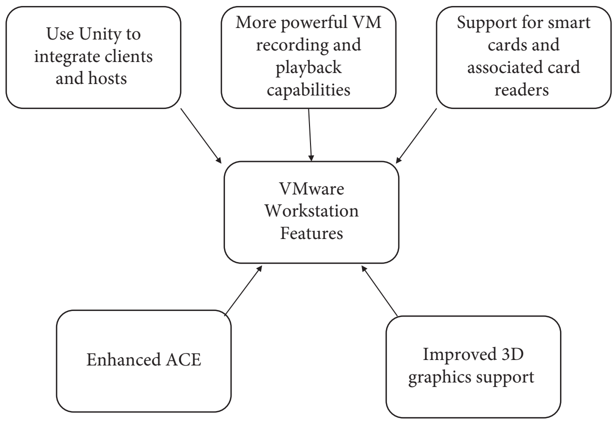

Figure 4: VMware workstation features.

Microsoft SQLserver2010 is based on Microsoft SQL server 7.0, greatly extended to increase database performance, reliability, quality management, and ease of use. Microsoft SQLserver2010 database edition is an enterprise relational database management system with high performance, high reliability, and ease of use.

Therefore, in this paper, SQLserver2010 is selected for big data analysis to analyze the innovative application of the teacher education management system.

3.2.3. Main Evaluation Method. To analyze the data collection and visualization application of VMware Workstation virtualization technology in university teaching management, efficient use of big data for education and management of university teachers requires comprehensive use of various analysis methods to quantify specific indicators of teachers, specifically see the strengths and weaknesses of teachers, and better manage and educate the teaching team, so this paper introduces the comprehensive evaluation index of teachers. The following is the formula for calculating the comprehensive teacher evaluation index, the higher the index value, the higher the evaluation and ability of teachers.

In the unsupervised learning part, the data are clustered by using clustering algorithms such as K-means to obtain the centroids of the radial basis function in the implicit layer, and then the width vector of the radial basis function is calculated by using the centroid information, and is calculated by the following formula:

$$\sigma_j = \frac{c_{xy}}{\sqrt{2h}}, \tag{1}$$

where c_{xy} is the maximum distance before the centroid and h is the number of nodes.

After that, the input data are scattered through the implicit layer and the output layer, respectively, and the output of x_i the first node of j the input sample in the implicit layer is calculated by the following equation:

$$\phi(x_i, j) = \exp\left(-\frac{1}{2\sigma_j^2}x_i - c_i\right), \tag{2}$$

where c_j and σ_j are the centroid and width m vector of the first node in the hidden layer, respectively.

The output x_i of the input j sample at the first node of the output layer (3) is calculated by

$$y_m = \varphi(\phi(x_i, j) * w_m), \tag{3}$$

where w_m is the weight of that φ node and is the activation function.

In the supervised learning part, it is mainly the process of continuously correcting the parameters in each layer, and this process is mainly calculated by the error function to calculate the gradient value of each parameter, and then the parameters are continuously corrected using traditional gradient descent methods, such as stochastic gradient descent (SGD), taking the weights used for linear calculation in the output layer as an example, the update formula is as follows:

$$w_t = w_{t-1} - u * \frac{\sigma E}{\sigma w_{t-1}}, \tag{4}$$

where E is the error function and u is the learning rate.

The higher the value of the radial-based teacher comprehensive evaluation neural network index indicates the higher the evaluation and competence of the teacher. In addition to the above method, the centroids and width vectors of the hidden layer can be directly generated randomly, after which they are updated according to the gradient correction formula of the supervised learning process.

4. Results and Discussion

4.1. Current Status and Results of the Study. In this study, based on collecting data from multiple departments such as the Ministry of Education and the National Bureau of Statistics, and finding relevant statistical yearbooks as reference, the results of this study were obtained by using VMware Workstation virtualization technology and SQLServer to dynamically process the relevant data, and analyzing the changes of some data for up to 21 years and 6 years, respectively.

In the 20 years from 2000 to 2020, the ratio of male to female teachers and the ratio of master to doctor in China's colleges and universities showed a decreasing trend year by year, although teachers with an undergraduate degree or below were not considered, it was enough to show the trend that the ratio of male to female teachers in China's colleges and universities was gradually balanced as well as the gradual improvement of teachers' education, which further showed that the teachers in China's colleges and universities were gradually balanced and the comprehensive quality of teachers was continuously improved, as shown in Figure 5.

In the span of 20 years from 2000 to 2020, foreign teachers and minority teachers in China also show a trend of increasing year by year. It not only shows that the increasing development level of China attracts more foreign teachers and other high-level talents, but also shows the determination of poverty alleviation identified in China and the practical implementation of minority

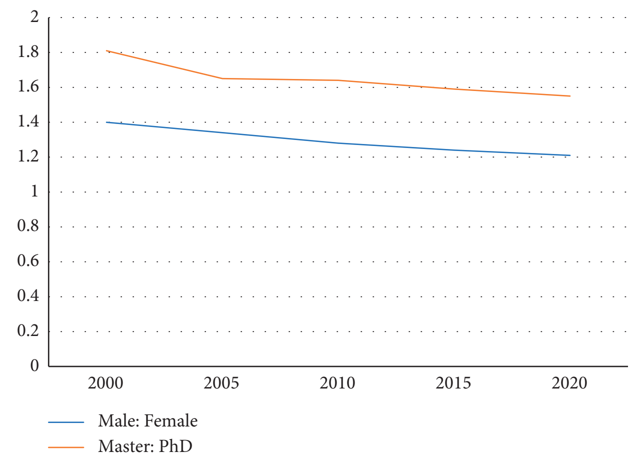

FIGURE 5: Changes of the gender ratio and the master's degree ratio of teachers in colleges and universities in China.

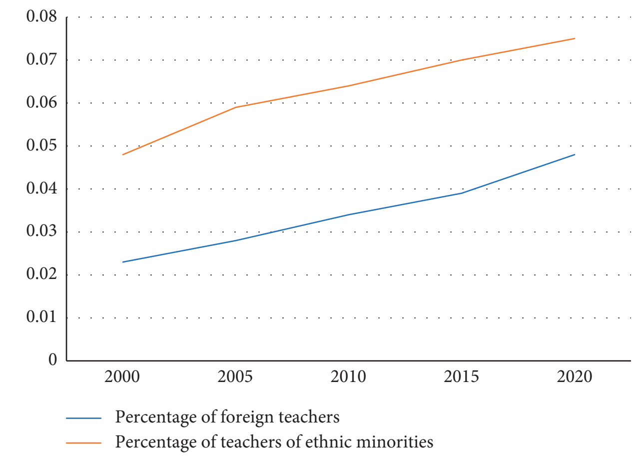

FIGURE 6: Changes in the proportion of foreign and minority teachers.

development policies. More importantly, exchanges with foreign scholars are more common and the academic atmosphere is more open; minority scholars also enrich the fields and perspectives of academic research, as shown in Figure 6.

The total proportion of all types of teachers in one of our institutions is higher. Other research institutions have the lowest proportion of all types of teachers, whether it is a bachelor's degree or independent college, high school, or other research institutions, the structure of teachers' titles shows a relatively normal distribution structure of middle and low on both sides. The distribution of teachers at all levels in China is more balanced. In addition, the structure of teachers in China shows a distribution of the highest percentage of undergraduates; the second highest percentage of senior high schools; independent colleges; and other research institutions are less. Basically, it has adapted to the rapid growth of China's development situation, as shown in Figure 7.

The comprehensive evaluation index of teachers in colleges and universities in China shows a trend of increasing year by year. The radial basis teacher comprehensive evaluation neural network index mainly processes the input data from two parts, which are supervised learning and unsupervised learning, and in the unsupervised learning part, the data are clustered by using clustering algorithms such as K-means, so as to obtain the centroid of the radial basis function in the implicit layer, and then the width vector of the radial basis function is calculated by using centroid information, and finally the comprehensive evaluation index of teachers. It can be seen that the comprehensive quality of teachers in China has been improving, the system of education and research in China's universities has been improving, and the ecological management system of universities has been improving, as shown in Figure 8.

4.2. Discussion of Data Collection and Visualization Application in Teaching Management of Colleges and Universities

4.2.1. Improving Academic Standards and Establishing a Professional Access Qualification System. Teachers in higher education continue to engage in the academic profession of teaching firstly need that students have undergone long-term solid training in theoretical knowledge and technical professional quality of this academic discipline, and have a fairly certain high theoretical academic quality foundation and potential academic research development growth potential. Therefore, an improved system of access and qualifications for the education profession should be established to fully ensure the comprehensive overall quality of our teaching population.

(1) To improve the qualification standards for practitioners in accordance with the law and strengthen the qualification legislation for access to the education profession. The revision of the professional qualification standards for teachers in colleges and universities should focus on clarifying their corresponding academic conditions and professional ethical and moral conduct requirements, highlighting in the assessment that they have the basis of disciplinary professional competence and the ability to teach and research in their disciplines, improving the accreditation standards for the admission of relevant academic professionals, and ensuring the overall quality of knowledge of the general group of teachers in colleges and universities. At the same time, three different levels of professional qualification standards have been formulated and promulgated according to the needs of different historical regions, different academic types of colleges and universities, and different levels of ability development of students trained by teachers of different national academic career ladders in China. The construction of the higher education teacher qualification system is an important strategic

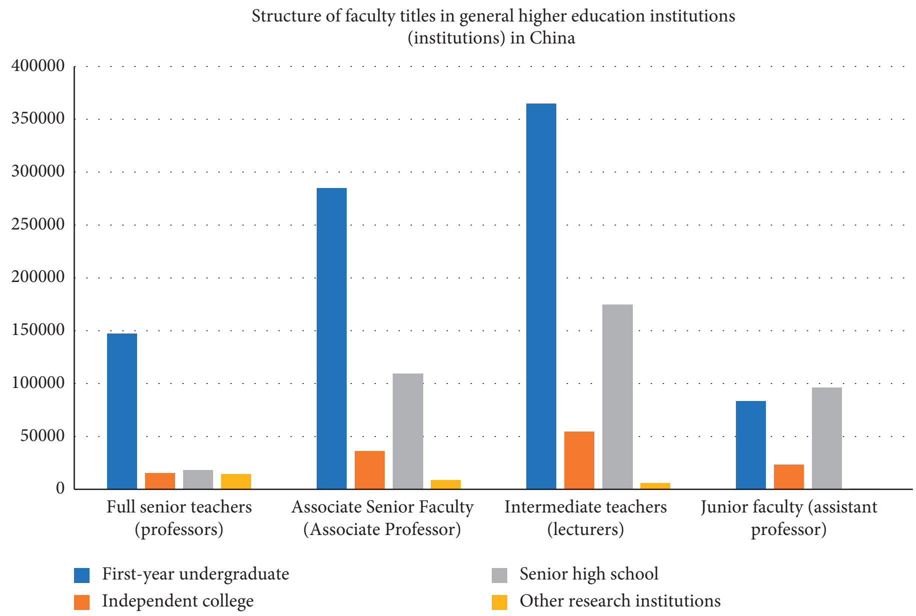

Figure 7: Structure of teachers' titles in China's general higher source schools (institutions).

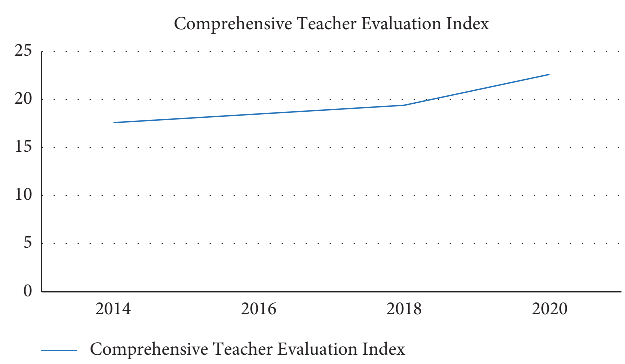

Figure 8: Changes of the teachers' comprehensive evaluation index.

component of the work to establish a national professional qualification system with national legal norms, and the implementation of the school teacher qualification system certification is an important part of the work to implement the principle of unified state management of education in accordance with the law.

(2) To study the establishment of a multi-level, time-sensitive, and highly operable accreditation standard system for relevant vocational qualification levels and the establishment of provincial vocational qualification accreditation and implementation certification bodies. Based on the actual need situation of meeting the needs of individual lifelong development of the academic career and the value concept of pursuing comprehensive lifelong development education of academic career, a multi-level, current and effective system of academic career qualification, and certification professional standards is established. Therefore, it is recommended to gradually establish academic career and certification professional standards covering several minimum levels above the college teaching career, and use these minimum levels as the core qualification standards for evaluating academic career talents. At the same time, a system of regular and certified assessment and evaluation of teaching qualifications at all levels should be established, and examinations should be set for students at each level according to the level of teaching qualifications valid once (e.g., every five years). In the study validity period, you must pass the corresponding course assessment of the corresponding next level of the education qualification training certification level standard by obtaining a certificate of experience and study results of teaching and continuous learning education training of a certain scale, and pass the corresponding course assessment of the corresponding next level of the education qualification training certification level as required, in order to successfully obtain the education continuing training teaching practice qualification. In this way, the level of development between the dual standards of qualification and certification can be mutually permeable and integrated, guiding teachers and the community to encourage in-service teachers to carry out continuing in-service learning, indicating the right direction for the in-service professional and technical development and upgrading of China's teachers, in an effort to effectively ensure the improvement of the overall quality of teachers nationwide.

4.2.2. Following Academic Freedom and Equality, and Improveing the Teacher Appointment System. The management of teacher appointment system is one of the several major administrative links stipulated in the formulation of the basic system of teacher recruitment management in colleges and universities. Researchers in colleges and universities should adhere to the basic characteristics of the academic career ability of college teachers, adhere to the employment principles of following academic evaluation and free flow and peaceful flow, and optimize and improve the work system of appointing college teachers to positions.

(1) To establish a system of career "admission period" and improve the job management system. Academic career is a special profession with its own special requirements. The construction of teachers in colleges and universities is a process of "selection" and "optimization," and a reasonable "admission period" should be set. For example, "fixed-term" appointments and "open-ended" appointments should be used as the institutional design. The setting of "entry period" of university teachers should pay attention to the following points: firstly, to establish reasonable "entry period," secondly, to provide professional development and equal competition opportunities for the "entry" group; thirdly, to implement peer academic review and "developmental evaluation" in the "admission" stage; fourthly, there should be corresponding regulations for the "appointment period" to protect the legitimate rights and interests of university teachers. The purpose of post-management is to optimize the structure of university teachers, promote reasonable flow of academic career, and promote academic prosperity and development. According to the overall planning of the university and disciplines, the strategy of classifying posts and management is appropriately implemented so that teachers' duties are clear, each has its own role and the academic performance is maximized and most effective.

(2) The system of appointing teachers for employment positions in colleges and universities, which is flexible and effective in various forms, has been categorized and standardized and perfected. First, the flexible and efficient diverse types of appointment teacher positions employment position system established for all types of colleges and universities of different professional types of schools in China. In the overall design work of the appointment system, three different levels of assessment and evaluation standards and two types of appointment should be used at the same time. In order to fully promote the development of diversified academic heterogeneous research and professional diversified research of teachers' work in higher education institutions, and to promote the diversified characteristic academic development of various types of university research, various different types of academic career ladders responding to the diversified development characteristics of the teaching profession in China should be created by adopting some different and flexible cooperative approaches. Secondly, an effective labor contract system that effectively guarantees the equal development of academic interests of faculty members should be established to improve academic productivity. According to some characteristics that exist in the academic career characteristics of higher education itself, the signing of employment staff contracts by university teachers should also take two forms of signing collective contract statutes and labor contract forms, respectively, to clarify the division of rights and obligations of each school staff and the various rights of the individual teachers employed, to gradually promote the realization of real equality of status between the rights and obligations of the two cooperating parties, and to ensure legality and reasonableness when signing labor dispatch contracts.

4.2.3. Adhering to the Principle of Academic Fairness and Optimizing the Evaluation System of Teachers. The evaluation system of teachers in higher education should take the promotion of teachers' academic career development and teachers' self-fulfillment as the ultimate goal of evaluation. Therefore, in order to promote the development of teachers and the academic career, it is necessary to adhere to the principles of academic fairness and freedom to optimize the evaluation system of teachers in colleges and universities.

(1) To scientifically establish the evaluation system of educational assessment to promote the overall development of their academic careers. Teachers in colleges and universities must engage in academic work of higher education mainly according to the law, and the principle of academic evaluation freedom is its fundamental internal operation logic. The scientific establishment of the evaluation system standards of teachers' titles must all take into account the specific characteristics of academic career personnel training in colleges and universities, and follow the evaluation principle of free and standardized educational academic work. On the one hand, to create a scientific, harmonious, and fair environment atmosphere for academic education evaluation of university teachers, reflecting social humanistic care. On the other hand, it is necessary to gradually change the concept of traditional evaluation indexes and adopt the method of the comprehensive developmental evaluation index system. High evaluation recognizes the value of teachers' academics and their creation, boldly advocates encouraging the innovative practice of academic achievements and academic creation of university teachers, and pays attention to the direction of development and progress that teachers' academic potential excavation and education may bring in the future; however, at the same time, attention should be paid to consider the principle provisions and

relative flexibility of the policy of talent evaluation work, so that high-level outstanding innovative talents are fully cultivated freely and fully healthy. However, at the same time, we should take into account the principles and relative flexibility of the talent evaluation process, so that high-level innovative talents can be cultivated freely and healthily, and the innovative humanistic concept of "teacher-oriented" projects can be implemented effectively. To establish a system of evaluation and assessment of university professors' titles with the assessment of professors' academic and professional reputation as the leading index.

(2) To actively establish a multidisciplinary academic position evaluation standard system for high-level teachers. The main work assigned to teachers in colleges and universities mostly involves major academic affairs such as teaching, scientific research, and social public service undertakings in colleges and universities. The evaluation results of academic ability are two important objective indicators used to measure the effectiveness of professional construction of a college teacher team and the effectiveness of improving the level of teaching or scientific research development. Therefore, it will be particularly necessary to establish a more diversified and scientific high-level academic level evaluation system, to respect the individual differences in knowledge of the majority of university teachers' groups, and to fully evaluate the level of reasonable individual needs that meet the development of each highly qualified teacher. The second feature is to emphasize students' participation in all-round, multi-faceted and comprehensive assessment, and to integrate the whole set of information systems formed by the university, including their self-perception assessment, student quality assessment, peer quality assessment, and assessment in connection with other academic groups. The final evaluation results of the final evaluation by teachers and students are integrated together, and the scientific fairness and accuracy of evaluation information are ensured by the feedback results of professional information from multiple perspectives of students.

4.2.4. Based on the Characteristics of Academic Profession, Innovative Incentive Mechanism for College Teachers. The design of incentive mechanism is one of the three important practical content links of performance management practice for teachers in colleges and universities in China. Researchers in colleges and universities should be able to innovate various incentive mechanisms for the work of college teachers based on certain intrinsic spiritual motivation characteristics of teachers' academic career pursuits, so as to promote high-level academic moral innovation enhancement and healthy professional development of college teachers in China.

(1) It is necessary to strengthen the internal cultural motivation of the main body of cultivating academic professional culture and create a long-term incentive mechanism for cohesion of academic group wisdom. As another special academic profession, competition, reputation, and group honor also constitute an important internal and external incentive mechanism for this academic professional behavior. The analysis of the working group on the internal distribution of income in colleges and universities found that the first thing that should be taken into consideration when assigning staff to work in local colleges and universities is not performance pay and salary and benefits, but the nature of the work and the local academic atmosphere. The research on incentive mechanism of innovative research teachers in colleges and universities should be more based on the characteristics of internal incentive methods of academic professional managers' own behaviors, insisting on the combination of internal material factor incentive as the main and internal spiritual factor incentive, the combination of material and spiritual principle incentive, the combination of school internal factor incentive principle and the college external factor incentive method, the combination of school internal factor incentive principle, the combination of school positive incentive means, and internal negative factors motivation methods combined, with external positive motivation methods as the main ones, to maximize the reasonable guidance to stimulate the subjective enthusiasm and independent creativity of young teachers' innovation and promote high-level academic innovation.

(2) To pay attention to create a university culture atmosphere with the spirit of academic service first and pay attention to the academic humanistic power of promoting academic career innovation. As a national academic organization, the university research association has relatively strong and unique characteristics of university culture. First, it actively discards some old academic culture systems that are not conducive to the development and improvement of young teachers' academic career ability: it discards the traditional incentive mechanism that "seniorization of government and academia" can independently nurture college teachers, establishes a scientific incentive mechanism that is really suitable for the actual needs of academic professional development of college teachers and matches the needs of self-sustainable development, and correctly and reasonably. The reform of the negative academic moral incentive tendency based on the existing academic value standard of anti-monetarism, materialism, and academic utilitarianism enriches the theoretical content and application of academic social incentive theory; the reform of the administrative system to effectively control and eliminate the

tendency of academic moral "relationship" and abuse of "rent-seeking," such as academic status power. The reform has effectively controlled and eliminated the tendency of academic ethics "relationship" and the abuse of academic status and power and other "rent-seeking" phenomena, and ensured the fairness of academic ethics in society. Rent-seeking is a common theory in economics and sociology. Generally speaking, it is the act of bribing government officials to obtain monopoly status and monopoly income by virtue of the privilege granted by the government.

4.2.5. Creating a System of University Faculty Development for Academic Career Development. The teacher CPD evaluation system is also one of the two main core content items of the teacher training management application system research. The reform of the system of continuous development of teachers in colleges and universities should be aimed at effectively promoting the comprehensive development of contemporary college teachers' academic careers into success and their personal self-development ability as an important goal.

(1) To gradually form a flexible and diverse effective higher education professional literacy development planning system and promote the development of Chinese teachers' professional quality toward legalization. The basic composition system of higher education teachers' talents is extremely complex and large, and the development status of each type of individual university teachers' main professional fields is significantly different in degree. Therefore, each university in different teaching type backgrounds should also have a system of policies for the development of high-level teacher professionalism of different degrees. Such as the establishment of an open, flexible, diverse, and efficient mentor training mentor system, a flexible and diversified system of university-enterprise cooperation talent development programs, academic norms, a system of lifelong education development planning, and the construction of an academic sabbatical system. At the same time, according to the actual characteristics of various types of college teachers in different historical academic career stages of development, free professional training, further training, academic experience exchange seminars, and other training opportunities are provided for college teachers at all levels to meet the needs of their own educational professional development orientation and actual academic position development planning. The process of legalization of the development of higher education teachers' positions is an important legal sign of the results of the construction of the professional path of higher education teachers. The main guidelines that should be followed through administrative legislation to guarantee the in-depth implementation of the strategy of professional development of highly qualified teachers are the relevant mandatory legal norms and government normative laws.

(2) To accelerate the construction of a new framework system of institutional development of teachers that is conducive to promoting the development of academic talents under the core objective of maximizing their professional specialties. College teachers themselves are to engage in a variety of academic career forms, and their educational careers and their development should be through a relatively lifelong and continuous evolutionary process. In short, the policy system of university teachers' management development should also take the promotion of academic career development and professional education development reform as an important goal to help young teachers better realize academic self-actualization. In the context of internationalization, popularization, and marketization of higher education, the administrative management of university teachers is facing a lot of serious problems and challenges in the new situation, which naturally requires us to strengthen the forward-looking research on the innovation and development of the reform mechanism and related system for the management and development of teachers.

5. Conclusion

In this study on the data collection and visualization application of VMware Workstation virtualization technology in university teaching management, data processing is carried out by the SQLServer database processor using VMware Workstation virtualization technology, and finally the radial-based teaching comprehensive evaluation neural network index is used to calculate the teaching management quality to conclude that China's teaching The team is gradually balanced and the comprehensive quality of teaching team is improving; the academic atmosphere is more open; the fields and perspectives of academic research are richer; the distribution of teaching at all levels in China is more balanced the comprehensive quality of teaching in China is improving, the system of education and scientific research in China's colleges and universities is improving, and the ecological management system of colleges and universities is improving. Conclusions include

(1) Improving academic level and establishing professional access qualification system

Teaching in colleges and universities to continue to engage in teaching academic careers first requires students to have gone through long-term solid theoretical knowledge of this academic discipline and technical professional practice training, with a fairly certain high level of humanistic academic quality foundation and potential academic professional development potential. Therefore, a perfect education career teaching access and qualification system should be established to fully guarantee the overall professional quality of professional teaching staff to improve qualification standards and strengthen legislation on professional access and qualifications, to establish and improve a multi-level and more timely national professional qualification and certification standard system, and to set up a professional qualification implementation agency.

(2) Follow academic freedom and equality and improve the teaching appointment system

Teaching appointment system management is one of several major administrative links stipulated in the formulation of the basic system of teaching recruitment management in colleges and universities. The academic journal of colleges and universities should be able to adhere to the actual characteristics of the nature of our academic profession, adhere to the principles of basic academic freedom and equality and other employment principles, and optimize the system for the appointment of teaching titles in colleges and universities. The nature of academic profession is a legal profession of extremely special nature in China, with many requirements of its relative speciality. To establish and improve a flexible and diversified employment system for teaching in colleges and universities.

(3) Always adhere to the principle of implementing academic fairness and optimize the evaluation method system of teaching in colleges and universities

The evaluation system of teaching in colleges and universities should take the promotion of teaching academic career development and teaching self-fulfillment as the ultimate goal of evaluation. Therefore, in order to promote the development of teaching and academic career, it is necessary to adhere to the principle of academic fairness and freedom to optimize the evaluation system of teaching in colleges and universities, to establish an evaluation system to promote academic career development, to establish a multidisciplinary academic evaluation system for teaching.

(4) It is necessary to innovate and design the incentive mechanism for teaching in colleges and universities according to the own characteristics of academic career groups in colleges and universities

The design of incentive mechanism is one of the three important practice content links of teaching performance management practice in China's colleges and universities. How should the scientific researchers in colleges and universities innovate and construct the scientific incentive mechanism of teaching research in colleges and universities according to the intrinsic subjective motivation characteristics of teaching academic occupational features, so as to promote the innovative transformation of high-level academic values and promote the development of professional innovation in teaching research in Chinese colleges and universities. To strengthen the scientific internal motivation incentive for academic professionals and create an incentive mechanism for academic group innovation. To create a good cultural atmosphere where academic values are paramount and value the historical and humanistic environmental motivation for the flourishing of China's academic career.

(5) Establish a university teaching development system to promote academic career development

Teaching professional development evaluation system should be one of the three main research content systems developed by the university teaching academic management information system. The research system of professional development of teaching disciplines in colleges and universities should also take the construction goal of actively promoting the construction of professional development of teaching academic career and realizing self-development and innovation in contemporary colleges and universities. Formation of a system of teaching flexible and diverse changes in the development of professionalism of students, legitimizing the development of professional abilities of our teaching students. The system of standards for the development of teaching professionalism in China with the highest target requirement of professionalization of the academic career of teachers should be constructed.

Data Availability

The dataset is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Evaluation Method of Creative Dance Teaching Quality Based on Fuzzy Comprehensive Evaluation

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In order to improve the teaching quality of creative dance, this paper puts forward an evaluation method of creative dance teaching quality based on fuzzy comprehensive evaluation. On the basis of clarifying the evaluation criteria, the overall framework of the creative dance teaching quality evaluation system is given; the hardware part optimizes the design of the database and storage module of creative dance teaching-related materials, and the software part completes the quality evaluation of creative dance teaching through the fuzzy comprehensive evaluation method. Experiments show that the proposed method can effectively evaluate the quality of creative dance teaching; when collecting data, the resource discovery rate is high, and the data collection effect is better; the method has high data storage capacity, low rejection times, and good data storage performance.

1. Introduction

The creative dance education is different from traditional dance education. The traditional dance education mainly emphasizes "one move, one board, one eye," and pays more attention to the training of physical skills [1]. Creative dance stresses constantly change to stimulate thinking rotation, so that students do not mechanically imitate action shapes in class, but control their body movements through their own brains [2, 3]. Creative dance education is the dual development of students' body and wisdom. Teachers should patiently induce students' natural needs for creation and do not encourage students to pursue artistic results prematurely. Therefore, the relevant teaching evaluation methods have attracted extensive attention of scholars.

Reference [4] studies the dance teaching practice of preschool children under the concept of OBE. This method is based on students' dance teaching needs after taking office, from clarifying the direction of curriculum objectives, modifying traditional teaching content, extending teaching implementation methods, and broadening the level of teaching evaluation. It has trained preschool art teachers with comprehensive ability. This method improves the quality of dance teaching for preschool education students. Reference [5] aims at the current situation of dance teaching of preschool education specialty, from formulating the "dance curriculum goal" of preschool education specialty to transforming the core quality of dance subjects; adjust the dance curriculum structure based on core literacy and professional standards; vigorously strengthen the research and development of dance teaching materials for preschool education; establish the integrated dance course teaching mode of preschool education specialty; optimize the teaching methods of dance courses in preschool education; and establish a diversified assessment and evaluation system based on dance core literacy and professional standards; this paper puts forward teaching reform measures from the aspects of changing teaching ideas and improving the "professional" quality of dance teachers. The above two methods mainly focus on teaching reform and teaching mode innovation, and less on the evaluation content. Reference [6] established a multi-attribute fuzzy evaluation model of sports dance teaching quality based on fuzzy theory and gray system theory. Finally, it puts forward some suggestions to improve address quality of sports dance. Reference [7], based on Addie (analysis, design, development, implementation, and evaluation) development model, studied the evaluation method of dance learning effect in primary school based on multiple intelligences. Quantitative and qualitative data are used to verify the effectiveness of the method. The above methods realize the teaching evaluation, but the application of creative dance teaching quality evaluation needs to be further tested and analyzed. According to the comprehensive analysis of the above reference, the research content on dance teaching is mainly divided into two parts. One part mainly focuses on teaching and does not involve evaluation. The other part designs the evaluation content, but due to the particularity of creative dance teaching, the performance of the corresponding evaluation methods needs to be further tested.

The premise of fuzzy comprehensive evaluation is fuzzy mathematics. It belongs to a method of simulating the human brain to analyze fuzzy information. It has the function of multi-level evaluation [8]. It has obvious advantages in dealing with uncertain problems and effectively improves the objectivity and accuracy of evaluation results. In order to improve the interactivity and practicability of the evaluation, this paper designs a creative dance teaching quality evaluation system based on fuzzy comprehensive evaluation from two aspects of hardware and software. Finally, the effectiveness of this method is verified by performance test.

2. Design of Creative Dance Teaching Quality Evaluation System

2.1. Selection of Evaluation Criteria. Because the attributes of creative dance teaching are more complex, it needs to be handled very carefully when establishing the quality evaluation standard system of creative dance teaching. In order to scientifically evaluate the quality of creative dance teaching, the following principles should be observed when selecting standards:

(1) Leading type and representativeness: select the key factors that restrict the teaching quality from the numerous standards that interfere with creative dance teaching, and improve the simplicity and scientificity of the evaluation of creative dance teaching quality [9]. The selected standards also need to be representative, and they also need to be widely representative in different stages, so that the evaluation results can be compared with each other to provide basis for scientific decision-making.

(2) Desirability and practicability: the selection criteria not only need to be practical, but also need to be easy to obtain; that is, it is easy to capture data and conduct quantitative processing of data at the same time. The system does not need to be too large and simple to facilitate calculation and analysis, and the standards used need to be accepted by relevant departments and consistent with the standards of national statistical departments as far as possible.

(3) Objectivity and comprehensiveness [10]: the standard system needs to comprehensively reflect the quality of creative dance teaching, but it also needs to avoid less relevant and practical standards.

2.2. Overall System Architecture Design. According to the above evaluation criteria, a creative dance teaching quality evaluation system is constructed by using fuzzy comprehensive evaluation. The system structure is shown in Figure 1.

Use the database to collect relevant data of creative dance teaching. Collect and store the data related to the evaluation of creative dance teaching quality through the data access layer, which is responsible for providing the business entity layer with the data required for the evaluation of creative dance teaching quality, collecting the data related to the evaluation of creative dance teaching quality by using the data acquisition module, and storing the data required for the evaluation of creative dance teaching quality in the data storage module to improve the data access efficiency; build a data storage module according to HDFS file system [11] to store data related to the evaluation of creative dance teaching quality and improve the fault tolerance of data storage. The business entity layer is responsible for determining different business logics. The most critical modules are the system management module and the creative dance teaching quality evaluation management module. The system management module provides the evaluation index system for the creative dance teaching quality evaluation management module. The creative dance teaching quality evaluation management module completes the creative dance teaching quality evaluation through the fuzzy comprehensive evaluation method according to the evaluation index system. The business appearance and rule layer belong to the control layer [12], which is used to control the permissions of users at different levels to view the evaluation results and edit the corresponding business appearance and role permissions in different forms and control functions according to the attributes of each object. The user interface layer belongs to the view interface of the system and presents the evaluation results to users.

2.3. Hardware Module Design. According to the system structure of Figure 1, the hardware module is designed from the following aspects.

2.3.1. Data Storage Module. The data storage module is built according to the HDFS file system, and the specific architecture is shown in Figure 2.

The function of metadata server is to store metadata information of small files. If the file of the database is a small file, the file is stored in the data storage module according to the additional writing method, and the metadata information of the file is recorded in the metadata server. When the system needs to call the file, it can directly locate and read the metadata information according to the file, so as to improve the efficiency of data call; in the process of calling a file that

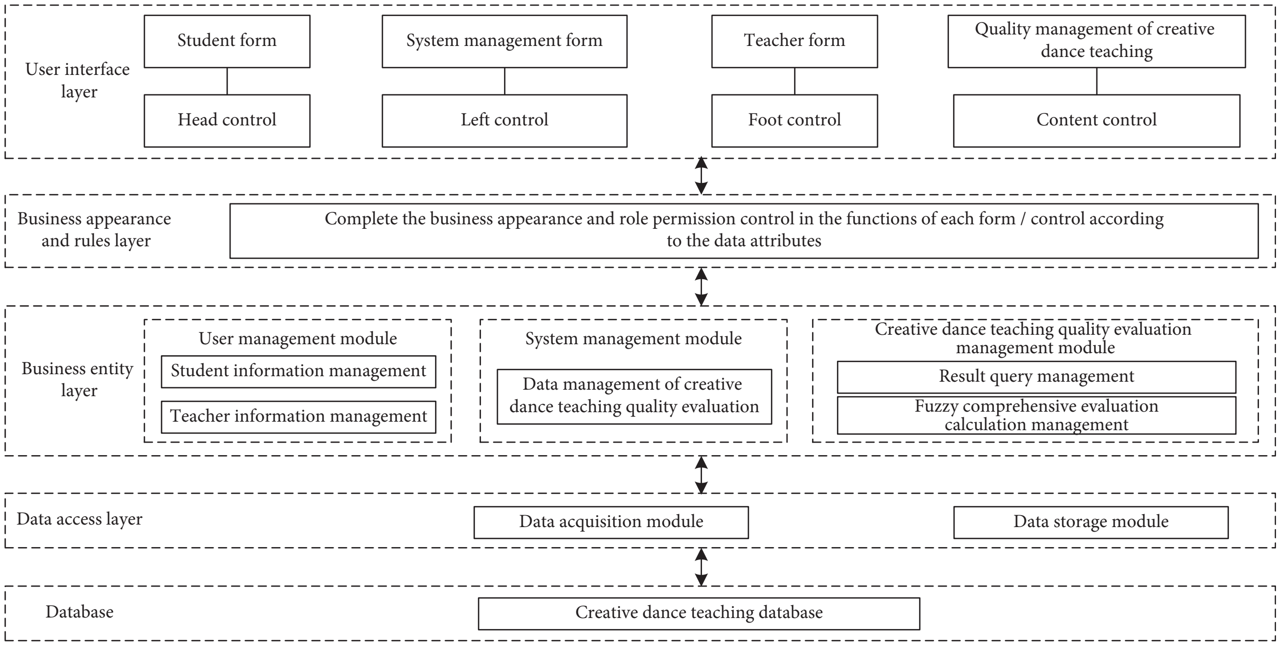

Figure 1: Structure of creative dance teaching quality evaluation system.

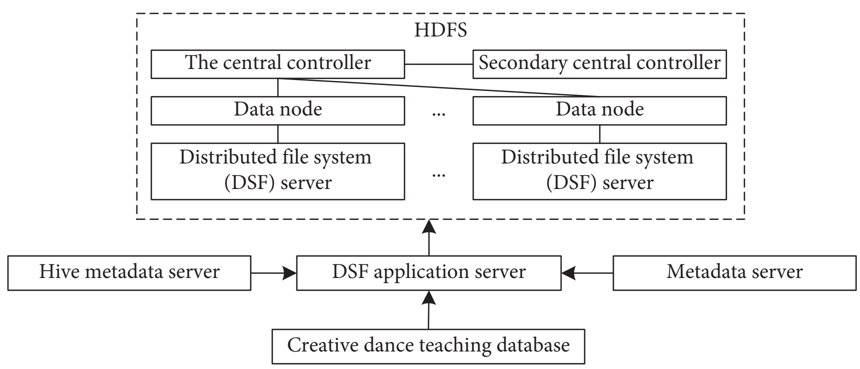

Figure 2: Data storage module architecture.

does not exceed the file block, the DSF server can directly go to the data node, which can directly transmit the call data for the business entity layer, reduce the pressure on the DSF server, and speed up the response time of the server. Hive metadata server is used to analyze the metadata information of hive table. It has the function of log analysis. The log analysis results are stored in the relational data and can be viewed by users. The function of the central controller is to manage and maintain all files in the data storage module [13]; the secondary central controller backs up the namespace image file in the central controller to improve the fault tolerance of data storage.

2.3.2. Database Design. The construction of the database is the data storage process of the key steps in the design and development cycle of the evaluation system. The data stored in the database [14] are the basic data of the overall structure of the evaluation system. At the same time, the construction quality of the database will directly interfere with the evaluation results of the evaluation system.

When designing the system at the beginning, the data will be stored through the Derby database [15]. Derby is a platform-independent, open-source, and easy-to-manage database management system, which can support all the features in the database, such as crash recovery, row/table-level lock, transaction rollback, view, transaction submission, subquery description, foreign key/primary key constraint, and trigger.

In addition, in order to ensure the scientificity of the database, we need to comply with the three most basic paradigms. These three paradigms can be divided into four tables: single table, tree table, associated table, and master-slave table. They have five kinds of constraints: primary key constraint, uniqueness constraint, nonempty constraint, foreign key constraint, and check constraint.

2.3.3. Creative Dance Teaching Data Processing Module. In the actual evaluation process of creative dance teaching quality, it is necessary to analyze the evaluation objectives and creative dance teaching environment. The results obtained through the analysis can enable the evaluators to better evaluate the quality of creative dance teaching. This module includes creative dance teaching database, graphic drawing, and evaluation data statistics.

2.4. Software Design. On the basis of hardware design, the quality evaluation system of creative dance teaching is optimized from the aspect of software design. The theoretical basis of the software part is the fuzzy comprehensive evaluation method. The specific implementation process of this method is as follows:

The first step is to clarify the factors affecting the quality evaluation system of creative dance teaching and establish the evaluation index system of creative dance teaching quality evaluation system.

The second step is to determine the weight of each index [16, 17].

The third step is to determine the standard set of the evaluation index system evaluation level of the creative dance teaching quality evaluation system and determine the membership of each index in the index system according to the expert scoring results and the membership function model.

The fourth step is to conduct multi-level comprehensive evaluation according to the weight and membership degree of each index obtained in the second and third steps, and the evaluation results of the upper level index can be obtained from the last level index in turn.

The fifth step is to get the comprehensive evaluation results of the creative dance teaching quality evaluation system.

2.4.1. Fuzzy Comprehensive Evaluation Model. The fuzzy comprehensive evaluation model is established through index set $U = \{u_1, u_2, \ldots, u_m\}$, evaluation set $P = \{p_1, p_2, \ldots, p_n\}$, and evaluation matrix V, so that the weight of each index is fuzzy subset $W = (w_1, w_2, \ldots, w_m)$ in U, the weight corresponding to the i-th index is w_i, and $\sum_{i=1}^{m} w_i = 1$; the judgment of the i-th index is the fuzzy relationship $V_i(v_{i1}, v_{i2}, \ldots, v_{\text{in}})$ in U to P, and then the V of m indexes is as follows:

$$V = \left(v_{ij}\right)_{m\times n} = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix}. \tag{1}$$

There are many evaluation indexes to be referred to in the evaluation of creative dance teaching quality, and there are certain levels between each index, so it is necessary to classify U, carry out comprehensive evaluation on various types [18], and then carry out multi-level comprehensive evaluation on the evaluation results. Therefore, u_1 in U is constructed as $u_1 = \{u_{11}, u_{12}, \ldots, u_{1k}\}$ through K sub-index, u_2 is constructed as $u_2 = \{u_{21}, u_{22}, \ldots, u_{2o}\}$ through a sub-index, and similarly, u_m is constructed as $u_m = \{u_{m1}, u_{m2}, \ldots, u_{ml}\}$ through l sub-index.

For a single sub-index u_{ig} in u_i, $V_i^{(l)}$ is obtained from the evaluation results of each evaluation index:

$$V_i^{(l)} = \left[v_{ig}^{(l)}\right]_{m\times n}. \tag{2}$$

Obtain $F_i^{(l)} = W_i^{(l)} V_i^{(l)} = (f_{i1}^{(l)}, f_{i2}^{(l)}, \ldots, f_{in}^{(l)})$ according to the synthetic operation formula, that is, obtain the primary fuzzy evaluation result [19], and then take $F_i^{(l)}$ as the single index evaluation vector of u_i to obtain $V^{(2)}$ of all indexes related to U:

$$V^{(2)} = \begin{bmatrix} F_1^{(l)} \\ F_2^{(l)} \\ \vdots \\ F_m^{(l)} \end{bmatrix} = \begin{bmatrix} f_{11}^{(l)} & f_{12}^{(l)} & \cdots & f_{1n}^{(l)} \\ f_{21}^{(l)} & f_{22}^{(l)} & \cdots & f_{2n}^{(l)} \\ \vdots & \vdots & \ddots & \vdots \\ f_{m1}^{(l)} & f_{m2}^{(l)} & \cdots & f_{mn}^{(l)} \end{bmatrix}. \tag{3}$$

Finally, obtain the comprehensive evaluation vector of U:

$$F^{(2)} = (f_1, f_2, \ldots, f_n). \tag{4}$$

There are several evaluation subjects in the evaluation system. Solve the comprehensive evaluation vector $F_1, F_2, F_3, \ldots,$ of each evaluation subject, respectively, to obtain the overall comprehensive evaluation matrix $V = (F_1, F_2, F_3, \ldots,)$ [20]. According to the weight $W = (W_1, W_2, W_3, \ldots,)$ of each evaluation subject, obtain $F = WV$, which belongs to the final evaluation result matrix. Obtain the final comprehensive evaluation value Y (score) F according to $Y = FG^{\mathrm{T}}$, and the transposition of the evaluation grade scoring line vector is G.

2.4.2. Weight Distribution Scheme. Describe the weight distribution scheme using Euclidean distance [21, 22] β and alternative weight allocation scheme α. The feasible degree is as follows:

$$d_{\varepsilon}(\alpha, \beta) = \left(\sum_{i=1}^{m} \left|\alpha_i - \beta_i\right|^2\right)^{1/2}. \tag{5}$$

According to d, the selection method of index weight allocation scheme can be defined. Let $W' = \{w_{11}', w_2', \ldots, w_s'\}$ be a weight allocation scheme, and the number of indicators is s. According to the weight set of each single indicator in the same category [23, 24], suppose that the set of different index weight distribution schemes designed by several experts is $\overline{W}_s = \{w_{11}', w_2', \ldots, w_s'\}$, and the number of index weight distribution schemes designed by experts is s. Select a weight distribution scheme that can meet all other weight distribution schemes in s distribution schemes; that is, select an W' and W' in $\overline{W}$, which must be representative to make it meet:

$$W' = \arg\max \sum_{\varepsilon=1}^{s} d(W'', W_{\varepsilon}'). \tag{6}$$

Obtain the weight distribution result according to formula (6).

2.4.3. Realize the Evaluation of Creative Dance Teaching Quality. This paper selects the quality of creative dance teaching as the main factor, establishes the index evaluation set, and then uses the fuzzy comprehensive evaluation method [25, 26] to calculate the index evaluation set. This time, the evaluation of creative dance teaching quality is divided into five different levels. The first class is that the teaching quality of creative dance is very poor, and the expert score is 9; the second grade is that the teaching quality of creative dance is relatively poor, and the expert score is 7; the third grade is the general quality of creative dance teaching, and the expert score is 5; the fourth grade is that there are few problems in the quality of creative dance teaching, and the expert score is 3; the fifth grade is the excellent quality of creative dance teaching, and the expert score is 1. The higher the score, the worse the quality of creative dance teaching.

According to the index evaluation set corresponding to the index weight of creative dance teaching quality extracted, the set composed of creative dance teaching quality factors of fuzzy comprehensive evaluation is obtained, and the fuzzy transformation is carried out:

$$XoK = Y, yi = xj \times kij. \tag{7}$$

Among them, X is the weight of the factors affecting the quality of creative dance teaching; K is fuzzy matrix; Y is the result of fuzzy transformation; o is the operation symbol of fuzzy synthesis operation; yi is the influencing factor of a specific creative dance teaching quality; xj is the weight of the factors affecting the quality of specific creative dance teaching; kij is the value assigned to the fuzzy matrix. When the grade calculated by the comprehensive fuzzy judgment exceeds class III (including class III), the calculated result is transmitted to the system display interface by using the network communication protocol. Give warnings to teachers or relevant leaders through the display interface of the system, so as to complete the software design of creative dance teaching quality evaluation system.

3. Experimental Analysis

In order to verify the effectiveness of the method proposed in this paper, the multi-attribute fuzzy evaluation model of sports dance teaching quality in reference [6] is used as comparison method 1, and the multiple intelligences evaluation method in reference [7] is used as comparison method 2 to carry out the following experiments.

3.1. System Development Environment. Select ASP Net as the development platform of creative dance teaching quality evaluation system, ASP Net is built on the common language runtime, so a variety of applications can be added between the web interface and the database, which increases the user access of the system and facilitates the maintenance and operation of the system. The selected system development language is c# language, the system development environment platform is Microsoft Visual Studio 2005, and the installed server, switch, and router models are IBM System x3300, s5700-24tp-si, and H3C er3100, respectively. Connect the hardware system of the system according to the design structure and put it into use after debugging to avoid the error of test results caused by hardware failure.

3.2. Data Collection and Sample Selection. In order to ensure the accuracy of the experimental results, an educational platform is selected as the experimental object, and the students' feedback is taken as the data sample of the experiment. During the experiment, the actual creative dance teaching quality is artificially controlled, and the students' quality evaluation results are adjusted. The set quality evaluation results are used as the standard comparison results of the experiment.

3.3. Results and Analysis

3.3.1. Evaluation Effect Test. Using this system to evaluate the creative dance teaching quality, test the evaluation effect of the creative dance teaching quality of this system, and analyze the teaching quality of the education platform. The evaluation set $P = \{p_1, p_2, p_3, p_4, p_5\}$ represents good, good, average, poor, and poor, respectively. The score table of creative dance teaching quality evaluation is shown in Table 1.

Using the system in this paper, the fuzzy evaluation matrix of the weight of creative dance teaching quality evaluation index and three-level index is obtained, and the obtained results are shown in Tables 2 and 3.

According to the data in Tables 2 and 3, the evaluation results of the creative dance teaching quality of the education platform are calculated by using the system in this paper. The evaluation results of each level-1 index are 98 points, 93 points, 91 points, and 83 points, respectively, and the average score of the four level-1 indexes is 91.25 points. According to the level score in Table 1, the evaluation results of the creative dance teaching quality of the education platform are good. Experiments show that this system can effectively evaluate the quality of creative dance teaching of the education platform. According to the evaluation results, the teaching staff of the education platform is relatively poor. In the future, we need to focus on expanding the teaching staff and improving the quality of creative dance teaching.

3.3.2. Teaching Quality Data Collection Effect. Data collection is the basic operation of the system. In order to ensure the accuracy of the system evaluation, accurate data are needed as support, highlighting the importance of data collection. Test the resource discovery rate of the system when collecting data related to the evaluation of creative dance teaching quality in the education platform. The higher the resource discovery rate, the better the system data collection effect. The test results are shown in Figure 3.

According to Figure 3, with the increase of the amount of data, the resource discovery rate of the data collected by the

Table 1: Grade scores.

Grade	Good	Preferably	Commonly	Poor	Bad
Score	≥95	(95, 85]	(85, 70]	(70, 60]	<60

Table 2: Weight of each index.

Primary index	Weight	Secondary index	Weight	Tertiary indicators	Weight
Teaching ideas, methods, and objectives	0.21	Teaching concept	0.42	Highlight the main body of students	0.41
				Teach students in accordance with their aptitude	0.59
		Teaching methods	0.30	Diversity of teaching methods	0.35
				Progressiveness of teaching methods	0.65
		Teaching objectives	0.28	Cultivate practical ability	0.46
				Cultivate autonomous learning ability	0.54
Teaching process, resources, and activities	0.34	Teaching process	0.38	Interactive link settings	0.62
				Scientific nature of time planning	0.38
		Teaching resources	0.33	Resource-type richness	0.66
				Degree of meeting students' needs	0.34
		Teaching activities	0.29	Theoretical teaching activities	0.43
				Practical teaching activities	0.57
Teaching attitude and feedback	0.22	Teaching attitude	0.48	Respect students and be enthusiastic in class	0.18
				Prepare well before class and attend class on time	0.32
				Answer questions in class patiently and timely	0.28
				Careful evaluation of homework and course assessment	0.22
		Curriculum evaluation	0.52	Course qualification rate	0.44
				Multi-direction evaluation	0.56
Teaching staff	0.23	Faculty and structure	0.41	Teacher-student ratio	0.53
				There is a proportion of master's and doctoral degrees among teachers in school	0.47
		Lecturer	0.59	Qualification of lecturer	0.68
				Lectures of professors and associate professors	0.32

Table 3: Fuzzy evaluation matrix of three-level indicators.

Tertiary indicators	p_1	p_2	p_3	p_4	p_5
Highlight the main body of students	0.24	0.28	0.21	0.11	0.16
Teach students in accordance with their aptitude	0.18	0.27	0.13	0.23	0.19
Diversity of teaching methods	0.42	0.08	0.17	0.21	0.12
Progressiveness of teaching methods	0.02	0.13	0.48	0.25	0.12
Cultivate practical ability	0.61	0.19	0.01	0.09	0.10
Cultivate autonomous learning ability	0.21	0.39	0.28	0.09	0.03
Interactive link settings	0.01	0.27	0.52	0.11	0.09
Scientific nature of time planning	0.59	0.18	0.03	0.11	0.09
Resource-type richness	0.11	0.01	0.42	0.26	0.20
Degree of meeting students' needs	0.22	0.28	0.31	0.11	0.08
Theoretical teaching activities	0.32	0.41	0.12	0.03	0.12
Practical teaching activities	0.02	0.13	0.38	0.28	0.19
Respect students and be enthusiastic in class	0.12	0.31	0.26	0.00	0.31
Prepare well before class and attend class on time	0.09	0.43	0.00	0.27	0.21
Answer questions in class patiently and timely	0.23	0.52	0.00	0.25	0.00
Careful evaluation of homework and course assessment	0.33	0.39	0.12	0.01	0.15
Course qualification rate	0.16	0.00	0.33	0.31	0.20
Multi-direction evaluation	0.14	0.28	0.00	0.26	0.32
Teacher-student ratio	0.21	0.00	0.33	0.22	0.24
There is a proportion of master's and doctoral degrees among teachers in school	0.23	0.33	0.24	0.11	0.09
Qualification of lecturer	0.00	0.61	0.12	0.08	0.19
Lectures of professors and associate professors	0.00	0.00	0.72	0.26	0.02

system in this paper shows an upward trend. When the amount of data reaches 35 TB, the resource discovery rate of the data collected by the system in this paper is close to 100%, indicating that the data collection effect is the best at this time. When the amount of data is small, the minimum resource discovery rate of the system in this paper has

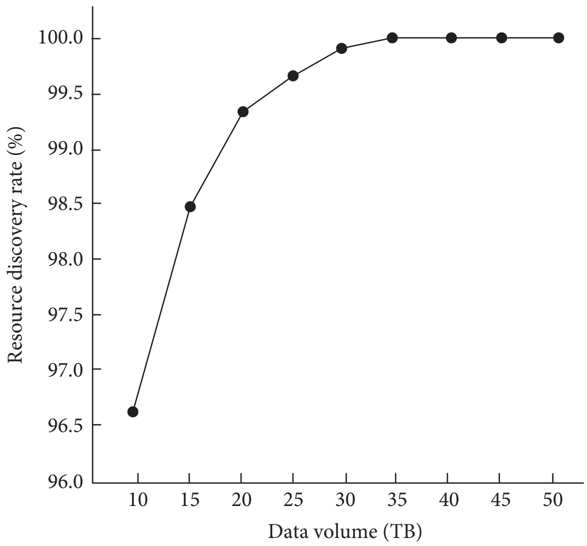

Figure 3: Data acquisition effect.

exceeded 96.5%, and the resource discovery rate is also high at this time. Experiments show that this system has a high resource discovery rate in data acquisition, which shows that the data acquisition effect of this system is better and more valuable data can be collected.

3.3.3. Function Operation Effect. In this experiment, the final experimental results are obtained by averaging multiple experiments. Therefore, six groups of evaluation data are set, respectively, and specific creative dance teaching quality scores are set to compare the error between the output results of the three evaluation systems and the setting results. The test results of system function operation effect are shown in Table 4.

As can be seen from the score output in Table 4, the average evaluation error of comparison method 1 and comparison method 2 is 2.83 and 2.0, respectively, while the average evaluation error of the designed creative dance teaching quality evaluation system is 1.17. In contrast, the evaluation function of the creative dance teaching quality evaluation system based on fuzzy comprehensive evaluation has better operation effect and higher evaluation accuracy.

3.3.4. Test of Total Stored Data and Rejection Times. In order to verify the data storage performance of the system in this paper, tested the total amount of stored data and rejection times of the three systems for storing different requests. The test results are shown in Figures 4 and 5.

According to Figures 4 and 5, the larger the number of requests, the total amount of stored data of the three methods has increased, and the method in this paper has the largest increase. When the requested quantity is 16×10^3 times, the total amount of stored data reaches 9.3 tb. It can be seen that the total amount of data stored in this method is significantly higher than the other two methods at different request quantities, which indicates that this method has better storage performance in storing data; the number of requests is directly proportional to the rejection times of the three methods. The method in this paper increases slightly with the increase of the number of requests, and the growth rate is relatively slow. The rejection times of the other two methods increase faster, indicating that this method can meet all data storage requests of the method as much as possible, and the rejection times are the lowest.

3.3.5. Method Performance Test. In practical application, the improvement of method performance only depends on the improvement of accuracy and recall rate, and the effect is not ideal. Therefore, another index should be given by combining accuracy and recall rate, represented by Q_1. Therefore, in this experiment, the accuracy (b), recall (m), accuracy (H), and Q_1 value are taken as the performance comparison indexes of the three methods. The calculation method of each index is as follows:

$$\begin{aligned} H &= \frac{R_H}{R_H + Q_H}, \\ M &= \frac{R_H}{R_H + Q_F}, \\ B &= \frac{R_H + R_F}{R_H + Q_H + R_F + Q_F}, \\ Q_1 &= \frac{2 \cdot H \cdot M}{H + M}, \end{aligned} \tag{8}$$

where R_H is the number of times that an evaluation index exists and is tested at the moment; Q_H is the number of times that an evaluation index does not exist at the moment and the result is that it exists; R_F is the number of times that an evaluation index does not exist and the result does not exist at the moment; and Q_F is the number of times an evaluation index exists but has not been tested.

900 groups of characteristic data were randomly selected and evenly distributed in the training and evaluation of the three methods, of which 75% (225 groups) of the data were used as part of the training samples, and the remaining 25% (75 groups) of the data were used as test samples. The performance of the three methods was compared with the accuracy (H), recall (m), accuracy (b), and Q_1 value as the comparison indicators of the performance of the three methods. In the experiment, the effectiveness of the experimental data is ensured through four training and inspection processes. The evaluation index accuracy, Q_1 value, accuracy, and recall rate of each method in the inspection results are calculated. The calculation results are shown in Table 5, and the average accuracy, average Q_1 value, average accuracy and average recall rate of each method are calculated according to Table 5. The calculation results are shown in Table 6.

By analyzing Tables 5 and 6, it can be concluded that the performance indexes of this method are almost higher than those of the other two methods, and the average accuracy, average Q_1 value, average accuracy, and average recall rate reach more than 92%, which is much higher than those of

Table 4: Comparison results of system function operation effect test.

Experimental group	Set score (score)	Comparison method 1 output score (point)	Comparison method 2 output score (point)	Output score of this method (point)
1	64	59	60	62
2	89	88	88	89
3	85	82	83	84
4	72	68	70	70
5	93	91	91	95
6	96	94	95	96

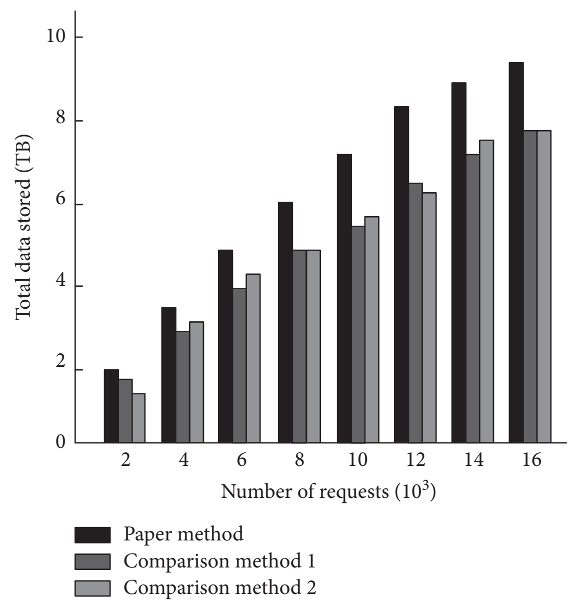

Figure 4: Test results of total stored data.

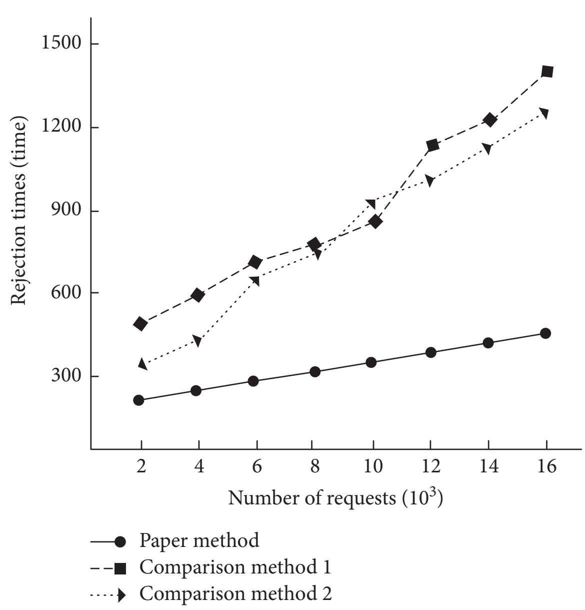

Figure 5: Test results of rejection times.

Table 5: Test results.

Evaluation index		Correctness	Integrity	Uniformity	Accuracy	Effectiveness
Paper method	B/%	98.28	99.61	99.99	99.99	99.82
	H/%	99.99	98.99	99.99	99.99	99.01
	M/%	99.99	99.99	99.99	99.99	99.99
	Q_1	0.97	0.98	0.99	0.99	0.98
Comparison method 1	B/%	96.61	98.28	98.84	94.12	88.7
	H/%	70.3	82.61	98.23	96.13	87.65
	M/%	98.78	99.99	99.99	39.1	98.99
	Q_1	0.71	0.8	0.78	0.45	0.68
Comparison method 2	B/%	98.61	97.33	98.74	94.55	85.64
	H/%	85.6	73.89	97.03	99.99	89.33
	M/%	99.99	99.99	99.99	43.45	99.98
	Q_1	0.81	0.75	0.78	0.5	0.7

Table 6: Average value of test results.

Method	Paper method (%)	Comparison method 1 (%)	Comparison method 2 (%)
Average accuracy	99	95	94
Average accuracy	99	86	89
Average recall rate	99	87	88
Average Q_1 value	98	68	71

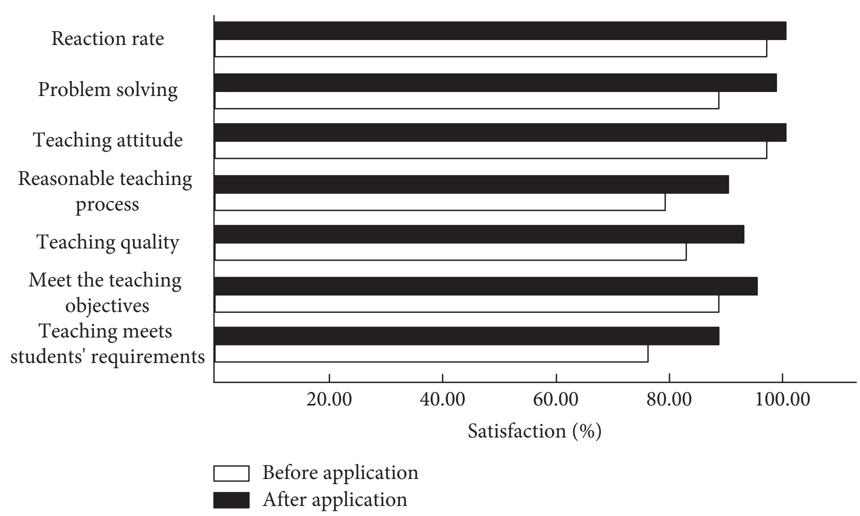

Figure 6: Statistical chart of student satisfaction before and after the application of the evaluation method.

the other two methods, indicating that this method has better performance in evaluating the quality of creative dance teaching.

3.3.6. Student Satisfaction Test. Satisfaction test is to apply the designed creative dance teaching quality evaluation system to the actual teaching and adjust the teaching mode and teaching attitude combined with the evaluation results of the design method. Observe the changes in students' satisfaction with the quality of creative dance teaching before and after the application of the method. After a period of operation cycle, the comparison results of satisfaction before and after the application of the method are obtained, as shown in Figure 6.

As can be seen from Figure 6, the students' satisfaction has increased significantly after the application of the creative dance teaching quality evaluation method, and the satisfaction is higher than 85%. Therefore, it can be determined that this method has certain application value in the actual creative dance teaching quality work.

4. Conclusion

In order to improve the quality of creative dance teaching, this paper designs a creative dance teaching quality evaluation system based on fuzzy comprehensive evaluation, obtains the comprehensive evaluation results according to the fuzzy comprehensive evaluation method, obtains the shortcomings of creative dance teaching quality according to the evaluation results, and formulates relevant strategies to improve the quality of creative dance teaching. The experimental test shows that the system in this paper has good application effect in the field of evaluation.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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Research Article

Voice Quality Evaluation of Singing Art Based on 1DCNN Model

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Traditional speech recognition still has the problems of poor robustness and low signal-to-noise ratio, which makes the accuracy of speech recognition not ideal. Combining the idea of one-dimensional convolutional neural network with objective evaluation, an improved CNN speech recognition method is proposed in this paper. The simulation experiment is carried out with MATLAB. The effectiveness and feasibility of this method are verified by simulation. This new method is based on one-dimensional convolutional neural network. The traditional 1DNN algorithm is optimized by using the fractional processing node theory, and the corresponding parameters are set. Establish an objective evaluation system based on improved 1DCNN. Through the comparison with other neural networks, the results show that the evaluation method based on the improved 1DCNN has high stability, and the error between subjective score and evaluation method is the smallest.

1. Introduction

Signal processing is a general term for processing various types of signals according to various expected purposes and requirements. The processing of analog signals is called analog signal processing, and the processing of digital signals is called digital signal processing. The so-called signal processing refers to the process of processing the signals recorded on a certain medium in order to extract useful information. It is a general term for the process of signal extraction, transformation, analysis, synthesis, and so on. Among the common audio signal types, there is also a music signal. Music signal is affected by music theory, musical instrument pronunciation rules, psychological perception, and other factors, which is different from voice signal in analysis and processing methods. Moreover, the music-level analysis involves many knowledge fields, and knowledge is easy to spread. So in this lesson, we will first introduce some basic concepts of music signals and then take you to see the principles and solutions behind these problems from the cases of music scenes in our real-time audio interaction. Music has no national boundaries. Different regions and languages can be related to each other through music. As the most influential field in the world, music has its unique charm. However, due to the influence of people's subjective consciousness and old ideas, the scientific development of singing art is restricted, and talents in the field of singing are gradually lacking [1]. In 2019, Nygren et al. studied the impact of gender on individual vocal cords on sexual development. By investigating the satisfaction of the research objects on their own voice, everyone has a preliminary evaluation of their own voice from the perspective of gender [2]. In addition, David et al. also discussed the impact of gender on voice function in 2019 and found that people with gender diversity will be limited by a variety of voice function fields, which further supplements the voice quality caused by gender differences [3]. Rachel et al. analyzed the signal processing of singing voice and explored the technology of applying audio signal processing method to singing voice on the basis of previous research, in order to realize large-scale personalized listening experience [4]. For the processing of singing voice, Nanzaka R. led his team to propose a novel vocal music enhancement system, which can make the voice of amateur singers reach the professional level. By using the singing voice of professional singers, the singing voice of amateur singers can be enhanced in a frequency band representing the distinctive characteristics of professional singers, opening up a new mode in the field of singing art [5]. Kim et al. studied the automatic analysis of pop music of singing voice, constructed a music tag data set, which was specially used for singing voice, and demonstrated the potential application of vocal music tagging system in music retrieval, music thumbtack, and singing evaluation [6].

Saleem et al. used the binary classification method of deep neural network to separate the target speech from the mixed signal in 2020, solved the problem of over smoothing, and carried out spectral variance equalization to match the estimated and clean speech features [7]. In the field of separation of singing voice and accompaniment, members of Lin K. collaborative group put forward a unique neural network method, which adopts the most advanced singing separation system competition of multi-channel modeling, data enhancement, and model mixing, making song evaluation more comprehensive [8]. In the latest research, Medeiros et al. compared the measurement methods of the variation of the predetermined fundamental frequency between singing and speech, and confirmed that the stability of the predetermined fundamental frequency in singing is higher, so as to facilitate the processing of the singing voice in the later research [9]. Lehner et al. proposed a machine learning method for vocal music detection, which can automatically identify the region in the music record of at least one person singing [10]. Based on the denoising self-coding model of mixed magnitude spectrum, Mimilakis et al. studied the mapping function of neural network, estimated the magnitude spectrum of singing voice from the corresponding mixture, and realized the separation of singing voice [11]. Murthy et al. used the new features based on formant structure to segment the vocal cord region and nonsound region, and the accuracy of the developed system in the song music segment detection test is as high as 98% [12]. Meiyanti et al. established a voice recognition research on singing technology based on female voice register in 2018. The detection results show that the average success rate of introducing voice register in real time is 57% [13].

To sum up, with the progress of science and technology, people pay more and more attention to the objective evaluation of sound, and the requirements for the quality of singing are also higher and higher. However, few studies have proposed an excellent method in singing speech recognition. Most of the objective evaluation of singing only focuses on the sound quality, the parameter selection is single, and the indicators in the sound evaluation are not detailed enough. Therefore, this study will optimize CNN with better feature classification ability and apply CNN optimization algorithm to the objective evaluation of singing art voice, in order to achieve the objective selection of singing art talents and protect the singer's voice environment.

2. Feature Extraction and Recognition of Singing Speech Signal

2.1. Singing Speech Recognition and Processing Method. Singing speech recognition is a special kind of speech recognition, and the biggest difference is that the singing voice has accompaniment and melody. However, the general principle of singing speech recognition remains unchanged, which is to identify continuous speech signals, retrieve keywords, and finally determine the position of words in sentences. The specific implementation process is shown in Figure 1.

As shown in Figure 1, the received voice signal is first converted into electrical signal by voice acquisition equipment such as microphone and then transmitted to the recognition system for front-end processing. Secondly, after the front-end processing, it is necessary to extract the features of the speech signal. Some of the extracted feature parameters are directly measured and estimated. The other part of the parameters constitutes a new pattern. By comparing with the original pattern of the database in the computer, a better matching combination is found. One part turns to measure estimation, and the other part turns to expert knowledge. Finally, all the new patterns get their corresponding recognition results according to the corresponding recognition decision.

Art voice audio is the same as other voice. After receiving the signal, it will be converted into digital signal, and then it will be sampled and quantified. Signal sampling is a discrete transformation process, which can ensure the integrity of the signal and reproduce the original signal. The quantization after sampling is to divide the amplitudes equally and ensure that there is no difference in the characteristics of samples in the same amplitude range. But in the process of signal processing, signal weakening is inevitable. In order to reproduce the original signal, it is necessary to emphasize the singing sound in advance to improve the high-frequency component of the audio and gradually make the signal close to the original signal. Cable connection is also a key factor affecting signal quality. In practice, in order to better ensure the quality of the signal, it is necessary to control various factors involved. In the continuous production process, the continuous phenomenon will occur due to the influence of factors such as improper size or large diameter of the cable. The poor working condition of continuous instruments is the key to these factors.

In order to facilitate the reproduction of the original signal, it is necessary to pre-emphasize the singing voice to improve the high-frequency component of the audio and gradually make the signal close to the original signal [14]. Generally, filter processing is used for pre-emphasis. The commonly used filter is actually FIR digital filter. FIR filter is a high-pass filter, which can improve the high-frequency components. At the same time, it is also convenient for formant detection, which improves the stability of signal in quantization processing [15].

There is no periodicity and no fixed law in singing voice. The sampling value and characteristic parameters of the signal will change irregularly with time, so it has time variability [16]. In signal processing, it is often considered that the voice signal of singing art is stable in a very short time, so the signal also has short-term stability. According to the characteristics of voice signal, the signal can be divided into several voice segments before processing [17]. Then, the signal is divided into several smooth fixed lengths by the

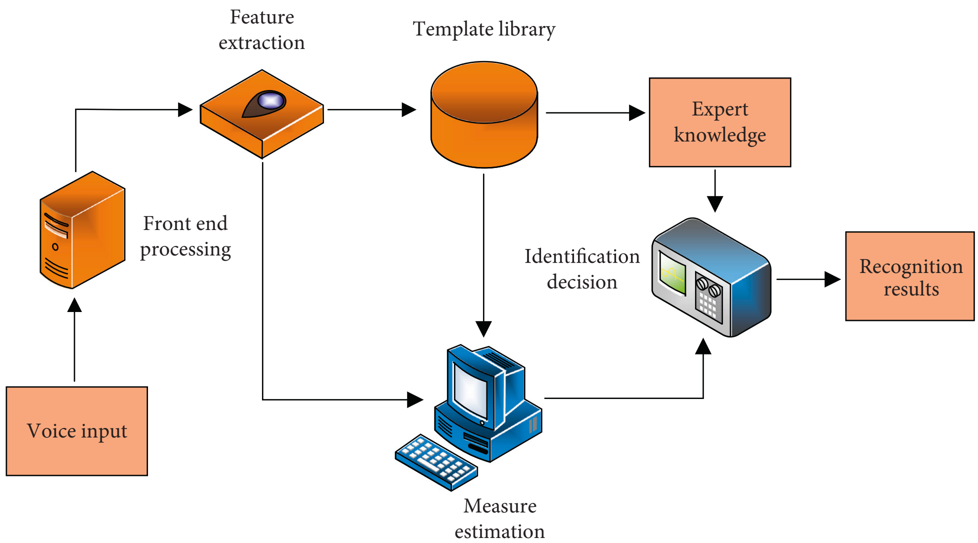

Figure 1: Schematic diagram of speech recognition.

windowing processing function, and the expression of the processing function is shown in

$$s_w(n) = s(n)w(n), \tag{1}$$

$s(n)$ in formula (1) represents the original signal, $w(n)$ is the windowing function used in processing, and the commonly used window functions are rectangular window, Hamming window, and Hanning window [18]. The comparison of the main lobe width and the first side lobe attenuation of the three window functions is shown in Table 1.

In Table 1, $B/\triangle w$ represents the width of main lobe falling, and $A/\mathrm{d}B$ represents the attenuation of the first side lobe. It can be seen from Table 1 that the main lobe width of Hanning window is the largest, followed by the Hamming window, and the Hamming window is the largest of the three [19]. Therefore, considering the two indicators, the Hamming window is selected as the window function.

2.2. Acoustic Parameter Extraction of Singing Speech. The main acoustic parameters of singing art voice include formant, fundamental frequency, range, and average energy. Extracting these acoustic parameters for research can better understand the beauty of sound. The voice of a singing performance is used for audio analysis. Among them, formant plays a decisive role in the depth and emotional color of voice, so the extraction of formant can basically show the singer's personal ability. In this study, AR model detection method is used to extract the first and third formants, and the extraction process is shown in Figure 2.

Figure 2 shows that the sample data are preprocessed first, and the processed signal is then sent to the AR model for detection. In order to ensure the accuracy of formant extraction, the AR model detection results need to be further extracted by LPC spectrum detection, then the formant points in the signal are captured by peak detection method, and finally the formant frequency is obtained. As one of the important standards to reflect the quality of voice, it is also very important to accurately extract the range for voice quality evaluation. The pitch value in the range is calculated by

$$\overline{D} = \frac{1}{N}\sum_{j}^{N} D_j, \tag{2}$$

In equation (2), $\overline{D}$ is the average of all pitches, n is the number of audio samples, D_j is the j pitch, and the standard deviation of all pitches is calculated as shown in

$$\sigma = \sqrt{E\left[\left(D_j - \overline{D}\right)^2\right]}. \tag{3}$$

In equation (3), $E[\ldots]$ is the average pitch, j is [1, 2, ..., n], N is the number of audio samples, and D_j is the j-th pitch. The average energy is often used to measure the signal size of singing voice. The calculation method is shown in

$$E_n = \sum_{k=-\infty}^{+\infty} x^2(k)w(n-k), \tag{4}$$

E_n in equation (4) is the energy in a short time, the input signal is represented by $x(k)$, and $w(n-k)$ is the window function.

Formant perturbation is a parameter used to measure the change value of formant in the corresponding period, which can reflect the voice quality of singers and evaluate their technical level. The first formant perturbation is defined by

$$\frac{1}{N-1}\sum_{i=1}^{N}\left|\frac{1}{F_{1i}} - \frac{1}{F_{1(i-1)}}\right|. \tag{5}$$

In equation (5), F_{1i} represents the first formant of i cycles, $F_{1(i-1)}$ represents the first formant of i–1 cycles, and N represents the number of audio samples. The third formant perturbation is defined by

Table 1: Comparison of window functions.

—	Rectangular window function	Hanning window function	Hamming window function
B/Δw	0.87	1.68	1.5
A/dB	14	34	45

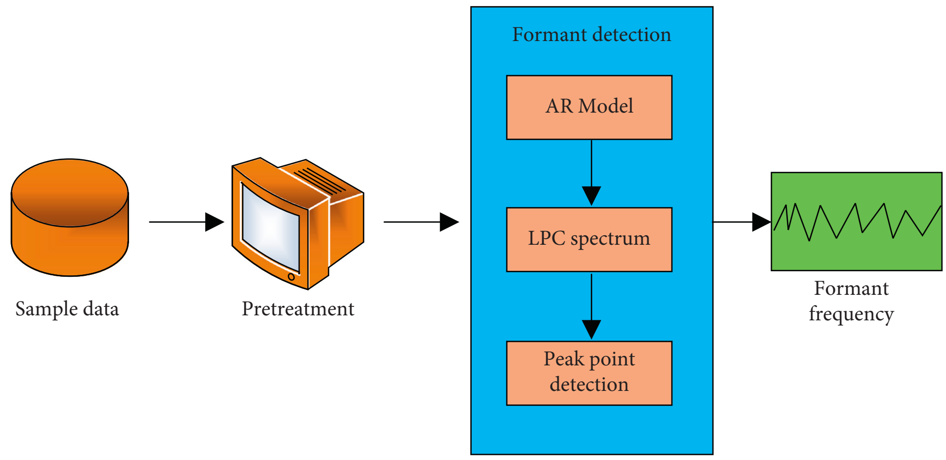

Figure 2: AR model peak detection.

$$\frac{1}{N-1}\sum_{i=1}^{N}\left|\frac{1}{F_{3i}}-\frac{1}{F_{3(i-1)}}\right|. \tag{6}$$

In equation (6), F_{3i} represents the first formant of i cycles, $F_{3(i-1)}$ represents the first formant of i–1 cycles, and N represents the number of audio samples.

3. Objective Evaluation of Singing Voice Based on Improved 1DCNN

3.1. Improved 1DCNN Speech Recognition Algorithm. Convolutional neural network is a frequently used technology in the field of image. The difference between speech and image is that speech is a one-dimensional signal. If two-dimensional means similar to image parameters are used to extract speech signal, large errors will inevitably occur. Therefore, in order to preserve the one-dimensional features of speech signal, a convolutional neural network based on one-dimensional vector is proposed. In order to reduce the training time of convolutional neural network and ensure the accuracy of calculation, the fractional order processing node theory is proposed for the training function to reduce the training time.

Sigmoid function is the default activation function of neuron, because sigmoid function is continuous and differentiable everywhere in the definition domain. At the same time, it can be interpreted as the probability of occurrence of events, so it becomes the activation function of neurons. In this paper, sigmoid is used as a training function to simulate the characteristics of biological neurons in convolutional neural network.

$$f(x)=\frac{1}{1+e^{-x}}, \tag{7}$$

x in equation (7) represents the training time, and the first derivative of the training function is expressed as

$$f'(x)=\frac{e^{-x}}{\left(1+e^{-x}\right)^{2}}. \tag{8}$$

It can be seen from equation (8) that when x is 0, the function has a maximum value, and there is no steep waveform of the function, which means that the fast convergence cannot be obtained. The 0.5th derivative of the training function is shown in

$$\begin{aligned} D^{0.5}f(x) &= \frac{1}{T_{(0.5)}}\int_0^x \frac{f^{(1)}(t)}{(x-t)^{0.5}} \\ &= \frac{1}{\sqrt{\pi}}\int_0^x \frac{e^{-t}}{(x-t)^{0.5}\left(1+e^{-t}\right)}\mathrm{d}t. \end{aligned} \tag{9}$$

From equation (9), it can be seen that the convergence speed is much faster than the first derivative when x is close to 0 or 1, which can greatly reduce the training time of the network.

The speech signal will be imported into 1DCNN structure after pre-emphasis. The speech signal is divided into multiple local speech by adding windows and frames, and multiple segmented speech is connected back and forth. This process is called long-term feature, and then speech recognition is carried out, as shown in Figure 3.

As shown in Figure 3, long-term features are imported into 1DCNN as input, and local convolution is performed in convolution layer to extract swimming information.

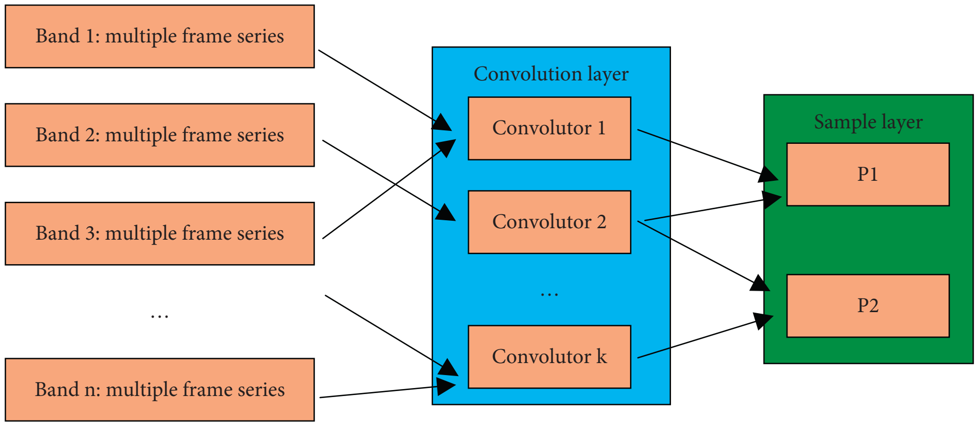

FIGURE 3: Convolution neural network recognition block diagram.

Convolution operation is performed on different filter bands by the same convolutor, and the output value obtained by convolution is taken as the output of the convolutor. The output formula is shown in

$$T_{i,k} = \theta \sum_{b=1}^{n-1} X_{b,k} Y_{b+i}^{T} + a_k. \tag{10}$$

In equation (10), n is the width of the convolver, Y_{b+i}^{T} is the input eigenvector of group i, $X_{b,k}$ is the weight of group k, and the network offset is set to a_k.

3.2. Evaluation System of Artistic Voice Recognition. With the interdisciplinary development, the intelligent objective evaluation method is gradually recognized by people in the music industry. This research will use the compact combination method to combine the wavelet theory and neural network, so as to carry out the objective evaluation of singing art voice. The neural network training process is based on the idea of error back-propagation. In order to get the minimum mean square error of actual output and predicted value, gradient descent search method is used to train the neural network. The calculation method of the output pattern vector of the sample in the training process is shown in equation (11), in which the number of neurons in the input layer is n, the number of neurons in the hidden layer is m, and the number of neurons in the output layer is N.

$$y_j(t) = f\left(\sum_{j=0}^{N} w_{kj} \psi_{(a,b)} \left(\sum_{j=0}^{m} w_{ik} x_i(t)\right)\right). \tag{11}$$

In equation (11), $f(\ldots)$ is the training function, w_{kj} is the weight from the input layer to the hidden layer, w_{ik} is the weight from the hidden layer to the output layer, the wavelet function is $\psi_{(a,b)}$, and the input mode vector is $x_i(t)$. Take the output mode vector into equation (12) to obtain the error function.

$$E = \frac{1}{2} \sum_{j=1}^{N} \left(y_j(t) - o_j\right)^2. \tag{12}$$

In equation (12), E is the error function of the training process, $y_j(t)$ is the output mode vector, and the expected output is o_j. Objective evaluation of singing art voice is carried out through neural network, and the evaluation process is shown in Figure 4.

As shown in Figure 4, the extracted acoustic feature parameters are normalized first to avoid the influence of scale and dimension. Then, it is input into the learning samples for data classification, which is one of the contents of the initial network establishment. At the same time, the initial weights are input through the subjective evaluation of professional teachers to construct the initial network. After training, the trained neural network can evaluate the input samples to be tested and finally get the evaluation results.

To improve the objective evaluation system of singing voice of 1DCNN, we need to design five parts. First, we need to design the input layer of 1DCNN. The input layer is composed of characteristic parameters, including the first formant, the first formant perturbation, the third formant, the third formant perturbation, fundamental frequency, range, fundamental frequency perturbation, and average energy. A complete speech signal is divided into 1000 frames, and feature parameters are extracted from each frame. In order to avoid the influence of noise, 10 frames of short-term signals are taken as a group to form a long-term signal. The characteristic parameters of the long-term signal are the average characteristic parameters of the short-term signals in the group. A total of 100 long-term signals are arranged to form one-dimensional eigenvectors, which are input to convolution operation of convolution layer. The number of neurons in input layer is 800. The network model architecture that deletes the maximum pool layer has a hierarchy problem. Therefore, first, reduce the number of elements of the feature map to be processed, and second, introduce the hierarchical structure of the spatial filter by making the observation window of the continuous convolution layer larger and larger (i.e., the proportion of the window covering the original input is larger and larger).

The second part is to design the convolution layer. A convolution layer is designed to avoid overfitting. 100 convolution cores are set in the convolution layer, and the edge feature information is retained by zero filling operation.

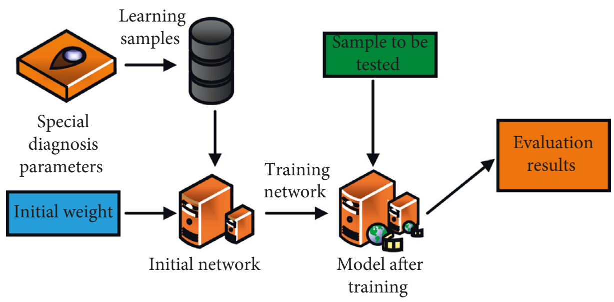

Figure 4: Voice evaluation process.

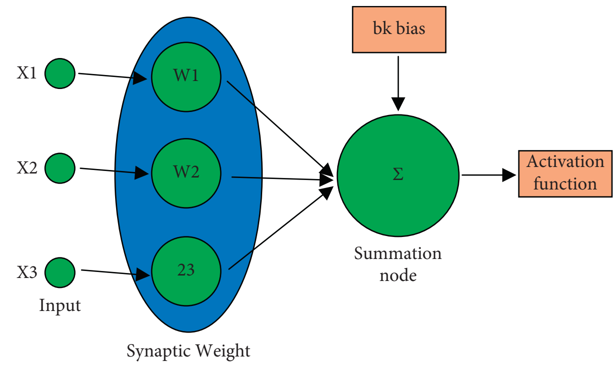

Figure 5: Principle of local convolution.

The convolution layer adopts local convolution, which can share weights. The specific local convolution process is shown in Figure 5.

As shown in Figure 5, the local convolution process requires the input of three neuron nodes and the output of only one neuron node. Among them, three synaptic weights are the values of convolution kernel. In addition, another parameter in the process is the offset BK, and four parameters converge at the junction node to sum up the input activation function.

The third part is the design of pooling layer. The pooling layer needs to sample the average or maximum of one-dimensional eigenvectors of convolution results to reduce the number of output nodes and avoid overfitting. According to the characteristics of speech signal, the maximum pooling method is used to reduce the estimation error caused by convolution layer parameter error and can retain more texture information of speech signal. If the step size of pooling region is set to 3, the tail of eigenvector needs to be zeroed, and the number of neurons is set to 2.67×104.

The fourth part designs the full connectivity layer and sets up 1024 full connectivity layer neurons. Finally, the output layer is designed and 500 output layer neuron nodes are set. The neuron nodes in the output layer are connected with all the neuron nodes in the full connection layer. The neuron of output layer corresponds to the category, and the category is set as the basis, with 5 points and 10 points as the full score. The activation function is used to get the probability of the output value in all categories, and the category value with the largest output probability.

The training of objective evaluation of the singing voice of the improved 1DCNN is the basis of ensuring high accuracy in practical application. In the training process of this network, the data of 1DCNN are set first, including training, verification, and test data. The training set is the parameter involved in the gradient descent process, and the data in the verification set are used to test the accuracy of the model, which can be improved by manually adjusting the parameters. The test set is used after the model training, which is the data set of the accuracy of the final model. 800 samples are set as the training set, and the number of samples in the verification set and the test set is 100, respectively.

Secondly, the parameters of 1DCNN are set, the learning rate is set to 0.1, the super-parameter batch size is the block size divided into the training process, which is set to 50, and epoch is a round-trip process of the data set in CNN, which is set to 10. Then, the forward operation of the training is carried out, and the network is run in the positive order. The influence of the previous neuron node on the subsequent layer of neuron nodes is calculated, and the forward weight and offset are calculated.

$$\mathrm{net}_{h1} = i_1 \times w_1 + i_2 \times w_2 + b_1 \times 1. \tag{13}$$

In equation (13), h_1 is the neuron to be calculated, i_1 and i_2 are the values of the input neuron, w is the weight between the values of the input neuron and h_1, and b_1 is the offset.

The deviation of forward operation is very large, so it needs to use directional propagation to adjust and gradually reduce the deviation between the real value and the output value. In CNN, we need to train the data in each epoch, take 50 voice signals as a group, and continuously train and adjust the weight.

4. Experimental Results and Analysis

4.1. Comparison of 1DCNN and 2DCNN Evaluation Methods. In this study, 100 students of music major in a university were selected as the experimental subjects, so the subjects did not appear any disease within 3 months. The professional recording studio is selected as the recording environment, the noise is less than 45 dB, the voice acquisition equipment is Levitt LCT 940 professional recording microphone, the Fireface UCX computer sound card is used, the accompaniment is Roland electronic piano, the voice signal recording software is CoolEdit, and the recording processing is MIDI computer. The simulation environment is Intel (R) core (TM) i3-2310 m CPU 2.10 GHz (4 CPUs), and MATLAB r2016a is used for simulation.

Under 1DCNN and 2DCNN evaluation methods, the comparison of the influence of the number of time rule frames on the recognition rate is shown in Figure 6.

It can be seen from Figure 6 that the same network model will have a certain impact on the recognition rate when the number of time rule frames is different, and the greater the number of time rule frames, the higher the recognition rate of the network. And it is not difficult to see that under the same time rule frame number level, 1DCNN has a higher recognition rate in the evaluation of singing art voice. In addition, by comparing the convergence rates of the

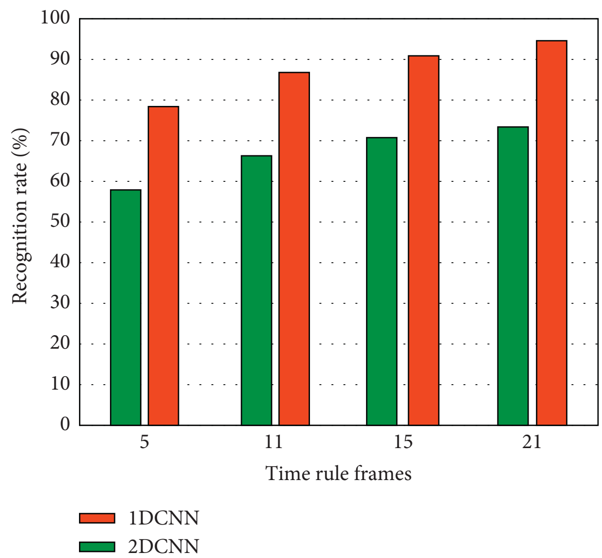

Figure 6: Influence of time rule frame number on recognition rate.

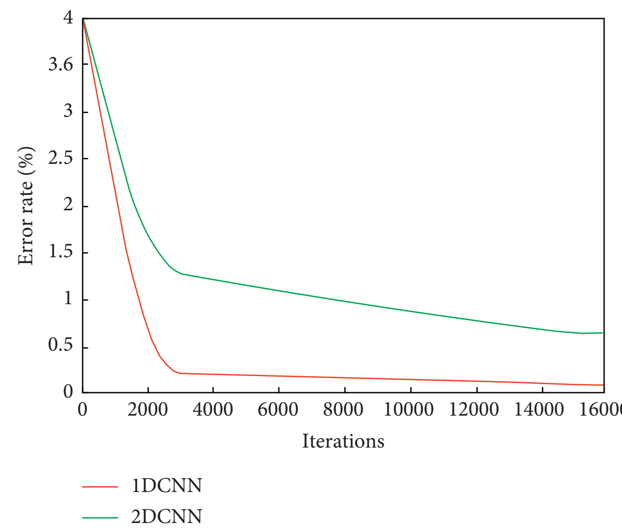

Figure 7: Error convergence trend.

two networks, the stability of the network is analyzed, as shown in Figure 7.

As can be seen from Figure 7, with the increase of the number of iterations, the error rates of the two networks also decrease. When the number of iterations is less than 3000, the slope of the convergence curve of 1DCNN is significantly larger than that of 2DCNN, which indicates that the convergence speed of 1DCNN is significantly faster than that of 2DCNN. The results show that 1DCNN has lower error rate and faster convergence speed than 2DCNN. The comparison of the experimental results of the two network models is shown in Table 2.

It can be seen from Table 2 that under the premise of the same convolver, the accuracy of one-dimensional convolutional neural network is as high as 86.3%, which is 5.9% higher than that of two-dimensional convolutional neural network, and the test time is only 125 S, which is far lower than 181 s of two-dimensional convolutional neural network. The results show that the one-dimensional convolutional neural network can obtain high accuracy and spend less time in evaluation.

4.2. Comparison of Different Neural Network Evaluation Methods. In general evaluation neural network, we can evaluate the neural network through some indicators. Improve our neural network through evaluation. The methods of evaluating neural network and machine learning are similar. Common methods include error, accuracy, R^2 score, etc. Through literature search, it is concluded that wavelet neural network and BP neural network are the more effective and commonly used objective evaluation methods at present. The objective evaluation results and subjective evaluation scores of the two networks and 1DCNN are compared, as shown in Figure 8.

It can be seen from Figure 8 that the highest score of experts for 100 experimental subjects is 9.8, and the lowest is 6.9. The deviation between BP neural network score and

Table 2: 1DCNN and 2DCNN experimental result comparison.

Algorithm	Number of convolutor	Accuracy (%)	Time (s)
1DCNN	100	86.3	125
2DCNN	100	80.4	181

expert score is serious. The coincidence degree of wavelet neural network score and expert subjective evaluation result curve is much higher than that of BP neural network score. The score curve of improved 1DCNN evaluation method is almost consistent with that of expert. It shows that the improved 1DCNN evaluation method is closer to the subjective evaluation of experts. The two neural networks are compared with 1DCNN for objective evaluation and subjective evaluation error values, and the comparison results are shown in Figure 9.

As can be seen from Figure 9, since wavelet neural network is based on wavelet concept, it has more advantages in the whole network structure, and the learning and training process of wavelet neural network is simpler than that of BP neural network. Therefore, in the objective evaluation, although the BP neural network evaluation error for most of the samples is small, the maximum error value of BP neural network is 3.87, the error value between the sample numbers 41~71 fluctuates the most, the average error value during the period is as high as 2.76, and the total average error value is 1.48. The maximum error value of wavelet neural network is 1.12, there is no area with large error fluctuation, and its average error value is 0.84, so on the whole, the error value of wavelet neural network is smaller and more stable, and its performance is better. It is not difficult to see that the error value of the improved 1DCNN evaluation method is almost zero, and there is no error fluctuation in 100 sample tests. The maximum error value is only 0.34, and the average error value is 0.21, which is far less than the average error value of BP neural network evaluation of 1.48 and wavelet neural network evaluation of 0.84. The above results show that the stability of the improved 1DCNN

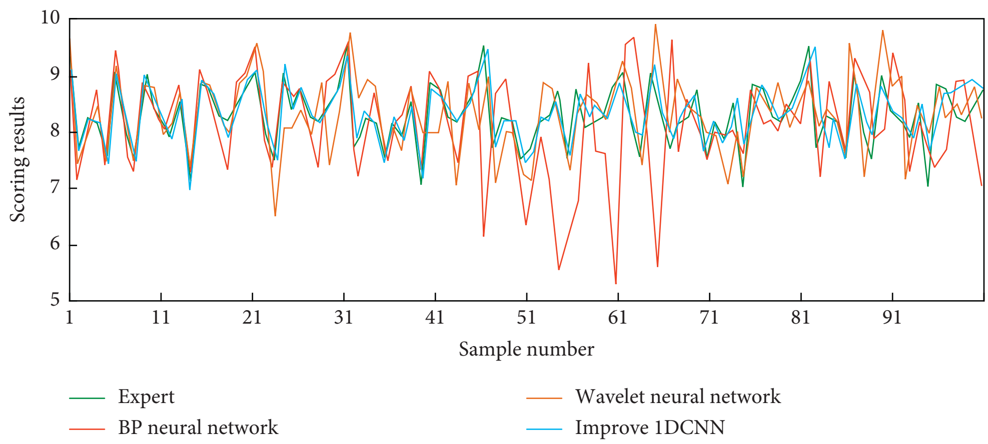

Figure 8: Comparison of a different neural network expert scoring.

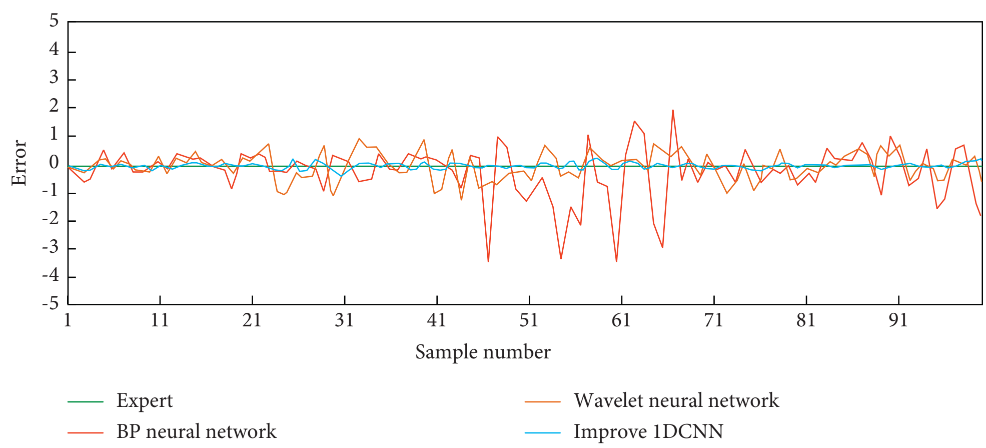

Figure 9: Error comparison of three neural networks.

evaluation method is better than other network evaluation methods, and the error range is very small, which can be ignored.

5. Conclusion

For how to recognize and objectively evaluate the singing voice, this paper proposes an improved CNN speech recognition method, which combines the idea of one-dimensional convolutional neural network with objective evaluation, and uses MATLAB for simulation experiment. The effectiveness and feasibility of the method are verified by simulation. This new method is established on the basis of one-dimensional convolutional neural network. The traditional 1DNN algorithm is optimized by fractional order processing node theory, and the corresponding parameters are set to build an objective evaluation system based on the improved 1DCNN. The final test analysis shows that, compared with 2DCNN, the improved 1DCNN has higher recognition rate, and the convergence speed has been improved, which shows that it is effective to use 1DCNN as the basic algorithm of singing speech recognition. At the same time, in order to verify the superiority of the method, through comparing with other neural networks, the results show that the evaluation method based on the improved 1DCNN has higher stability, and the error between the subjective score and the evaluation method is the smallest. Therefore, it is undeniable that the improved 1DCNN has superior performance and more scientific objective evaluation. To sum up, for the recognition of singing voice, the improved 1DCNN method can effectively process the voice signal with small distortion, and on this basis, it can also objectively evaluate the voice quality of singers, which promotes the scientific development of music talent selection. At the same time, the combination of music and computer technology can also promote interdisciplinary cooperation.

However, the improved 1DCNN method still has some problems in dealing with distorted sound signals. It is necessary to analyze its limitations and future research directions in the future.

Data Availability

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

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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Research Article

Evaluation Model of College Students' Mental Health Quality Based on Computational Intelligence

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In order to realize the reliability evaluation of college students' mental health quality, a model of college students' mental health quality evaluation based on computational intelligence is proposed. The mutual information quantity is used as the benchmark parameter to measure the interaction between the two variables of college students' mental health quality. The greedy algorithm to find the best feature subset for college students' mental health quality assessment is designed. The feature sequence sampling and the reassembly model of college students' mental health quality is constructed. The reliability assessment and nonparametric quantitative feature estimation are carried out, so as to complete the quantitative analysis and assessment of college students' mental health quality. The test results show that this method has a high confidence level and good reliability. The evaluation results can accurately reflect the depression, stress, anxiety, and other emotions related to college students' mental health, and have a good effect.

1. Introduction

With the high-level development of society, interpersonal relationships are becoming more and more extensive and complex, and individuals are under more and more pressure in social life, and their psychological problems are gradually increasing by 300%. Moreover, college students are in the transition stage from late youth development to early adulthood, and their psychology is not fully developed, and the incidence of psychological problems is higher than that of the general population. In recent years, relevant research shows that a large proportion of college students have psychological barriers to adaptation and adverse reactions. The incidence of psychological problems such as depression, sensitivity, hostility, and interpersonal tension is about 30%, and it is developing towards an increasingly serious trend. Many research studies on college students' mental health show that in recent years, the overall mental health level of college students is gradually declining, and the number of people with various psychological problems or barriers is increasing day by day. The research results show that 31.13% of college students have psychological problems with different symptoms and different severity. Studies have shown that 8.7% of college students have serious mental health problems, and the proportion of college students with moderate mental disorders is even more than 20%. Many domestic research conclusions show that although the overall mental health level of college students is higher than that of the general population, some psychological problems such as compulsion, interpersonal relationship, anxiety, and hostility are prominent. Studies show that the proportion of college students with moderate obsessive-compulsive symptoms is as high as 9.77%, the proportion of college students with moderate interpersonal sensitivity is 7.33%, and the proportion of college students with moderate anxiety and hostility is 3.76%. Moreover, many research results show that college students', Lu Luo Xiao, and others pointed out that college students have serious psychological confusion in interpersonal sensitivity, compulsion, and paranoia [1–3]. Therefore, it is of great significance to study an effective evaluation model of college students' mental health quality in preventing college students' mental health diseases [4].

Traditionally, the evaluation algorithms of college students' mental health quality mainly include particle swarm optimization (PSO)-based evaluation algorithm, statistical analysis algorithm, and association rule feature extraction algorithm. Through the statistical analysis and construction of college students' mental health quality time series, the correlation feature detection method is adopted to realize the evaluation of college students' mental health quality [5]. As an important research method, computational intelligence and the knowledge network pay attention to the network relationship between computational intelligence and the network structure. Based on this, this paper attempts to effectively combine the knowledge network with the scale for detecting college students' mental health status, and tries to find out the relationships among the dimensions in the scale, so as to better evaluate the college students' mental state and solve their psychological problems pertinently [6–8].

Therefore, an evaluation model of college students' mental health quality based on computational intelligence and the multidimensional feature selection algorithm is proposed in this paper. An evaluation model of college students' mental health quality based on computational intelligence and the multidimensional feature selection algorithm is proposed. Among them, computational intelligence refers to an empirical computer thinking program. It is a branch of the artificial intelligence system. It is a system with independent thinking ability that assists human beings to deal with various problems of college Students' mental health quality. The key features are continuous evolution, environmental friendliness, and open ecology. This paper designs a greedy algorithm to find the best feature subset for the evaluation of college students' mental health quality, constructs a feature sequence sampling and a recombination model based on the regular term feature selection method, and combines the statistical information analysis method to evaluate the reliability and nonparametric feature estimation of college students' mental health quality, and constructs a sample regression analysis model for quantitative analysis and evaluation of college students' mental health quality. Finally, the empirical analysis is carried out and the validity conclusion is drawn.

2. Statistical Analysis and Big Data Modeling of College Students' Mental Health Quality

The quality of college students' mental health includes the relativity, overall coordination, and development of the standard. The specific contents are as follows:

Relativity of standards: for most college students, it is normal to face psychological problems in the process of life development. There is no need to make a fuss and they should be actively corrected. At the same time, individual gray areas also exist. College students should improve their awareness of self-care and adjust themselves in time. The activity of the people's health state is a problem of development. When a person has a certain psychological barrier, it does not mean that it will be maintained or aggravated forever. It is very normal to form psychological conflicts, and they can be solved by themselves. Overall coordination: from the perspective of the psychological process, the psychological activities of healthy people are a complete and unified coordination body, which ensures the high accuracy and effectiveness of individuals in the process of reflecting the objective world. Developmental: the developmental standard of mental health is an ideal scale. On the one hand, it provides people with a standard to measure whether they are mentally healthy or not, and also points out the direction of efforts to improve their mental health.

2.1. Statistical Analysis of College Students' Mental Health Quality. In order to realize the evaluation of college students' mental health quality based on computational intelligence and the multidimensional feature selection algorithm, it is necessary to first build a statistical analysis model of college students' mental health quality, and through big data analysis and feature detection, establish a statistical analysis model of college students' mental health quality, pay attention to the development and education of college students' mental health, scientifically and objectively understand their psychological burden and mental pressure, and work out some effective measures to solve college students' mental problems, so as to provide reference for comprehensively and effectively improve the college students' mental health level [9, 10]. It can improve the comprehensive quality of college students, promote their future growth and progress, and help colleges and universities to continuously provide high-quality talents for national development and construction. According to the method of constrained variable analysis, this paper analyzes the characteristics of college students' mental health quality, estimates the characteristics and parameters of college students' mental health quality based on data mining theory, uses big data fusion scheduling and statistical information mining methods to analyze college students' mental health quality, and uses the cluster analysis method to establish a classification analysis model of college students' mental health quality evaluation [11]. Cluster analysis is a dimensionality reduction statistical analysis technique, which divides the research objects into relatively homogeneous research objects according to their characteristics. Cluster analysis has the advantages of simple and fast processing of datasets, and improves model building capabilities through efficient scalable performance. Its goal is to collect data for classification based on similarity. The principle is that objects of the same type are more similar, while objects of different types are more different. The tool can analyze the classification status of the research objects into pedigree charts or ice wall charts, and intuitively display the relationship between the objects [12]. Thus, the implementation structure of college students' mental health quality assessment based on computational intelligence is shown in Figure 1.

It can be seen from the implementation structure of college students' mental health quality assessment based on computational intelligence in Figure 1 that the cooccurrence matrix scale relationship is made according to the common occurrence times of two symptoms. The cluster analysis method, combined with factor analysis, principal component analysis, and multidimensional scale analysis, can also

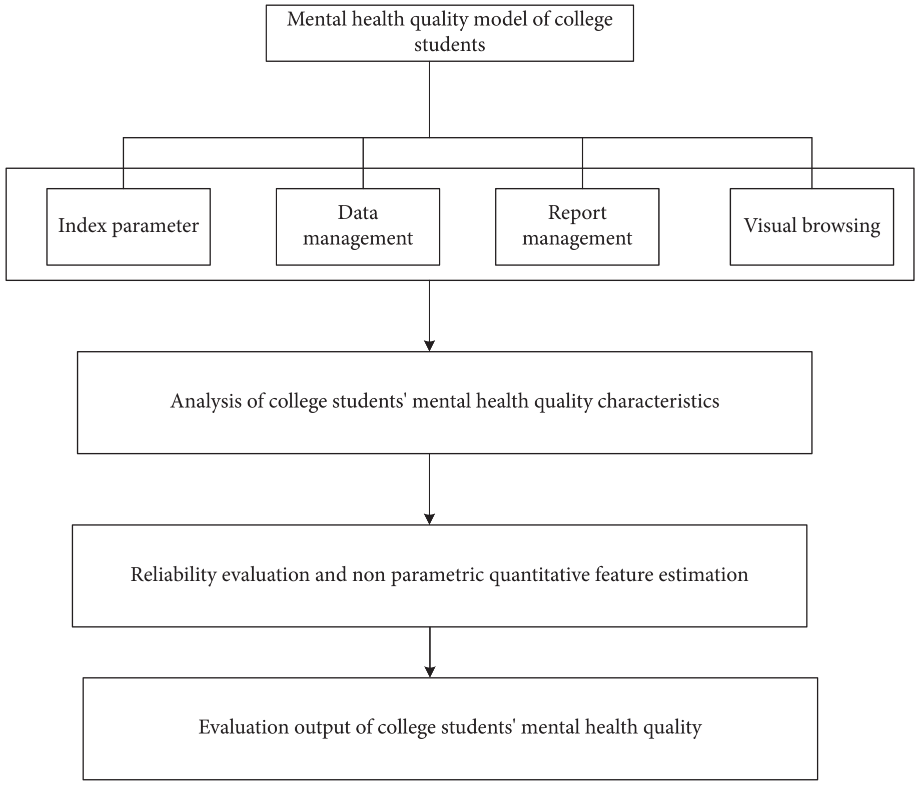

FIGURE 1: Implementation structure diagram of college students' mental health quality evaluation based on computational intelligence.

be called system clustering when analyzing the cluster diagram of SCL-90 factors. Variables can be selected in the path analysis classification system clustering [13–15]. By analyzing the cluster ice chart and the cluster tree diagram of each factor, the nine dimensions in SCL can be roughly divided into four categories. The first category includes terror, paranoia, and hostility; the second category includes depression; the third category includes coercion; the fourth category includes anxiety, psychosis, interpersonal relationship, and somatization factors, and establishes a fuzzy information distribution mathematical model of college students' mental health quality statistics, which is expressed as

$$\begin{cases} \sigma_1(\varphi_a, \dot{\varphi}_a) = \dfrac{1}{1 + e^{-(\omega_{11}\varphi_a + \omega_{21}\dot{\varphi}_a)}}, \\ \sigma_2(\varphi_a, \dot{\varphi}_a) = \dfrac{1}{1 + e^{-\int(\omega_{21}\varphi_a + \omega_{22}\dot{\varphi}_a)\mathrm{d}t}}, \\ \sigma_3(\varphi_a, \dot{\varphi}_a) = \dfrac{1}{1 + e^{-\mathrm{d}(\omega_{11}\varphi_a + \omega_{21}\dot{\varphi}_a)}}. \end{cases} \tag{1}$$

In the above formula, φ_a is the first-level dynamic parameter of the evaluation index of college students' mental health quality, $\dot{\varphi}_a$ represents the differentiation of it, $\omega_{11}, \omega_{12}, \omega_{21}, \omega_{22}$ represent the dynamic parameter of the relationship between objects, and w is the weighted feature vector, so as to construct a distributed fusion model of prior information of college students' mental health quality. The calculation formula is

$$SLi = \begin{cases} Li, & \text{if} \quad i = 1, \\ \text{Newi'}, & \text{otherwise}, \end{cases} \tag{2}$$

where, $\text{New}_{i'} = (e_{i',1}, e_{i'2}, \ldots, e_{i'D})$ is the dynamic influencing parameter of anxiety, psychosis, and interpersonal relationship, which is the distributed dispatching set of college students' mental health quality evaluation, $c = 1/n_j$, and Li represents the influencing parameter of terror and paranoia. According to the above analysis, a statistical analysis model of college students' mental health quality is established, and a statistical analysis model of college students' mental health quality evaluation is constructed. According to the method of constrained variable analysis, the multiobjective characteristics of college students' mental health quality are analyzed [16].

2.2. Big Data Analysis Model of College Students' Mental Health Quality. Taking the related research literature of college students' mental health on the Web of Science as the research object, this paper makes a visual analysis of the research status of college students' mental health from the perspectives of annual development [17], national or regional distribution, research institutions, subject distribution, key words, research hotspots, etc. and obtains that the dynamic migration of college students' mental health can be expressed as follows:

$$L_t^{\text{eff}} = \frac{1}{n_j}\frac{1}{1+e^{-\int(\omega_{21}\varphi_a+\omega_{22}\dot{\varphi}_a)\mathrm{d}t}} \otimes \frac{1}{1+e^{-\mathrm{d}(\omega_{11}\varphi_a+\omega_{21}\dot{\varphi}_a)}}, \tag{3}$$

where, n_j indicates that there are significant differences in the scores of evaluation factors of college students' mental health quality. In the process of calculating the correlation of positive factors by traditional statistical methods, the Pearson correlation coefficient is used. The Pearson correlation coefficient is a measure of the similarity of vectors, and the output ranges from −1 to +1, where 0 represents no correlation, a negative value represents a negative correlation, and a positive value represents a positive correlation. The Pearson correlation coefficient is optimized on the Euclidean distance, and the values of these vectors are centered, that is, the mean of the elements is subtracted for all dimensions in the two vectors. The average value of all dimensions after centralization is basically 0, and the cosine distance is calculated for the centralization result, but the calculation of cosine distance requires that all values in each vector must be non-empty. The Pearson correlation coefficient can assign all dimensions in the vector as 0, carry out cosine calculation to obtain the mental health status of college students. The self-adaptive optimization method is used to evaluate the reliability of college students' mental health quality. Through the quantitative optimization method, the optimization model of college students' mental health quality is designed, and the optimal parameter estimates are

$$op_{ij} = k * \left(\min_j + \max_j\right) - x_{ij}. \tag{4}$$

In the above formula, k represents the dynamic parameters under the constraints of natural conditions and living habits, x_{ij} is the related characteristic quantity that affects the healthy development of normal interpersonal relationships, $\min_j$ is the minimum fuzzy characteristic distribution set, and $\max_j$ is the maximum fuzzy statistical distribution set. Therefore, the multiple linear fusion method is the most basic and simplest one in multiple regression analysis. Using regression models, as long as the model and data are the same, a unique result can be calculated by standard statistical methods. Combining the multiple linear fusion method to make fuzzy decisions in the process of evaluating college students' mental health quality, the quantitative regression analysis model of statistical big data analysis of college students' mental health quality is established:

$$[\nabla F(x)]_j = \frac{\partial F(x)}{\partial x_j} = 2\sum_{i=1}^{N} v_i(x)\frac{\partial v_i(x)}{\partial x_j}. \tag{5}$$

In the above formula, $F(x)$ represents the control objective function of college students' mental health quality evaluation, and $v_i(x)$ represents the adaptive expansion coefficient, so as to construct a dynamic analysis model of college students' mental health quality evaluation. In condensed subgroup analysis, we find that mild symptoms are closely related to severe symptoms. And mild somatization, mild hostility, mild terror, mild depression, and mild anxiety are the most closely related [18–20]. There is also a close relationship between mild paranoia and mild psychosis. Using the method of frequent item sets association rule reconstruction, the similarity of college students' mental health quality distribution is solved as follows:

$$S(x) = \sum_{i=1}^{N} v_i(x)\nabla^2 v_i(x), \tag{6}$$

where, $v_i(x)$ is a subgroup factor of college students' psychological symptoms, and ∇ is a gradient function. In the limited state space, the related characteristic information of college students' mental health quality is extracted to obtain

$$\begin{aligned}\left[\nabla^2 F(x)\right]_{kj} &= \frac{\partial^2 F(x)}{\partial x_k \partial x_j}\\ &= 2\sum_{i=1}^{N}\left[\frac{\partial v_i(x)}{\partial x_k}\cdot\frac{\partial v_i(x)}{\partial x_j} + v_i(x)\frac{\partial^2 v_i(x)}{\partial x_k \partial x_j}\right]\\ &= 2J^T(x)J(x) + 2S(x),\end{aligned} \tag{7}$$

where, $F(x)$ is the importance distribution function of college students' abnormal psychological symptoms, the correlation characteristics of different subgroups, x_k is the cross-correlation vector, x_j is the relative position distribution set of college students' psychological symptoms, SD is a feature distribution set that further refines symptoms. $S(x)$ is a feature distribution set that further refines symptoms, $J(x)$ is the feature distribution set of further refinement of symptoms, and $J_T(x)$ is the transpose matrix of $J(x)$ F. Through the above formula, the big data analysis model of college students' mental health quality evaluation is obtained, and the adaptive scheduling weighted control method is adopted. This paper makes a statistical analysis of college students' mental health quality, designs a greedy algorithm to find the best feature subset for college students' mental health quality evaluation, and realizes the evaluation of college students' mental health quality by the feature selection method based on regular terms [21].

3. Optimization of the Evaluation Model of College Students' Mental Health Quality

3.1. Characteristics Screening of College Students' Mental Health Quality Evaluation. By using the traditional statistical method, the nine dimensions in SCL are divided into four categories, and the characteristic sequence sampling and recombination model of college students' mental health quality is constructed [22]. Combined with the statistical information analysis method, the reliability evaluation and nonparametric quantitative characteristic estimation of college students' mental health quality are carried out. The fuzzy correlation big data analysis model of college students' mental health quality is established, and the fuzzy degree evaluation and parameter evaluation of college students' mental health quality are carried out by the method of correlation regularity detection. The initial gradient function of college students' mental health status correlation is expressed as follows:

$$x_{ij} = x_{\min,j} + \mathrm{rand}(0,1)\left(x_{\max,j} - x_{\min,j}\right), \tag{8}$$

where, $x_{\min,j}$ and $x_{\max,j}$ represent the minimum and maximum interclass distribution feature sets of college students' mental health status distribution, and rand represents random function. The weighted coefficient is expressed as follows:

$$\left[\nabla^2 F(x)\right]_{kj} \cong 2J^T(x)J(x), \tag{9}$$

where, $J(x)$ and $J^T(x)$ represent the dynamic detection factors of the distribution factors of college students' mental health quality.

According to the prior data of college students' mental health results, the multidimensional distributed task set of college students' mental health quality is established, and the fuzzy iterative equation of college students' mental health quality evaluation is obtained by the method of priority attribute scheduling:

$$\begin{aligned} V_{\mathrm{id}}^{t+1} &= wV_{\mathrm{id}}^{t} + c_1 r_1\left(p_{\mathrm{id}} - x_{\mathrm{id}}\right) \\ &\quad + c_2 r_2\left(p_{gd} - x_{gd}\right), \end{aligned} \tag{10}$$

where, w is the characteristic factor of the tree model, c_1 and c_2 are dynamic factors of mental health evaluation, r_1 and r_2 F are dynamic parameters of differential selection, $x_{g\ d}$ and $x_{i\ d}$ are clustering parameters of various factors, $p_{g\ d}$ and $p_{i\ d}$ are hierarchical clustering parameters, and the correlation characteristic quantity of college students' mental health quality is determined. For each $w \in Z$, a statistical analysis and parameter evaluation model of college students' mental health quality is constructed. Data mining can support colleges and universities to accurately evaluate the psychology of college students through the useful and accurate data about college students' mental health quality evaluation and evaluation behavior, so as to help college students to establish a good psychology. Based on the trend of college students' psychological development, teachers can more accurately direct college students' attention to study and life, and improve their learning enthusiasm. In addition, data mining can also help teachers predict students' mental health status. Through this prediction, teachers can maintain and promote the needs of college students' physical and mental health, help colleges and universities to carry out mental health education, so that college students take the initiative to learn basic knowledge of psychology, master the basic skills of maintaining mental health, learn to self-resolve psychological troubles, prevent the generation of psychological disorders. Objective function of college students' mental health quality evaluation is obtained by combining the method of big data mining:

$$F = \sum_{j=1}^{n}\sum_{i=1}^{m} C_{ij}X_{ij}, \tag{11}$$

where, X_{ij} is the correlation parameter to explain the original variables, C_{ij} is the factor and principal component characteristics, and m, n are the hierarchical structure parameter. And the characteristic resolution function of the mental health quality evaluation of college students is obtained

$$g_k + A_k \Delta x_k = 0, \tag{12}$$

where, g_k is the statistical characteristic quantity of the common factor, A_k is the correlation parameter between the original variables explained by the factor, and Δx_k is the comprehensive variable. The statistical big data analysis model is established to evaluate the mental health quality of college students, and the output statistical characteristic quantity is

$$\begin{cases} \mathrm{net}_{s1}(k) = r_s(k), \\ \mathrm{net}_{s2}(k) = y_s(k), \end{cases} \tag{13}$$

where, $r_s(k)$ represents the original variable of factor interpretation, and $y_s(k)$ represents the characteristic quantity of the principal component. Combined with the statistical information analysis method, the reliability evaluation and nonparametric quantitative characteristic estimation of college students' mental health quality are carried out. The output statistical characteristic quantity is

$$u_{si}(k) = \mathrm{net}_{si}(k), \tag{14}$$

where, $\mathrm{net}_{si}(k)$ represents the constraint parameter related to the principal component. According to the attribute clustering of big data of college students' mental health quality, multiobjective programming is carried out, and the multiobjective programming function is obtained as follows:

$$x_{si}(k) = \begin{cases} 1, & u_{si}(k) > 1, \\ u_{si}(k), & -1 \le u_{si}(k) \le 1, \\ -1, & u_{si}(k) < -1. \end{cases} \tag{15}$$

In the formula, $u_{si}(k)$ represents the edge node vector of the flow load of college students' mental health quality. According to the above analysis, the characteristic sequence sampling and the recombination model of college students' mental health quality is constructed, and the reliability of college students' mental health quality is evaluated by the statistical information analysis method.

According to the method of constrained variable analysis, the multiobjective planning and feature analysis of college students' mental health quality are carried out, and the fuzzy correlation big data analysis model of college students' mental health quality is established [23–26]. The physical load of college students' mental health quality is, and the fuzzy evaluation and parameter evaluation of college students' mental health quality are carried out by the method of association rule detection, and the output migration load of passenger flow is obtained as follows:

$$L_t^{\mathrm{eff}} = \frac{1}{n_j}\,\frac{L_0 P_j^{\min} - L_j P_0^{\min}}{P_0^{\min} + P_j^{\min}}. \tag{16}$$

In the above formula, $P_j^{\min}$ represents the modified optimal load transfer of college students' mental health quality, $P_0^{\min}$ represents the decision variable of college students' mental health quality evaluation, X_{ij} is the autocorrelation variable of college students' mental health quality evaluation, n_j represents the marginal feature distribution of college students' mental health quality evaluation.

3.2. Evaluation Output of College Students' Mental Health Quality. The characteristic sequence sampling and the recombination model of college students' mental health quality is constructed, and combine the statistical information analysis method to conduct the reliability evaluation and nonparametric quantitative characteristic estimation of college students' mental health quality. The optimization control module of college students' mental health quality assessment is described as follows:

$$\min(f) = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij} = \begin{cases} \sum_{j=1}^{m} X_{ij} = a_i, & i = 1,2,\ldots,m, \\ \sum_{i=1}^{m} X_{ij} = b_i, & j = 1,2,\ldots,n, \\ X_{ij} \geq 0, & i = 1,2,\ldots,m,\ j = 1,2,\ldots,n, \end{cases} \tag{17}$$

where, C_{ij} and X_{ij} are related. Through the above mathematical model construction, a multiobjective programming model for the evaluation of college students' mental health quality is established, which is expressed as

$$x_i = \begin{cases} 0, M - \sum_{j=1}^{\lfloor n/2 \rfloor} w_j - \sum_{j=\lfloor n/2 \rfloor+1}^{i} w_j - \sum_{j=i+1}^{k} w_j < 0, & i \leq k, \\ f_i(M,n,w,c,r) = \min\{f(M,n,w,c,r)\}, \\ 1, M - \sum_{j=1}^{\lfloor n/2 \rfloor} w_j - \sum_{j=\lfloor n/2 \rfloor+1}^{i} w_j - \sum_{j=i+1}^{k} w_j > 0, \end{cases} \tag{18}$$

where, M is the original variable of factor explanation, w_j is the statistical characteristic quantity of common factor, and $f_i(M,n,w,c,r)$ is the positive correlation parameter between factors. Through the autocorrelation feature matching method, intelligent learning and output control can be achieved, and the statistical characteristic quantity of college students' mental health quality evaluation meets the multiobjective linear mapping. Multiobjective linear mapping usually refers to the correspondence between two different spaces. Under the same conditions, multiobjective linear programming can obtain the evaluation value of college students' mental health quality, and realize multiobjective linear programming planning by using objective function and constraints. The correlation mapping relationship between the constraint parameter set of multiobjective programming and existence is expressed as follows:

$$p\left(R^N = r_i\right) = p\begin{pmatrix} X^N = x_i \| x_i| = |r_i|, \text{angle}(x_i) \\ = \left(\text{angle}(r_i) - \varphi_g\right)\text{mod}(2\pi) \end{pmatrix}, \tag{19}$$

where, X^N is the total score parameter of depression and anxiety, x_i is the correlation parameter of depression and psychotic diseases, r_i is the dynamic distribution parameter of depression and anxiety, $\text{angle}(x_i)$ is the multivariate statistical characteristic parameter. Combining with the artificial intelligence learning method, the self-adaptive learning of college students' mental health quality evaluation is obtained, and the reliability constraint parameter model describing college students' mental health quality evaluation is as follows:

$$\begin{aligned} H\left(R^N\right) &= -\sum_{i=1}^{M} p(r_i)\log(p(r_i)) \\ &= -\sum_{i=1}^{M} p(x_i)\log(p(x_i)) \\ &= H\left(X^N\right), \end{aligned} \tag{20}$$

where, M is the number of elements in the symbol set, the fuzzy characteristic analysis method is adopted, $p(r_i)$ is the correlation parameter between the original variables of mental health quality evaluation, $p(x_i)$ is the factor explanation process parameter, and X^N is the fuzzy characteristic quantity, so as to evaluate the mental health quality of college students.

Combining the statistical information analysis method, the reliability evaluation and nonparametric quantitative feature estimation of college students' mental health quality are carried out, and a sample regression analysis model is constructed to quantitatively analyze and evaluate college students' mental health quality. The sample regression analysis model is as follows:

$$\begin{aligned} H\left(X^N | Z^N\right) &= H\left(R^N, \varphi_g | Z^N\right) \\ &= H\left(R^N | Z^N\right) + H\left(\varphi_g | Z^N\right) - I\left(R^N; \varphi_g | Z^N\right), \end{aligned} \tag{21}$$

where, the objective window function of college students' mental health quality evaluation is $R_2{}^T R_2 = V_2 \sum{}_2 V_2{}^T$, and the statistical evaluation of college students' mental health quality is carried out by rough set evaluation and the multiobjective programming method, and the optimal learning weight of college students' mental health quality evaluation is obtained as follows:

$$\omega = \omega_{\max} - t\frac{\omega_{\max} - \omega_{\min}}{T_{\max}}, \tag{22}$$

where, $\omega_{\max}$ and $\omega_{\min}$ respectively represent the regulation coefficient of college students' mental health quality evaluation, $T_{\max}$ is the maximum control time scale. Based on the above analysis, this paper constructs the characteristic series sampling and the recombination model of college students' mental health quality, combines the statistical information analysis method, carries out the reliability

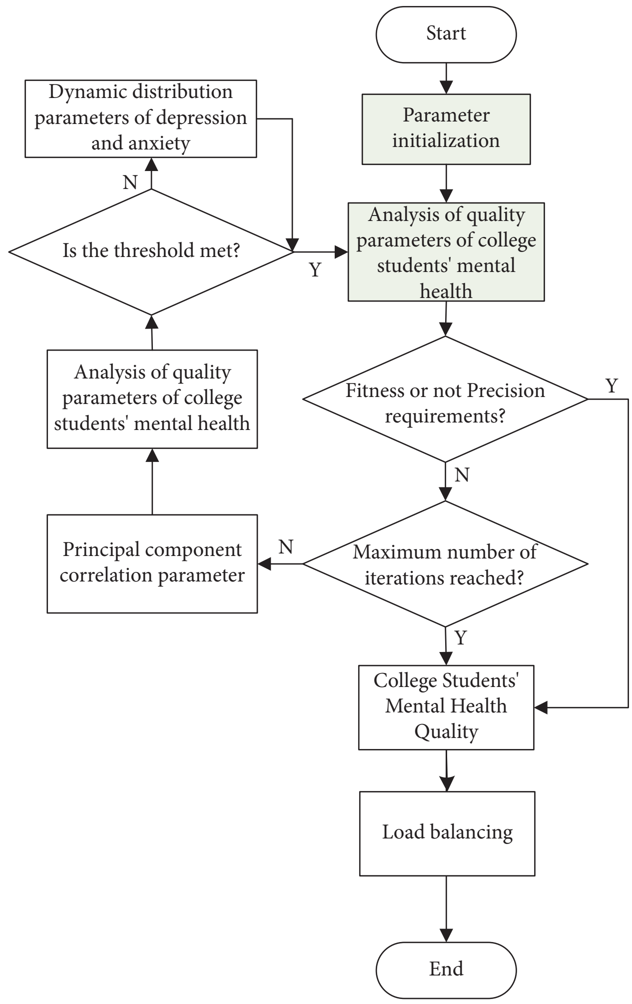

Figure 2: Optimization process of college students' mental health quality assessment.

evaluation and nonparametric quantitative feature estimation of college students' mental health quality. The optimization process is shown in Figure 2.

According to the optimization implementation process in Figure 2, the research on the construction of the college students' mental health quality evaluation model based on computational intelligence is completed.

4. Simulation Analysis

4.1. Test Environment. In order to verify the application performance of this method in the evaluation of college students' mental health quality, a simulation test analysis is carried out, which is combined with 14.0 Matlab 7 and SPSS14.0. When analyzing the cluster diagram of each factor of SCL-90, hierarchical clustering is adopted, which can also be called systematic clustering. In SPSS, the path is analysis-classification-systematic clustering, and variables are selected in clustering. Analyze the cluster ice wall chart and the cluster tree chart of each factor, as shown in Figures 3 and 4, respectively. Considering the two figures, we can see that these nine dimensions in SCL can be roughly divided into four categories. The first category includes terror, paranoia and hostility; the second category includes depression; the third category includes coercion; the fourth category includes anxiety, psychosis, interpersonal relationship, and somatization. The statistical population is 2000, including 1000 boys and 1000 girls. The states before and after the application of the mental health quality assessment model are analyzed, respectively. The number of optimization iterations of the multiobjective programming is 400, according to the above simulation parameters, the simulation analysis of college students' mental health quality evaluation is carried out.

4.2. Model Application. The evaluation model of college students' mental health quality was applied to the test of college students' psychological influencing factors to verify the feasibility and effectiveness of the model. The reliability of the evaluation model of mental health quality of college students reaches 90% to meet the test requirements. The credibility calculation formula is

$$R = [r(M - \lambda)] \times 100\%. \tag{23}$$

Among them, r is the different content of model verification; λ is the transient value of feature change. According to the above credibility formula, the measurable content of

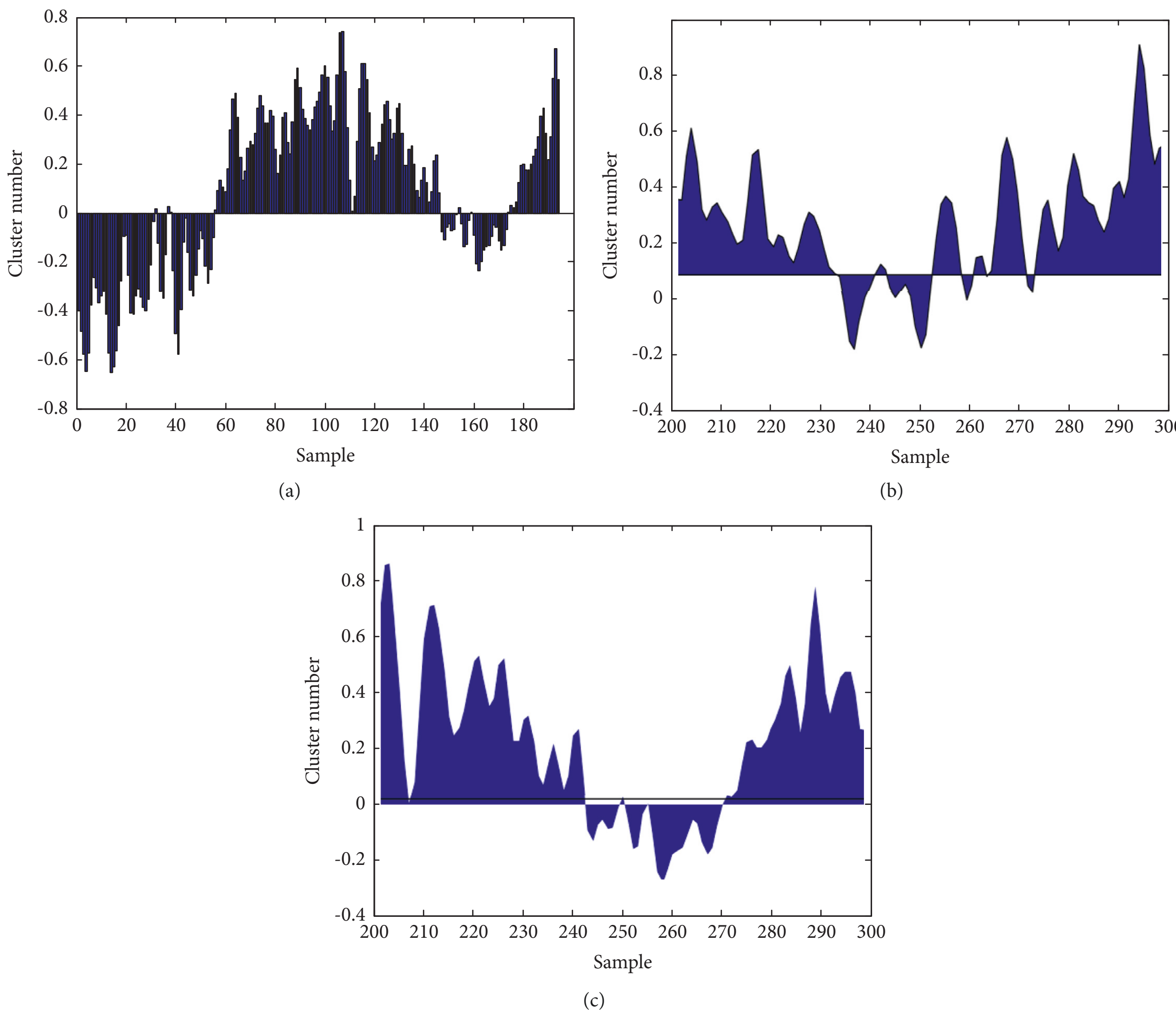

Figure 3: Cluster ice chart of various factors in mental health quality evaluation of college students. (a) Sample 1. (b) Sample 2. (c) Sample 3.

the model is used as the basis for judging the application. Table 1 shows the results of comparing the reliability of different content models.

According to the contents in Table 1, the correlation feature degree, feature sequence sampling, and data logic tracking have high reliability, the model data fidelity and fuzziness feature quantity have relatively low reliability, and all feature values are more than 80% as a whole.

4.3. Test Results. The proposed model is used to evaluate the mental health quality of college students, and the cluster ice hanging and cluster tree comparison results of each factor of the mental health quality evaluation of college students are analyzed, respectively. The detailed test results are shown in Figures 3 and 4.

It can be seen from Figures 3 and 4 that the nine dimensions in SCL can be roughly divided into four categories. The first category includes terror, paranoia, and hostility; the second category includes depression; the third category includes coercion; the fourth category includes anxiety, psychosis, interpersonal relationship, and somatization. Taking the data in Figures 3 and 4 as the research object, the fuzzy correlation big data analysis model of college students' mental health quality is established. The fuzzy evaluation and parameter evaluation feature distribution of college students' mental health quality are carried out by using the association rule detection method, as shown in Figure 5.

According to the analysis of Figure 5, 748 selected positive subjects' data, according to the scoring standard that any factor score greater than 2 but less than 3 is regarded as mild symptom, and a factor score greater than 3 is regarded as severe symptom, the original 9 factors are converted into 18, that is, mild somatization, mild compulsion, mild interpersonal relationship, mild depression, mild anxiety, mild hostility, mild terror, mild paranoia, mild psychosis, severe somatization, severe compulsion, severe interpersonal relationship, severe depression, severe anxiety, severe hostility,

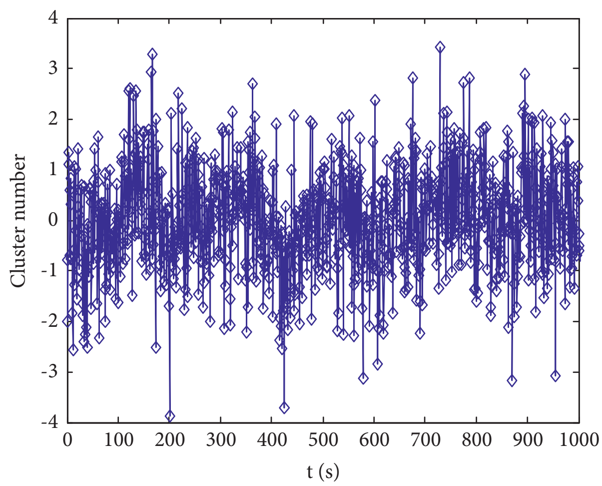

Figure 4: Cluster tree diagram of each factor of college students' mental health quality evaluation.

Table 1: Model verification content credibility.

Content	Content reliability (%)
Degree of association	91
Feature sequence sampling	94
Ambiguity feature quantity	82
Model data fidelity	84
Data logic tracking	93

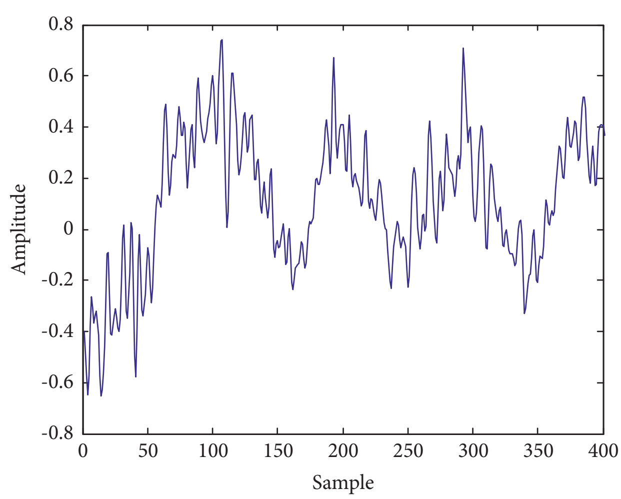

Figure 5: Distribution of characteristics of college students' mental health quality evaluation.

severe terror, severe paranoia, and severe psychosis. We compare the test confidence level, and the results are shown in Table 2.

According to Table 2, the confidence level of college students' mental health quality evaluation by this method is high and the reliability is good. The evaluation results can accurately reflect the depression, stress, anxiety, and other emotions related to college students' mental health. The somatization, interpersonal relationship, depression, and paranoia obtained by the evaluation have significant differences ($P < 0.05$), while other factors have no significant differences. Somatization and depression were significantly lower than the norm ($P < 0.05$), while interpersonal relationship and paranoia were significantly higher than the norm ($P < 0.05$).

Table 2: Confidence level test of college students' mental health quality evaluation.

Test objects	Somatization	Hostile	Depressed	Terrifying
1	42.433	357.603	12.443	55.348
2	41.740	262.636	14.590	54.443
3	41.109	319.317	13.238	53.620
4	40.982	357.451	11.885	53.455
5	40.705	430.681	13.189	53.093
6	40.692	157.821	11.794	53.076
7	40.263	175.267	12.053	52.517
8	41.428	218.104	13.010	54.036
9	41.996	240.533	14.601	54.777
10	40.626	85.719	12.287	52.991
11	40.452	273.452	12.123	52.764
12	42.238	387.355	13.854	55.093
13	40.165	228.598	11.816	52.389
14	42.974	335.016	11.845	56.053
15	40.596	84.266	13.391	52.951
16	40.458	94.439	12.084	52.771
17	37.819	81.497	12.871	52.617
18	39.472	303.630	11.791	54.917
19	38.467	32.405	12.916	53.519
20	38.134	433.097	14.141	53.056

To sum up, the college students' mental health quality evaluation model based on computational intelligence has high confidence level, good reliability, good performance, and can effectively respond to depression, stress, anxiety, and other emotions related to college students' mental health, with significant differences.

5. Conclusions and Prospects

5.1. Conclusion. The following conclusions are drawn from the above research:

This method has a high confidence level and good reliability. The evaluation results can accurately reflect the depression, stress, anxiety, and other emotions related to college students' mental health. Somatization, interpersonal relationship, depression, and paranoia obtained from the evaluation have significant differences ($P < 0.05$), and other factors have no significant differences. Somatization and depression were significantly lower than the norm ($P < 0.05$), and interpersonal relationship and paranoia were significantly higher than the norm ($P < 0.05$).

5.2. Prospect

(1) Schools should actively communicate with students' parents to comprehensively improve college students' psychological quality and psychological coping ability, so as to build a mental health education mechanism based on the classroom and supplemented by extracurricular activities. At the same

time, the screening mechanism of psychological problems should be continuously improved. The selection of scales and the use of reasonable statistical methods must be comprehensive and objective. When abnormal psychological symptoms of college students are found, timely and effective intervention should be carried out.

(2) The mental health of college students will be affected by the outside world, such as society, native family, and school, but its essence still lies in the appropriate self-regulation. College students are intellectuals in the contemporary social group, who have high social expectations, and their self-requirements are relatively high-level and high-quality. Therefore, it is very important to strengthen college students' self-regulation and control of their own mental health, and improve their self-education level and their awareness of psychological crisis. In daily study and life, we should objectively understand ourselves, actively accept ourselves, and strengthen self-education. This aspect should be further studied next.

Data Availability

The data are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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Retraction

Retracted: An Analysis of the Historical Process of Cultural Confidence in Ideological and Political Education Based on Deep Learning

Mathematical Problems in Engineering

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

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

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

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

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[1] X. Wang, "An Analysis of the Historical Process of Cultural Confidence in Ideological and Political Education Based on Deep Learning," *Mathematical Problems in Engineering*, vol. 2022, Article ID 8797533, 9 pages, 2022.

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Research Article

An Analysis of the Historical Process of Cultural Confidence in Ideological and Political Education Based on Deep Learning

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Ideological and political education can improve people's ideological and moral character and psychological quality, improve social governance, and promote the harmonious development of society. However, the current data of ideological and political education have the trend of mass and diversification. In order to improve the effect of ideological and political education, this paper proposes an analysis method of the historical process of cultural self-confidence of ideological and political education based on in-depth learning. By preprocessing the ideological and political education data to obtain text keywords, the principal component analysis method is improved to reduce the dimension of the ideological and political education data, and the vector space model is used to complete the text balance processing of the reduced dimension data. The data sensitivity after dimensionality reduction is analyzed by data training, the historical text data mining model is constructed to extract data features, and the bidirectional recurrent neural network is used to complete data extraction. The semantic features of the extracted data are obtained by using the forward and reverse feature generation methods, and the historical process of the cultural confidence of ideological and political education is analyzed by using the two-way generation method. The experimental results show that the accuracy rate of the historical process analysis method of cultural self-confidence in ideological and political education based on deep learning is 95%, the recall rate is 94%, and the degree of collaborative performance is good.

1. Introduction

The so-called curriculum politics is to integrate the ideological and political education into the various links of subject course teaching and teaching reform, so as to achieve the goal of establishing morality and cultivating people and moistening things silently. Teachers of ideological and political theory course in colleges and universities should establish confidence in the value of ideological and political theory course with high cultural confidence. The spread and development of culture cannot be separated from the intrinsic self-confidence of culture as the driving force. Colleges and universities must shoulder the mission of integrating cultural self-consciousness and cultural self-confidence into the whole process of ideological and political education. At the same time, culture bears the blood of a nation's development, reflecting the historical changes of the past and present. It is not only the cornerstone of building national spirit, but also an important standard to measure a country's soft power and comprehensive national strength. Analyzing the history of ideological and political education can help us to understand the present situation of ideological and political education and the development of cultural confidence. Deep learning is a new research direction in machine learning field. Deep learning is the inner rule and expression level of learning sample data. The information obtained in the process of learning is very helpful to the interpretation of data such as words, images, and sounds [1, 2]. Its ultimate goal is to enable machines, like humans, to analyze and learn, and recognize data such as words, images, and sounds. Deep learning is a complex machine learning algorithm that has achieved far more results in speech and image recognition than previous related technologies [3]. Deep learning has achieved a lot in search technology, data mining, machine learning, machine translation, natural language processing, multimedia learning, voice, recommendation and personalization technologies, and other related fields [4]. Deep learning makes machines imitate human activities such as audio-visual and thinking, and solves many complex pattern recognition problems, which makes great progress in artificial intelligence. There is also research on the application of deep learning in teaching. Xu et al. [5] proposed a target detection algorithm based on deep learning, which can extract depth information to identify low-level defect information, fuse defect features with PAN network, and complete single size feature image output. Mallikarjuna et al. [6] identify aircraft gearbox vibration data in both time and frequency domains by constructing long- and short-term memory models and bidirectional long- and short-term memory models to ensure stable operation of aircraft engines. Akgul et al. [7] designed a real-time traffic sign recognition system that supports digital imaging, extracts traffic signs from public data sets through deep learning, develops RT-TSR software using convolution neural networks, completes coding under the TensorFlow and OpenCV frameworks using the Python programming language, and enhances traffic sign recognition by using parallel CNN training. Li et al. [8] proposed an optimal grasping attitude detection algorithm based on dual-network architecture, improved the target detection model of deep learning, improved detection speed and object recognition performance, designed a multi-target grasping detection network using convolution neural network, and established an IOU region evaluation algorithm to screen the optimal grasping region of the target to achieve attitude detection. Deng et al. [9] proposed a new method based on Lucas–Kanade optical flow, which improves the traditional SLAM framework and improves the perception ability of intelligent devices such as robots to indoor environment. Hu and Feng [10] proposed a lightweight symmetrical U-encoder-decoder-based image semantic segmentation network named UNET, which is constructed by depth-separable convolution to improve image semantic segmentation.

Therefore, this article applies the deep study technology to the ideological and political education culture self-confidence historical process analysis. The data of ideological and political education were preprocessed with word segmentation assistant to eliminate sensitive words. Through the text emotion calculation method to extract ideological and political education cultural data features, feature keywords for dimensionality reduction processing complete the text balance processing. Based on deep learning theory, this paper analyzes the sensitivity of historical text data, constructs feature extraction of historical text data, and uses bidirectional recurrent neural network and attention model to extract historical text data. Through the forward and reverse feature generation methods, a two-way feature generation algorithm is designed to effectively analyze the historical process of ideological and political education and cultural confidence.

2. Balance of Historical Data Text of Confidence in Ideological and Political Education and Culture

2.1. Data Preprocessing. The socialist core value system is the essence of socialist advanced culture, and ideological and political education is an important carrier to build the socialist core value system. The socialist core value system is a complete theoretical system. Its basic contents include the guiding ideology of Marxism, the common ideal of socialism with Chinese characteristics, the national spirit with patriotism as the core, the spirit of the times with reform and opening up as the core, and the socialist concept of honor and disgrace with "Eight Honors and Eight Disgraces" as the main content. Because the content of the socialist core value system is rich, rational, and systematic, it needs a good carrier to integrate the socialist core values into the national education in order to integrate them into the minds of the public. The ideological and political education is such a carrier to carry out the education of the socialist core value system. Through ideological and political education, the educated can consciously use Marxist positions, viewpoints, and methods to observe, analyze, and deal with problems, strengthen the young educatees' belief in socialism with Chinese characteristics, and consciously participate in the great practice of China's socialist modernization.

In order to analyze the history of self-confidence of ideological and political education culture accurately, it is necessary to preprocess the historical data of self-confidence of ideological and political education culture to reduce the interference of multi-noise data, so as to improve the accuracy of analyzing the history of self-confidence of ideological and political education culture.

Under normal circumstances, there is no division between the historical data of ideological and political education culture confidence, only by artificial reading to distinguish the pause. Therefore, this model adopts a word segmentation assistant to deal with the historical data of ideological and political education culture confidence [11]. In the historical data of self-confidence of ideological and political education culture, there are usually names of people, places, and special organizations in the texts. To this end, before word segmentation, we must pay attention to identify idiomatic nouns and names involving confidential documents, after the removal of its name can be word segmentation.

In order to make participle easier, auxiliary words such as "de," "di," and "de" which are not conducive to judging text sensitivity can be removed. In addition, NbZ method is used to remove auxiliary words. List all the words with similar contents, judge the similarity between the historical data and the sensitive words, record the minimum similarity, and compare several minimum similarity ranges. The process is shown in Figure 1.

In Figure 1, because the similarity between the self-confidence historical data of ideological and political education and culture is less than the similarity between the self-confidence historical data of ideological and political education and culture and the sensitive words is less than the final range, the sensitive factors of the self-confidence historical data of ideological and political education and culture are removed by default, and the preprocessing of the self-confidence historical data of ideological and political education and culture is completed.

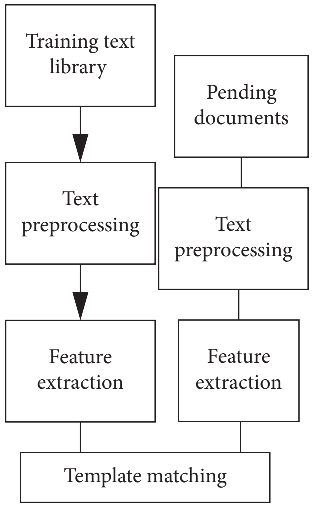

FIGURE 1: Pretreatment process.

2.2. Keyword Extraction. All content of the historical data text of ideological and political education culture is expressed by words. In a text, each word plays a different role in expressing the text theme. Therefore, extracting a keyword from the historical data text of ideological and political education culture self-confidence plays a more important role in expressing the theme of the text. This article uses the affective computing algorithm to extract text keywords, the expression of which is as follows [12]:

$$p_c = \exp\left(\frac{\overrightarrow{r}_c)}{\sum_c^{z=1} \exp(\hat{r}_t)}.\right. \tag{1}$$

In the formula, $\overrightarrow{r}$ represents the affective content of each word after pretreatment, and $\hat{r}$ is the affective parameter.

2.3. Dimension Reduction of Keywords. A typical feature of historical text data is that the dimension is high, and the higher the dimension is, the more difficult the classification will be in the later period. At present, there are five methods to reduce the dimension of historical text data: canonical correlation analysis [13], partial least squares [14], hyperspectral learning [15], linear discriminant analysis [16], and shared subspace learning [17]. However, in the process of application, these methods will destroy the integrity of text to some extent. To solve this problem, this section adopts a new method to reduce the dimension of historical text data, i.e., improved principal component analysis method.

2.3.1. Reduction of Dimensions by Principal Component Analysis. Assuming that the text matrix to be reduced is Y, it is a $d \times m$ matrix, expressed as follows:

$$Y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1m} \\ y_{21} & y_{22} & \cdots & y_{2m} \\ \cdots & & & \\ y_{d1} & y_{d2} & \cdots & y_{dm} \end{bmatrix}. \tag{2}$$

Step 1: Centralize the reduced dimension text matrix Y, and get the centralization matrix Y'.

Step 2: Calculate the eigenvalues and eigenvectors of Y'.

Step 3: Calculate cumulative contribution rates.

Step 4: According to the cumulative contribution rate in descending order of the feature value.

Step 5: Select the principal component corresponding to the first m characteristic value.

Step 6: Calculate the scores of m principal components to get the text set R with the new attribute.

2.3.2. Dimension Reduction of Text Based on Improved Principal Component Analysis. According to the number of projection vectors t in the projection matrix, the improved principal component analysis method projects the reduced dimension text vectors to t dimension. In a word, the feature set selected by principal component analysis is further extracted and compressed twice under the premise of minimizing information loss. The basic principles are as follows:

Based on the above analysis, the amount of information carried by the eigenvalue $\lambda_1, \lambda_2, \ldots, \lambda_m$ decreases in turn, so y_{ij} is set as the j feature of the i type text, and all positive eigenvalues are transformed as follows:

$$P_i = \frac{\lambda_i}{\sum_{i=1}^k \lambda_i}, \quad i = 1, 2, \ldots, k; 0 < P_i < 1. \tag{3}$$

Define the information function, represented as:

$$q(\lambda_i) = a_{ij}(1 + P_i), \quad i = 1, 2, \ldots, k. \tag{4}$$

In the expression, a is the distribution probability of the j feature in the feature space of the i class.

$q(\lambda_i)$ is an increasing function, and the larger the value, the greater the amount of information λ_i contains, if $q(\lambda_1) \geq q(\lambda_2) \geq \cdots \geq q(\lambda_i)$ is present and makes

$$\frac{\sum_{i=1}^t q(\lambda_i)}{\sum_{i=1}^k q(\lambda_i)} > 1 - b. \tag{5}$$

In the expression, b is a descriptive parameter of information, and $b \in (0, 50)$ is often used. Based on the projection matrix $C = (c_1, c_2, \ldots, c_t)$, the feature set is projected and the dimensionality is reduced.

$$Z = C^t R. \tag{6}$$

2.4. Text Balancing. Because the whole operation process is accomplished by computer, and the language computer such as text is incomprehensible, so it is necessary to convert the text data into structured data. Among the text balancing methods, vector space model is the most commonly used, and the specific process is as follows:

The result of the text dimensionality reduction processing Z is represented as the following eigenvector:

$$Z = \{(t_1, w_1), (t_2, w_2), \ldots, (t_n, w_n)\}. \quad (7)$$

In the expression, t_i is the i of the text, w_i is the weight of t_i, and n is the imbalance of the text.

Simplify Z to

$$Z = W = \{w_1, w_2, \ldots, w_n\}. \quad (8)$$

The degree of balance of two similar texts Z_1 and Z_2 is $\mathrm{bla}(Z_1, Z_2)$; that is, the degree of balance of two feature vectors is calculated according to the following formula:

$$bla(Z_1, Z_2) = (W_1, W_2) = \sum_{i=1}^{n} W_{1i} w_{2i}. \quad (9)$$

The larger the $\mathrm{bla}(Z_1, Z_2)$ is, the higher the degree of eigenvector balance is. According to the balance degree of the two feature vectors, the root of a text word can be extracted quickly. Based on the artificially defined rules, the root extraction method using the index can not only effectively extract the root of a word, but also does not need to use the artificially defined rules, so as to obtain the text balance processing results.

3. Feature Extraction of Historical Text Data Based on Deep Learning

3.1. Analysis of Historical Text Data Sensitivity. Historical text data sensitivity is to establish a cognitive connection between numbers and business, and identify the business meaning, problems, and reasons behind historical text data through numbers and business in a positive or negative way. Based on the deep learning theory, in order to improve its efficiency and accuracy, the model should be trained before being put into use. In this study, Ydht method is used to train the model, and the formula of output layer is as follows:

$$\begin{cases} p(h_i x_w, \theta_i) = \sigma\left(x_w^T \theta_{i-1}\right), h_i = 1, \\ p(h_i | x_w, \theta_i) = 1 - \sigma\left(x_w^T \theta_{i-1}\right), h_i = 0. \end{cases} \quad (10)$$

In the expression, p stands for historical data sensitivity, h_i for sensitivity coefficient, x_w for sensitivity, and θ_i for sensitivity level. The final results show that 1 and 0 represent the normal operation of the model, and accurate results can be obtained.

The specific model workflow is shown in Figure 2.

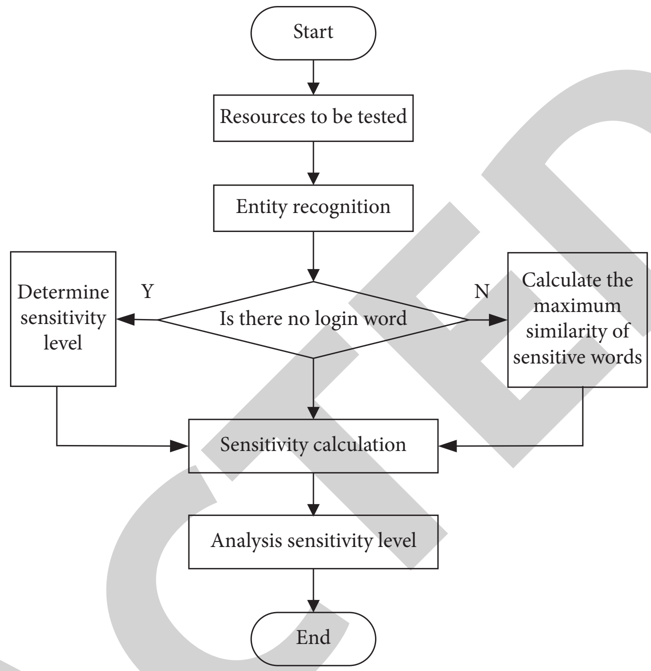

Figure 2: Sensitivity analysis process.

3.2. Construction of Feature Extraction of Historical Text Data. Firstly, a model of historical text data mining is constructed, in which the input layer corresponds to a large amount of historical text data and the output layer corresponds to the target text. The output function of historical text data is

$$b_r = f\left(\sum_{i=1}^{m} \alpha_i \times W_{ir} + T_r\right), \quad r = 1, 2, 3, \ldots u. \quad (11)$$

The input function for historical text data is

$$c_j = f\left(\sum_{r=1}^{\mu} b_r \times V_{rj} + \theta_j\right), \quad j = 1, 2, 3, \ldots, n. \quad (12)$$

In the formula, α_i is the input of historical text data in semantic network, W_{ir} is the weight of connection between layers in semantic network model, V_{rj} is the partial derivative function of output and input layer, and the threshold of output and input layer is T_r and θ_j, respectively.

The steps of constructing the mining model for historical text data are as follows.

Step 1: W_{ir}, T_r, V_{rj}, and θ_j take arbitrary values within the network semantic interval (0, 1).

Step 2: Set the input value and output value of the historical text data mining model as $c_j^{(k)}$ and c_j, respectively, and get the error value $d_j = c_j(1 - c_j)(c_j^{(k)} - c_j)$ between them.

Step 3: Calculate the historical text data allocation variance $e_r = b_r(1 - b_r) \cdot (\sum_{j=1}^{n} V_{rj} \cdot d_j)$ hidden in the model.

Step 4: Weight the thresholds in the historical text data model:

$$\begin{aligned} \Delta V_{vj}(t+1) &= \lambda\left(\sum_{j=1}^{n} d_j \times V_{rj}\right) + \eta, \\ \Delta W_{ij}(t+1) &= \sum_{k=1}^{N} (\beta a_i e_r) + \delta \Delta W_{ir}(t). \end{aligned} \quad (13)$$

In the expression, λ and β represent the learning steps of the semantic network model and η and δ represent the momentum factors.

Step 5: Normalize the thresholds in each layer of the model: $\Delta T_r(t+1) = \beta \sum_{r=1}^{N} e_r + \delta$.

Step 6: Keep repeating the above steps until the mining error reaches the target value, to achieve the historical text data mining model.

3.3. Bidirectional Recurrent Neural Network Coding in Deep Learning. The bidirectional recurrent neural network (BiRNN for short) mainly trains each intermediate semantic vector training sequence to use forward and backward recurrent neural networks. The two network algorithms are the same, but the directions are different [18]. In the forward recurrent neural network, the potential state of semantic vectors in each unstructured table document is stored in the data of the current sentence and the preceding sentence. BiRNN can be used to encode the text data for the prephase and the postphase. Among them, the active unit is used to deal with the problem of incomplete gradient in the long sequence training by using the network method of long and short memory. Set the unstructured table document to $E = (e_1, e_2, \ldots, e_m)$, and the weight of the hidden layer t_h in the h time period is

$$\left[\begin{array}{l} \qquad\qquad j_h \\ \qquad\qquad g_h \\ \qquad\qquad U_h \\ \widetilde{d}_h] = \begin{bmatrix}\beta\\ \beta\\ \beta\\ \tan t\end{bmatrix} V \times \left[t_{h-1}, x_j\right], \\ E_h = g_h \oplus E_{h-1} + j_h \oplus \widetilde{d}_h, t_h = U_h \oplus \tan t\left(E_h\right). \end{array}\right. \tag{14}$$

In the formula, the input layer is set to j_h; the forget door layer is set to g_h; the output layer is set to U_h; the refresh candidate vector is set to $\widetilde{d}_h$; the weight matrix and the excitation function are set to V and β; and the point–by-point calculation is set to $\oplus$.

3.4. Attention Model. The encoder-decoder framework is a common form of analysis for text-processing problems and is widely used [19]. In this paper, it is used to extract document data from unstructured historical text data tables. One unstructured table document in the classified table document X is Y, which generates intermediate semantic vectors in the encoder-decoder framework. Assuming that the unstructured form document is $Y = \{y_1, y_2, \ldots, y_n\}$, the input Y is encoded, and the input Y is transformed into D by nonlinear transformation. For decoder, the intermediate semantic vector output x_j is established according to the obtained D and historical semantic vector output $x_1, x_2, \ldots, x_{j-1}$. Provisions:

$$x_j = f\left(D, x_1, x_2, \ldots, x_{j-1}\right). \tag{15}$$

Because of differences in unstructured form document data, the intermediate semantic vector required for decrypting the attention model is imported in the encoder-decoder framework.

3.5. Historical Text Data Extraction. Automatic data extraction model based on deep learning can decode RNN, make attention model AM compatible with it, and implement data extraction to remove the correlation and redundancy between data [20]. Assume that the state of the BiRNN hidden layer in the encoder is $(t_1, t_2, \ldots, t_m)$ and $(t_1', t_2', \ldots, t_m')$, and the state of the RNN hidden layer in the decoder in the h time period is $(\bar{t}_1, \bar{t}_2, \ldots, \bar{t}_m)$. The data $\bar{t}_m$ extraction method is as follows:

$$Q_{x_j(h)} = P\left(\bar{t}_h, t_h, t_h'\right). \tag{16}$$

In the formula, the P describes the processing value entered after the state of the two RNN hidden layers before and after the BiRNN in the encoder is fused with the state of the RNN hidden layer in the decoder; q_{h-1} describes the probability that the previous data in the unstructured table document are extracted into the desired data; LSTM describes the long-term and short-term memory network method.

4. Design of Feature Generation Method of Ideological and Political Education and Cultural Confidence

4.1. Forward Feature Generation Method. The single-layer neural network structure of the algorithm operation model is shown in Figure 3.

In the selection of machine learning algorithms [21], cloud computing such as Sina and Tencent has both high storage and fast computing capabilities, but Sina has a higher starting point and is China's first and largest provider of PaaS (platform-as-service, platform services), which fully covers the needs of IaaS, PaaS, and SaaS layers. It is simple, efficient, reliable, and multi-functional and has good learning effects. The generation process of forward text semantic features is shown in Figure 4.

Single-layer neural network outputs single-point text semantic features, referring to each text semantic corresponding to a separate feature [22, 23]. As shown in Figure 4, each neural network layer has a text encoder, which is trained from bottom to top by the supervise-free means of deep learning. The visibility layer of Sina cloud algorithm is the text information module of deep learning algorithm operation model. Sina cloud algorithm is used to learn text semantics, simulate netizen thinking, and redefine text semantics. With the above development, the specific gravity of neurons in single-layer neural networks has changed, and the single-layer neural networks are developed according to the gradient. The whole text semantics of standard neural network is trained to generate low-level text forward semantic features.

4.2. Reverse Feature Generation Method. The generation process of semantic features of reverse text is shown in Figure 5.

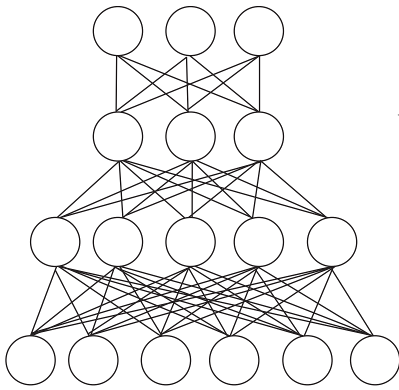

Figure 3: Single-layer neural network for algorithm operation model.

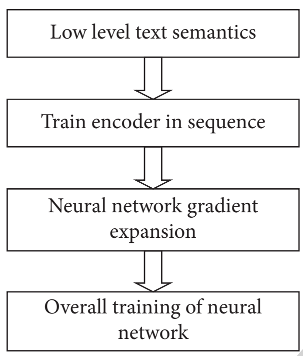

Figure 4: Forward text semantic feature generation process.

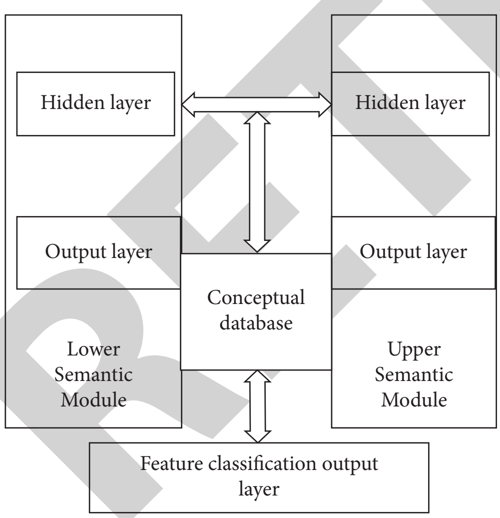

Figure 5: Reverse text semantic feature generation process.

Reverse text semantic features are called "reverse features" because Sina cloud algorithm cannot fully realize that some text semantic information has higher-order statistical features. As shown in Figure 5, the deep learning algorithm builds the hidden layer and the output layer in the upper and lower semantic modules, respectively, and uses convolution operation in the lower semantic module to analyze the deep reverse of the semantic features of the positive text. The learning of single neural network is bottom-up, and the deep learning of concept database is top-down. Input data from object layer can supplement the mining loopholes of text information. After this process, we begin to extract high-level text semantic features, and the whole process is basically the same as the process of extracting semantic features of positive text.

The functions used in the deep learning process of the hidden layers of semantic modules derived from the upper and lower layers are

$$I\left(h_k^{\text{low}}\right) = 2VW_k^{\text{low}} + b_k^{\text{low}},$$
$$I\left(h_k^{\text{high}}\right) = \sum_{k=1}^{n} W_k^{\text{high}} p + b_k^{\text{high}}. \tag{17}$$

Among them, low and high represent the lower semantic module and the upper semantic module, respectively, h_k refers to the k neuron in the hidden layer, W_k is the convolution kernel of h_k, b_k is the text semantic characteristic error of h_k, V is the volume of standard neural network, n is the number of hidden neurons in the upper semantic module, and p is the posterior probability.

The forward semantic derivation module has two posterior probabilities, namely, the hidden layer p_1 and the output layer p_2, which are expressed as follows:

$$p_1 = \frac{\exp\left[I\left(h_k^{\text{low}}\right)\right]}{1 + \sum \exp\left[I\left(h_k^{\text{low}}\right)\right]},$$
$$p_2 = \frac{1}{1 + \sum \exp\left[I\left(h_k^{\text{low}}\right)\right]}, \tag{18}$$
$$p = \sqrt{p_1^2 + p_2^2}.$$

4.3. Design of Bidirectional Generation Algorithm for Characteristics of Historical Process. To a great extent, the learning effect of the operational model of the deep learning algorithm is related to the usability of the semantic features of the generated text [24]. According to the previous literature, the derivation problems mainly include the selection of the derivation algorithm, the control of the learning efficiency, the processing of the similar characteristics of information, the management of the proportion of neurons, and the improvement of the model operation rate [25, 26]. Some derivation issues have been addressed above, such as assigning text encoders to all modules for distributed text semantic extraction, and separate upper and lower semantic modules for implicit and output layers to reduce confusion about the similarity of text information. Following is the design of the model calculation rate derivation method.

In the standard neural network, good proportion of neurons can give full play to the learning effect of deep learning, but too much emphasis on learning effect will constrain the model speed. The number of neurons in the hidden layer of the semantic module of forward derivation is much less than that of the hidden layer of the semantic

Table 1: Setting simulation parameters of historical data of ideological and political education and culture confidence.

Serial number	Data text	Number of text occurrences/quantity	Number of words/quantity
1	Reform and opening up	241	265
2	Socialism	142	253
3	Role models	236	423
4	Ideological construction	104	342
5	Red tourism	278	118
6	Ecological civilization	93	323
7	Moral cultivation	155	354
8	Patriotism	161	291
9	Spiritual culture	127	124
10	Legal basis	173	291

module of reverse derivation. Therefore, using the average convolution core $\widetilde{W}_k$ of neurons instead of W_k will not have a great impact on the learning effect. Therefore, the deep learning process of the semantic module of forward and reverse derivation can be designed as follows:

$$I\left(h_k^{\text{high}}\right) = \sum_{k=1}^{n} \widetilde{W}_k^{\text{high}} p + b_k^{\text{high}}. \tag{19}$$

5. Experiment and Comparative Analysis

In order to verify the effectiveness of the proposed algorithm, 2000 online cultural resources were randomly collected as experimental samples, including time and historical process. Simulation tests are carried out in MATLAB to verify the performance of this method, such as analysis accuracy. Lab Platform: The CPU model is Intel Xeon (R) E5-2650, the GPU model is GTX 1080 Ti, running 64 GB of memory, the OS version is Ubuntu 7.10, and the deep learning framework is PyTorch. Randomly select popular ideological and political education and cultural vocabulary from the experimental samples, set simulation parameters (as shown in Table 1), and carry out an analysis experiment on the historical process of online ideological and political education and cultural confidence.

It can be seen from Table 1 that the historical data of ideological and political education and cultural confidence have 10 aspects of data information, with the largest number since the reform and opening up.

5.1. Accuracy of Historical Process Data Analysis. Through the iteration, using the accuracy of P to study the historical process analysis results, the larger the P value, the more accurate the data analysis, the higher the value of the method. The calculation formula is as follows:

$$P = \frac{T}{T + M}. \tag{20}$$

In the formula, T and M represent the number of historical texts of the same type and different types divided into the same content, respectively. The accuracy rate of historical process data analysis is calculated by formula (20), which is taken as the test index. The test results of this method are shown in Figure 6.

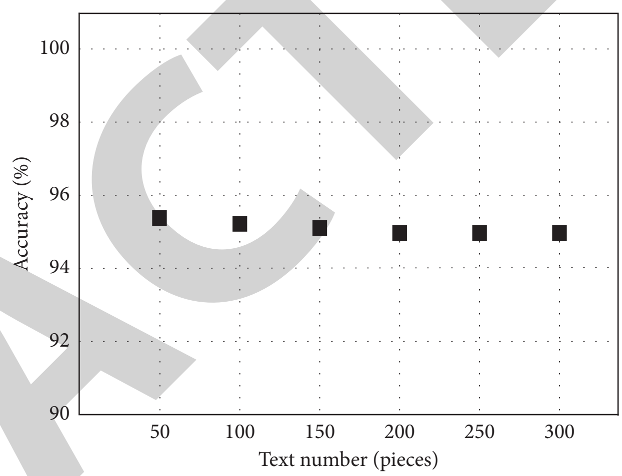

Figure 6: Historical process data analysis accuracy results.

According to Figure 6, with the increase of the number of texts, the accuracy of the classification is stable, and the accuracy is 95%. This is because the method extracts the features of ideological, political, educational, and cultural data by text emotion calculation, and improves the balance of feature vectors by dimension reduction.

5.2. Historical Process Data Analysis Recall Rate. The recall rate is based on the original sample, which means the probability of the positive sample in the positive sample. The recall rate R is the proportion of the positive sample in the total sample. Its calculation is shown in formula

$$R = \frac{T}{T + N}. \tag{21}$$

In this formula, N represents the sample that is actually positive. Formula (21) is used to calculate the recall rate of historical process data analysis, and 300 data of different types are randomly selected from the simulation parameters of historical data of ideological and political education and cultural confidence as test data. The results are shown in Figure 7.

According to Figure 7, the proposed method extracts the features of historical text data based on the bidirectional recurrent neural network coding and attention model.

To sum up, with the increase of the number of texts, the accuracy of information data classification of this method is

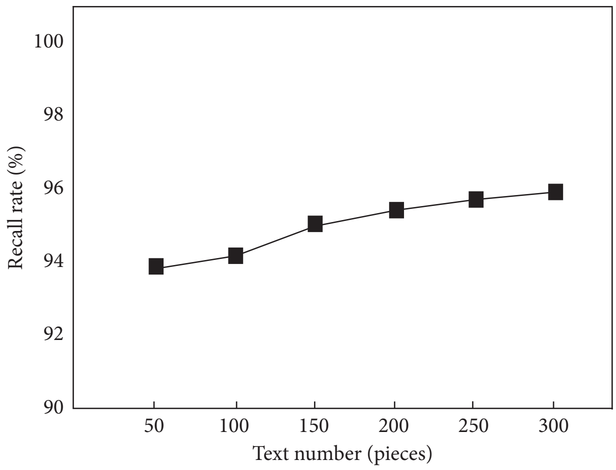

Figure 7: Historical process data analysis recall rate results.

relatively stable and tends to be stable when analyzing the number of texts of 200 historical processes, with an accuracy rate of 95%. According to the bidirectional cyclic neural network coding and attention model in deep learning, the feature extraction of historical text data is completed to improve the recall rate of historical process data analysis. The recall rate is high and has good performance.

6. Conclusion

To sum up, this paper puts forward a deep learning-based ideological and political education and cultural self-confidence in the historical process of analysis. Through deep learning and analyzing the sensitivity of historical text data, we can get the characteristics of balanced historical text data of ideological and political education culture. The conclusions are as follows:

(1) The method proposed in this paper has high accuracy in analyzing historical process data and stable accuracy in information data classification. It tends to be stable when the number of historical process texts is analyzed to 200, and the accuracy is 95%.

(2) According to the bidirectional recurrent neural network coding and attention model in deep learning, feature extraction of historical text data is completed to improve the recall rate of historical process data analysis with good performance.

(3) It can effectively improve the precision of ideological and political education text mining, with strong convergence.

Data Availability

The raw data supporting the conclusions of this study can be obtained from the author upon request, without undue reservation.

Conflicts of Interest

The author declared that there are no conflicts of interest regarding this work.

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Research Article

Professional Training and Tutorial Mode of Social Media SPOCS under the Background of "1+x" Certificate System

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SPOCS is a brand-new teaching concept, which focuses on reflecting the dominant position of students. The application of SPOCS guidance mode in international trade practice teaching will help stimulate students' interest in knowledge, improve classroom-teaching effect, and improve classroom teaching quality. In order to fully mobilize students' subjective initiative and creativity, we should cultivate students into new talents with strong comprehensive quality. Let students study actively and autonomously under the correct guidance of teachers. From the perspective of "$1 + x$" certificate system, this paper introduces the necessity of developing application-oriented undergraduate education. This paper expounds the requirements of the "$1 + x$" certificate system for the classroom teaching of applied economics and analyzes the problems existing in the classroom teaching. This paper puts forward the reconstruction of efficient classroom teaching mode, makes great efforts to deepen the cooperation between industry and education in classroom teaching, and realizes the goal of "$1 + x$" certificate system to cultivate talents. A three-stage tutoring mode of "knowledge transfer before class," "knowledge internalization in class," and "evaluation and reflection after class" is designed. Practice has proved that the combination of microclassroom and flipped classroom is an effective strategy to improve the effect of learning knowledge. It provides some references and suggestions for front-line teachers to implement flipped classroom teaching in the future.

1. Introduction

With the rapid development of information in modern society, new production methods, business circle models, and industrial structures have gradually formed, and the occupational positions of workers have also undergone new changes [1]. New occupations are emerging in an endless stream, the occupational cycle is shortening, the phenomenon of cross-integration of various occupations is obvious, and the requirements for knowledge and ability of occupational positions are also greatly improved [2]. From 2019, through the "$1 + x$" certificate system, the long-standing serious deviation between education and employment needs in school enterprise cooperation can be corrected. At the same time, the "$1 + x$" certificate system is extensible, which can implement the standardized operation of education for college students, and also provide standards and services for the re-education of social technical personnel, so as to realize the dual services for colleges and society [3].

Through a "combination of education and training" and "combination of books and certificates," high-quality talents which are urgently needed by the society, can be cultivated, and the development and utilization of human resources can be fully realized [4]. In the teaching reform, the use of the SPOCS mode mainly changes the traditional teacher–student relationship by flipping the arrangement of knowledge imparting and internalizing. In the teaching process, teachers provide teaching resources, and then students learn independently before class. Through classroom knowledge question and answer, exchange and discussion, students' thinking can be expanded, and students can develop the habit of autonomous knowledge and form a certain sense of innovation [5]. There are many definitions of Social Media in the former academic circles [6].

It is generally believed that compared with traditional media, Social Media has the following characteristics: immediacy, openness, personalization, focus, etc.[7]. The theoretical system of international trade is huge, and the theory is abstract and difficult to understand (such as marginal utility, consumer surplus, price discrimination, return to scale). Classroom teaching alone cannot meet the knowledge needs of students for this course [8]. The SPOCS tutorial mode is applicable to the teaching of international trade practice courses. The adoption of this tutorial mode can stimulate students' interest in knowledge, improve classroom-teaching effect, and improve classroom teaching quality [9]. The SPOCS teaching method can also be called the inverted classroom teaching method, which is a subversion and innovation of traditional teaching. This teaching method disrupts the traditional classroom teaching sequence, flipping students to learn new knowledge before class, and teachers only guide students to consolidate new knowledge through exercises and other methods in the classroom [10]. This paper mainly focuses on media economics and Social Media. In the continuous expansion of ideas and literature combing, it has discovered the important but still in the new research field of the relationship between the two, which is the Social Media platform development mode to be discussed in this paper, thus, generating the research motivation.

This paper analyzes the characteristics and economic process of the current social media development economics, discusses the development trend and influence of the current social media from the perspective of political economics and communication political economics, and puts forward theoretical prospects. The innovative contribution of this paper lies in taking the development mode of social media SPOCS platform as the research object, and this paper discusses the economic motivation behind it. Based on the value embodiment of social media SPOCS development, this paper analyzes how its value is generated. SPOCS counseling mode emphasizes the organic combination of students' extracurricular online knowledge and classroom interactive knowledge. The research in this paper has helped the students understand the key points and difficulties in the knowledge content and can study pertinently in the classroom.

2. Related Work

After Wang entered the Internet era, many new economic forms appeared: eyeball economy, attention economy, sharing economy, meaning economy, long tail economy, and platform economy[11]. The fundamental significance of Qian Y's "$1+x$" certificate system is to cultivate modern compound technical and technical talents, that is, to enable students to improve their diverse skills on the basis of obtaining academic certificates, so as to extend the depth and breadth of skills and enhance their employment competitiveness[12]. Zheng et al. proposed and even recently appeared the concept system of the Internet celebrity economy. The commonality is a summary of a new value model in the SPOCS and practice of the Internet delivery platform. The Internet presents a new value model. The value model of Internet is constantly innovating, and the profit forms and tools are constantly changing, which not only reveals the great vitality of the development of the Internet economy but also reflects the singleness of traditional industry forms and profit models [13]. Dai believes that the definition of Social Media should be based on three clues: the evolution process of the concept, the basic characteristics of the relative stability of Social Media, and the different situations and specific directions of the concept [14]. Luo et al. are gradually taking shape of various new teaching methods with microclass, microvideo, and Mu class as the media, and SPOCS methods such as personalized knowledge, mobile knowledge, and flipped knowledge are also gradually prevailing [15]. Taking the school as the main place for imparting knowledge and skills and cultivating quality talents, an X must comply with the requirements of educational informatization [16]. Liu has also made key changes in teachers' curriculum development, the establishment of education and tutorial mode, the updating and transmission of knowledge materials, and students' knowledge methods. This is in line with the development trend of the times and an inevitable requirement of education development [17]. Based on the political economy of communication, Shu et al. pointed out the problems of digital labor and the integration of production and consumption involved in Social Media, but they mainly analyzed from the perspective of culture and communication, and did not analyze the political economy characteristics of Social Media. For an in-depth analysis [18], Hu from Webl.0. The transformation from "media-people" in the O era to "people-people" in the Web 2.0 era, the most essential connotation lies in the emergence and construction of platforms. Information dissemination platforms are not only a means of organizing and integrating information resources, but it is also an important business development model for Social Media institutions and enterprises that provide information services [19]. Bao et al.'s slogan of "creating a Social Media platform" is also increasingly applied to other industries. From the perspective of political economy, what are the characteristics of production and consumption of the current Social Media? These characteristics determine which Social Media are producing negative effects? These problems deserve further study.

3. Methodology

3.1. The Application of the SPOCS Tutorial Model in the Teaching of International Trade Practice. International trade practice course is a comprehensive course with strong theoretical and practical characteristics of foreign activities. Facing this course, if students want to learn solidly, they must increase their study time and invest more energy. Self-study before class, which is emphasized by the SPOCS tutorial mode, undoubtedly breaks through the limitation of classroom time and creates conditions for students to master this knowledge. The teaching models have highlighted the students' dominant position in teaching. It plays a very important role in mobilizing students' initiative, enthusiasm, and creativity in learning. The diversification and individualization of teaching mode is one of the directions of the new curriculum reform. It is a means to promote the healthy growth and all-round development of students. The course objectives have clear requirements for students: enhance physical fitness, master and apply basic sports, and health knowledge and sports skills. Cultivate sports interests and hobbies and form the habit of persisting in exercise. Have good psychological quality, show the ability of interpersonal communication and the spirit of cooperation. Through improving the students' sense of responsibility for their personal health and group health, a healthy lifestyle will be formed. Carry forward the spirit of sports and form a positive, optimistic, and cheerful attitude toward life. Through one-on-one tutoring, teachers can effectively solve problems encountered by students in self-study, so that students can truly master the knowledge they have learned. This satisfies the individualized knowledge needs of students to the greatest extent, and at the same time improves the teaching efficiency and the teaching effect. In the SPOCS tutorial mode, the teaching activities are composed of four major parts: the preparation of teaching materials, students' autonomous knowledge, classroom teaching activities, and teacher evaluation and summary. Its tutorial model is shown in Figure 1.

The preparation of teaching materials is the basis for the implementation of the SPOCS tutorial mode. The preparation of teaching materials includes the following two contents: first, make teaching videos and upload them to relevant network platforms to ensure that students can watch them online. The second is to use the network platforms such as WeChat group, the spike group, and the Learning Course group to realize the sharing of various knowledge resources such as electronic courseware, practice question bank, case materials, so as to provide convenience for strengthening the interaction between teachers and students and students and summarizing the knowledge experience of International trade practice courses. SPOCS is an online course-teaching model that emerged in the postmoors era. Small and piae are relative to massive and open in MOCS. It tends to be small-scale, localized, and personalized. At present, there are many problems in College English Teaching in China, including the difference of local teaching level, the imbalance of teaching resources, and so on. College English teaching reform is in progress and will always be in progress. The introduction of SPOCS teaching mode into College English Teaching in China will help to solve the problems existing in College English teaching. Students' autonomous knowledge is the key to the implementation of the SPOCS tutorial mode. In the SPOCS tutorial mode, teachers no longer arrange the teaching of course content in the classroom, but answer questions and conduct knowledge expansion training for students. The SPOCS tutorial mode of O-PIRTAS has been verified through teaching practice to verify the positive impact of its mode on teaching. The O-PIRTAS SPOCS mode is shown in Figure 2.

This model designs of the SPOCS from the perspective of curriculum (preparation stage of SPOCS) and teaching methods (implementation stage of SPOCS). The preparation stage is to select the teaching content, design the teaching plan and courseware, record the teaching video and prepare the teaching materials. In the implementation stage, seven links, namely, setting teaching objectives, preparing activities before class, knowledge teaching videos, reviewing the contents before class, conducting classroom tests, conducting classroom activities, and summarizing and improving the class, are completed in turn. At the same time, the feedback from teaching and knowledge can be obtained according to the summarizing and improving link, so as to prepare for the next class, so as to start the next circular teaching process of O-PIRTAS. Therefore, it is not difficult to see that the O-PIRTAS model has strong adaptability, operability, and flexibility in practice. The teaching goal of classroom teaching activities is to help students deepen and expand their theoretical knowledge, and at the same time, cultivate their study habits of linking theory with practice and enhance their practical ability. Encourage students to share their experiences and achievements in independent knowledge and classroom knowledge with their classmates in the classroom, so as to realize the common progress and improvement of all students.

Under the pilot implementation of the "$1+x$" certificate system, although teachers have strengthened the teaching of skills and technologies in classroom teaching and paid more attention to the improvement of students' various professional abilities, it is always difficult to break through the shackles of traditional teaching methods due to the firm traditional educational concept of teachers. The classroom uses more old and backward teaching methods such as teaching and demonstration, and students passively construct the knowledge framework, which leads to the boring of the whole teaching process, It is also difficult for students to get more knowledge experience, and more students are less interested in knowledge so that it is difficult to obtain the expected teaching effect. Teachers should change their role from "knowledge imparting" to "knowledge guide," and the classroom should also change from closed to open. Teachers can set up questions to guide knowledge, so that students can preview and consult relevant materials in advance, help students construct knowledge situations, and have an overall framework for knowledge new knowledge. In addition, the classroom should adopt more independent and cooperative inquiry knowledge methods to mobilize students' enthusiasm and promote students' active knowledge. Of course, this is not to weaken teachers' role in classroom teaching. On the contrary, teachers should study and practice in depth, so as to give timely guidance to students when they are in doubt. Classroom teaching should also create the situation of integration of production and education, take the actual work tasks as the main line, highlight the cultivation of students' ability and the development of their thinking, and form a multi-dimensional interactive space. Under the "$1+x$" certificate system, enterprises should be incorporated into the classroom system, more emphasis should be placed on practice and application, a new integrated teaching of theory and practice should be established, and a model of on-campus theoretical knowledge + off-campus practical training should be formed. The school evaluation method

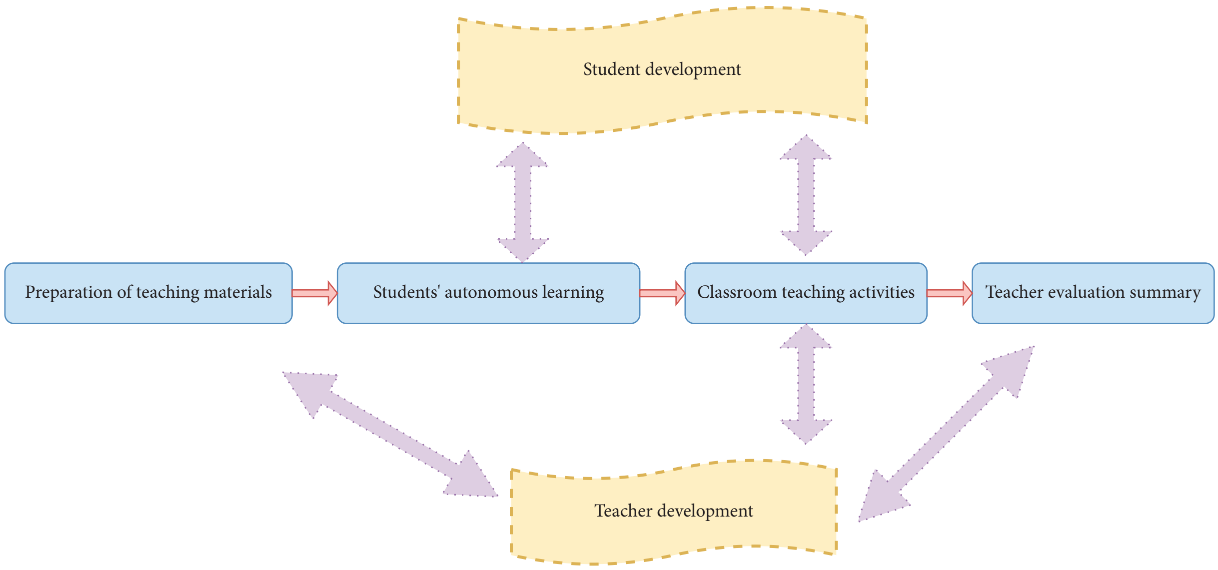

Figure 1: Education activity model under SPOCS tutorial mode.

needs to break through the way that only the teacher is the main body of the assessment. The school can introduce enterprise personnel into the campus to guide students' practical operation, which constitutes the teacher's mastery of their knowledge, the enterprise's implementation of their professional ability, and the students' teamwork. The subject of examination.

3.2. Fuzzy Model Algorithm Based on Microeconomics. The traditional teaching mode is not conducive to cultivating students' abilities in all aspects. The traditional teaching mode is teacher-centered. It only emphasizes teachers' teaching and ignores students' learning. All teaching designs focus on how to "teach" and unilaterally exaggerate the leading role of teachers. It regards students as the object of knowledge inculcation, so that students are always in a passive position in the process of teaching and learning. The reason why the traditional tutorial mode is not helpful to students' creativity is that it deprives students of the most vivid, rich, and powerful emotional factors, leaving only mechanical rational training and even simple knowledge indoctrination." In the fuzzy unicast road mountain selection algorithm, students' teaching is classified, and then teaching selection is made according to different teaching categories. This idea can also be used in online and offline tutorial model algorithm. It is known that an undirected connected graph $G = (v, e)$, where v is the set of nodes and e is the set of edges.

Because the smaller the heuristic cost sum is, the closer it is to the Pareto optimal state under Nash equilibrium.

When building a multicast tree, the heuristic cost of the multicast tree is pursued to be the smallest, that is,

$$\min \sum_{l_{wt} \in Te_n \in l_{wl}} \sum T_1\left(\Omega, ws_{ij}, us_{ij}\right). \tag{1}$$

Step 1. Initialization: $n=0$, mT0 = {v}, Mo = M, K=S. For every v ∈ V and v≠V let

$$\lambda'(v) = 0, \lambda'(v) = m'. \tag{2}$$

(i) $T_t(v_h) = 0$;
(ii) $mbw(v_h) = +\infty$;
(iii) $\mathrm{mdel}(v_h) = 0$;
(iv) $\mathrm{mjitter}(v_h) = 0$;
(v) $\mathrm{mioss}(v_h) = 0$.

Calculate the following values:

(1) $\mathrm{mbw}(v_{t'}) = \min\{\mathrm{mbw}(v_k), \mathrm{bw}(v_h, v_t)\}$:
(2) $\mathrm{mdel}(v_t) = \mathrm{mdel}(v_k) + \mathrm{del}(v_k, v_t)$
(3) $\mathrm{mjitter}(v_t) = \mathrm{mjitter}(v_k) + \mathrm{jitter}(v_k, v_t)$
(4) $\mathrm{mioss}(v_t) = 1 - (1 - \mathrm{mioss}(v_k))^* (1 - \mathrm{ioss}(v_k, v_t))$

This requires that in the process of applying the discussion teaching method to the teaching of international trade practice, we should transform the passive position of students in the traditional tutorial mode, that is, the object position as the subject position. In the cultivation of students' subject spirit, we should emphasize giving students more autonomy, and grant students the freedom to choose international trade practice discussion topics, conduct independent exploration, negotiate and discuss with each other, express their own unique opinions, and self-display their achievements. The right to self-evaluation and reflection enables students to truly become the masters of the knowledge behavior of international trade practice courses, always in a stable and independent position in the process of "teaching" and "knowledge" of the course discussion, and truly take students as the main body and center.

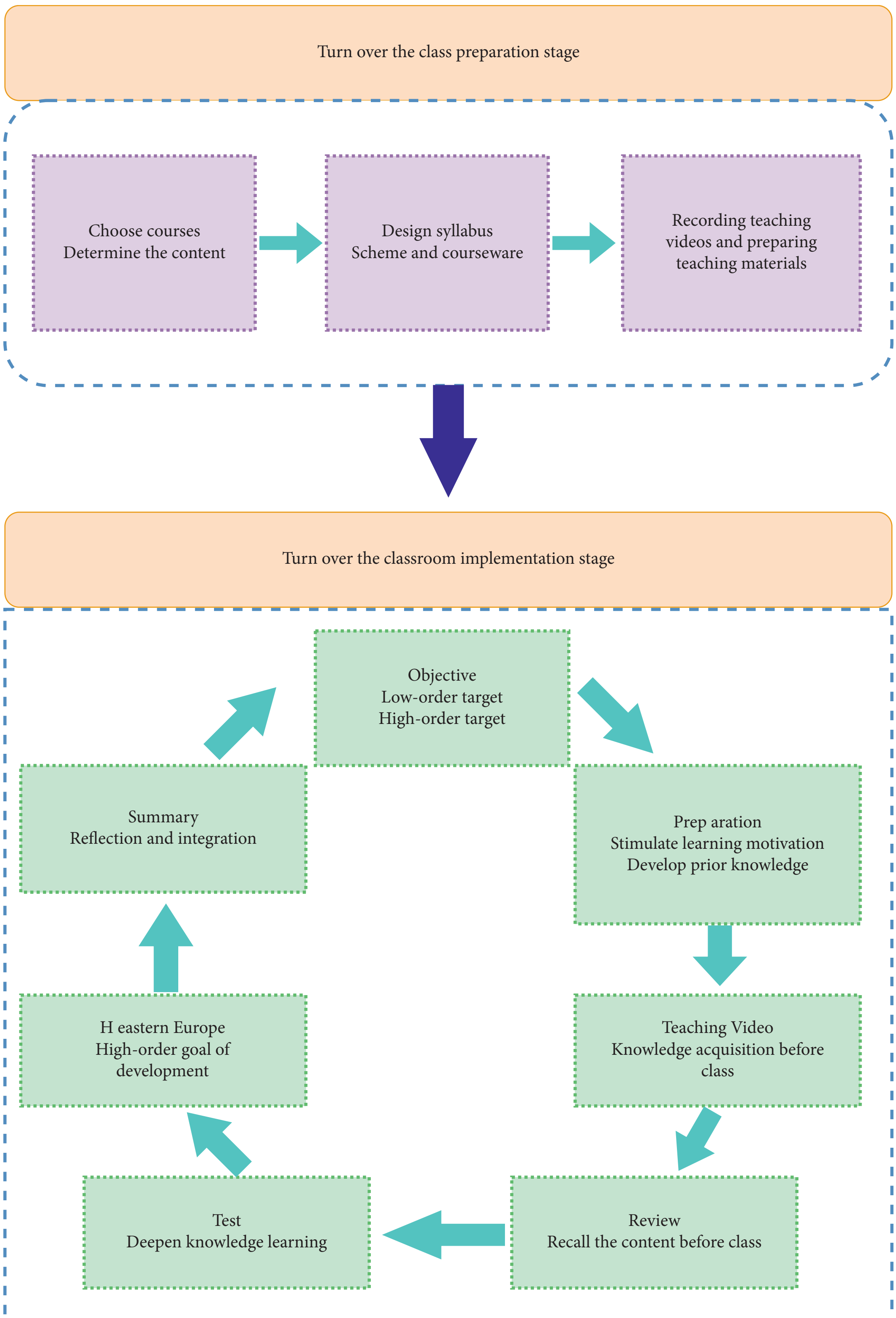

Figure 2: The O-PIRTAS SPOCS mode.

4. Result Analysis and Discussion

In order to have a more objective and comprehensive understanding of students' knowledge situation, this paper once again uses the questionnaire method to investigate the influence of SPOCS on knowledge from the aspects of students' preclass knowledge mastery, classroom knowledge effect, and overall view of SPOCS. According to the survey of students' knowledge mastery in preclass knowledge stage, from three aspects of "very good," "average," and "poor," the students' knowledge mastery before class is shown in Figure 3.

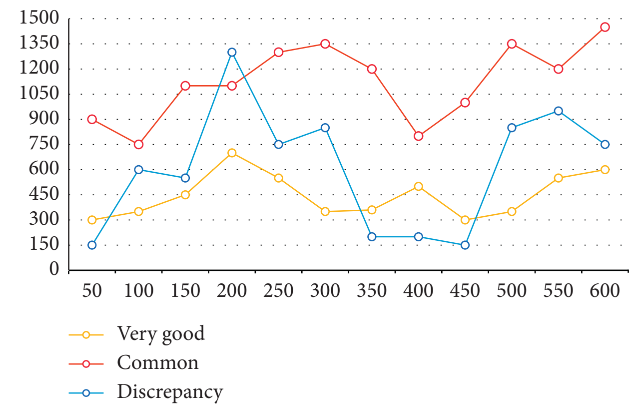

Figure 3: Students' mastery of knowledge before class.

The abscissa of Figure 3 represents the number of student samples surveyed. Ordinate represents students' knowledge mastery. As shown in Figure 3, in the preclass autonomous knowledge stage of the SPOCS, most of the students use the class video to master the knowledge and skills they have learned well and better by pausing or watching repeatedly. For these students, teachers should guide students to change their minds and let them know that we are about to enter a knowledge society, and autonomous knowledge is an inevitable trend of development. The effect of classroom knowledge is mainly investigated from two aspects: students' views on the content of classroom activities and their mastery of classroom knowledge. Students' views on the content of classroom activities are shown in Figure 4.

About 89% of the students think that the activities in class are appropriate, reasonable, and targeted, which can stimulate interest in knowledge, actively participate in class discussions and positive thinking, master key and difficult knowledge in limited time, and improve knowledge efficiency.

In order to scientifically test the difference between, before, and after the experiment, the author carried out the traditional "lecture-reception" tutorial mode for two classes, and then changed the seminar tutorial mode to Class N181 of Textile, while ClassN171 of Textile still adopted the traditional tutorial mode. Now, the knowledge effects of the first two months of the experimental class and the control class are compared and analyzed in terms of grades, and the results are shown in Table 1:

After the teaching practice, in order to make the test results more scientific and comparable, the author tests the experimental class and the control class. The experimental class and the control class adopt unified test questions and scoring standards. The inspection results are shown in Table 2:

From the comparison of the overall distribution of the posttest scores of the two classes, it can be seen that there are significant differences in almost every fractional distribution of the posttest scores. The average score of the experimental class is 82.1 and that of the control class is 76.97. The posttest scores of the experimental class are significantly higher than those of the control class. This shows that the implementation of flip teaching in the course of international trade practice is helpful to the improvement of students' academic performance. After a period of preclass, microclass study, they found that preclass study can make classroom problem exploration and practice activities successfully completed. Some students even search for relevant videos on the Internet to study when they encounter problems in other subjects to make up for their knowledge deficiencies. Figure 5 shows the statistical results of the cultivation of students' thinking and cooperative inquiry ability in SPOCS.

After the scientific experiment of teaching practice, the author conducted a questionnaire survey to investigate the students' knowledge motivation, and the control of survey results is shown in Figure 6.

Through comparing the language expression ability, information collection ability, and innovation ability of the control class and the experimental class. The results are as follows: as shown in Figure 7.

The satisfaction survey on SPOCS knowledge is carried out from five levels: "very much like," "somewhat like," "general," "dislike," and "very dislike." The statistical results of students' satisfaction with SPOCS knowledge are shown in Figure 8 shown.

As can be seen from Figure 7, 86% of the students like to flip the classroom knowledge. They believe that preclass knowledge can repeatedly watch microclass videos and master the basic knowledge. Besides, there is more time for inquiry and practice in the classroom, which can consolidate and sublimate what they have learned in a relaxed atmosphere. At the same time, they can exchange ideas with their peers and groups, pool ideas, and deepen the friendship among classmates. Therefore, students are highly satisfied with the SPOCS teaching. It can be seen from the questionnaire survey on the effect of SPOCS that most students have a positive attitude toward the SPOCS tutorial mode. According to the above analysis, teaching with SPOCS can stimulate students' interest in knowledge accumulation and project design, and deepen their interest in further learning of the course. The degree of understanding and mastery of the knowledge learned can improve students' knowledge efficiency, autonomous knowledge ability and thinking, and inquiry ability.

After the implementation of SPOCS teaching, through the comparison of test scores and classroom homework completion speed between the control class and the experimental class, it is concluded that the students' scores of the experimental class are significantly higher than those of

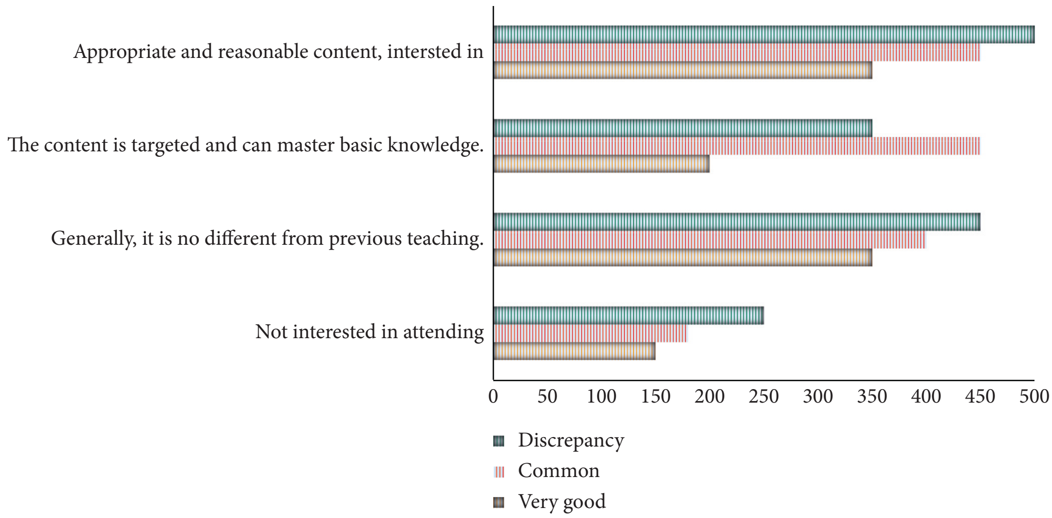

Figure 4: Students' views on classroom teaching content.

Table 1: Comparison of the pretest scores of the control class and the experimental class.

Score/class	Experimental class	Control class
100–90	4	3
89–800	6	7
79–70	19	15
69–60	26	25
Below 60 points	4	6
The average score	72.35	71.68

Table 2: Comparison of posttest scores of control class and experimental class.

Score/class	Experimental class	Control class
100–90	15	3
89–800	20	20
79–70	13	10
69–60	9	10
Below 60 points	0	0
The average score	82.1	76.97

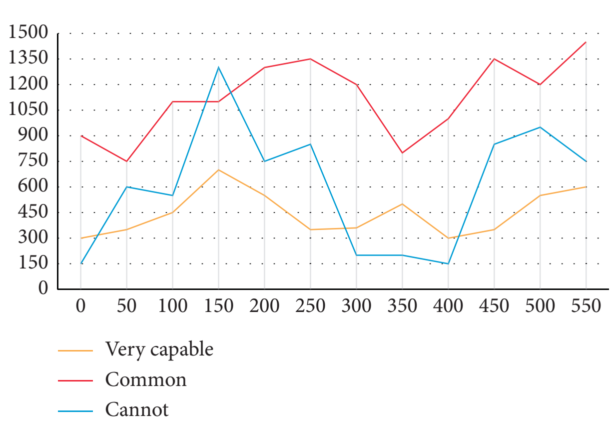

Figure 5: Analysis of the cultivation of students' independent inquiry ability of thinking.

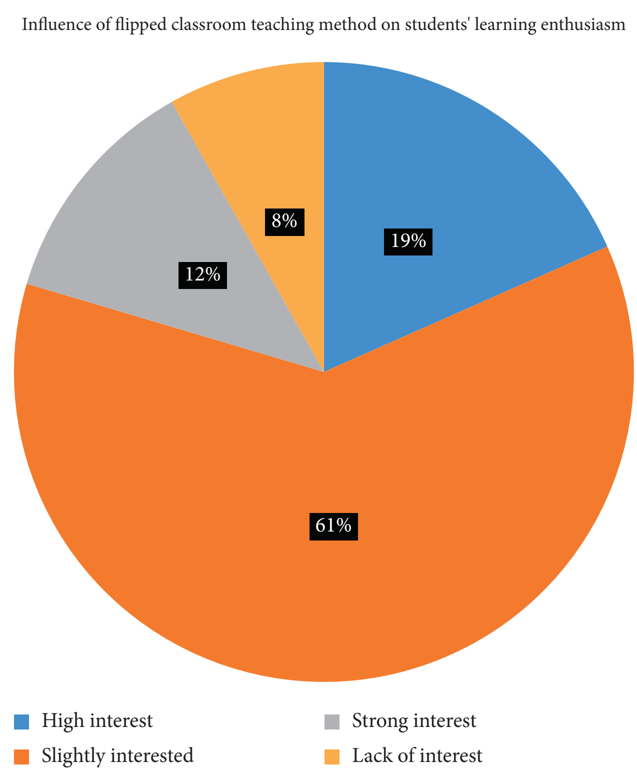

Figure 6: The influence of SPOCS teaching on students' knowledge enthusiasm.

the control class, and the homework completion speed is significantly faster than that of the control class. In addition, after the questionnaire survey on the effect of SPOCS, the statistical results show that in SPOCS teaching, students' knowledge mastery is good, classroom knowledge efficiency is high, and their autonomous knowledge ability and thinking, and exploration ability have also been significantly improved. They have a high acceptance and satisfaction with the SPOCS tutorial model. It is hoped that teachers will continue to adopt this tutorial model in knowledge development and project design courses.

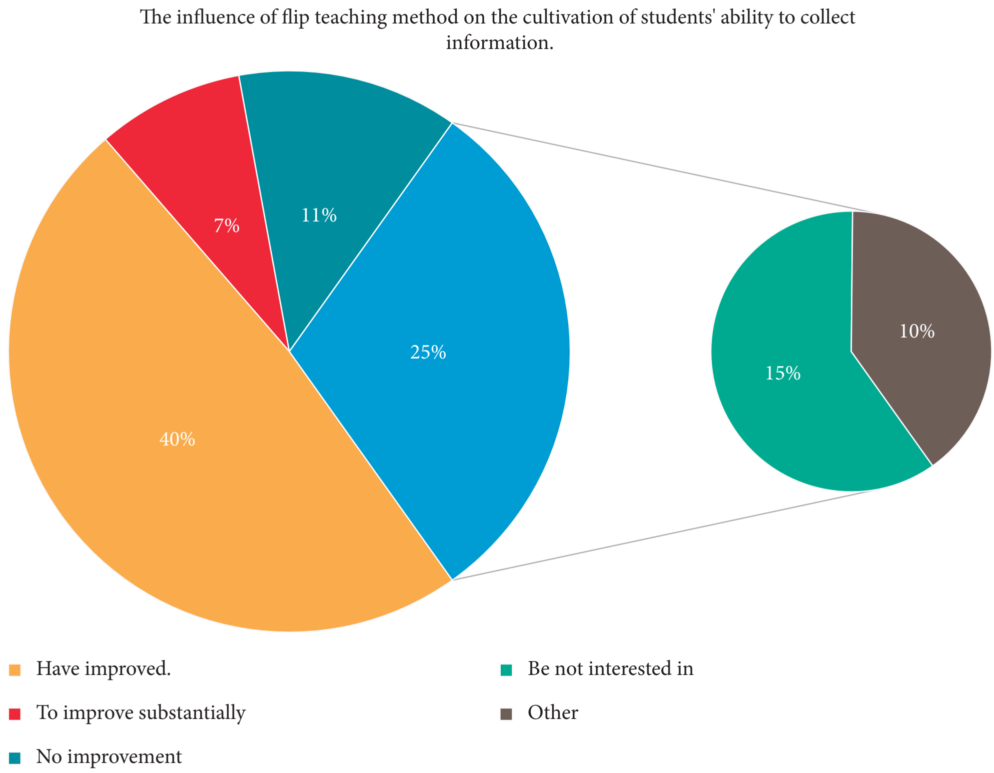

Figure 7: The influence of flip classroom teaching method on the cultivation of students' ability to collect information.

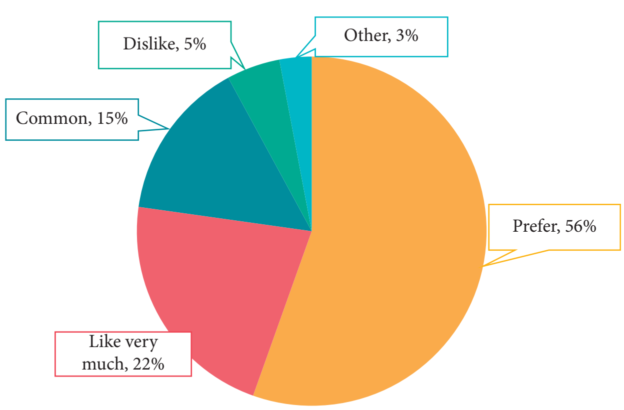

Figure 8: Students' satisfaction with SPOCS knowledge.

5. Conclusions

Under the "SPOCS" teaching concept, the college economics and management courses should combine the students' actual knowledge, make effective teaching resources, and fully mobilize the students' knowledge enthusiasm through extracurricular knowledge. Through the reform of the economics course guidance mode, combined with the "$1 + x$" system, with the help of cloud classroom, Tencent classroom, and other platforms, students are guided to actively participate in online knowledge interaction, so as to achieve effective monitoring of the teaching process and evaluation of knowledge effects. By using the online discussion function, students can fully mobilize their knowledge enthusiasm and stimulate their interest in knowledge. Students can communicate anytime, anywhere. The "$1 + x$" certificate system is a new system design that the development of vocational education follows the problem orientation. It is of great significance to highlight the characteristics of vocational education, build an employment oriented vocational education talent training model, and improve the quality of talent training.

Integrating the "mooc + spoc + spocs" mixed tutor mode under the "$1 + x$" certificate system" of applied undergraduate education is an effective way to optimize educational resources, which not only saves a lot of teachers but also improves students' knowledge efficiency. The application of diversified teaching mode can make up for some shortcomings of traditional teaching. Improving students' knowledge efficiency is an important innovation of Applied Undergraduate Education in the process of cultivating applied talents. To sum up, the research results of this study are as follows: a three-stage counseling model of "preclass knowledge transfer," "in class knowledge internalization," and "after class evaluation and reflection" in professional course teaching is designed. Practice has proved that the combination of microclassroom and flipped classroom is an effective strategy to improve the effect of learning knowledge. Practice has proved that the flipped classroom teaching based on microcurriculum is beneficial to stimulate students' interest in knowledge and cultivate students' independent knowledge, thinking, and cooperative exploration ability. It provides some references and suggestions for front-line teachers to implement flipped classroom teaching in the future.

Data Availability

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

Conflicts of Interest

The author declared that they have no conflicts of interest regarding this work.

Acknowledgments

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Research Article

Analysis of English Translation Model Based on Artificial Intelligence Attention Mechanism

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The particularity and quantity of English translation terms have a great impact on the quality and effect of machine translation and can not meet the requirements of English translation of terms. At the same time, technical exchange and communication in different fields need the expression of professional terms. In addition, although the neural machine translation model has good translation performance, it is not ideal for target languages with small translation needs and limited corpus resources. In order to solve the problems existing in the English translation model, this paper constructs the transformer model by replacing the cyclic neural network variables and introducing the attention mechanism. The term information is integrated into two pretraining models to improve the learning ability of model language sentence relationship. Maintain the integrity of terminology information by fully completing the training. The experimental results show that, compared with the other three term translation models, the translation model in this paper has the advantage of term information. At the same time, the deep neural network English term translation model can obtain more fine-grained word relevance. In different corpora, the Bleu score of the model is good, showing obvious translation performance advantages. This study provides a good professional reference value for the translation of English terms.

1. Introduction

Natural language processing technology has been gradually developed and valued in the process of continuous communication among countries all over the world. Machine translation has gradually replaced the simple task of natural language translation. However, the formation of language is greatly influenced by social culture and has its own unique structure and language characteristics. Therefore, machine translation can not achieve the refinement of words and smooth meaning as manual translation. Modern high and new technology provides the driving force for the development of artificial intelligence technology. Its application in the field of natural language processing technology provides a new direction for the development and research of machine translation. In the era of information explosion, machine translation corpus contains a large amount of data information, rich content, and many professional fields. It not only has strong technicality and professionalism, but also contains the specific background of the times [1]. The massive text corpus will inevitably have duplicate content, which will affect the quality of machine translation. The information processing ability of the traditional machine translation model can not meet people's translation requirements. After the introduction of artificial intelligence technology into machine translation, under the framework of the original translation principles, it will use the translated corpus to compare and translate the reoccurred content in a short time, greatly improve the translation efficiency, and ensure the consistency of the translation content, and so the quality of the translation results is better, which is enough to complete the general translation task [2].

With the development of high and new technology, the refinement of professional fields, and the continuous renewal of knowledge system, the core vocabulary of different professional fields has changed, and a batch of new professional terms have emerged. Terms express specific meanings in specific fields. Therefore, in machine translation, the translation of professional terms requires higher accuracy, professionalism, and scope than general translation requirements, which increases the difficulty of machine translation [3]. The knowledge base expert system in artificial intelligence combined with big data technology provides technical support for term translation in professional fields. The constructed translation model and database provide a direct and automatic translation method for term English translation according to the corresponding relationship between source language and target language. The application of neural network improves the effect of machine translation in language learning and expression and improves the quality of translation. However, direct automatic translation is difficult to ensure the accuracy of translation for a large number of unlisted words [4]. In addition, in order to improve the translation effect of specific professional fields, the machine translation model based on neural network needs to be trained through a large number of bilingual materials to obtain the required word vector. Many professional fields with limited translation resources are difficult to fully train the model. Therefore, some scholars propose to introduce the word vector model for translation model corpus training [5]. On this basis, some scholars put forward the improvement of the parameter initialization problem. The parameters at either end of the model are randomly initialized, and the other end is completed through the pretrained fast text. The experimental results show that this method significantly enhances the translation quality of the model [6]. Other scholars used Elmo neural network in the pretraining of monolingual corpus of Ukrainian English translation and achieved better translation results [7]. In addition, some scholars believe that term English translation can integrate term information through the decoding of constraint decoding in the neural machine translation model, so as to realize the specified translation and improve the quality of term English translation [8].

The innovative contribution of the research lies in simplifying the internal structure of the machine translation model through the improvement of the deep loop neural network and introducing the attention mechanism to construct the transformer model. Through the comparative experiments of the four translation models, it can be seen that the size of the non-Analects database of the deep neural network English term translation model and the fusion of term information show good translation performance. It reduces the difficulty of learning the corresponding relationship and information between the source language and the target language words in the translation modeland achieves the purpose of improving the accuracy and professionalism of term English translation. The fluency of translation results, term matching, and expression standardization are closer to the requirements and requirements of term translation norms.

2. Research Status and Development of English Machine Translation Combined with Artificial Intelligence Technology

The research of artificial intelligence technology starts with giving human thinking to machines and assisting human behavior research. Language has always occupied an important position in human behavior and communication. Therefore, artificial intelligence technology has been deeply applied and studied in the task of natural language machine translation and has achieved good research results [9]. Model training is required in the early stage of the application of artificial intelligence technology. The machine algorithm model can improve the algorithm performance, learn more relevant knowledge, accumulate relevant expert knowledge on the basis of understanding the control target object and control law, and build an integrated system of expert knowledge and experience. The machine algorithm model can view the distribution of data and compare the relationship between data, cultivate intuition of data, summarize data, etc. The exploratory data analysis method is simply to understand the data, analyze the data, and figure out the distribution of the data. It mainly focuses on the real distribution of data and emphasizes the visualization of data. So the analyst can see the hidden rules in the data at a glance, so as to get inspiration and to help the analyst find a model suitable for the data [10]. The system can not only help MT solve various complex problems in translation, but also provide powerful decision support for MT and realize control optimization [11]. The combination of neural network and machine translation greatly improves the autonomous learning ability and information processing ability of translation model and shortens the distance between machine translation and human language use thinking. Neural machine translation, first published in 2013, takes encoder decoder as the translation framework and performs source language related information acquisition, semantic vector conversion, and decoding through convolutional neural network and cyclic neural network to complete target language translation [12, 13]. The operation of this model marks the formal transformation of deep neural network from machine translation optimization auxiliary model to a model that can complete translation tasks independently. After that, many scholars conducted in-depth research on the basis of this model. Some scholars pointed out the problems existing in the cyclic neural network and proposed to introduce its variants to simplify the structure. The experimental results show that the gap between the two translation effects is small [14]. According to the characteristics of language translation, some scholars have added attention mechanism to the neural machine translation model to solve the problem of fixed word vector length [15]. For the research of neural machine translation framework, some scholars have designed the coding structure and bidirectional decoding of bidirectional cyclic neural network, and others have proposed a dynamic bidirectional decoding model with random direction of word decoding [16].

With the strengthening of exchanges in different cultures and fields, translation in many languages and professional fields, such as small translation demand and small use scale, has gradually become one of the hotspots of machine translation research. Some scholars have completed the initial parameterization of masked language translation model through three different pretraining models, which has improved the effect and quality of Mongolian Chinese translation [17]. Other scholars have completed the translation output of the preset language through grid beam search and lexical constraints [18]. In addition, some scholars believe that there is a certain gap between the preset translation results and the meaning of the original word itself, which can not reflect the integrity of the source language, and the fluency of the text and meaning of the target language results are limited. Therefore, they try to complete the model training by replacing the source language phrases and strengthen the accuracy and rationality of the use of professional terms [19]. Machine translation technology is bound to develop in a more specialized and intelligent direction in the future. The development and combination of intelligent decision support system, data processing technology, information mining, and other technologies will continue to improve the performance of machine translation, optimize model structure and translation technology schemes, improve translation efficiency, provide diversified translation schemes and results according to different translation needs and requirements, and optimize the economic benefits of machine translation models [20].

3. English Term Translation Model Based on Artificial Intelligence Technology

The machine translation model introduces artificial intelligence technology to diversify the posttranslation strategies, adjust the translation parameters according to the information such as cultural and language characteristics and determine the translation standards for different needs [21]. Different languages have their own language patterns [22]. Machine translation needs accurate simulation on the basis of language structure and flexible processing of language information. The application of neural network in machine translation can improve the autonomous learning ability and adaptive performance of translation model and improve the efficiency of language signal processing, detection, and operation through dynamic learning. With the updating of neural network learning strategies, the performance and quality of machine translation have been improved. Therefore, this paper will integrate professional term information into neural machine translation to study the English translation effect of terms.

3.1. Construction of English Machine Translation Model Based on Neural Network. The translation of natural language should be carried out as a whole on the premise of sentence understanding. Only paying attention to the meaning of each word or disconnecting the relevance between words cannot achieve the ideal translation effect. Therefore, the neural network in machine translation needs to be connected with the previous information when processing information, especially when there is a large gap between the output prediction content and relevant information. Neural network still needs to complete the translation task according to the memory information, and the variant of cyclic neural network, long-term and short-term memory cyclic neural network, can meet this demand. The cyclic link formed by the hidden layer of simple cyclic neural network without nonlinear activation function is shown in the following formula:

$$h_t = W^T h_{t-1}. \tag{1}$$

When the time is t, the hidden layer is expressed as

$$h_t = \left(W^t\right)^T h_0. \tag{2}$$

The weight matrix is decomposed and the orthogonal matrix result is substituted into formula (2), and the time is hidden layer representation can be obtained, as shown in

$$W = Q\Lambda Q^T, \tag{3}$$

$$h_t = Q^T \Lambda^T Q h_0. \tag{4}$$

The diagonal elements contained in Λ in the formula are the eigenvalues of the weight matrix. It can be seen that the multiplication of the weight matrix will have a great impact on the hidden layer of the simple cyclic neural network layer, resulting in the gradient problem. The long-term and short-term memory is introduced into the cyclic neural network, and three control gate structures are added in the hidden layer, as shown in Figure 1.

The three control gates in the hidden layer mainly filter and update the information according to the requirements of the gate layer state unit. Through formula (5), the forgetting gate can filter out the information to be forgotten:

$$f_t = \sigma\left(W_f \cdot [h_{t-1}, x_t] + b_f\right). \tag{5}$$

In the formula, the weight matrix of the gate is expressed as W_f, and its bias term is expressed as b_f. The dimensions of x_t, h_{t-1} and hidden layer state are d_x, d_h, d_c, respectively, and the dimension of weight matrix can be obtained as $d_c \times (d_x + d_h)$.

The first mock exam is the input gate that stores new information, which is divided into two parts, such as

$$\widetilde{C}_t = \tanh\left(W_c \cdot [h_{t-1}, x_t] + b_c\right), \tag{6}$$

where C_t represents the hidden layer state and the alternative $\widetilde{C}_t$ is obtained after the first part is updated.

The second part is shown in

$$m_t = \sigma\left(W_m \cdot [h_{t-1}, x_t] + b_m\right). \tag{7}$$

The information contained in $\widetilde{C}_t$ will determine the amount of cell state information added through the sigmoid layer of the second part.

The update of the unit status after passing through the above two control doors is shown in

$$C_t = f_t \odot C_{t-1} + m_t \odot \widetilde{C}_t. \tag{8}$$

The output gate filters out the output information according to the relevance of the information before and after the update. The final output is shown in

$$\sigma_t = \sigma\left(W_o \cdot \left[h_{t-1}, x_t\right] + b_o\right), \quad (9)$$

$$h_t = \sigma_t \odot \tanh\left(C_t\right). \quad (10)$$

In computer vision, the essence of attention mechanism is to find the correlation between them based on the original data and then highlight some of its important features. This is also a natural feature of the human eye for a long time. For example, in the decoder layer of the transformer, we use masked attention. This operation can be understood as that the model sees the remaining answers in advance to prevent the decoder from "cheating" when decoding the output of the encoder layer. Therefore, it is necessary to force the model to carry out attention according to the results on the left of the input sequence. Transformer model introduces the self-attention mechanism into the cyclic neural network to urge the translation encoder to pay attention to its words when encoding each word. Its calculation formula is shown in

$$\text{attention}(Q, K, V) = \text{soft}\max\left(\frac{QK^T}{\sqrt{d_k}}V\right). \quad (11)$$

The word vector input in the self-attention mechanism will have query vector, key vector, and value vector. The corresponding matrix is expressed as Q, K, V, and d_k representing the dimension of key vector, respectively.

3.2. A Machine Translation Model of English Terms Based on Term Information. In the English neural machine translation model based on transformer model, the domain term information that needs to be translated is fused. Firstly, the bilingual corpus in the process of data preprocessing is segmented through the definition of term dictionary. At present, the performance of neural machine translation depends on high-quality large-scale parallel corpora. Due to the limitation of computing resources, training time, and model framework, model training can only use parallel sentence pairs with moderate length. Too long sentence pairs will be discarded, resulting in a waste of resources. Therefore, the research on how to segment long bilingual sentences into effective sentence pairs has important theoretical significance and practical value. Traditional bilingual sentence pair segmentation methods include rule-based, statistics based, rule-based, and statistics combined methods. This paper studies the segmentation method of long sentence pairs in bilingual parallel corpus based on deep learning, so as to improve the utilization of corpus and the translation accuracy and quality of translation system. At the same time, the word vector obtained from a large number of monolingual corpus after training has both text and term information. The parameters of the embedding layer of the translation model are initialized according to the two word vectors, and the unlisted words of terms in the field in the translation are found and replaced through the external term dictionary. Figure 2 shows the translation framework of English neural machine translation model based on transformer model integrating term information.

As can be seen from the frame diagram, there are two pretraining models of word vectors in the model, in which glove model obtains the required complete set of word vectors from the statistical information and context information of the paragraphs to be translated through pretraining. Word2vec is a group of related models used to generate word vectors. These models are shallow and double-layer neural networks used for training to reconstruct linguistic word texts. The network is represented by words, and it is necessary to guess the input words in adjacent positions. Under the assumption of word bag model in word2vec, the order of words is not important. The pretraining word vector of word2vec is completed through the continuous word bag model; that is, the training word is placed near the predicted center word, which can reduce the difficulty of learning the corresponding word relationship between the two languages. The calculation formula of likelihood function is

$$\prod_{t=1}^{T} P\left(w^{(t)} \mid w^{(t-i)}, \ldots, w^{(t-1)}, w^{(t+1)}, \ldots, w^{(t+i)}\right), \quad (12)$$

where T represents the length of the text sequence, $w^{(t)}$ represents the time step of the word t, and i represents the size of the background window.

Assuming that the key word whose index is c in the term dictionary is represented by w_c and its background word is represented by GG, the calculation formula of occurrence probability is shown in

$$P\left(w_c \middle| w_o\right) = \frac{\exp\left\{u_c^T vo\right\}}{\sum_{m \in V} \exp\left\{u_m^T vo\right\}}, \quad (13)$$

where vo represents the average of w_o vector, u_m, u_c represents the vector of the central word with the index word m, c, respectively, and V represents the vocabulary composed of all words.

3.3. Experimental Analysis of English Term Translation Model Based on Deep Neural Network. The professional terminology field of model translation experiment is electrical field. Before model translation test experiment, corpus and professional terminology database need to be established. The establishment of corpus is mainly based on the characteristics of the experimental object corpus, large-scale retrieval of scientific and technological papers on related topics, obtaining text materials containing bilingual and monolingual corpus, and then cleaning the corpus. According to the source of the corpus, it can be divided into three corpora. After cleaning, more than 30000 pairs of sentence pairs remain in each corpus, of which the second and third corpora are large corpora. The corresponding electrical terminology library obtains the term pairs in the electrical field through relevant standard documents, dictionaries, and relevant authoritative websites. In addition, through the extraction model and related website translation, the bilingual term word pairs of the professional term library are expanded, and finally

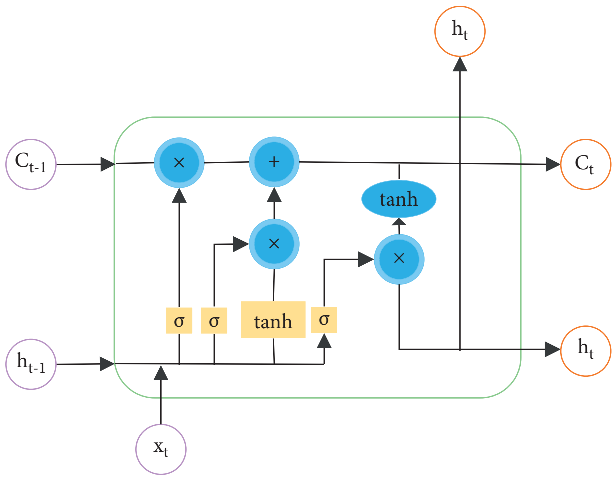

Figure 1: Example of LSTM neural network structure diagram.

about 41000 electrical professional term word pairs are obtained.

The deep neural network English term translation model with term information is tested and compared with the transformer model without term information and two models with other different term word segmentation and translation. The coder and decoder layers of the four models in the experiment are the same, which are six layers, and the dimension of the hidden layer is 512. The translation quality of the four models is measured by Bleu value, and its calculation formulas are shown in

$$BLEU = BP \times \exp\left(\sum_{j=1}^{J} w_j \times \log p_j\right), \tag{14}$$

$$BP = \begin{cases} 1, & l_c > l_r, \\ \exp\left(1 - \dfrac{l_r}{l_c}\right), & l_c \leq l_r. \end{cases} \tag{15}$$

In the formula, the length of the translated text is expressed in l_c, and the minimum length of the reference translated text sentence is expressed in l_r. Generally, $j = 4$, w_j are the weights, and p_j represents the accuracy of the corresponding coincidence of the sentences contained in the corpus.

In addition, the translation quality of the four models will be evaluated manually. Ten relevant personnel will score the sentences translated by the four models and take the corresponding average value as the final evaluation score.

The four machine translation models are trained in three corpora for multiple rounds until the performance of the model is the best and the training ends when the model shows convergence at the same time. Figures 3–5 show the Bleu value curve of four English term translation models in three different corpora. It can be seen from the data in the comprehensive figure that the training times increase, and the scores of the four models in each corpus fluctuate in a small range, showing an increasing trend as a whole. The

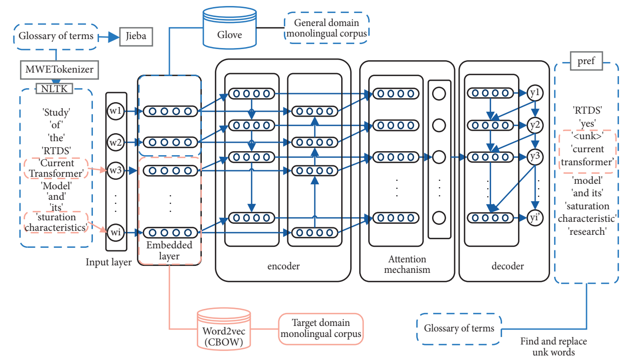

Figure 2: Translation framework of English neural machine translation model based on transformer model with term information.

transformer model introduces the term segmentation translation model, and the score in any language database is the lowest among all the model scores. The occurrence frequency of electrical professional terms in the text is high and there are long-term words, resulting in the term segmentation staying at the coarse-grained level, reducing the coverage of thesaurus, and the translation quality and score are not high. The translation model of this paper performs best in all corpora. Except for the score of the first corpus, the scores of the model with term replacement are higher than those of the transformer model. First, the corpus is small, the training data set has some limitations, the training of translation model is insufficient, and the quality is relatively low. Due to the small scope of corpus, it is easier to obtain correct translation results by directly replacing target terms in source prediction training, but the score of term replacement model is only higher than that of term segmentation model. The two word vector training methods in this paper are relatively less difficult to obtain the mapping relationship between the source language and the target language in a small corpus, and the Bleu score of the best translation is 29.79.

Second, after the data scale of electrical terms in the corpus has been expanded several times, the quality of the four English term machine translation models has been greatly improved, especially that the translation scores of this model and term replacement model are higher than 70 points. The training is sufficient, the model performance is improved, and the translation quality is increased, but the gap between the translation quality scores of the two models tends to expand with the increase of epoch. Term replacement in a large range of corpora has lost its advantage in a small corpus. The more the word mapping relationships learned in this model, the stronger its translation expression and the better the term translation effect. In addition, the number of words selected in the translation process of this model is higher than that of term replacement; that is, the granularity level is finer, which makes it easier to obtain the semantic relationship between words and enhance the overall translation performance.

The third corpus is a mixed corpus; that is, its scale is large, but the proportion of corpus about electrical terms is

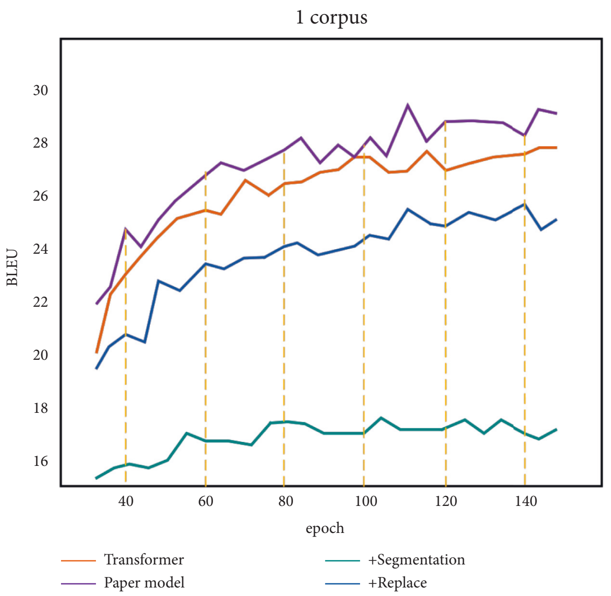

FIGURE 3: Bleu value curve of four English term translation models in the first corpus.

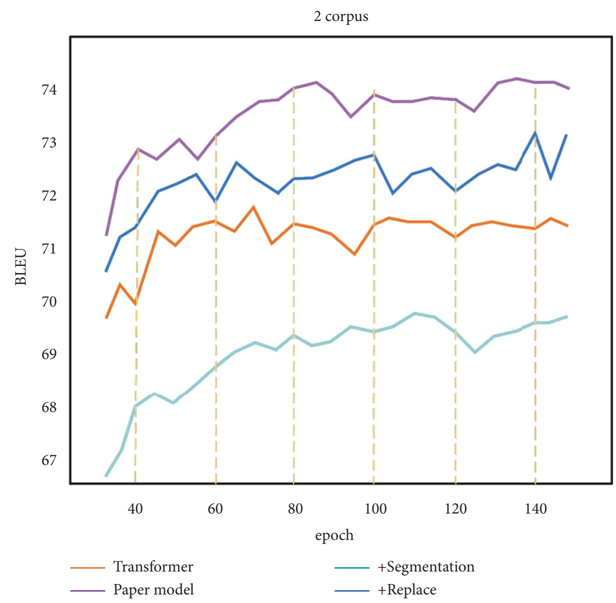

FIGURE 4: Bleu value curve of four English term translation models in the second corpus.

lower than that of the second corpus, and the structural difference between sentences is more obvious. The Bleu scores of the four translation models are reduced slightly, and the score difference between the models in the early stage of training is reduced. The gap between term replacement model and transformer model is significantly reduced compared with the first two corpora, while the gap between this model and term replacement model will continue to expand with the improvement of training adequacy.

Figure 6 shows the comparison results of the best Bleu value and manual score of the four English term translation models. The measurement of English translation quality of electrical terms by relevant professionals focuses on the accuracy, fluency, matching, tense change, expression standardization, and acceptance of translated sentences. The figure shows that the size of the corpus has a certain impact on the translation quality evaluation of the translation model. The model can obtain more word association information in a large corpus, show higher fluency and standardization in translation expression, and be closer to the actual translation requirements of professional terms in terms of format. Combined with Bleu evaluation score, the performance of this translation model and term replacement model is outstanding, and the score gap between the two manual evaluations is small. The score of translation quality sorting of this model is slightly better, indicating that its translation quality is more widely accepted and the matching degree of professional terms is higher.

In general, two languages with large cultural differences will choose an independent thesaurus, which is different from the actual model training. For the translation model, the joint thesaurus method will provide more word semantic association information that can narrow the language difference. Figure 7 shows the comparison results of Bleu evaluation average values of four English term machine

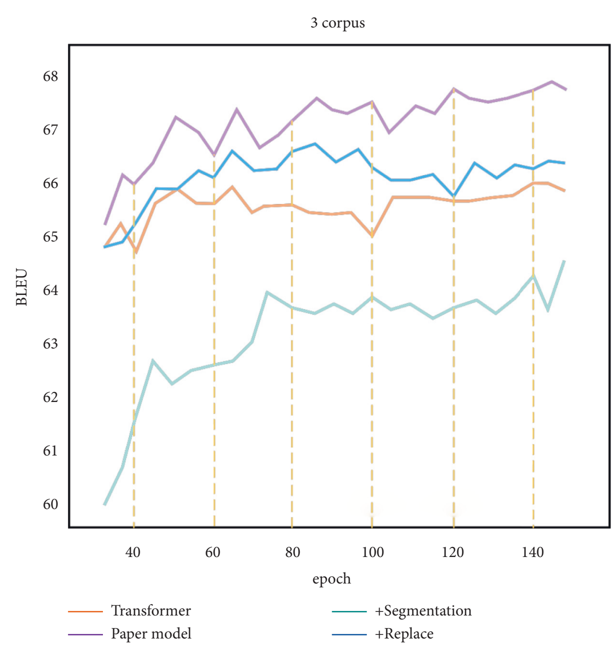

FIGURE 5: Bleu value curve of four English term translation models in the third corpus.

translation models in independent thesaurus and joint thesaurus. The results show that the transformer model has little difference in the performance of the two word lists and maintains the performance stability. The evaluation scores of the other English term translation models through the joint thesaurus are better than the independent thesaurus. The translation performance of this translation model in the joint thesaurus has been significantly improved.

To sum up, the deep neural network English term translation model integrating term information is easier to

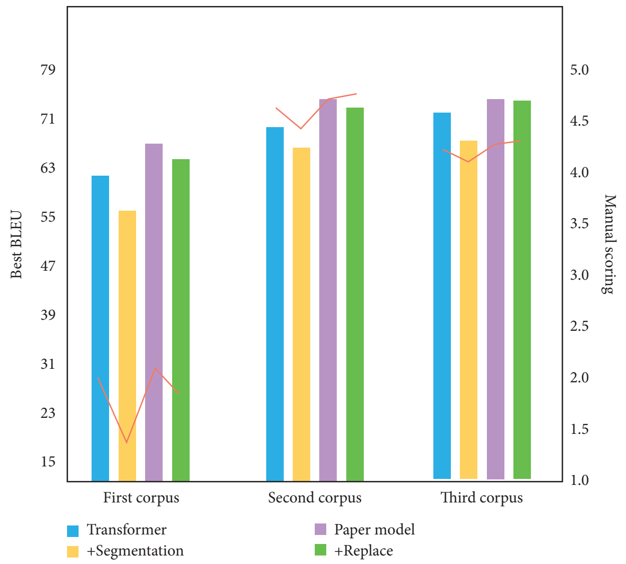

FIGURE 6: Comparison of the best Bleu value and manual score of four English term translation models.

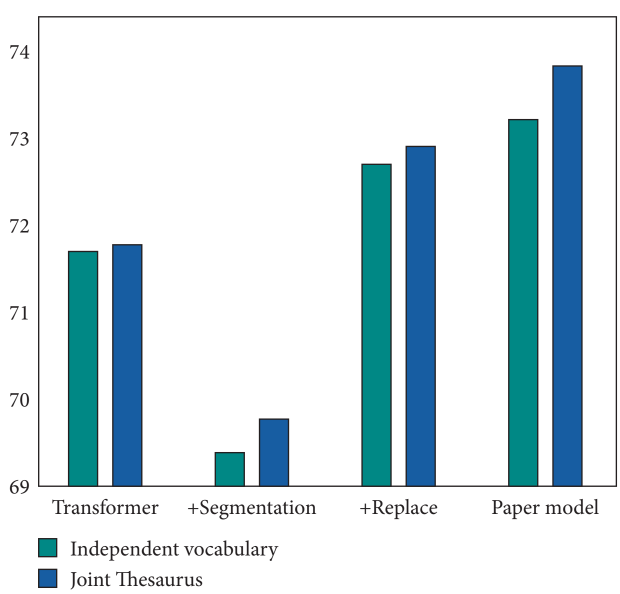

FIGURE 7: Comparison of Bleu evaluation average values of four English term machine translation models in independent thesaurus and joint thesaurus.

obtain the relevance information between words at the fine-grained level, showing good translation performance and better translation results in different corpora. In a large corpus, adequate training can improve the translation performance of the model and expand the translation advantages. The manual scoring shows that the model has higher translation accuracy of electrical terms and higher term matching while maintaining the fluency of translation results, and the expression standardization is closer to the requirements of the actual standard expression of terms.

4. Conclusion

Terms play an important role in professional communication and patent documents and will affect the translation effect of machine translation to a great extent. At the same time, the development of technology and the renewal of knowledge system will add more professional terms and improve the difficulty of English translation of machine terms. In this paper, the internal structure of machine translation model is simplified through the variant of deep circulating neural network, and the attention mechanism is introduced to construct transformer model. On this basis, the electrical term information is integrated into the two word vector pretraining modes to improve the ability of the model to map the words between the source language and the target language. Through the comparative experiment of four translation models, it can be seen that the size of the non-Analects database of the deep neural network English term translation model fused with term information shows good translation performance. The two pretraining modes of copper drum are easier to obtain the word connection information with finer granularity, improve the adequacy of model training, and improve the integrity and accuracy of electrical terms. In large-scale corpus, the model shows that the translation advantage will be continuously improved with the increase of training times. In addition, among the manual evaluation scores, the model has the highest score, which indicates that the fluency, term matching, and expression standardization of its translation results are closer to the requirements and requirements of term translation norms.

However, in this study, the scale of the experimental corpus is relatively limited, and a larger corpus is needed to verify the translation effect of the model terms. We can also try to optimize and adjust model parameters to improve the overall translation effect. Therefore, further analysis is needed in future research.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest regarding this work.

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Research Article

Improvement of Mobile Learning Model in Flipped Classroom in English Classroom Teaching: Based on Big Data Analysis

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This paper innovates the improvement of the mobile learning model of flipped classroom in English classroom teaching on the basis of big data analysis technology. Through the case study, the big data analysis technology is used to analyze and explore the learning characteristics of students and combine with teachers' teaching experience to dynamically adjust the teachers' teaching strategies. And on the basis of the new model, an assessment model for students, teachers, and school leadership is proposed as a way to build a new and harmonious teacher-student relationship.

1. Introduction

Education is a major matter related to the future development of our country. Nowadays, while the economy is developing rapidly, China's education reform has been on the uphill road and in deep water, paying more attention to quality education, focusing on the essence of education and improving the quality of teaching is the key construction project of China in the reform of higher education [1]. And English is one of the essential teaching subjects for multinational enterprises and teaching education in the modern economic globalization development today. However, since the native language of Chinese people in China is Chinese, learning English can be difficult, and this becomes the reason why many students cannot be interested, not only because the learning of English itself is difficult, but also because there are problems in the English classroom today, such as delayed and circuitous teaching links and difficulty in stimulating students' interest in the teaching introduction, so it is extremely important to innovate the learning mode in English classroom teaching. The mode of learning in the English classroom is extremely important [2].

With the improvement of science and economic technology and the change of education system in China, big data analysis technology has been widely used in the field of English teaching. How to innovate teaching models and improve students' independent learning ability and interest in learning in English classroom teaching is the primary issue to think about in modern English classroom teaching, and it is also important to think about how to instantiate the development of modern technology into English classroom teaching so that the teacher groups can assess students' learning effects in English classroom teaching in a timely, accurate, and quality-weighted manner.

In the past two years, due to the successive epidemics, offline class suspensions have become the norm in epidemic areas, but according to the national education policy of emergency response, China has now achieved the solution of nonstop online learning despite offline class suspensions, which is also an opportunity for China to further innovate its teaching model and be able to fully promote online learning through online video learning and live lectures [3]. Compared with traditional English classroom teaching, online teaching, live teaching, watching, and replaying videos can make English classroom teaching content no longer a "one-time English classroom" of "fast food consumption". The teacher can record videos for students who do not understand the class to watch again and again, so that they can give feedback to the teacher on the problems of the students in that section or the whole teaching session [4]. At the same time, the use of big data analysis and other technologies to assess the degree of students' mastery of knowledge and to explore the laws that exist, allows teachers to better identify students' weaknesses and teaching problems in learning English, so as to change the teaching mode or consolidate students' weaknesses, etc. The innovation of online teaching and the application of English classroom teaching cases to practice, based on the original mobile learning, using the educational theory of flipped classroom and analyzing and researching new teaching models and assessment models through big data technology will definitely help to improve the quality of teaching. Improving intelligent teaching and learning in the English classroom with the flipped classroom mobile learning model will not only innovate teaching concepts and teaching models, but also improve the students' overall English proficiency, which is of great significance to English classroom teaching [5].

2. Current Situation and Problems in Today's English Classroom Teaching

Many problems exist in English classroom teaching in China today, from the object point of view, among which there are teachers' problems and students' problems; from the cause point of view, there are subjective reasons and objective reasons. Next, we will analyze the problems on English classroom teaching today from teachers' and students' perspectives, so as to find countermeasures and introduce the flipped classroom and mobile learning model from the perspective of teaching.

2.1. Emphasis on Test-Taking, Not on the Application of Language in Real Life. Although China's education reform policy has long been to move away from test-based education to quality education, we do not have a well-developed system to address the problem of test-based education [6]. Since the beginning of the imperial examination, the examination has existed as a talent competition for selection. As a result, many traditional teachers are influenced by the thinking of "exam-oriented education" and focus only on explaining knowledge and instilling knowledge into students in the English classroom, without paying attention to the application of English knowledge in real life. They do not pay attention to the fact that the essence of English education is to let students learn to use English, speak English, and express themselves in English as a second language, which leads students to learn English only in the process of English grammar and examinations, and deviates from the essence of learning English. This has led many students to become "dumb English".

2.2. Only Focus on Teaching Students, But Not on How They Should Learn. With the reform of education, English teaching materials are constantly updated, and the use of new teaching materials makes English teachers who only pay attention to teaching methods ignore the lack of research on how students learn English, and the methods of teaching students are not updated with the new teaching materials. For example, the English classroom in modern secondary schools can make many students drowsy, not only because of the students themselves, but also because some students cannot understand the natural inability to stimulate the enjoyment of learning English, so in the English classroom teaching English teachers should also adjust their teaching methods and take different teaching methods for different levels of students. In the same classroom, there are naturally poor students and good students, so how to achieve a balance for different students in the same classroom is one of the key points of intelligent teaching research in English education today. To address this issue, this paper will investigate on the basis of big data analysis [7].

2.3. Teachers Do Not Pay Enough Attention to Students and Do Not Fully Mobilize Students' Learning Motivation and Initiative. In modern English classroom teaching, many teachers may neglect to pay attention to students due to problems such as the pressure of classroom tasks, which leads to students' lack of confidence in learning English well. This neglect of students' motivational assessment can leave students without a sense of accomplishment and thus not paying enough attention to learning English well. Therefore, this paper addresses this problem by analyzing the data obtained based on big data analysis, uncovering its patterns, and proposing an assessment model based on big data analysis [8].

3. Flipped Classroom

The "flipped classroom," also known as the "upside-down classroom," is an innovative teaching model. It refers to the transfer of learning options from the teacher to the student, with the student deciding when and where to learn. The traditional classroom and the flipped classroom are shown in the following diagram, as shown in Figures 1 and 2.

As you can see in Figures 1 and 2, the biggest difference between a flipped classroom and a traditional classroom is that students first use wireless technology and Internet technology to study on their own, then complete the knowledge and assignments on their own, wait for the teacher to correct the assignments, and then consolidate and answer questions on the knowledge [9].

Aaron Sams and Jonathan Bergmann, two teachers teaching at Woodland Park High School in the United States, discovered a new form of teaching —the flipped classroom—in which these two teachers put their recorded teaching. In this teaching activity, these two teachers put their recorded videos online for students to learn independently in advance, and then the teachers communicate directly with all students in class to reinforce what they have learned in advance and to further solve any problems that arise during their self-study by answering the questions. Since the flipped classroom has more advantages than the traditional teaching model, Salman Khan's presentation at the TED conference in 2011 became more widely known until it was introduced to China, and more education

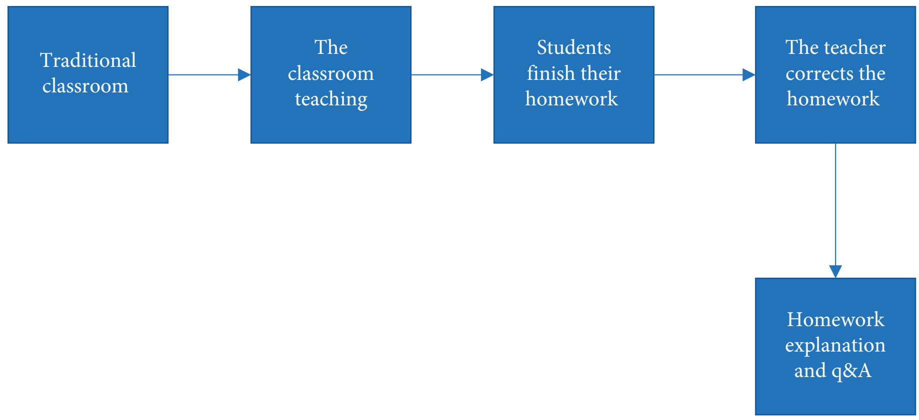

Figure 1: The teaching and learning process of traditional classroom.

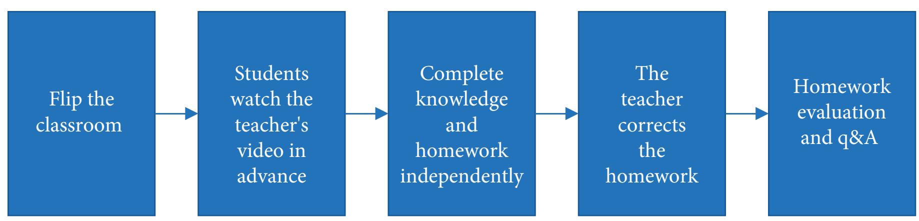

Figure 2: The teaching process of a flipped classroom.

scholars in China were aware of it, thus starting a wave of research on flipped classroom [10].

The flipped classroom flips the relationship between the internalization of knowledge and the transmission of knowledge in actual teaching activities, which is conducive to improving the students' ability of collaboration, self-exploration, and independent learning within group work, in line with the design theories and design ideas of system theory and architecture attention.

First, in terms of its advantageous performance, the flipped classroom can build a collaborative learning environment in the English classroom and help students to learn English in a quality and quantity way [11]. In the new teaching mode of flipped classroom, wireless terminals and Internet technology are used to internalize the knowledge in face-to-face classes, and the control of learning is in the hands of students, then the teacher in the real classroom is supplemented by guidance, and teachers and students conduct inquiry learning together, giving guidance and help to students who encounter problems in learning. It is also conducive to creating a learning environment and atmosphere where students and teachers have equal and harmonious self-drive, which can make the relationship between teachers and students more harmonious and more conducive to building a new type of teacher-student relationship. This kind of learning atmosphere is indispensable for English learning.

Secondly, flipped classroom in English classroom teaching can implement the purpose of tiered teaching in teaching activities. Within a class or a university grade, there are always differences in individual students, and each student has different abilities, which leads to different intensities of receiving knowledge. But with the emergence of flipped classroom, compared to the traditional classroom of "teaching first and practicing later", the flipped classroom of "learning first and practicing later" is able to deal with the problem of different levels of students and different learning abilities. In the flipped classroom, students can decide how many times they want to watch the video according to their own needs, and they can also discuss with others after watching the video to solve their own questions, so that students can strengthen their knowledge through discussions with teachers and classmates on the premise of self-learning [12].

4. Flipped Classroom + Mobile Learning

4.1. Problems in Teaching Practice under the "Flipped Classroom" Learning Model. In this paper, we take the classroom teaching in English grammar class as an example, and find that the following problems exist in the learning process.

(1) Students are not excited to learn, and they are not motivated by the lack of teacher supervision. In the case of the "flipped classroom" model, students were not as excited to learn English as expected, and instead watched the videos just to brush up on their learning tasks, which was the opposite of what was expected. However, most of the students were still able to complete the learning tasks as requested by the teacher [13].

(2) In terms of teaching content, the length of the instructional videos was too long. The teaching format of flipped classroom is mainly through students'

independent learning and watching videos to complete the task, but many students are impatient in the process of watching videos and find them too long, so they cannot concentrate on watching the teaching videos, which leads to more inefficient learning and students have less confidence in learning English well.

(3) Many students do not complete the tasks of watching the videos and assignments on time [14]. In the practice of flipped classroom, teachers assign students the content and knowledge to be learned in the next lesson before each lesson, but many students do not finish the task of watching the videos on time and independently, which leads to the delay of teaching progress and the overall teaching level decreases.

4.2. Mobile Learning. To address the problems of flipped classroom in college English grammar class, this paper introduces a new teaching model—the new learning model of flipped classroom + mobile learning. First, we introduce what mobile learning is.

The word "mobile" in mobile learning refers to the fact that students are free to learn at the time and place they want, not controlled by the teacher, and are mobile. Mobile learning is a new mode of learning that has emerged in recent years with the development of technology, and advanced communication in the world. Mobile learning is also defined by some scholars as learning with the help of mobile electronic devices. Mobile learning has the following characteristics [15].

(1) Mobility: Mobile learning is a way of learning with the help of electronic devices, and students only need to download or connect to the Internet to achieve independent learning, which is very flexible for both the teachers and students.

(2) Autonomy: Mobile learning is not constrained by time, place, and occasion, so students have a strong learning initiative. The use of mobile learning in the English classroom helps students develop self-discipline and autonomy in learning English and activates their internal drive to learn [16].

(3) Higher collaboration rate: In order to avoid problems such as students only know English grammar or only English exams or writing, using mobile learning allows students to preview the class content they learn in advance, so that they dare to speak English and use English to express their thoughts in the real classroom [17]; at the same time, through collaborative methods such as group discussions, students can participate in the discussions and try to ensure that. We also make sure that every student does not fall behind in oral expression through collaborative methods such as group discussions.

(4) Fragmented learning: Fragmented learning refers to the use of fragmented time to learn and internalize knowledge in daily life. Mobile learning is a new model of fragmented learning. In the mobile learning mode, students can watch the teaching resources released by the teacher in their own leisure time, so as to achieve the purpose of self-learning, as shown in Figure 3.

4.3. Flipped Classroom + Mobile Learning. Firstly elaborate the changes in English teaching. In "Exploring English Change" by Zhong Ping in 2020, he pointed out that "the key to English teaching is to explain the logic behind English clearly". Since the epidemic, many places in China have been asking for online classes from time to time, and Mr. Zhong Ping also pointed out in his online course "Logical English" that "the teaching of English should be a whole, not modularized or blocked". At the same time, China has made some changes in the reform of English in universities. For example, in terms of course content, the "Requirements for Teaching English in University Courses" also points out that English in universities should be taught by learning the theory of English teaching and learning the practical application of English and the essence of English knowledge. As one of the skills of cross-cultural communication, and also to clarify the strategies of teaching English and to keep up with the times, integrating the development of today's economy and technological advances, and gathering a variety of teaching modes integration and teaching means of education system [18].

The definition and advantages of the flipped classroom and the mobile learning model are described in Section 2 and Section 3, respectively, and the problems in teaching practice with the "flipped classroom" learning model are also described in Section 3. In response to the problems of untimeliness, long teaching videos, and insufficient self-drive of students, this paper proposes a new teaching model that combines the fragmentation, mobility, and independent learning characteristics of mobile learning. This paper proposes a new teaching model--"Flipped Classroom + Mobile Learning." Next, the new teaching model of flipped classroom + mobile learning is elaborated [19].

In terms of classroom assessment, teachers can analyze students' learning and questions by observing the background data, and then adjust the teaching content according to the students' learning data in the actual classroom, so as to start targeted teaching activities [20]. In addition, in the assessment of classroom teaching, teachers and students can not only communicate their knowledge online, but also evaluate students' ability to express themselves in English through their language output offline, so that they can turn their knowledge into internal use and understand how to use different English expressions in different scenarios to improve their language skills.

In terms of classroom organization, the new teaching model of "flipped classroom + mobile learning" is also a good way to cope with the current trend of time compression and credit reduction in English learning. The traditional classroom teaching time is 45 minutes a class, with a 5 to 10 minute break between classes, which is very unfriendly to a class with complex content like English grammar. Therefore, the new teaching model of "flipped classroom + mobile

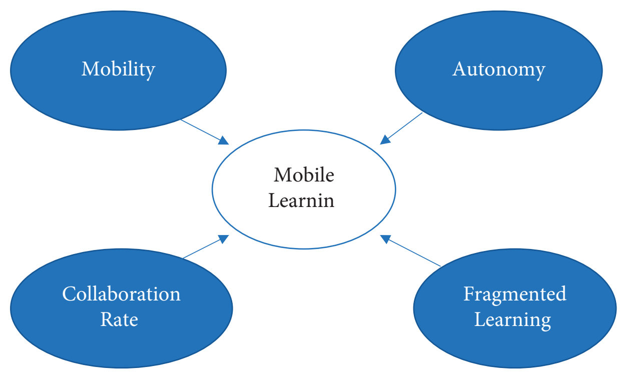

Figure 3: Features of mobile learning.

learning" will be a good choice for the content and time of the class, and more importantly, for the students in the same classroom group with a wide range of levels [21].

In this paper, the following pedagogical requirements and goals are proposed for this new model.

4.3.1. The Length of the Recorded Video Should Not Be Too Long. In a simple "flipped classroom" learning model, some videos are too long, even more than one hour. The excessive length of learning can lead to mental fatigue and lack of learning satisfaction, which can lead to students becoming less and less interested in the learning process [22]. Therefore, in the new mode of "flipped classroom + mobile learning", teachers should divide several knowledge points into multiple videos when recording teaching videos, and ensure that the length of the videos for students' self-study is about 10 minutes. Such fragmented teaching videos not only make teachers feel relaxed in the recording process, but also make students easily get a sense of achievement and satisfaction in the learning process, thus making English learning more interesting and ensuring students' learning efficiency and learning effect [23].

4.3.2. Teaching Content Should Be Focused, Not Learning for Exams. From test-based education to quality education, many teachers still have the inherent "test-based education" mentality, which leads many teachers to emphasize where to focus on exam points and where to focus on nonessential points when teaching [24]. This has led to a situation where many students only know how to take the test but not how to apply it in their lives. Therefore, in this new paradigm, it is recommended that teachers can change their thinking and focus more on students' ability to apply in real life. For example, in the explanation of English grammar, it is not necessary to explain only how to analyze the definite clause and how to write it well, but also to tell students how the definite clause will appear in real conversation, how to express themselves in the spoken language with the definite clause, and so on. If we can combine the knowledge of English with real-life conversations and make the boring English lessons active and interesting, then students will have more interest in learning English and naturally their academic performance will improve. Therefore, it is important to change the previous thinking in the teaching practice activities under the new model.

4.3.3. Guiding Learning to Use Fragmented Time to Study and Stimulate Students' Inner Drive. As mentioned earlier, the teaching videos recorded by teachers should not be too long to prevent students from mental fatigue in the process of independent viewing, which leads to the problem of inattention, so a teaching length of about 10 minutes is the most appropriate video length [25]. At the same time, teachers should also instruct students how to use the fragmented time to study, how to make the best effect of learning in the fragmented time, and how to drive students' intrinsic interest in learning according to their learning situation, so that the students can achieve the best learning efficiency.

4.3.4. Selecting the Right Mobile Learning Platform. Under the new model of "flipped classroom + mobile learning", the teacher team should choose a suitable mobile learning platform to prevent students from picking up smart terminals such as tablets or cell phones and opening entertainment software such as Akiyay and Tencent Video instead of teaching videos. Therefore, it is necessary to use a suitable mobile learning platform, and a professional mobile learning platform is especially important here. You can choose such learning platforms as China Muzi, Learning Pass, etc., or you can choose a learning platform developed exclusively by your own school to publish teaching videos [26].

4.3.5. Be a Good Supervisor for Students. In the new model, students have more independent control over their learning, but after all, there are too many temptations in real life, so as teachers should be good supervisors of students, while students are not only teachers' students, but also parents' children, teachers and parents should maintain good communication, and jointly supervise students to complete the teaching videos on time and in quality, teachers and students working together to complete their studies is the vocation of teachers.

4.3.6. Pay Attention to Students' Feedback. Under the new model of "flipped classroom + mobile learning", teachers should always pay attention to students' feedback and opinions. It is recommended to let students give their opinions and questions in the discussion forum after each lesson, so that the teacher and students can work together to improve the quality of teaching. Therefore, in the new model, teachers should pay attention to students' feedback, build a new type of teacher-student relationship, collaborate to accomplish teaching tasks and learning goals, and strive to make every student achieve the best learning effect and the highest learning efficiency in every lesson.

5. Big Data Analysis

Big data analysis refers to the technique of analyzing and processing a wide variety of data related to the behavior of any recorded individual or group [27]. The term big data is common both on the Internet and in real life, but to understand what big data analytics is, you have to start with big data. First of all, big data contains two layers of meaning, the first layer is that the various activities of human beings will produce the corresponding data records, these data records are remembered and stored by the network, it becomes the superficial sense of “big data”; the other layer is from the technical level, big data actually refers to the big data technology, that is, big data analysis and processing technology. This paper uses big data analysis to analyze the new teaching practice model of “flipped classroom + mobile learning” because the essence of big data analysis is to visualize the value of the data obtained, so that we can see the pattern and visualize the learning effect of students in this model. In addition, the new teaching practice model of “flipped classroom + mobile learning” combined with big data analysis technology can also fully collect students’ learning data and dig deeper into their characteristics, and adjust teaching strategies based on the data analysis results, so that teachers can more fully grasp the learning situation of students and the differences between students’ learning abilities. At the same time, it is also a new attempt for online English teaching mode [28].

6. English Classroom Teaching Case Design Based on Big Data Analysis

6.1. Sources of Big Data in English Teaching Classroom. In this paper, according to the different sources of big data, education big data can be divided into national education big data, regional education big data, school education big data, classroom education big data, curriculum education big data, and individual education big data according to the top to bottom and large to small [29]. In order to fully consider this paper as a study on the improvement of “flipped classroom + mobile learning” model based on big data analysis, the big data adopted in this study are mainly classroom education big data and individual education big data.

6.2. Analysis and Mining of Big Data of English Teaching Classroom. The research object of this paper is a college English grammar class composed of students of different majors, and the data collected are class education big data and individual education big data. The research is about the new model of “flipped classroom with mobile learning” in English classroom teaching based on big data analysis technology. In the teaching practice of the new model, teachers need to continuously adjust the teaching objectives based on students’ feedback and midterm and final grades, that is, based on the results of big data analysis and mining. In other words, based on the results of big data analysis and mining, combined with the characteristics and advantages of the flipped classroom + mobile learning mode, teachers need to innovate and optimize the teaching design methods in teaching practice. The next paper selects the data on the content of the definite clause in the English grammar class to analyze the problems and observe the weaknesses of students in the teaching process under the new model [30].

In the video on the teaching of definite clauses, firstly, before starting the teaching of definite clauses, examples of Chinese definite clauses are given, and then the differences between Chinese and English definite clauses are compared, so that students can deeply feel that there are differences between English definite clauses and Chinese definite clauses, and the main difference is in the grammar. Next, in the next video, an overview of the definite article is explained, and these basic concepts such as what is a prior word and a relative word are made clear, followed by the classification of the definite article, what is a restrictive definite article and what is a nonrestrictive definite article. These contents are all fragmented by the new mode of mobile learning and flipped classroom learning, and the length of the video does not exceed 10 minutes.

6.2.1. Overall Student Quiz Data Analysis. First is the data analysis of the overall students. In this paper, the data from the quizzes on the grammar of the definite article in college English grammar are selected for analysis. In this paper, there are 10 questions on the grammar of the definite article. The first 5 questions were on choosing the appropriate relative pronoun; the 6th to 8th questions were on translating the definite clause into Chinese, and the 9th to 10th questions were on translating the given Chinese using the definite clause in English. The total number of students in the class was 43. Questions 6 to 10 were scored out of 10, and those above 7 were considered correct and those below 7 were considered wrong. The quiz data are as follows, as shown in Figure 4.

6.2.2. Data Analysis of Different Students in the Score Range. Secondly, the multiple-choice questions set in this paper are 5 points each, and the full score of multiple-choice questions is 25, among which the Chinese and English translations of the 6th to 8th questions are 10 points each. In this paper, the distribution of students in the 0–25, 26–50, and 50–75 score ranges was calculated to show the weaknesses of students in the learning process. The distribution of the number of students in different score ranges is shown in the figure below, as shown in Figure 5.

6.2.3. Students’ Overall Chapter Learning. In this paper, the study is based on the research of the new mode of English classroom teaching and learning, so the video recording process is a complete teaching of college English grammar, not only limited to the definite clause in college English grammar, in order to better observe the students’ interest in the new mode of flipped classroom + mobile learning or whether the task-driven nature is reasonable, so this paper extracts a part of the chapter learning completion. In order to better observe whether the students are interested in the new model of flipped classroom + mobile learning or whether it is task-driven, this paper extracts the learning completion data of some sections for analysis, as shown in Figure 6.

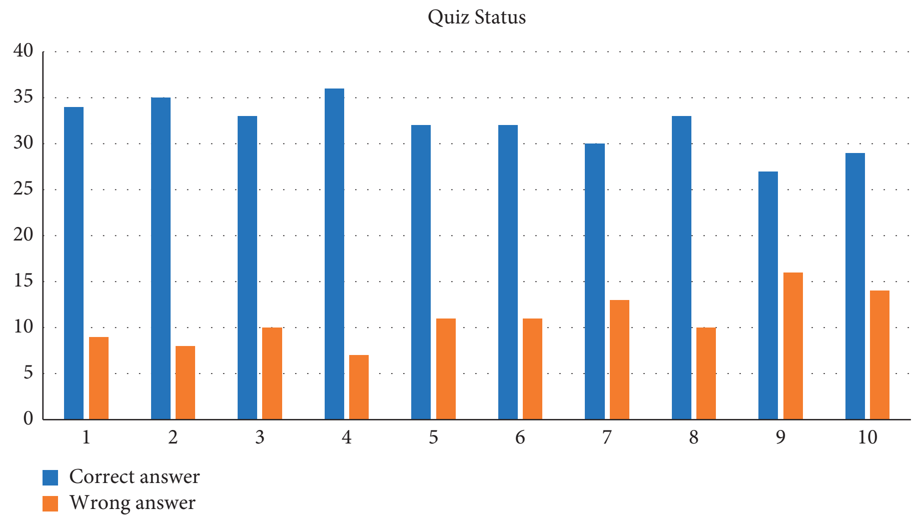

FIGURE 4: Quiz on the grammatical points of definite clauses.

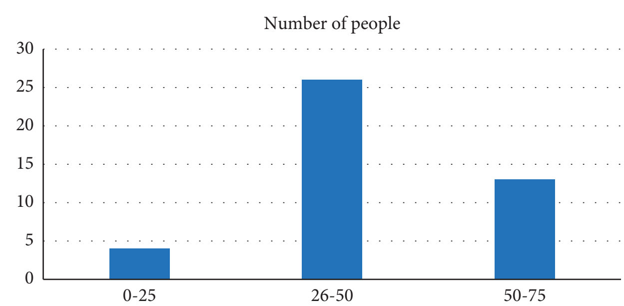

FIGURE 5: Distribution of the number of students in different score ranges.

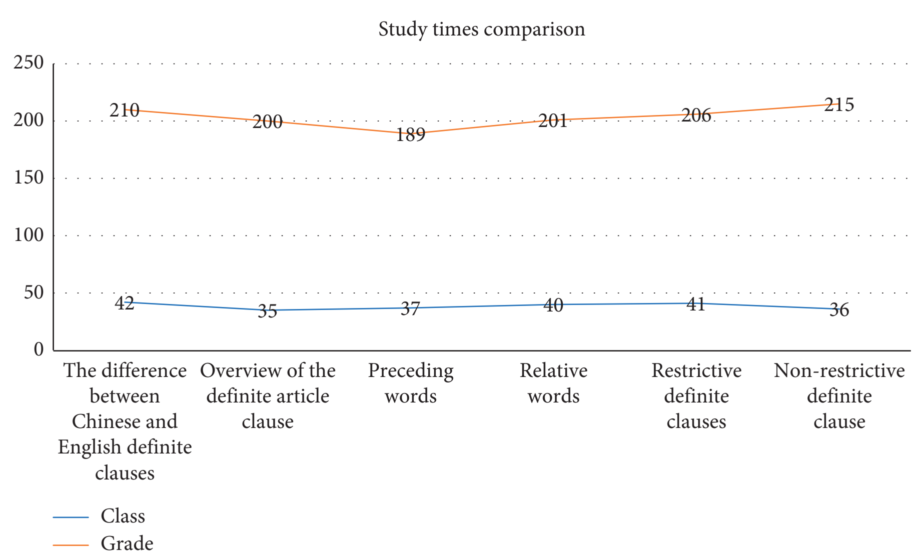

FIGURE 6: Comparison of learning trends by class and grade level.

6.2.4. Students' Feedback on the New Model. Under the new model of "flipped classroom + mobile learning" and supported by big data analysis technology, the evaluation page is given after each video chapter, allowing students to evaluate the teacher's teaching style, knowledge explanation, and the reasonableness of the length of the video. The evaluation score is 100 points, above 70 is considered as approval, and below is considered as disapproval. The data is shown as follows, as shown in Figure 7.

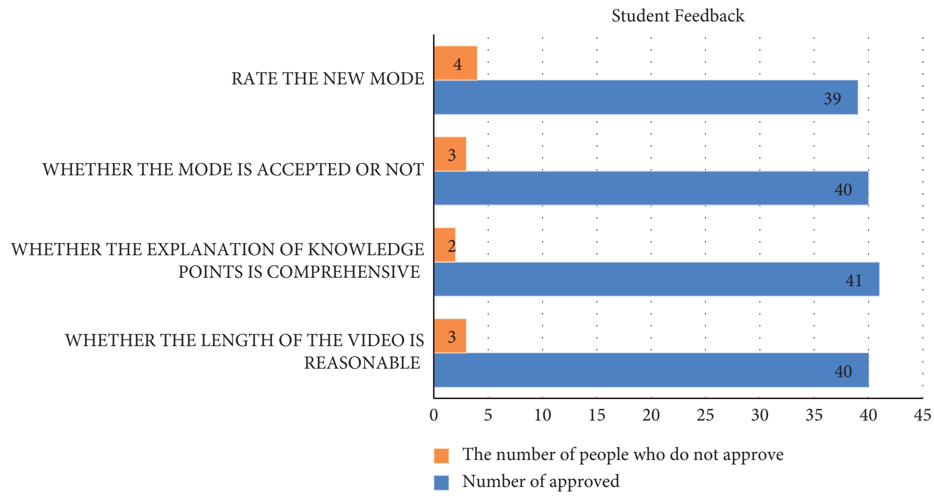

Figure 7: Students' feedback on the evaluation of the new model.

7. The Construction of Precision Teaching in English Classroom Based on Big Data Analysis

This paper analyzes the evaluation system of teachers' teaching development based on the premise of improving the "flipped classroom + mobile learning" model, and proposes the expectations and requirements for accurate teaching based on big data analysis.

The first step to solve the problem is to understand how the problem arises. On today's teaching evaluation system, the lack of teaching big data support and an information system to comprehensively and objectively evaluate teachers' teaching effectiveness is the primary problem. Generally speaking, teachers carry out teaching activities according to syllabus and credit hours, which is not wrong, but due to different teachers and schools, there are differences in teachers' teaching activities, teaching contents, teaching methods, and teaching research, etc. The evaluation methods for teachers are also various and independent, which makes it difficult to achieve comprehensive analysis and accurate judgment of teachers' teaching results. This makes it difficult to analyze and accurately judge teachers' teaching [9]results. At the same time, students' feedback and evaluation responses are not properly addressed, which affect the "teaching-learning" relationship between teachers and students and leads to deviations in teaching and learning, and as a result of poor communication, some students directly become "biased" or bored. Or directly lead to aversion to learning. Therefore, in order to solve this problem, we need to build a feedback system for teachers' evaluation of teaching.

In recent years, due to the synthesis of information and big data, many education data have the requirement of using big data analysis technology. At the same time, the development and progress of China's education system over the years, has long accumulated a huge amount of education big data, how to use these big data well, to the tip of the knife for the development of a new model of contemporary education will be a very important issue. At the same time, the use of big data technology to build a teacher evaluation system and student feedback system is an essential part of building a new type of teacher-student relationship, and is a key point for "teaching and learning" to go hand in hand. In addition, it is also very important to use the feedback system for teaching English to address the problems of language bias and the fact that most students can only use but not speak English. Therefore, this paper proposes a research direction of assessment model based on big data analysis based on the new model of "flipped classroom + mobile learning".

8. Assessment Model Based on Big Data Analysis

The assessment model based on big data analysis in the new learning model of "flipped classroom + mobile learning" is shown in the figure below. In this model, an evaluation model with interactive feedback between students and teachers is proposed.

First, after a certain degree of learning in the new mode of "flipped classroom + mobile learning", students give feedback on English classroom teaching or video teaching through the information-based comprehensive evaluation system, and then, through the interaction between students and teachers, teachers reflect the feedback results to school leaders. Then, through the interaction between students and teachers, teachers will reflect the feedback results to the school leaders; then, through the school leaders and teachers' feedback, they will discuss and make improvements, and then feedback to the evaluation system, and students can finally view the school and teachers' solutions to the problems raised through the evaluation system. This mutual feedback evaluation system not only breaks the traditional teacher-student model of "teaching and learning" and "learning and teaching," but also strengthens the communication and exchange between teachers and students, as well as the exchange and discussion between school leadership and teachers, which greatly facilitates the mutual understanding between students and teachers, and teachers

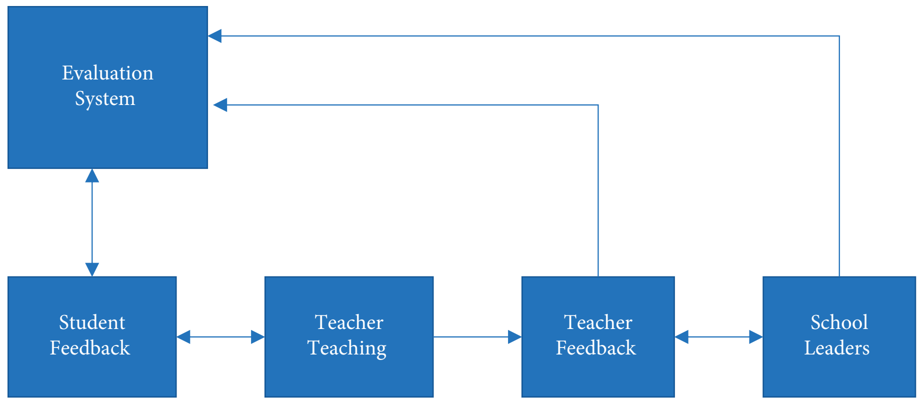

FIGURE 8: Assessment model based on the new learning model using big data analysis.

and school leadership. This model greatly facilitates mutual understanding between students and teachers, and between teachers and school leaders. For the students, the assessment model helps to improve their learning effectiveness and efficiency, encourages them to express their ideas, and helps to develop innovative and bold thinking; for the teachers, the implementation of the assessment model helps to create a harmonious teacher-student relationship, allowing teachers to understand students' ideas and learning problems, and allowing school leaders to hear teachers' voices, as shown in Figure 8.

9. Conclusion and Outlook

Based on the learning model of flipped classroom, this paper proposes a new learning model —the improvement of flipped classroom + mobile learning model; in addition, it also analyzes and digs into issues such as students' adaptation level under this model by using big data analysis technology, and through the analysis of big data, the conclusion shows the students' acceptance of this new model. In addition, we also analyzed and explored the adaptation level of students in this model through big data analysis. Finally, based on the research of the new model of flipped classroom + mobile learning, an evaluation model, an interaction model between teachers and students, and between teachers and leaders, is proposed. This evaluation model will facilitate the construction of a new and harmonious relationship between students and teachers, and teachers and schools.

Data Availability

The dataset can be accessed upon request

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

The Impact of Big Data Technology on Phrase and Syntactic Coherence in English Translation

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In the era of big data, data are ubiquitous. The proliferation of data leads to a surge in the demand for communication, which in turn promotes a surge in the demand for language services. Big data technology is a comprehensive technology, and its important feature is a more active technological factor, where technological development and technological innovation dominate, which will have an incalculable impact on the development of the translation industry. In the language service industry, much information that used to be difficult to quantify will be transformed into data for storage and processing, and a large number of complex items to be translated will gradually surface. Therefore, it is the general trend of the translation industry to stimulate and utilize the unexplored values hidden inside the data and develop the blue ocean of the language service industry. Traditional translation researchers are confined to the study of language and text and are not fully aware of it. The huge role played by translation technology in today's business environment, and the traditional translation theory can hardly describe and explain the new modern translation technology phenomenon and translation technology activities. Whether we are ready for it or not, the rapid development of translation technology in the era of big data will lead to significant changes in translation inquiry and translation teaching on a global scale. The integration and development of translation with cloud computing, big data, the Internet, and artificial intelligence are driving a series of innovations in the traditional translation model. The development of translation technologies and tools is breaking new ground, rapidly expanding into all aspects of the translation industry and triggering disruptive changes in the language service industry.

1. Introduction

Technological innovations, especially the rapid development of cloud computing, big data and artificial intelligence technologies have made people's lives more convenient; in the translation industry, they have promoted the emergence of many new translation technology models [1]. Mechanical translation has officially become an integral and important part of the history of translation and one of the highly regarded cutting-edge technologies. Automated translation technology is a technique for quickly converting written or spoken language into many different languages [2]. For a large number of preliminary translation jobs, automated translation technology is simple and efficient and can also reduce a significant amount of labor. The world is converging under the catalyst of the Internet, and communication has become a bridge to globalization, which makes translation technology shine in the language service industry. The semantic problem in the artificial intelligence perspective is one of the most central problems among the many difficulties faced by artificial intelligence. The philosophical debate and questioning of the semantic problem have posed an inevitable and serious challenge to the advancement of AI [3]. It has been sixty-five years since the concept of artificial intelligence (AI) was introduced at the Dartmouth Conference in 1956. Artificial intelligence is a new field that requires the integration of many different disciplines, and it involves cross-disciplinary issues and cutting-edge problems, thus giving rise to a number of "cross-border scholars" with different disciplinary backgrounds, such as Marvin L. Minsky, one of the founders of artificial intelligence and an American mathematician. For example, Marvin L. Minsky, one of the founders of AI, was not only an expert in computer science but also studied the philosophical issues related to AI; Noam Chomsky, an American philosopher, not only made outstanding contributions to philosophy and linguistics but also thought about the issues related to AI [4]. It is in such a complex disciplinary context that the semantic problem of artificial intelligence emerges in the collision of computer science and philosophical linguistics. Some philosophers have even argued that the semantic problem is a major obstacle limiting the development of AI, and that the inability of syntactic operations to have semantic capabilities has become an inherent shackle, from which AI cannot escape. John Searle, an American philosopher, has suggested that AI can achieve syntactic operations based on symbolic language but cannot achieve understanding and thus does not have semantic capabilities. This idea has not only provoked intense discussions in the field of philosophy but also various responses in the field of artificial intelligence. The semantic problem has long been a complex but important proposition in the philosophical community. Many linguists and philosophers have studied the concepts of "meaning," "interpretation," and "intentionality" in depth and have explored the production and realization of semantics in the field of linguistics [5]. The semantic problem of artificial intelligence is a problem that must be faced both in the fields of philosophy and artificial intelligence, both of them testify to the inevitability of the semantic problem from the dimensions of theory and reality respectively, and the problem cannot be solved without the joint efforts of the two fields, that is, the union of theory and reality. There is still a lot of work to be done to solve the semantic problem in concrete terms. In general, the first step is to solve the problem of the conditions and mechanisms of how human beings can realize semantic capabilities, and on this basis, to try to simulate such situations in artificial intelligence systems to demonstrate whether machine languages have the ability to realize semantics. At this stage, neither the philosophical view nor the technical means can solve the semantic problem perfectly yet, and time is needed to explore new ideas [6].

2. Research Background

The translation of Buddhist scriptures has appeared in China since 25 A.D. During the period of Emperor Huan of the Eastern Han Dynasty, as a large number of Buddhist scriptures were introduced to China, the development of translation in China also emerged, and a number of translators such as Xuanzang and Zhiqian emerged, who made outstanding contributions to the development of translation in the world. The second climax of translation in China originated in the late Ming and early Qing dynasties. With the development of economy and transportation and the increasing trade, a large number of western works on natural sciences flowed into the country. Among them, Li Zhizao and Xu Qiguang as representative figures translated a large number of Western scientific and technological works, and some foreign missionaries such as Tang Ruowang and Matteo Ricci made outstanding contributions to the spread of Chinese culture in the West [7]. The third translation climax was the translation activities before the May Fourth Movement, especially after the defeat of the Sino-Japanese War, which triggered the concern of all people for Western studies. After the First Sino-Japanese War, some rulers thought it was necessary to learn capitalist ideas and to master the long skills of the barbarians to control them. Liang Qichao, Kang Youwei, and Yan Fu were representative figures of this period, especially Yan Fu's theory of translation with letter, reach, and elegance has been influential to this day. The period from the May Fourth Movement to the founding of New China was a period of unprecedented development and magnificent waves of translation. Since vernacular languages were used in translation, the translations became more popular with the general public and also made the translated texts expand from informational texts to expressive functional texts; the translation methods developed from single semantic translation to communicative translation, and the translation theories were also continuously improved [8]. With the globalization of the world and the continuous intermingling of cultures, translation has ushered in a new climax, and the huge amount of translation work has made human translation unable to meet the translation needs. In the background of this era, machine translation, as well as cloud computing and big data, provides new opportunities for the development of translation. With the increase of information volume, the accuracy of machine translation is also improved, as shown in Figure 1. However, the research on natural language processing and the related application of machine translation in the field of artificial intelligence also face difficulties in cross-domain semantic analysis obstacles such as problems with phrases and syntactic coherence, which are urgent problems for both artificial intelligence and philosophical linguistics, and until the current breakthroughs in computerized symbolic language and cognitive science of thinking, these are still tricky problems for the time being, as shown in Figure 1.

2.1. Review of Foreign Research. Artificial intelligence is an emerging field, but as an interdisciplinary field, there is no lack of research progress [9]. The Turing test in Computing Machinery and Intelligence (1950) represents the starting point of AI research. By the end of the 1980s, the symbolist research path encountered a theoretical and practical bottleneck, and AI research entered a period of decline [10]. What Computers Can't Do: The Limits of Artificial Intelligence, published in 1972, and Mind, Brain, and Program, published in 1980, were also born in this period. Both had a profound impact on artificial intelligence and semantic issues.

The breakthroughs and advances in the field of artificial intelligence have led to a growing wealth of philosophical research related to artificial intelligence. The next step was that Hogeland, under the influence of his teacher, also took AI as his main research direction and achieved a series of results, mainly introducing the emergence and development of philosophical ideas on AI in recent times and analyzing formalism and computer architecture and discussing

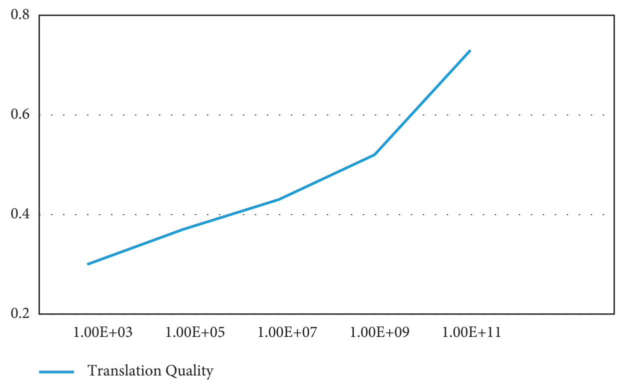

Figure 1: The relationship between vocabulary and translation quality.

semantics. In addition, Hogeland compiled the book in 1981 in order to integrate related research in the field of artificial intelligence, and it includes not only research in the field of computer science but also representative articles in the field of philosophy such as Dreyfus' work [11]. The book contains 15 papers on AI and its philosophical issues, and the main arguments in Boden's collection focus on classical judgments of AI and the connectionist approach to research. In 2006, Boden published a monograph, Mind as Machine: A History of Cognitive Science, which can be regarded as one of the most comprehensive works in the cognitive science community [12]. The breadth of knowledge and the richness of the material in this work provide a rich ground for the study of artificial intelligence and open up a new field of artificial intelligence research at the level of cognitive science. However, compared with the thinking and direction in the field of computer science, Boden's research on AI is obviously philosophical and critical [13]. According to Yingjin Xu, "We seem to get the impression that Boden is more interested in the entanglements between some AI schools that have become historically silent, but more or less detached from what AI experts are doing at the moment."

In 2011, Floridi, a British expert on the philosophy of information, published a monograph, The Philosophy of Information. The book offers a serious and profound exploration of the problem of semantic information. Floridi argues that information is more than a simple physical phenomenon, and that uninterpreted data in a collection cannot be transmitted by encoding and transmission for semantic information. The book gives a realistic dilemma of the semantic information problem; the study of information theory does not require the realization of the transmission of the meaning of information, while the generation and transmission of semantic information are the most important concerns in the field of philosophy.

In addition, there is a journal for the study of artificial intelligence and its philosophy, Minds and Machines [14]. Founded in 1991, Minds and Machines serves as a platform for communication between the different disciplines of AI research, including philosophy, psychology, cognitive science, and computer science. The preamble issues of the journal also require close cooperation and collaboration among different disciplines to solve, which has greatly contributed to the development of research in the field of artificial intelligence.

2.2. Review of Domestic Research. After a brief review of foreign research literature, a review of domestic research on this issue is as follows. Due to the division of arts and science education in China, most scholars engaged in philosophical research lack disciplinary backgrounds in mathematics, logic, or even computer science, resulting in not much research focusing on the interdisciplinary field of semantic issues of AI indeed [15]. The domestic research on the semantic problem of AI is mainly divided into two directions: on the one hand, we start from the philosophical problems related to the development of various fields of AI and explore the semantic problem in the process of problem-solving; on the other hand, we start from semantics and conduct research through the path of language logic and language philosophy. The philosophical research on AI in China is still mainly in the form of introduction and translation of foreign research results, but in recent years, there is also a research on the philosophical issues of AI. From the direction of semantics research, both logic and philosophy of language have discussed the semantic problem of AI. Although the research on the semantics of artificial intelligence has not yet taken shape, the discussion and concern on the semantics have never ended [16].

In 2008, Professor Gao Xinmin of Huazhong Normal University published a book entitled "Contemporary Development of Intentionality Theory," which provides a comprehensive analysis of the problem of intentionality in the field of philosophy and discusses the difference and connection between the problem of meaning in different perspectives such as semantics, hermeneutics, and psychology [17]. The semantic properties of individuals are based on relations in the environment, and without informational relations, individuals cannot think and thus do not have semantic properties [18]. In addition to this, "Intentionality and Artificial Intelligence" was published in 2014. The main issues studied in that book are closely related to this study [19]. The problem of intentionality that Intentionality and Artificial Intelligence focuses on is the focus of whether artificial intelligence can be truly realized, and the semantic problem of artificial intelligence that this study tries to solve is also the bottleneck of artificial intelligence [20].

In terms of dissertations, the doctoral dissertation of Weiwei Liu from Shanxi University in 2013, "Research on the Semantics of Science," introduces the relevant theoretical contents of semantics. The dissertation argues that the reason for the complexity and difficulty of semantics research is precise because the research objects and contents of semantics are too much influenced by various schools of thought and positions. The study of semantics is an academic field that requires continuous in-depth research to resolve controversies. In addition to this, Xu Yu's 2016 PhD thesis on "Machine and Language" from the Central Party School explores the issues and controversies raised by language in the development of artificial intelligence [21]. After sorting out the background of the development of language processing in AI through the dialectical development of both machine and language, the thesis introduces the exploration of the problem of intelligence and language in the field of AI, shows the questioning of the philosophical community in the field of AI through the representative philosophers' views as an example, and finally analyzes the inner logic and the deep reasons for the emergence of the problem of language and intelligence that are difficult to solve [22]. Although the number of articles on the improvement of various problems in translation in combination with big data artificial intelligence and other means has been increasing this year, as shown in Figure 2, according to the literature published in recent years, it can be seen that most researchers mainly explain and elaborate on some problems in machine translation, such as the impact of machine translation on grammar, syntax problems in machine translation, etc., but they report on the syntax problems that do not exist in machine translation. However, they have not followed the trend of using big data technology to analyze the influence of existing artificial intelligence on phrases and syntax in English translation, so the influence of big data technology on phrases and syntax in English translation still needs to be investigated [23], as shown in Figures 2 and 3.

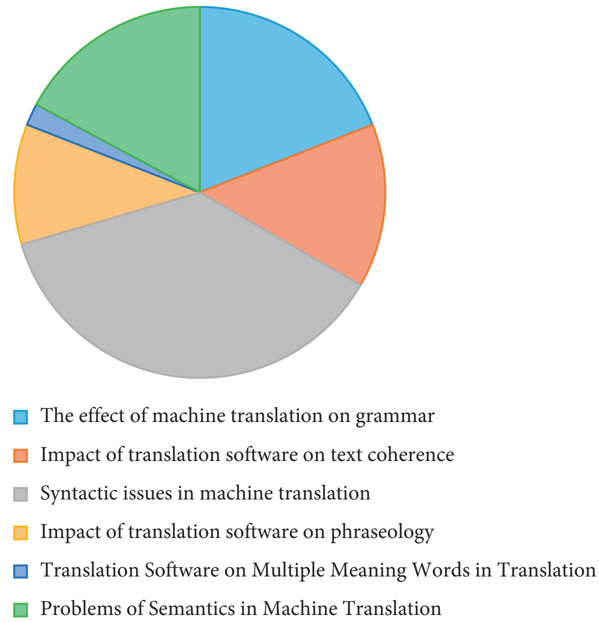

Figure 2: Percentage of the published content in recent years.

3. Research Ideas

The semantic problem of artificial intelligence requires theoretical knowledge in the field of artificial intelligence technology as well as philosophical analysis due to the complexity and specificity of the disciplines involved [24]. In this study, we try to grasp the causes and development of the semantic problem of artificial intelligence from the intersection of disciplines. On the one hand, it introduces the exploration and attempts of semantic issues in the field of AI, and on the other hand, it introduces the debates and views on semantic issues in the field of philosophy [25].

This study also tries to take this as a clue to combine the technical progress of AI with the philosophical debates to achieve a three-dimensional and comprehensive argument. In this line of thought, it would have been conventional to arrange the materials for alternating arguments between the explorations and debates in the two fields for the semantic problem according to the chronological order. This would have provided a clear contrast between the technical explorations and philosophical theories of the same period. However, in the course of the study, it was found that such a way of thinking jumped around too much, making it impossible to achieve coherence in the content of the study. For the sake of the overall sense and coherence of the study, the research idea has been adjusted. First, we introduce the theoretical background of AI and clarify what the semantic problem of AI is and why it occurs. Finally, possible solutions to the semantic problem are given from the perspective of different disciplinary fields. This arrangement of ideas roughly follows the logical thread of problem emergence and solution [26].

4. Results and Discussion

In the 1950s, mathematical logic and electronic computers were sufficiently mature to be the basis for an important moment in artificial intelligence. First, in 1950 the Turing test asked "Can machines think?" the question of what is artificial intelligence officially opened the research direction; second, the Dartmouth Conference held by John Mc Carthy, Marvin L. Minsky, C.E. Shannon, N. Rochester, and others in 1956. The conference first clarified the concept of artificial intelligence. Since then, AI has had a theoretical foundation and an academic community and has become a new disciplinary field with specific research content and research methods [27]. Of course, for a mature discipline, a research agenda is essential to guide the direction of the discipline's research progress, and this is also true for AI. The disciplinary field of AI has seen the emergence of three different research agendas along the lines of symbolism, connectionism, and behaviorism. For the purpose of the rest of the article, a brief introduction to each of these three lines of thought will be presented.

4.1. Symbolism Based on Symbolic Language. John Hogeland, an American philosopher of artificial intelligence, first proposed the term symbolism. He divided AI into two major categories based on the basis of research and thinking. The first category is directly translated as "old-fashioned classical AI," which refers to symbolic AI [28]. The development of symbolic AI began with Turing machines. However, Turing did not think in terms of Turing machines for AI research, but in terms of "computable numbers." In 1936, Turing wrote the article "Computable Numbers and their Application to the Problem of Determination" published in the Proceedings of the London Mathematical Society. In 1931, the Austrian logician Kurt

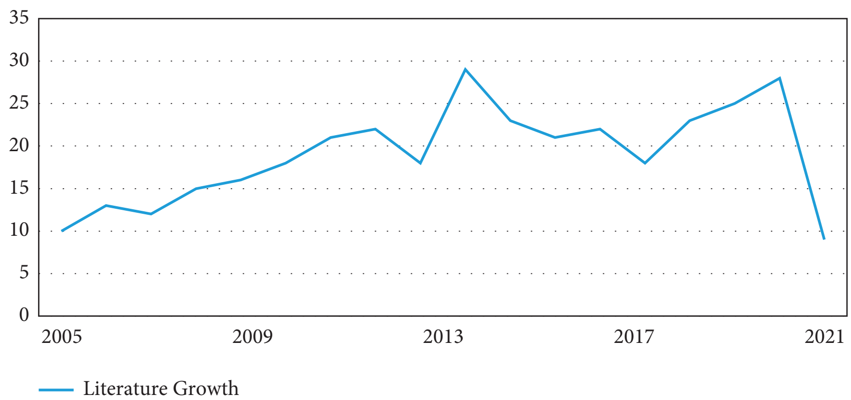

Figure 3: Trends of literature growth in recent years.

Gödel proposed the famous "GodelIncompleteness Theorems." Since Gödel has shown us that it is axiomatically impossible to prove all reasonable propositions in a system, it is considered inappropriate to think about the relationship between them through machines. Among other things, the rejection of the Judgment Theorems illustrates the current development of mathematical logic, just like the problems of Dividing Angles into Three Equal Angles, Turning Circles into Squares, and Cubic Multiplication, which are bound by the way they are treated. It was on the basis of these elements that von Neumann proposed the principle of stored programs for computers. Finally, it should be emphasized that Turing was not the only one who did not have evidence of the "judgment problem." In the 1970s and 1980s, neuroscience had already begun to study the function of the brain and related mechanisms and had made a lot of progress. Based on this, Libet tried to use experiments to prove that conscious mental states indicate the illusion in people's experience [29]. Turing gave his answer to the question of Gödel's theorem by designing the Turing machine.

The symbolist view is that artificial intelligence is based on symbolic rules of formal language. But other views of different schools of thought point out that the concrete implementation of artificial intelligence requires not only the physical basis of symbolic language but also cannot ignore the important semantic content. The realization of semantic content cannot be achieved by physical symbolic language alone; the ambiguity of language leads to the necessity of external contextual qualifications and denotations. If the generation of intelligence is just some binary sequence of numbers or the design of circuit connections, then human awareness of self-intelligence would be unacceptable.

4.2. Connectionism of Neuronal Distribution Representations. The article "A logical algorithm for the intrinsic concept of neural activity" published in Bulletin of Mathematical Biology in 1943 marked the emergence of connectionist artificial intelligence [30]. Connectionism is based on networks of neurons that use multilinear manipulation and parallel processing of networks to solve representations of mental states.

In 1986, David E. Rummelhart et al. published Parallel Distributed Processing: Explorations in Cognitive Microarchitecture, which can be considered as the thriving work of connectionism. Among other things, in their view, the multilinear distributed expression of the associativist meshlike underlying structure has the following advantages: first, it allows for memory functions. The ability to remember was originally the exclusive domain of the human brain, and the multithreaded distributed representation can process the signals between neurons in parallel, thus simulating the process of fetching memory in the human brain. The second is the extremely strong ability of regulation and adaptation. Different external inputs and stimuli will cause rearrangement among neurons, and this ability to respond to external inputs and adjust its own structure in time is very impressive. Problems that would otherwise require a predetermined program to solve can be accomplished independently by the connectionist structure on its own.

4.3. Perception-Led Behaviorism. Behaviorism only began to emerge in the 1980s. Behaviorism focuses on the research area of perceiving the external environment and tries to achieve intelligent attempts to guide behavior through perception. The behaviorist view is that artificial intelligence should focus on natural intelligence or humans themselves, and that the path of artificial intelligence should be guided by observing and learning from the patterns of perception-controlled behavior of humans themselves. In 1991, Rodney Brooks of the Massachusetts Institute of Technology (MIT) proposed that there was no need for artificial intelligence to adopt the classical sense-to-model-to-plan-to-act framework, and that the two intermediate steps were unnecessary in his view; only sense-to-act was required.

The emergence of behaviorism and the study of artificial life are inextricably linked. The study of artificial life attempts to trace the essential characteristics of life and along this path to achieve the evolution and transformation of simple to advanced lifeforms. Artificial life mainly relies on genetic algorithms rather than the simulation of intelligence, trying to realize the process of life evolution at the genetic level, and behaviorism is deeply influenced by this. Professor Xiaoli Liu of Renmin University of China summarizes symbolism, connectionism, and behaviorism as follows: symbolists try to simulate the human brain with symbolic algorithms, connectionists try to construct the brain through parallel computation of artificial neural networks, and behaviorists try to evolve the brain through genetic algorithms, as shown in Figure 4.

Neither linguistics nor semantics has been able to accurately define and grasp semantics, and this is the deep confusion of the semantic problem in the AI perspective. Language serves as a symbolic formal system capable of conveying meaning and thus achieving various other functions. This symbolic formal language system must be able to be endowed with meaning in order to carry the ability to communicate, cognitively experience, or mediate media. The meaning that language has or is given is semantics, which is the essence and foundation of language.

Because of the complexity of the field of research on semantics, the different views of each school and discipline on semantics, and the irreplaceable position of semantics in the progress of research in many fields due to its specificity, there are many different studies on semantics. As the emerging field of artificial intelligence has focused on semantic issues, philosophy, psychology, and cognitive science have also paid attention to semantic issues. In general, the concept of "semantics" that is the focus of this study is the ability to express and even understand the meaning of symbolic languages. The study of semantic issues is not only an important way for humans to understand how they communicate with the outside world but also a doorstop for humans to explore their own thinking processes and cognitive abilities.

In the development of artificial intelligence, there has been a disconnect between syntax and semantics. John Searle was the first to explicitly state that this disconnect is at the heart of the semantic problem. Searle said that "the human mind is not only syntactic, it also has a semantic aspect. Computer programs can never replace the heart for a simple reason: computer programs are only syntactic, while the heart is not only syntactic. The mind is semantic, that is, the mind is not just a formal structure, it has a content." That is, the syntax of formal language in a computer system is not capable of realizing the semantic content of natural properties, and it is impossible for an artificially intelligent machine to achieve understanding. Is there really a complete disconnection between syntax and semantics? The answer is obviously not exact. Thus, the semantic problem is not unanswerable in the direction of technological development and in the field of philosophical research where new situations may arise. It is just that until the level of science and technology reaches that level of awareness, we have to explore the answers to the questions with an open mind. In fact, from a deconstructive point of view, the theoretical roots of artificial intelligence value logic and use symbolic language, while the requirements of semantic implementation are object-oriented and grounded in reality. Logic and symbols do not exist in reality, but are methods and tools abstracted subjectively by humans. Therefore, solving the semantic problem of AI is equivalent to solving the problem of real objects without abstraction by means of abstraction-based AI. To solve the semantic problem perfectly, we must reconcile the reactionary connection between foundation and purpose and the contradictory relationship between abstraction and reality.

Along with the development of the information age, artificial intelligence technology has also achieved corresponding results. However, the research on natural language processing, which is the core technology of artificial intelligence, has been difficult because of the difficulty in solving the semantic problem. Therefore, the technical dilemma of AI semantic issues must be sorted out from the semantic barriers faced by natural language processing, mainly in the following aspects.

The first is that the hierarchical structure of language processing implies that a shift from the morphological to the semantic stage of language analysis must be realized. Human analysis and understanding of language are hierarchical processes, which are the consensus of linguistics and computer science for natural language processing research. The process of natural language processing through the human brain can be broken down into two parts: the language is input to the brain, which analyzes and deconstructs the natural language; after that, the brain outputs new results after processing and reconstructing the language. The brain's analysis and processing of natural language can give the judgment that language can be decomposed into word-level degrees of being reconstructed and deconstructed. Based on this judgment, from a reductionist point of view, it can be argued that natural language can be divided into multiple levels of structure within it, and that computer processing of natural language should follow this hierarchical structure, just like the human brain, to analyze and process language. This requires the computer to simulate as much as possible the analytical logic and grammatical rules that the brain follows when processing language, so that the computer can achieve perfect processing of natural language. In this way, natural language processing can be roughly divided into two modules according to the human brain's processing of language, namely, the input of language, which requires the computer's ability to recognize and understand natural language, and the output of language, which requires the computer's ability to syntactically construct and express natural language. In this process, the recognition and syntactic construction ability of natural language processing need to be realized from the level of vocabulary and sentences, which is the research idea of semantic problem, while the understanding and expression ability of language needs to be realized through the direction of semantic analysis or semantic recognition. On this basis, the study of natural language processing faces the need to cross over from the direction of semantic analysis to the level of semantic analysis. At this stage, the technology and research of semantic analysis have been relatively mature, but the progress in the direction of semantic analysis is still slow, which creates a semantic barrier that natural language processing must face.

Second, neither rationalism based on grammatical rules nor empiricism based on statistical methods can achieve semantic analysis perfectly for the time being. The early

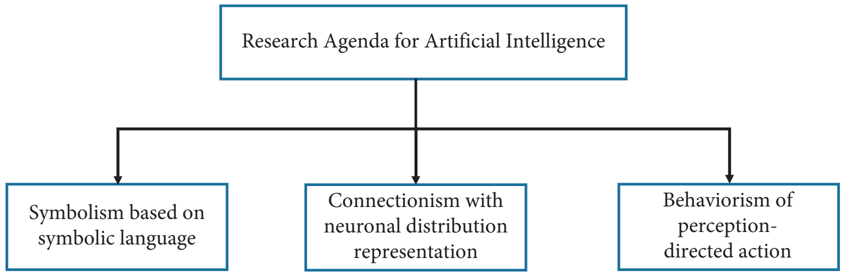

Figure 4: Research agenda of artificial intelligence.

research of natural language processing mainly adopts the simulation of human-computer dialogue to realize machine translation. After the emergence of Chomsky's transformational generative grammar, natural language processing realized widespread development and application through semantic analysis and recognition based on Chomsky's. Statistical methods were then added to the mix. At this stage, most of the semantic analysis is based on statistical methods, and the degree and accuracy of the analysis largely depend on the support of data volume. This method has no way to achieve the breakthrough and progress of semantic analysis ability, and it cannot solve the problem of constructing semantic analysis theory. The breakthrough of semantic analysis should be to build a word-level semantic lexicon and to realize the hierarchical analysis structure of the brain for semantics as much as possible; otherwise, it will not be able to break through the bottleneck faced by semantic barriers in theory and practice. With the progress in the field of artificial intelligence, natural language processing is indeed working toward the direction of semantic lexicon. Based on the limitations of statistical methods, natural language processing intends to think differently. It chooses to break away from the reliance on data and chooses to build semantic networks to make a breakthrough from the idea of context analysis and recognition. However, such an idea still has to be limited to syntactic rules and cannot meet the diverse demands on natural language processing. Thus, it seems that the core problem of semantic barriers lies in the fact that there is not a one-to-many logical relationship between syntactic rule-based semantic analysis and complex semantic analysis, but a complex many-to-many conditional relationship, which causes the problem of linguistic ambiguity. Therefore, the construction of a lexical-level semantic lexicon has become an urgent task. Since the 1990s, natural language processing research has indeed made many attempts to build semantic lexicons, but it still cannot escape the shadow of statistical methods and is still limited by the empiricism of the database. Some experts believe that from the perspective of theoretical methods, although the rule-based rationalism method restricts the development of the empiricism-based semantic knowledge base to a certain extent, there are more and more empirical methods that need to be made up by rationalism. Experts also point out that the integration of the two methods is also the current development trend of natural language processing.

Third, the semantic knowledge base based on statistical experience is too subjective and insufficient to support the realization of semantic analysis. The empirical thinking will always have theoretical loopholes, which will cause uncertainty in the results of natural language processing. "The basic semantic framework that constitutes the semantic knowledge base of the frame network starts from the analyst's intuitive judgment, and the establishment of a framework requires some iterative process of recognition. Because of the different knowledge backgrounds between analysts and analysts, and between analysts and users, their ways of thinking cannot be exactly the same, and thus their understanding and awareness of the problem will be different. The resulting frame network is bound to be subjective and uncertain to a certain extent, which cannot be avoided by constructing an empirical semantic knowledge base." Let us take synonymy as an example. The definition and division of synonymy criteria are artificially formulated and involved in computer systems, which makes the language processing at the level of synonymy subjective to humans. It can be seen that the key to the failure of the empirical approach is whether the construction of a semantic lexicon is really suitable to simulate the hierarchical structure of the brain. Not all words and things can be divided into hierarchical categories. In addition to synonyms, there are also things and words with multiple hierarchical properties and category distinctions, and the semantic expression of such things cannot be achieved by a simple hierarchical analysis structure only. On this basis, it is necessary to have the understanding that the capability of the semantic lexicon cannot achieve perfect semantic analysis for the time being, and the evaluation of the capability of the system should be based on its effectiveness and capability in practice.

Finally, the dynamic semantic analysis of the semantic web is difficult to achieve at this stage. The crossing of the semantic barrier of natural language processing cannot be explored only from a one-sided static viewpoint of the solution; after all, language is not just a simple textual expression but also involves the exchange and communication of ideas, which is a dynamic process. Based on this context, Berners-Lee proposed the concept of "semantic web." The semantic web is a kind of semantic Internet based on Internet technology, which can meet the dynamic communication and flexible needs of language processing. This requires the computer's intelligent algorithms and programs to run and be applied openly in the Internet so that the computer can communicate with people without barriers

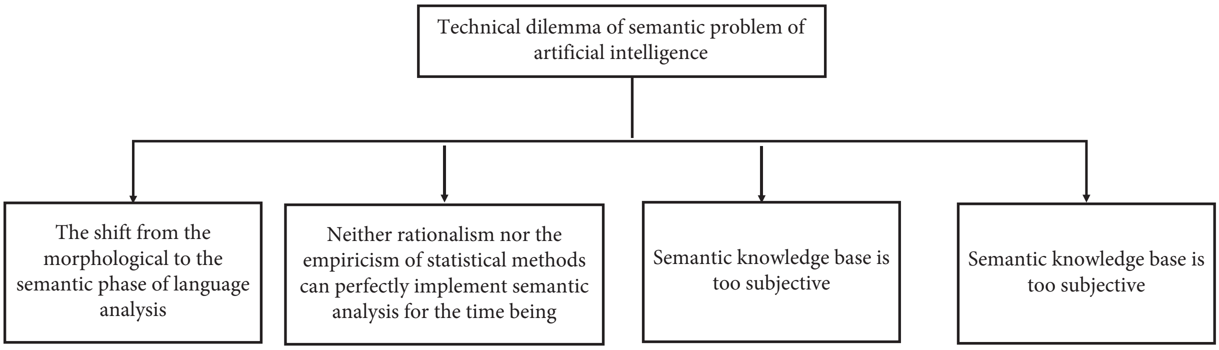

Figure 5: The various problems faced by AI semantics at this stage.

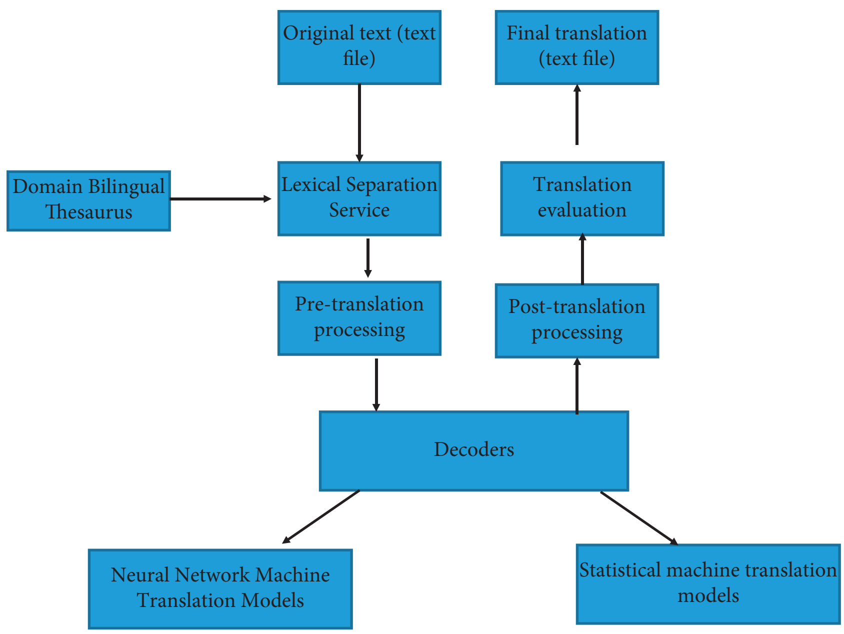

Figure 6: Machine translation engine training diagram.

and also so that the computer's processing of language can be continuously learned and improved. This puts new requirements on the computer's natural language processing system, because the instant communication in the Internet is dynamic and evolving and requires the computer to respond and give feedback in time so that the communication can proceed smoothly, as shown in Figure 5.

However, this requires more powerful natural language processing technology that can perform chapter-level semantic analysis, which is still an insurmountable difficulty at this stage, pending new breakthroughs in the technological progress of artificial intelligence. Therefore, the semantic problem in the AI perspective is also an important reason and core motivation to hinder the development of AI breakthroughs, for which many semantic explorations have been made in the technical field to try to solve the problem.

For example, the machine translation engine of New Translation Technology Company is used for training, the basic process is to import 20834 bilingual word pairs into the machine translation engine, and after the machine translation engine learns itself and deep learning, a machine translation model is generated using "neural network machine translation + statistical machine translation," as shown in Figure 6.

Nowadays, some researchers have also established a series of different framework models to improve the coherence of phrases and syntax in English translation by using artificial intelligence through big data technology; for example, a framework of Chinese to English machine translation system based on the phrase model, as shown in Figure 7.

From the figure, we can also see that the models used are trained: the phrase translation model and the sequencing model are extracted from the parallel corpus with bidirectional word alignment; the language model is trained from the monolingual corpus of the target language. Then, with the system framework diagram of the phrase-based machine translation model, it should be easy to obtain the system framework diagram of the phrase-based interactive machine translation system. What needs to be moved here should be focused on two places: first, the input of the system, in which the interactive case includes not only the source language

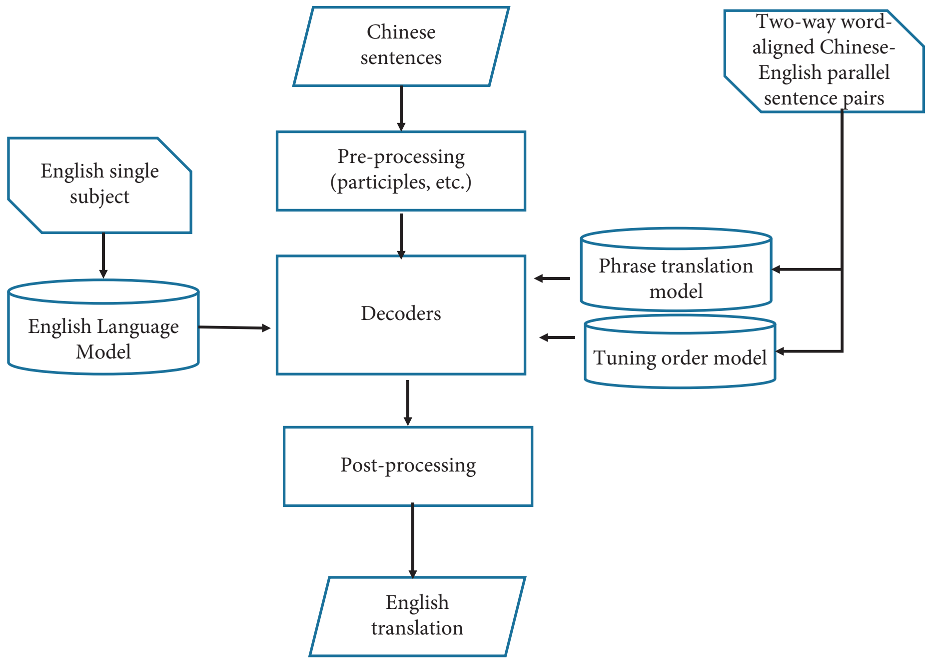

Figure 7: Framework of phrase model-based Chinese-to-English machine translation system.

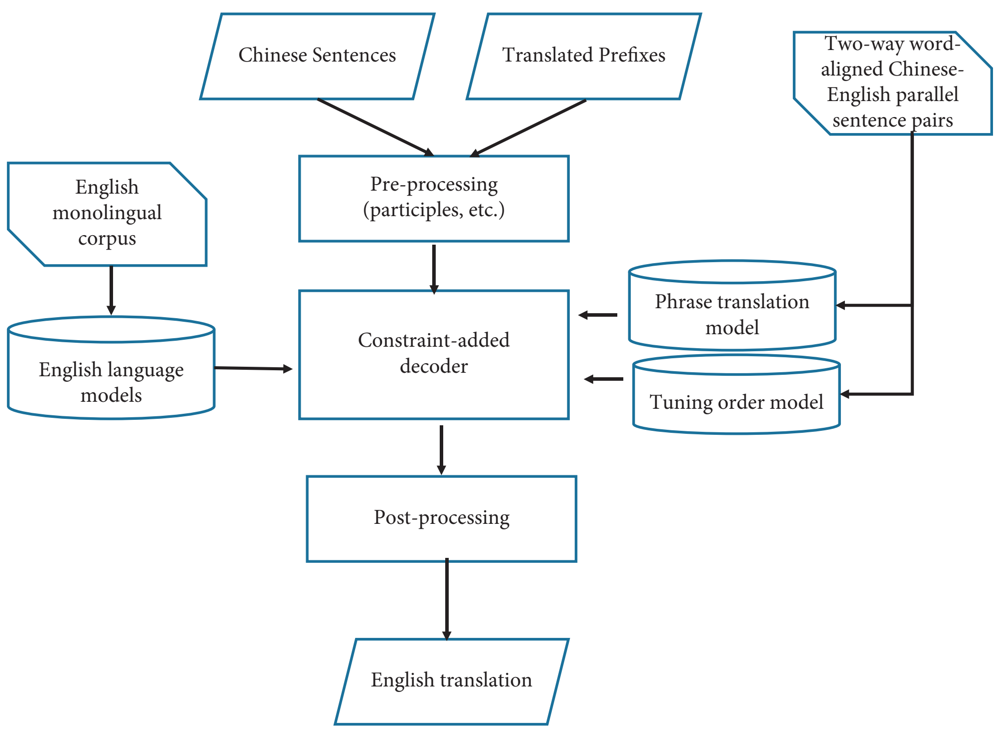

Figure 8: Framework diagram of the phrase-based interactive machine translation system.

sentences but also the translation prefixes confirmed by the user; second, the decoder part, where the search and decoding in the interactive environment becomes a restricted decoding process, that is, the paths that do not satisfy the restrictions are not considered. The framework diagram of the phrase-based interactive machine translation system is outlined, as shown in Figure 8. The framework diagram of the phrase-based model of the interactive machine translation system can be seen to be identical to the framework diagram of the underlying features (models) used in the phrase-based machine translation system, as shown in Figure 8.

5. Conclusion

Today's society has crossed from the information age into the data age, and the basic application based on big data can truly realize the universal and extensive communication mode of language, completely sweep away the difficulties caused by language barriers, and greatly improve the efficiency and quality of translation. As an innovative technology catering to the three elements of translation development, cloud translation further combines machine translation and human through big data, using information technology to bring high speed and rapidity to translation, cooperating with human understanding of the article, combining with context to accurately translate the text, and making it closer to fit the original text. Translators have the creativity and flexibility that cannot be replaced by machine translation, and the combination of cloud technology and human is the optimal solution for today's translation business. For example, under the mode of crowdsourcing translation, a large number of translation' teams and volunteers from the network participate in translation, which better solves the difficulties brought by heavy translation tasks to translators, thus realizing a large number of translation results output. To sum up, the continuous development of big data and cloud computing technology makes translation technology become more and more mature, and the complementary translation of efficient and fast machine translation and accurate human translation to fit the original text will become the new normal. In translation practice, neither the efficiency and convenience brought by machine translation to people in the translation business nor the translator's precise positioning of the translated text should be neglected; while the cloud technology should be fully utilized to pool translation resources, the translator's overall grasp of the text is needed to avoid unnecessary phrases and syntactic errors.

Data Availability

The dataset can be accessed upon request to the author.

Conflicts of Interest

The author declares no conflicts of interest.

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